DURATION DIFFERENCES IN DIFFERENT VOWEL CLASSES OF THE SPEECH OF THE ELDERLY

By

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DURATION DIFFERENCES IN DIFFERENT VOWEL

CLASSES OF THE SPEECH OF

THE ELDERLY

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PREFACE

The following study focused on the effects of aging on fricative durations in varying vowel contexts in the speech of the elderly.

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Chapter	Page

TABLE OF CONTENTS

LIST OF TABLES

Table Page

CHAPTER I

INTRODUCTION

Americans are living longer, healthier lives with the aid of medical breakthroughs and technological advances. This increased longevity also brings with it an increase in the proportion of the elderly population. The size of that population in America is projected to grow at an extraordinary rate in the 21st century and perhaps become one-third of the nation's population by end of the first two decades of the 21st century (Payne, 1997). Most of the 65-plus age group will exhibit some age-related changes of the advancing years. The human speech mechanisms of the young adult will begin to succumb to a number of changes after age thirty-five, which will eventually impact their oral communicative abilities.

Respiratory Changes

The respiratory system for speech is a pneumatic (air-drive) system that is one essential part for speech production. It is comprised of hard structures, such as the rib cage, that help protect the soft structures like the lungs themselves. In order for breathing for speech to occur, there must first be a pressure drop in the lungs which allows air to flow into the lungs. Then, on expiration a speaker must have an ability to control the velocity with which the air is released by using the musculature of the thorax – the recoil forces as well as elasticity of those structures. When all structures are intact and recoil forces are sufficient, the speaker then exhales the air out of the lungs while vibrating the vocal folds to produce phonation.

The anatomical makeup and overall shape of the thorax changes as a person ages. A young mature thorax is generally convex in shape, has fairly flexible joints, and is fairly elastic in nature. The aging thorax tends to become smaller and more concave in shape as a result of a narrowing of the anteroposterior dimension (Beasley & Davis, 1981). The inspiratory phase of breathing for speech in younger mature speakers is about 25% while the expiratory phase is about 75% (Zemlin,1998). This ratio of the inspiratory phase to the expiratory phase increases in the aging speaker who has to spend more time taking in air and has less control over the air he or she lets out, which results in a reduced vocal efficiency. The thoracic narrowing also causes the costovertebral joints to change. Joints between the ribs and the vertebrae become less resilient through the changing vertebral structure and result in an altered rib angle. The ribs of the aging adult become restricted in their movement (Beasley & Davis, 1981), and there is also a reported ossification of the costal cartilages, causing the ribs to be less mobile when elevating and returning to rest (Jamieson, 1937; Noback, 1949). Such changes force the aging adult to do more work and take more time to fill the lungs.

The aging adult also experiences changes in the soft structures of the respiratory system. The younger speaker has a very strong musculature which enables the relatively easy expansion and contraction of the thorax. The aging speaker has a weakened musculature (Beasley & Davis, 1981). The lungs of the younger adult contain pleurae and bronchi which are resilient and aid in the exchange of air in the lungs (Zemlin, 1998). The pleurae of the aging adult speaker become stiffer and less mobile as a result of a thinned uneven surface and a decreased ratio of collagen to elastin fibers in the lungs (Beasley & Davis, 1981). McKeown (1965) also reported a sclerosis of the bronchi of the aged lung. Together, all changes make it harder for the aging adult musculature to control breathing for speech and use the respiratory system with the greatest efficiency.

Changes in size, shape, and elasticity along with a reduction in thoracic musculature capabilities are reflected in reduced vital capacities. Kahane (1981) noted that the respiratory function (including vital capacity) for a man age 75 was only 40-55 percent that of a man age 30.

Laryngeal Changes

After the inspiratory phase, the speaker gradually releases the breath for speech as the hard and soft structures of the larynx work together to produce a sound. Anatomic changes that occur in the hard structures (cartilages and joints) of the larynx affect the way the vocal folds move. The thyroid and cricoid cartilages undergo extensive ossification (Beasley & Davis, 1981) which may cause an increased stiffness in the laryngeal structure and decrease an elderly person's ability to bring the vocal cords together completely (Hall & Sinard, 1998). The larynx of the younger adult speaker is more resilient in terms of cartilagenous structures.

Certain parts of the arytenoid cartilages change. The body and the muscular processes usually completely ossify (Beasley & Davis, 1981). Several studies have shown that changes in the cricoarytenoid joint also occur (Hall & Sinard, 1998; Kahane, 1981). There may be a disorganization of collagen fibers as well as an unevening of the joint's surface that causes pitch variability in the aging voice (Hall & Sinard, 1998). Together those changes may lead to laryngeal joints and structures in the aged adult that are less mobile than those in the younger adult speaker.

Changes in the soft structures of the larynx occur along with the changes in the hard structures. The laryngeal glands that secrete mucous for lubrication of the larynx become shrunken and atrophic in the aging adult (Hirano & Sato, 1998). There is a loosening of the connective tissue which adheres the lamina propria to the mucosa over the vocal folds. In the younger adult speaker, this mucosa usually tightly adheres to the lamina propria (Beasley & Davis, 1981).

The vocal folds themselves undergo structural and tissue changes that lead to a poorer voice quality in the aging adult. In males, the folds become thinner, stiffer, and atrophied with age (Hall & Sinard, 1998; Sataloff, et al., 1997; Honjo & Isshiki, 1980), which causes a decreased vocal efficiency (Sataloff et al., 1997). There is also a break down or thinning of the elastic fibers in the vocal ligaments (Beasley & Davis, 1981), which form the medial portions of the vocal folds. In the younger mature speaker, the vocal ligaments are thickened (Zemlin, 1998). The younger mature male speaker has thicker folds which allow for a lower fundamental frequency and pitch.

Pharyngeal and Articulatory Changes

Age-related changes also occur in the structures that affect resonating qualities, articulation, and speech intelligibility (Beasley & Davis, 1981). Changes in the pharynx include a weakening and dilation of the pharyngeal musculature, a thinning of the pharyngeal mucosa, and a reduction in sensory innervation (Beasley & Davis, 1981).

These changes affect the functioning of the velopharyngeal valving, causing it to become increasingly inadequate for valving and resonation (Beasley & Davis, 1981). Articulatory hard structures undergo anatomical changes which affect a person's speech production. Beasley & Davis (1981) stated that there are morphological changes in the facial bones of the aging adult which may result in an alteration in the points of attachments for certain facial muscles. Those alterations may affect the aging speaker's biomechanical efficiency during speech (Beasley & Davis, 1981). Changes in the size of the mandible and maxilla may alter the shape of the oral cavity and affect resonant characteristics of the aging adult (Beasley & Davis, 1981). There is also data to show that the temporomandibular joint undergoes anatomical changes with aging (Kahane, 1981).

There are many muscles involved with articulation – masticatory muscles, facial muscles, and the tongue itself. These vital soft structures of the articulators are also marked with anatomical and physical changes of the natural aging process. The masticatory muscles undergo changes that produce an overall reduction in the biting force of the elderly. There is an atrophy in the musculature that produces an overall weakening effect (Beasley & Davis, 1981). In fact, the weakening causes a reduction in the biting force from approximately 300 lb/sq in. in younger adults to 50 lb/sq in. in the aging adult (Kaplan, 1971).

Anatomical changes in the aging adult's facial musculature have also been noted, but to a lesser degree. Beasley & Davis (1981) reported that the degree of flaccidity and contracture of the muscles varies among individuals. There is also a sagging of the skin due to an accumulation of fat in the submandibular region in persons over 50 years of age

(Pitanguy, 1978). Though changes in these muscles mainly result in a cosmetic effect, there is little known about how they affect articulation (Beasley & Davis, 1981).

The tongue itself is a large complex muscle, the primary articulator in the production of consonants, vowels, and diphthongs. According to Beasley and Davis (1981) there is an increase in muscle-fiber size with increases in the amount of interstitial connective tissues indicating atrophy of the tongue muscles. That atrophy may produce an overall loss in muscle mass, tone, and size of the tongue (Kahane, 1981). There is also a reported decrease in the diadochokinetic rates of the tongue in the elderly ages 66 to 93 (Ptacek, Sander, Maloney & Jackson, 1966). That suggests that the neuromuscular mechanisms required for speech production may be more susceptible to age-related changes in the elderly (Beasley and Davis, 1981).

Neurological Changes

There must also be an intact higher-level mechanism performing planning and execution of the motor movements in order for speech to be produced in any individual. All planning and sequencing of motor speech actions are generated by the central nervous system. Messages to carry out the motoric action are sent to the peripheral nervous system's cranial nerves, which in turn innervate the structures critical for producing speech. These underlying nervous system structures are also susceptible to age-related changes. Even sensory avenues, such as vision and hearing are impacted (DiGiovanna, 1994).

Some morphological changes that occur in the nervous system of most aging individuals include a slight loss of brain weight, a significant loss of neurons, and an increase in ventricular size (Valenstein, 1981; Kenney, 1989; Wright & Duckworth, 1997.) Aged individuals also have reported atrophy of the cortex (Valenstein, 1981). Changes in nerve cell function as a person ages may include the decline in the speed of the action potentials through the nerve fibers by approximately 30% between 20 and 80 years of age as well as a gradual loss of the myelin layer covering the peripheral nerves. Both of these nerve cell changes may affect the speed and precision with which signals are transmitted throughout the system (Wright & Duckworth, 1997). Thus, it is not unlikely that these age-related changes may affect an aging person's speech output.

Elderly Speech Characteristics

A number of vocal parameters have been investigated in an attempt to reflect upon the anatomic, physiologic, and neuromuscular status of the speech system. One area, which has received considerable attention, is vocal pitch and other quality characteristics of the speech signal in older adults. Some of the noticeable changes that listeners observe in the speech of the aging adult involve the general characteristics of the speech signal. Ptacek and Sander (1966) reported hoarseness, reduced intensity, hesitancy, and less pitch variability as dominant vocal quality features of older (67-87 years) adult speakers. It is not unusual to hear breathiness, loss of range, change in vibrato characteristics, increased tremor, and pitch inaccuracies in the normal aging adult (Caruso & Mueller, 1997; Sataloff, 1997). Sataloff (1997) said that the average fundamental frequency in males drops from approximately 225 Hz in ages 20-29 years to approximately 195 Hz in 80-90 years. In women, the fundamental frequency was reported to drop about 100 Hz (Honjo & Isshiki, 1980).

Another noticeable change that listeners report in the speech of the aging adult is a reduction in rate of speaking. Young mature adults have achieved their prime in terms of neuromuscular maturity for speech and are at their best and most agile in producing segmental component movements and intergestural coordinations. Older speakers have slowed speaking rates (Caruso & Mueller, 1997; Hartman, 1979). Boone (1997) noted that speaking rate (in spontaneous speech) may drop from the normal 150 words per minute (wpm) at age 40 to approximately 125 wpm at 75. Ramig (1983) found that older adults had slower speaking and reading rates than young adults. Further research done by Mysak (1959) and Ryan (1972) showed that older speakers (60-90 years of age) exhibited slower speech, in terms of words spoken per minute while reading the Rainbow Passage, than middle-aged (40-50 years of age) speakers. Finally, Smith, Wasowicz, and Preston (1987) also found significant differences between the speech rates of young adults (24-27 years) and elderly adults (66-75 years). They found that elderly adults slowed their speech rate (an average of 21% slower than the young adults) on various tasks including sentence durations, syllable durations, and segment durations. These results show that elderly adults do exhibit slower speech rates in various contexts.

A crucial question relating to the topic of speech rate is why duration differences exist between the speech of younger and older adults. There are no absolute answers at this time. However, researchers have suggested possible causes relating to the speech signal itself. Caruso and Mueller (1997) reported various factors relating to the speech signal that are thought to be at the root of this slowed speech rate. They say that the slowed rate may be due to increased length and amount of pauses during connected speech; a reduced velocity of articulatory movements during sound and syllable production; and/or a tendency for elderly adults to produce longer consonant, vowel, syllable, and sentence durations. This information regarding the mechanism for rate reduction at the level of the speech signal may provide insight into another level of consideration when determining possible causes for slowed speech rate in the elderly. Maybe these changes in the speech signal are attributable to changes in the neuromuscular aspects of speech production.

When considering how neuromuscular changes could possibly affect the aging adult's speech production, it may be helpful to view the matter from a slightly different perspective. Young immature talkers (younger than 6 years old) take longer to produce utterances than their young adult (college age) counterparts (Kent & Forner, 1980; Smith, 1978). Immature speakers lack the neuromuscular maturity which makes it difficult for them to produce all the fine motor activities involved in executing the various speech movements and gestures. Therefore, they must proceed more slowly than adults in order to insure that all the necessary components are present for an acceptable rendition of the utterance (Kent & Forner, 1980; Browman & Goldstein, 1992; Smith, 1978). The children are also not well developed in terms of intergestural coordination, which is also a reflection of their immaturity and tends to slow their rate (Browman & Goldstein, 1992). The possibility exists that if children lack neuromuscular maturity which impacts their speech rate, then older mature speakers may possibly be experiencing some fading neuromuscular integrity which contributes to their slowed rate.

Once again, the topic of the age-related changes of the elderly adult's neuromuscular system must be considered, because the elderly do not slow their speech rate in the same manner exactly as children do, yet there is a slower rate. One reported difference between young adult and aging speakers is an increase in the lengths of the pauses used by the older talkers (Linville, 1996). However, that may or may not be the entire reason for rate reduction. On one hand, very young speakers have neuromuscular immaturity. On the other, aging speakers may be experiencing fading neuromuscular integrity. Very young speakers exhibit slowed segmental production and poor intersegmental coordination. Little is known about such capabilities in older adults.

Reviewing the literature on slowed speech rate in elderly adults may provide additional insight into their mechanism for rate reduction. Many anatomical and physiological aspects could possibly affect speech output of the aging adult. The decrease in respiratory efficiency could result in more breaths and an increase in the length of the speech signal. Changes in the anatomical and physiological makeup of the articulators themselves may also affect speech rate. It could even be that the age-related changes taking place in the neurological system affect the aging adult's neuromuscular control over his/her speech output. Whatever the mechanism for rate reduction, it is important to note that it is probably not just one specific area, but more likely a combination of age-related changes in several areas that contribute to a slowed speech rate in normal aging adults.

A study by Brazeal (1997) sampled sentence productions in normal young adult females (18-25; group II), a group of 65-75 year-old females (group III), and a group of elderly females (group IV), 80 years and older. Across-group comparisons of temporal dimensions (phrase durations, fricative durations, voice onset times, and closure for /k/) were made and the findings were contrasted with those of Kent and Forner (1980) who studied similar contexts in very young speakers (four, six, and twelve-years-old). An effort was made to determine whether very young and aging speakers appeared to have any common mechanisms, which might have an impact on both groups' rate of utterance production.

The results of the comparisons were not clear-cut. It appeared from the Kent and Forner (1980) data that each of the children produced the phrase "took a spoon," which contained a fricative cluster along with a lip-rounded consonant, with similar durations. That same phrase took groups III (65-75 years; mean=615 ms) and IV (80+ years; mean = 564 ms) in the Brazeal (1997) study significantly longer to produce than group II (18-25 years; mean = 542 ms). The phrase "blue and red" took both the children and group IV (80+ years) significantly longer to produce than group II. The phrase contained the /bl/ cluster and a glide /r/, both of which require fairly sophisticated articulatory manipulations. The phrase "saw you hit the cat," which does not contain clusters, took the children significantly longer to produce than group II (Kent & Forner, 1980). However, the complexity of the phrase did not slow the rate of groups III and IV. It appeared from that study that some of the difficult sound cluster combinations might place an undue workload on the older speech system, necessitating a slowed rate to appropriately produce all the phonemes. Those were not necessarily all the same sound combinations that appeared to contribute to the slowed rate in very immature speakers.

Stone (1998) conducted a study focusing on some of the suggestions (including comparing fricative singleton and fricative cluster lengths across age groups) of Brazeal's (1997) study in order to help explain which sounds or sound combinations were more problematic in the aging adult. Stone (1998) compared the performances of two groups of older speakers (group II, 65-75; group III, 85+) with a group of young mature speakers (group I, 18-25) on several segments that contained a variety of fricative singleton and fricative cluster sounds in both initial and final positions in words. Several findings emerged from Stone's (1998) investigation. When comparing the lengths of the fricative /s/ in the final position (*us*), statistically significant differences were found between groups I and III and between groups II and III, with group III having the longest final /s/ duration among all three groups. Second, when an /s/ cluster preceded a vowel requiring a considerable amount of coarticulation of lip rounding to occur, as in the word "stove," both groups II and III experienced significantly longer segment durations ($p<.02$) than group I. Findings such as those may provide insight into the aging adult's mechanism for speech rate reduction. It may be that when the older speakers are required to execute the constriction needed to produce the frication in fricative sounds, along with the buildup of sub-constrictive pressures at the end of the word, considerable duress is placed on the integration of lung, jaw, and tongue adjustments. Thus, a slowdown in speech production is possible, or perhaps the coarticulatory effects of the vowel following the fricative caused a slowdown.

It would appear from some of the preliminary results from Stone (1998) that intergestural coordination may become somewhat more difficult for older speakers as well. The process of lip-rounding involves the movement of a fairly large, heavy articulator. It may be that such movements are some of the first to be slowed in older speakers. However, at this point the data to support such a premise are not clear. If intergestural coordination is an early problem with the reasonably healthy aging speaker, then there are also implications for therapeutic strategies for intervention with aging speakers with communicative problems, such as those dealing with motor speech. Rate and production demands and goals must be tempered with normal age limitations. Also, demands and goals must be tempered with normal age limitations. Also, materials and stimuli, which require excessive amounts of intergestural coordination may not be appropriate at some stages in therapy.

More information is needed to determine whether the process of lip-shaping has any consistent effect on the lengths of segment durations. Additional information, which might reflect on durational changes that parallel the presence of lip rounding and retraction in the utterances of older speakers is important because it may serve as an indicator of one of the underlying mechanisms of the slowing rate of speech in aging adults. The general purpose of the present investigation is to expand and extend the work of Brazeal (1997) and Stone (1998) to better define the kinds of articulatory lip movements, which may be especially difficult for the healthy aging speaker and require slowing of the previous sound so that appropriate coarticulation can be executed. The specific purpose is to compare the lengths of fricatives, in lip-retracted, lip-rounded, and neutral vowel contexts across young, mature and older groups of speakers.

CHAPTER II

METHOD

Participants

A total of 45 female subjects participated in this study. Subjects were assigned to one of three groups according to age: Group I (18-25), Group II (65-75), or Group III (85+). Each group consisted of 15 subjects.

Existing Database

Thirty-five females in the age range of 65-75 years and 80+ years who were living independently participated in a study by Harris (1996). Harris' (1996) data set, also common to Brazeal (1997) and Stone (1998), was utilized as part of the data of the current study. The subjects were normal speakers who met the following criteria: demonstrated speech free of any observable disorder, had no formal voice or speech training; and reported no previous or existing pathological condition known to be associated with speech/voice disorders. Subjects passed a hearing screening meeting the criterion of a pure tone three-frequency average of 35dB (ANSI, 1969) or better in the better ear (Harris, 1996). An interview was conducted with each participant to gather information regarding selection criteria as well as information concerning educational level, residential setting, employment history, current medications, and alcohol and tobacco use (Harris, 1996).

New Database

A control group of 15 subjects between the ages of 18-35 was selected from a group of volunteers from Oklahoma State University. The subjects were normal speakers based on the following criteria: each subject demonstrated speech free of any observable disorder, had no formal voice or speech training; and reported no previous or existing pathological condition known to be associated with speech disorders. Subjects passed a hearing screening meeting the criterion of a pure tone three-frequency average, non-aided, of 15dB (ANSI, 1969) or better, in the better ear. An interview was conducted with each participant to gather information regarding selection criteria, current medication, and alcohol and tobacco use.

Materials

The reading task was a large-type version of "The Farm Script" (Crystal & House, 1982) containing 313 monosyllabic words. This script is included in Appendix A. The oral readings were recorded using a Nagra reel-to-reel tape recorder, a unidirectional microphone, and studio quality tapes. The microphone was positioned approximately 8-12 inches away from the subject.

Procedures

Subjects were assessed at the OSU Speech-Language-Hearing Clinic. Prior to testing, each subject was orally briefed about the purpose of the study and signed an informed consent form approved by the Oklahoma State University Institutional Review Board. Each subject was then assigned an alphanumeric reference number. Subjects were assessed individually in a quiet environment, free from as much extraneous noise as possible. After the examiner completed each interview, each subject was administered a hearing screening using a GSI model 17 portable audiometer. General speech behavior was screened during spontaneous conversation with the subjects.

Upon passing the hearing screening and the normal speech requirements, each subject was asked to orally read the "Farm Script." Large print copies of the "Farm Script" (Crystal & House, 1982) were provided to each subject. Each subject was given the following oral instructions: "Read this passage silently and familiarize yourself with the words. I cannot help you with any words." After reviewing the passage, subjects were then instructed in the following manner: "When I say 'go,' read the passage aloud at your normal speaking rate."

Data Analysis

Wide band spectograms were obtained from the recorded acoustic speech signal and fricative durations were measured from the spectograms. Twelve monosyllabic words containing fricatives in singleton and cluster contexts were chosen from the "Farm Scrip" for analysis. Four words contained a rounded vowel, four contained retracted vowels, and four contained neutral vowels. Fricatives measured were in the initial position of the word in the nine out of twelve words. The remaining three words contained fricatives in the final word position. See Table 1 for an inventory of words analyzed. Recording was started at the beginning of the sentence until the window of the spectrum analyzer was filled. The lengths of the fricatives occurring prior to or following the vowel were measured in milliseconds.

TABLE 1

MEASURED WORDS

	Rounded Vowels	Retracted Vowels	Neutral Vowels
Clusters	stove	stays	stuff
	most	least	box
Non-Clusters	sort	set	such
	so	seat	sun

The lengths of the fricative singletons and fricative cluster combinations with adjacent vowels varying according to lip position (rounded, retracted, neutral) were compared across age groups using three, two-factor, mixed-design analyses of variance. The three groups of speakers, grouped by age, made up three levels of a between-groups factor. The first group contained 18-35 year-olds; the second group, 65-75 year-olds; and the third group, 85+. Fricative duration for each word served as four levels of a repeated measure variable. Comparison 1 compared fricative durations in words containing lip-rounded vowels across age groups and across words. The second comparison compared fricative durations in words containing lip-neutral vowels across age groups and across words. The final comparison compared fricative durations in words containing lip-retracted vowels across age groups and across words. A final two-factor ANOVA was conducted to determine whether fricative length differed significantly across age groups or across vowel contexts.

Reliability

Interjudge reliability for measuring fricative lengths for the oral reading samples was determined. A second independent observer, a graduate student in speech-language pathology, performed the analysis procedures for one-third of the subjects randomly selected. The Pearson product moment correlation coefficient was calculated using independent observer and examiner measures. The Pearson product moment correlation coefficient was .903 for fricative length during the oral reading samples.

Intrajudge reliability was determined by the first examiner repeating the fricative measurements on a randomly selected one-third of the subjects. Pearson product moment correlation coefficients were calculated with the examiner's initial measurements. The Pearson product moment correlation was .903 for fricative lengths during the oral reading samples. Results of both inter- and intrajudge measures indicated a high level of reliability for test measures.

CHAPTER III

RESULTS

Three, two-factor mixed design analyses of variance (ANOVA) on the dependent variable of fricative duration as a function of word and age were run. The first ANOVA compared fricative durations in words containing lip-rounded vowels across age groups and across words. The second compared fricative durations in words containing lip-neutral vowels across age groups and across words. Fricative durations in words containing lip-retracted vowels were compared across age groups and across words for the third ANOVA. The final ANOVA compared fricative lengths across age groups and across vowel contexts (rounded, neutral, retracted).

Lip-Rounded

The first comparison involving fricatives in the presence of lip-rounded vowels was made across age groups and words. Significant main effects for age, $F\ (2, 42) = 5.72$, $p < .01$ and for words, $F\ (3, 126) = 34.32$, $p < .01$ were found (see Table 2). The age by word interaction was significant.

Means were combined across the different words and Tukey follow-up comparisons revealed that Group II (65-75) had fricative durations that were significantly longer than Group I (18-35). Group III (80+) had fricative durations which were significantly longer than those of Group I and shorter than Group II. See Tables 3 and 4 for a list of means for fricative durations for each word and age group.

TABLE 2

ANOVA SOURCE TABLE, ROUNDED VOWELS

Source	df	SS	MS	F	p
Between Subjects					
Group	2	26745.23	13372.61	5.72	0.006*
Between Subjects Error	42	98220.50	2338.58		
Within Subjects					
Word	3	63568.75	21189.58	34.32	0.000*
Group X Word	6	1888.97	314.83	0.51	0.800
Within Subjects Error	126	77792.52	617.40		

Note: * = statistically significant value.

TABLE 3

TUKEY FOLLOW-UP COMPARISONS MEAN FRICATIVE DURATIONS (msec) FOR EACH AGE GROUP COMBINED OVER ALL LIP-ROUNDED VOWEL CONTEXTS

	Group I (18-35)	Group II (65-75)	Group III (80+)
Fricative Duration msce	90.80	120.08**	110.50

Note: (CV 27.28); * * = statistically significant value.

TABLE 4

TUKEY FOLLOW-UP COMPARISONS MEAN FRICATIVE DURATIONS (msec) FOR EACH WORD COMBINED OVER ALL AGE GROUPS

Word	Stove	Most	Sort	So
Fricative Duration msce	105.10	83.12**	135.85**	104.45**

Note: (CV 27.28);** = statistically significant value.

Lip-Neutral

The next comparison involving fricatives in the presence of lip-neutral vowels was made across age groups and across words. Significant main effects for age, $\underline{F}$ (2, 42) = 7.51, $\underline{p} < .01$ and for words, $\underline{F}$ (3, 126) = 7.312, $\underline{p} < .01$. There was also significant age by word interaction, $\underline{F}$ (3, 126) = 2.93 (see Table 5).

TABLE 5

ANOVA SOURCE TABLE, NEUTRAL VOWELS

Source	df	SS	MS	F	p
Between Subjects					
Group	2	32673.98	16336.99	7.51	0.002*
Between Subjects Error	42	91332.87	2174.59		
Within Subjects					
Word	3	26935.10	8978.37	7.32	0.000*
Group X Word	6	21573.64	3595.61	2.93	0.010*
Within Subjects Error	126	154573.87	1226.78		

Note: * = statistically significant value.

Follow-up Tukey tests were run on the pairs of individual cell means. Table 6 lists those cell means. The mean durations of the /s/ fricative in *box* were significantly longer in Group III (CV 3, 42 = 16.91) than they were in Group II. The durations were significantly longer in Group II than they were in Group I. A comparison across the words revealed that all groups produced the /s/ fricative in the word *box* with significantly shorter durations than the fricatives in all the rest of the contexts (CV 4, 126 = 40.7).

TABLE 6

TUKEY FOLLOW-UP COMPARISON MEAN FRICATIVE DURATIONS (msec) FOR EACH LIP-NEUTRAL WORD COMBINED OVER ALL AGE GROUPS

Word	*Stuff*	*Box*	*Such*	*Sun*
Age Group				
18-35 years	122.46**	76.45	110.67**	107.84**
65-75 years	129.80	92.77**	154.08	132.71
80+ years	131.00	139.75	144.00	130.67

Note: Critical Value (CV) between groups = 16.91; CV within groups = 40.70; ** = statistically significant value.

Lip-Retracted

The third comparison involving fricatives in the presence of lip-retracted vowels was made across age groups and across words. Significant main effects for age, F (2, 42) = 18.58, $p < .01$ and for words, F (3, 126) = 21.36, $p < .01$ were found (see Table 7). The age by word interaction was not statistically significant.

TABLE 7

ANOVA SOURCE TABLE,
RETRACTED VOWELS

Source	df	SS	MS	F	p
Between Subjects					
Group	2	56927.03	28463.52	18.58	0.000*
Between Subjects Error	42	64341.34	1531.94		
Within Subjects					
Condition	3	40934.65	13644.88	21.36	0.000*
Group X Condition	6	2657.02	442.84	0.69	0.655
Within Subjects Error	126	80476.53	638.70		

Note: * = statistically significant value.

The measures were combined over age groups and compared across words in follow-up Tukey comparisons (see Tables 8 and 9). The fricative in the word *least* was significantly shorter than the fricatives in any of the other three words (CV 4, 126 = 40.7). The remaining durations did not differ significantly from each other. When the durations were combined over words and compared across age groups, Group III had significantly longer durations than the other two groups (CV 2, 42 = 16.91).

TABLE 8

TUKEY FOLLOW-UP COMPARISONS MEAN FRICATIVE DURATIONS (msec) FOR EACH AGE GROUP COMBINED OVER ALL LIP-RETRACTED VOWEL CONTEXTS

	Group I (18-35)	Group II (65-75)	Group III (80+)
Fricative Duration msce	76.32**	109.80	116.44

Note: (CV 22.00); * * = statistically significant value.

TABLE 9

TUKEY FOLLOW-UP COMPARISONS MEAN FRICATIVE DURATIONS (msec) FOR LIP-RETRACTED WORDS COMBINED OVER ALL AGE GROUPS

Word	Stuff	Box	Such	Sun
Fricative Duration msce	104.55**	76.03**	107.67	115.14

Note: (CV 16.95);** = statistically significant value.

Group II had longer durations than Group I and shorter duration than Group III. But, those differences were not large enough to be statistically significant.

Final Comparison – All Vowel Contexts Combined

The above age by word contrasts did not compare the three different vowel contexts across age groups. One of the main purposes of the study was to determine whether any vowel context (rounded, neutral, or retracted) appeared to lead to a slower production of fricatives in the older age Groups II and III than in Group I.

A fourth two-factor ANOVA was conducted. The three age groups constituted three levels of an independent variable. The fricative durations were averaged for the words containing lip-rounded vowels (*stove, most, sort,* and *so*), for words containing lip-neutral vowels (*stuff, box such,* and *sun*), and for words containing lip-retracted vowels (*stays, least, set,* and *seat*).

The rounded, neutral, and retracted fricative durations constituted three levels of a repeated measures variable. Significant main effects for age, (F 12.994, df 2, $p<.01$) and for vowel contexts (F 22.918, df 2, $p<.01$) were found. The age by vowel context interaction was not statistically significant.

When the mean fricative durations were combined across vowel contexts and compared using Tukey follow-up comparisons, Group I had significantly shorter fricative durations in all vowel contexts than Groups II and III. There were no statistically significant differences between Groups II and III.

The means for each of the age groups combined over vowel contexts are contained in Table 10. When the means were combined over age groups to contrast the fricative durations for each of the vowel contexts, the fricative lengths in the rounded or retracted vowel contexts. The durations of the fricatives in either lip-rounded or lip-retracted vowel contexts did not differ significantly from each other. The means for each of the vowel contexts combined over age groups are contained in Table 11.

TABLE 10

TUKEY FOLLOW-UP COMPARISONS FRICATIVE DURATIONS COMBINED OVER VOWEL CONTEXTS

	Group I (18-35)	Group II (65-75)	Group III (80+)
Mean	90.49*	119.07	121.35

Note: (CV 3,42 = 20.85); all values reported in msec; * = statistically significant value.

TABLE 11

TUKEY FOLLOW-UP COMPARISONS FRICATIVE DURATIONS COMBINED OVER AGE GROUPS

Rounded	Neutral	Retracted
107.13	122.68*	101.09*

Note: (CV 3,84 = 9.96); all values reported in msec; * = statistically significant value.

CHAPTER IV

DISCUSSION

The purpose of this investigation was to define the kinds of articulatory lip movements that may be especially taxing on the articulatory system of the healthy aging speaker. It was thought that some sounds which were especially later developing and difficult for young children to master (like fricatives) might be especially cumbersome for the aging speech system as well. It was also thought that fricatives in combination with vowel contexts that required large articulator movements might place a disproportionately large burden on such a mechanism, thus precipitating major adjustments in the speed of fricative execution. Participants, belonging to one of three groups – Group I (age 18-35), Group II (age 65-75), and Group III (age 80+) – were audio tape recorded while reading the "Farm Script." Fricative durations were determined using CSL analysis to measure them in milliseconds. Fricative durations were then compared across age groups and across words using a separate two-factor ANOVA for each of the different vowel types (rounded, neutral, retracted). A final ANOVA combined the lengths of the fricatives in the three vowel contexts and compared those lengths across age groups.

The present study compared fricative lengths in the presence of different vowel contexts across age groups to determine if vowels that differ in their lip-rounding characteristics appeared to have an impact on the length of time it took elderly adults to produce certain fricatives. Physiological changes that occur during the normal aging process were thought to affect the agility of the elderly individual's speech system, thus leading to a decreased rate of speech and slowed coarticulation. It was also thought that the elderly speakers would be especially susceptible to coarticulatory influences of fricatives that preceded lip-rounded vowel contexts because of the increased amount of articulator manipulation in such a sequence.

Lip-Rounded

The first comparison that involved fricative /s/ in the context of lip-rounded vowels found that both elderly age groups produced the /s/ with statistically significantly longer durations than the younger group of speakers. As was expected, follow-up Tukey tests which combined the different words revealed that the oldest group (III) produced the /s/ with statistically significantly longer durations than the young group of speakers. However, follow-up Tukey tests also revealed that Group II (65-75) had statistically significantly longer fricative durations than both Group I and Group III. This finding was not expected at the outset of the study. Since the oldest group (III) should have been exposed to the greatest effects of physiological aging, it was suspected that Group III would exhibit the longest fricative durations across all vowel contexts. In this particular instance, however, the 65-75 year olds' duration did not substantiate that theory.

There were also statistically significant main effects found for words indicating that some vowels abutted fricatives with longer durations than other fricatives. The /s/ in *most* was produced with the shortest mean duration among all the groups. The arresting consonant /t/ at the end of the word may cause speakers to cut the /s/ short as the /s/ is not the final sound in the word. The /s/ in the word *sort* had the longest mean duration among all the groups; the young group having the shortest duration, then the oldest group, then the middle elderly group with the longest. This fricative /s/ preceded a lip-rounded vowel context, which was originally assumed to be a difficult coarticulatory sequence to produce by the oldest group. Finding that the sequence was longer in all the groups suggests that an initial fricative preceding a lip-rounded vowel may be a sequence that requires the articulators to slow down disproportionately in older speakers.

Lip-Neutral

When comparing the /s/ fricative in the context of neutral vowels, statistically significant effects were found for age groups as well as for words. A statistically significant age x word interaction also indicated that the /s/ fricative durational patterns varied depending upon the ages of the groups of speakers. Group III had the longest durations for the production of /s/ fricatives in the neutral vowel context. This conclusion was expected because of the effects that normal physiological aging have on an elderly adult's speech system. Group II produced /s/ with longer durations than Group I in the neutral vowel context. Again, this conclusion was expected based on the fact that Group II was older and had undergone more of the natural aging process than Group I.

When looking at each word, the /s/ fricative in the word *such* was produced with the longest duration among all the groups. An explanation for this finding lies in the context of the material. The word *such* was contained in the phrase, *We had passed such a place on the road . . .* In this instance, the effects of coarticulation played a role in the length of the /s/ in *such*. The subjects in the study tended to coarticulate the words *passed* *such* so as they did not produce the final /t/ on the word *passed*, causing the /s/ in *such* to have a longer duration because it was a continuation of the /s/ from the preceding word.

The word fricative /s/ in the word *box* was produced with statistically significant shorter durations among all the groups. This word contained an /s/ preceded by an arresting stop consonant /k/. The brevity of the production of stop consonants, in this case /k/, may have influenced the duration of the fricative /s/, thus causing it to be produced with shorter durations.

<u>Lip-Retracted</u>

The final comparison involved the duration of the /s/ fricative in the context of lip-retracted vowels in the words *set, seat, stays,* and *least*. Statistically significant main effects were found for age groups and for words. As was expected, Group III had statistically significantly longer durations of the /s/ fricative in all words than both Groups I and II. Although Group II's /s/ fricative production durations were longer than Group I's, those differences were not great enough to be statistically significant.

Within the groups, across words, the /s/ fricative in the word *least* was significantly shorter than the fricatives in the other lip-retracted words. The /s/ in *least* is followed by an arresting consonant, /t/. The nature of production of the /t/ consonant is the abrupt stoppage of airflow followed by a plosive burst of air. The preceding fricative /s/ is cut short in duration in preparing for the production of the arresting consonant. This pattern was also exhibited in the first two comparisons. In comparison one, the /s/ fricative in the word *most* had the shortest mean duration among all the groups. In comparison two, the /s/ fricative in the word *box* had the shortest mean duration among all the groups. Stone (1998) also found this to be the case. She reported that all age groups (18-25, 65-75, and 80+) in her study produced the fricative /s/ preceding a /t/ in the final word position with shorter durations than the /st/ cluster in the initial word position.

Combined Vowel Contexts

The final comparison, which contrasted vowel context across age groups, indicated that the three age groups differed significantly across the three different vowel contexts. When the means for the vowel contexts were combined and compared using Tukey follow-up comparisons, Groups II and III demonstrated statistically significantly longer fricative durations than Group I. Mean fricative durations for Groups II and III were very similar to each other. The reason for that increased length in the older groups is not clear, bu may be due to a general slowing of the articulatory activities as a result of the complex influences of the aging process.

Though it is difficult to speculate about any specific cause of the findings of this study, one factor does remain clear. The lengthened fricatives appear in both the 65-75 year-old group (II) and the 80+ year-old group (III). It could be that as early as age 65, segmental execution has slowed significantly as a result of the normal aging process. It is possible that inter-gestural coordination and coarticulation skills have slowed as well, precipitating slower fricative durations in older speakers (65+).

The fricative means were also combined over the age groups and compared across vowel contexts in the Tukey follow-up comparisons. That contrast indicated that fricatives which occurred in the presence of lip-neutral vowel contexts were longer in duration than those that occurred in both lip-rounded and lip-retracted contexts. The reasons for this finding remain very speculative. Since the neutral vowels do not require as much articulatory manipulation as the rounded and retracted vowels, the articulatory have more time to spend on surrounding sounds (fricatives, in particular). In rounded and retracted vowel contexts, more time may be needed for the articulatory to maneuver into the proper positioning for those vowel productions. Thus, the fricatives surrounding those vowels may be cut short in duration. Whatever the reason, it appears that no particular vowel category appears to disproportionately impact fricative duration more in Groups II or III than in Group I, which was one of the questions that the present study attempted to clarify.

Looking at the overall picture, all the groups tended to follow similar patterns in the production of /s/ fricatives among vowel contexts. The contexts that slowed down the oldest group's productions also slowed those of the middle elderly group and the young adult group, but to a lesser degree. The original hypothesis that lip-rounded and/or retracted vowel context would slow down the elderly's production of /s/ fricatives was not substantiated. In fact, the opposite was found. It was the fricatives surrounding the lip-neutral vowels that were produced with longer durations in all three groups.

This investigation has supplemented the informational database concerning durational characteristics of fricative production in the elderly population. Results have shown that the segmental and suprasegmental durations of the speech of the elderly are significantly slower than that of young adults. According to this study, the fricatives abutting lip-neutral vowels were longer in duration than fricatives abutting lip-rounded or retracted vowels. However, the lip-neutral vowels do not appear to disproportionately affect the normal elderly person's duration of fricative production.

Areas that warrant further investigation include further examination of temporal dimensions in the speech of the elderly. The proportion of time an elderly adult spends on the production of certain sounds in relation to other consonants or vowels within a phrase or within a word may lead to a better understanding of what sounds are most affected by the normal aging process. A similar study done by Smith (1978) looked at the proportional time young children (6 years and younger) spent on fricatives in a phrase in relation to other consonants and vowels and if this proportion was significantly different from normal adults. He found that indeed the children did spend a disproportionately longer amount of time producing fricatives and later developing sounds than did the adults. From this information, it would be interesting to determine if the elderly population exhibits the same disproportionate amount of time producing some sounds in relation to others in the same manner that children do. If not, the question would be "What sounds do the elderly spend the most time producing?"

The data presented in this study provides an extension of the existing knowledge base from Stone's (1998) study on the effects of the normal aging process on fricative length. Although this study did not find that vowel context was a significant factor that predicts tremendously slower production on certain coarticulatory sequences in elderly adults' speech, it did identify that fricatives abutting lip-neutral vowels are produced with longer durations among all age groups. Future research in suprasegmental temporal dimensions in the areas of proportion of time spent on certain sounds in phrases, proportion of time spent on pauses in utterances, and proportion of time spent on transitioning from sound to sound within a phrase would provide a more extensive knowledge of the mechanism the normal elderly adult uses to slow down his rate of speech.

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APPENDIXES

APPENDIX A

FARM SCRIPT

The Farm Script

John and I went to the farm in June. The sun shone all day, and wind waved the grass in wide fields that ran by the road. Most birds had left on their trek south, but old friends were there to greet us. Piles of wood had been stacked by the door, left there by the man who lives twelve miles down the road. The stove would not last till dawn on what he had cut, so I went and chopped more till the sun set. The sky stays light quite late as far north as that, but I knew it would be a cold night. The car seat was piled high with stuff, but it would have to stay there for the night. It was too far to go to take it all out now. Food was the next thing. John had lit the stove, so I cooked up some hash and beans, which was what was in the cans that I could reach with least work. My box with most of the food was deep in the car and it was too dark now to dig my way down to it. When served hot, hash and beans taste quite good if it's been a long time since you last ate. We had some bread, of a sort that you find in small stores far from the towns, where the new ways to make bread, and the new types of flour have not yet been reached. We had passed such a place on the road, and had stocked up with things that can't be bought in town. Things like home baked bread; and real cheese made from cow's milk; jam with real fruit in it; and fresh milk with rich deep cream on top. We shall not have a chance to buy these in the cold months that are to come.

APPENDIX B

FRICATIVE DURATION DATA: ROUNDED

VOWELS 18-35 YEAR-OLDS,

GROUP 1

SUB	STOVE	MOST	SORT	SO
2101	89.38	61.98	113.73	81.15
2102	96.60	66.83	118.88	74.77
2103	122.18	55.38	95.78	144.08
2106	91.10	68.83	120.03	112.15
2107	100.38	62.58	132.10	62.73
2108	139.53	51.90	116.18	111.68
2109	123.60	63.43	118.83	113.18
2110	84.97	85.68	106.65	96.10
2111	99.93	64.32	120.53	59.38
2112	90.83	73.68	113.13	82.78
2113	97.07	61.53	102.45	77.00
2114	85.03	82.58	104.05	61.33
2115	51.00	88.13	130.25	83.72
2116	71.50	59.68	89.25	66.05
2117	77.33	44.53	146.75	81.88

APPENDIX C

FRICATIVE DURATION DATA: NEUTRAL

VOWELS 18-35 YEAR-OLDS,

GROUP I

SUB	STUFF	BOX	SUCH	SUN
2101	132.08	77.45	122.70	123.95
2102	150.65	60.28	97.15	97.48
2103	117.73	70.95	78.15	87.75
2106	125.08	74.60	109.35	98.75
2107	103.55	68.72	108.08	113.98
2108	142.15	61.73	117.40	95.30
2109	152.33	66.90	109.03	125.33
2110	131.05	90.08	112.80	122.55
2111	111.30	94.78	132.80	100.53
2112	154.60	80.65	119.35	108.48
2113	144.10	54.28	104.00	104.03
2114	92.08	72.03	109.25	111.78
2115	69.75	139.53	129.30	121.73
2116	104.23	84.38	100.00	84.05
2117	106.15	50.45	110.68	120.90

APPENDIX D

FRICATIVE DURATION DATA: RETRACTED

VOWELS 18-35 YEAR-OLDS,

GROUP I

SUB	STAYS	LEAST	SET	SEAT
2101	85.98	67.15	94.15	83.15
2102	89.90	69.88	99.63	99.40
2103	91.28	28.33	74.15	96.53
2106	73.58	68.42	98.73	85.30
2107	93.98	64.93	83.38	58.63
2108	100.10	52.75	45.03	72.50
2109	88.48	62.15	89.23	108.25
2110	93.15	52.43	97.53	94.23
2111	105.48	65.50	85.63	74.83
2112	61.25	50.70	67.10	63.00
2113	52.83	61.03	106.13	92.18
2114	64.65	47.13	91.33	91.53
2115	28.15	82.48	77.48	107.50
2116	67.03	23.80	52.55	64.78
2117	78.63	56.38	102.10	95.43

APPENDIX E

FRICATIVE DURATION DATA: ROUNDED

VOWELS 65-75 YEAR-OLDS,

GROUP II

SUB	STOVE	MOST	SORT	SO
6501	81.57	82.97	137.50	98.65
7402	92.92	96.15	165.70	112.85
7204	105.80	71.68	128.23	116.73
6606	114.30	53.68	200.85	117.70
7208	207.40	135.80	169.63	124.08
7510	309.20	263.93	187.48	162.08
7012	54.50	77.03	131.88	148.95
7013	129.65	107.78	128.85	115.83
7814	74.75	83.35	130.10	74.85
6715	65.88	68.58	112.38	68.75
7416	120.90	89.35	140.35	84.58
6917	85.88	91.10	151.70	125.60
6918	109.20	78.75	187.28	105.73
6822	91.45	83.78	130.08	91.93
7123	121.90	83.10	157.20	165.03

APPENDIX F

FRICATIVE DURATION DATA: NEUTRAL

VOWELS 65-75 YEAR-OLDS,

GROUP II

SUB	STUFF	BOX	SUCH	SUN
6501	109.78	184.98	255.50	105.73
7402	133.43	57.38	177.60	155.83
7204	94.48	99.95	142.68	124.40
6606	137.68	86.58	169.10	150.73
7208	239.95	86.58	177.83	110.63
7510	220.13	146.68	165.95	191.50
7012	71.28	70.28	160.23	118.23
7013	147.10	79.48	129.08	138.25
7814	104.38	122.00	142.08	115.70
6715	79.55	53.08	161.55	116.65
7416	139.70	72.65	41.55	149.20
6917	111.05	75.68	182.43	112.15
6918	125.35	89.05	144.68	155.35
6822	108.98	95.03	108.33	107.95
7123	124.13	72.15	152.55	138.40

APPENDIX G

FRICATIVE DURATION DATA: RETRACTED VOWELS 65-75 YEAR-OLDS, GROUP II

SUB	STAYS	LEAST	SET	SEAT
6501	80.93	60.83	92.50	119.80
7402	151.23	124.28	127.18	156.33
7204	101.15	77.83	115.33	117.90
6606	103.13	78.55	161.33	154.48
7208	146.23	113.00	118.78	158.10
7510	191.25	118.70	149.10	110.05
7012	50.65	23.93	107.08	144.05
7013	92.03	70.23	115.48	120.65
7814	99.45	73.83	119.50	108.83
6715	98.75	58.23	122.88	99.68
7416	86.70	74.10	88.48	99.00
6917	204.00	94.85	105.40	126.88
6918	119.08	129.55	102.43	110.53
6822	94.15	76.08	124.25	100.05
7123	97.03	116.20	88.13	117.70

APPENDIX H

FRICATIVE DURATION DATA: ROUNDED

VOWELS 80+ YEAR-OLDS,

GROUP III

SUB	STOVE	MOST	SORT	SO
8603	130.85	58.25	118.15	84.20
8005	46.13	73.45	112.85	109.00
8007	101.50	78.77	132.57	102.22
8109	59.83	57.51	122.45	95.78
8611	122.65	107.43	200.25	120.03
8124	85.43	67.70	130.98	98.05
8325	147.28	210.38	156.23	126.63
8026	88.83	121.45	150.50	121.00
8227	102.15	79.38	132.73	108.15
9128	112.33	55.53	163.98	115.85
8729	106.00	64.88	152.35	97.73
8330	94.65	96.32	142.28	136.15
8431	90.23	76.63	133.15	98.15
8234	103.63	99.53	138.33	86.95
8637	115.65	78.23	153.15	143.10

APPENDIX I

FRICATIVE DURATION DATA: NEUTRAL

VOWELS 80+ YEAR-OLDS,

GROUP III

SUB	STUFF	BOX	SUCH	SUN
8603	128.20	105.40	173.38	132.80
8005	78.90	98.18	49.70	93.63
8007	95.60	76.02	122.05	111.50
8109	131.47	111.37	114.90	131.60
8611	186.48	95.53	164.30	135.23
8124	113.83	71.70	121.20	119.15
8325	112.70	158.60	111.63	165.73
8026	190.18	76.30	127.68	158.18
8227	134.68	85.28	158.23	135.63
9128	151.48	261.85	262.35	144.25
8729	87.18	214.50	155.05	114.95
8330	95.20	119.85	176.75	117.85
8431	141.05	96.53	140.75	115.08
8234	105.00	64.98	129.25	149.13
8637	155.38	174.30	161.65	162.98

APPENDIX J

FRICATIVE DURATION DATA: RETRACTED

VOWELS 80+ YEAR-OLDS,

GROUP III

SUB	STAYS	LEAST	SET	SEAT
8603	151.83	67.95	67.95	114.45
8005	57.28	50.85	84.18	125.28
8007	81.75	85.25	152.98	105.15
8109	75.83	80.27	119.00	94.05
8611	109.38	152.35	120.08	158.08
8124	64.90	74.77	113.15	126.13
8325	181.38	84.93	140.98	217.15
8026	209.05	45.85	149.95	165.90
8227	66.63	86.50	84.18	124.85
9128	205.98	100.28	82.75	170.25
8729	102.88	74.10	114.00	135.53
8330	171.23	93.30	208.15	154.45
8431	143.93	106.60	146.30	138.10
8234	92.55	60.05	86.58	143.33
8637	89.80	103.78	143.33	155.58

APPENDIX K

MEAN AND STANDARD DEVIATIONS FOR GROUPS

I, II, AND III LIP-ROUNDED VOWELS

Means and Standard Deviations for Groups I, II, & III
Lip-Rounded Vowels

	STOVE	MOST	SORT	SO
Group I				
N of Cases	15	15	15	15
Minimum	51.00	44.53	89.20	59.38
Maximum	139.53	88.13	146.75	144.08
Mean	94.70	66.07	115.24	87.20
Stand. Dev.	21.82	12.22	14.65	23.99
Group II				
N of Cases	15	15	15	15
Minimum	54.50	53.68	112.38	68.75
Maximum	309.20	263.93	200.85	165.30
Mean	117.69	97.80	150.61	114.22
Stand. Dev.	63.95	49.56	26.42	28.83
Group III				
N of Cases	15	15	15	15
Minimum	46.13	55.53	112.85	84.20
Maximum	147.28	210.38	200.25	143.10
Mean	102.93	85.48	141.69	111.92
Stand. Dev.	27.54	39.52	22.18	16.44

APPENDIX L

MEAN AND STANDARD DEVIATIONS FOR GROUPS I, II, AND III LIP-NEUTRAL VOWELS

MEANS AND STANDARD DEVIATIONS FOR GROUPS I, II, & III
LIP-NEUTRAL VOWELS

	STUFF	BOX	SUCH	SUN
Group I				
N of Cases	15	15	15	15
Minimum	69.75	50.45	78.15	84.05
Maximum	154.60	139.53	132.80	125.33
Mean	122.46	76.45	110.67	107.84
Stand. Dev.	24.72	21.44	13.41	13.67
Group II				
N of Cases	15	15	15	15
Minimum	71.28	53.08	41.55	105.73
Maximum	239.95	184.98	255.50	191.50
Mean	129.80	92.77	154.08	132.71
Stand. Dev.	46.17	34.89	45.05	24.26
Group III				
N of Cases	15	15	15	15
Minimum	78.90	71.70	49.70	93.63
Maximum	190.18	350.88	262.35	165.73
Mean	130.10	139.75	144.00	130.67
Stand. Dev.	34.35	80.29	45.10	20.49

APPENDIX M

MEAN AND STANDARD DEVIATIONS FOR GROUPS

I, II, AND III LIP-RETRACTED VOWELS

MEANS AND STANDARD DEVIATIONS FOR GROUPS I, II, & III
LIP-RETRACTED VOWELS

	STAYS	LEAST	SET	SEAT
Group I				
N of Cases	15	15	15	15
Minimum	28.15	23.80	45.03	58.63
Maximum	105.48	82.48	106.13	108.25
Mean	78.29	56.87	84.28	85.82
Stand. Dev.	20.59	15.42	18.09	15.85
Group II				
N of Cases	15	15	15	15
Minimum	50.65	23.93	88.13	99.00
Maximum	204.00	129.55	161.33	158.10
Mean	114.38	86.01	115.86	122.94
Stand. Dev.	41.63	29.48	20.48	20.76
Group III				
N of Cases	15	15	15	15
Minimum	57.28	45.85	67.95	94.05
Maximum	209.005	152.35	208.15	217.15
Mean	120.99	85.21	122.88	139.67
Stand. Dev.	52.19	25.47	35.93	31.46

APPENDIX N

INTERVIEW QUESTIONNAIRE

Name: ______________________ Age: _______ Date of Birth: __________

Current Medications: ____

____

Check any of the following that apply:

Hearing loss _______

Speech Problems ______

Chronic Laryngitis ______

Neurological diseases ______

Cerebral Palsy ______

Paralysis ______

Hearing Aids _____

Cardiovascular Accident (Stroke) ______

Brain injury ______

Cleft Palate and/or lip ______

Smoker ______

Any formal speech training?

Any previous speech therapy?

APPENDIX O

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	February 21, 2000	IRB #:	AS-00-112
Proposal Title:	"DURATION DIFFERENT VOWEL CLASSES OF THE SPEECH OF THE ELDERLY"		
Principal Investigator(s):	Arthur Pentz Natalie Laverty		
Reviewed and Processed as:	Expedited		

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

February 21, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Natalie Rae Laverty

Candidate for the Degree of

Master of Arts

Thesis: DURATION DIFFERENCES IN DIFFERENT VOWEL CLASSES OF THE SPEECH OF THE ELDERLY

Major Field: Speech

Biographical:

Personal Data: Born in Tulsa, Oklahoma, November 26, 1975, the daughter of Brad and Heidi Wilkerson. Married Shannon Laverty August 7, 1999.

Education: Graduated from Buffalo High School, Buffalo, Oklahoma in May 1994; received Bachelor of Science degree in Communication Sciences and Disorders from Oklahoma State University, Stillwater, Oklahoma in May 1998; completed the requirements for the Master of Arts degree in Speech at Oklahoma State University in May 2000.

Professional Experience: Completed graduate internships at Oklahoma State University Speech-Language-Hearing Clinic, August 1998 to July 1999; LIFE Adult Day Center, August 1998 to November 1998; Chisholm Elementary, Edmond, OK, October 1999 to December 1999; Clyde-Howell Center, Edmond, OK, October 1999 to December 1999; Hearing Enrichment Language Program, Oklahoma City, OK, January 2000 to March 2000; Mercy Hospital, Out-Patient Physical Medicine, Oklahoma City, OK, March, 2000 to May, 2000.