THE EFFECTS OF AGING ON PHONEME AND PAUSE LENGTHS IN ELDERLY FEMALES

By

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LENGTHS IN ELDERLY FEMALES

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PREFACE

The purpose of this investigation was to determine the magnitude of certain fricative, blend and pause durations in speakers in different levels of the elderly maturational process. Subjects were assigned by age to one of three groups: Group I (18-25), Group II (65-75), and Group III (80+).

I would like to express my sincere appreciation to the members of my committee, Dr. Arthur L. Pentz, Dr. Jean Ashland, and Mr. Beeby, whose guidance, assistance, and encouragement were invaluable to the development and completion of this study. I would especially like to thank Dr. Pentz for chairing my committee and his continued support.

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CHAPTER I

INTRODUCTION

The speech mechanism goes through many changes as a person proceeds through life. The general pattern of aging is usually accompanied by a gradual maturing of most body structures up until about seventeen years of age; with relatively little further maturational change until about thirty years of age. There is a somewhat continuous decrement in function beginning around age 30 and continuing throughout life (Ramig & Ringel, 1983). The population composed of those 65 and older is expected to more than double from 20 million in 1970 to 45 million in 2020 (Deming & Cutler, 1983; Schow, Christensen, Hutchinson, & Nerbonne, 1978). The rising numbers of elderly people in our population and their increased longevity make it increasingly important to understand how the anatomical and physiological changes that occur with age influence the speech characteristics of older adults (Benjamin, 1982).

Physiological Changes

Respiratory system

Many of the structures of the speech mechanism mirror overall body maturational changes. Changes in speech characteristics due to aging have been reflected in the respiratory system. The shape of the thorax is known to become concave with advanced age (Kahane, 1981), which reduces the overall volume of the thoracic cavity. The thorax becomes more rigid or stiff, conforming less easily to respiratory muscle forces. The ribs become less mobile, costal cartilage ossifies, and muscles of the pleural membranes stiffen and slide over each other less easily (Comroe, 1965; Kenney, 1989; Hoit & Hixon, 1987). Stiffening of thorax and weakening muscles (Kahane, 1981; Honjo & Isshiki, 1980; Hoit & Hixon, 1987) contribute to the reduced efficiency of the respiratory system (Kenney, 1989; Schow, Christensen, Hutchinson, & Nerbonne, 1978). The smaller, stiffer lungs and thoracic unit must be manipulated by a musculature which is becoming progressively weaker and less precise in its management of the airflow system upon which speech is based. Speech rate slows down (Mysak & Hanley, 1959), and the speaker may use shorter phrases (Duffy, 1995) and sentences to accommodate the decline in overall function of the respiratory system. Older speakers also use longer pausal durations than before.

Phonatory System

The valving system which enables phonational vibration and manipulation to happen must also endure the consequences of the aging process. The thyroid and cricoid cartilages begin to ossify, and the arytenoid cartilages partially ossify (Kahane, 1981; Pressman & Kelemen, 1955). The laryngeal muscles undergo degeneration and atrophy, while incomplete glottal closure and vocal cord edema are also reported (Honjo & Isshiki, 1980). An increase in the mass of the vocal folds may also appear (Honjo & Isshiki, 1980).

Many laryngeal muscles are affected by the aging process to varying degrees, but the posterior cricoarytenoid muscles show a pronounced deterioration. Moderate effects are found in the cricothyroid muscles, with lesser amounts found in the adductor muscles (Bach, Lederer, & Dinolt, 1941). Other researchers have found atrophy in all laryngeal muscles. Reduction of the number of muscle fibers and a breakdown of elasticity are known to occur in the vocal folds as well. Drying out of the mucous membranes affects the texture and surface of the vocal folds, which can lead to noise in the glottal spectrum (Kahane, 1981).

Thus, perched on top of the entryway to the lungs and thoracic unit is a highly variable and adjustable valve which is stiffer and harder to manipulate; slower to move; and is weaker in its movements than it once was. The speaker takes longer to achieve a constricted airstream for phonating; has less glottal resistance when the folds are closed; and takes more time to make less precise vocal fold adjustments than ever before. Consequently, vocal intensity, speaking fundamental frequency (SFF), voice onset time (VOT), phoneme duration, and intra-oral air pressure all change as the aging process continues (Morris & Brown, 1994).

<u>Articulatory System</u>

The articulatory system is also known to be affected with the advancement of age. The articulatory muscles begin to atrophy. The oral cavity experiences a loss of moisture (xerostomia), causing tongue movement across the palate to be difficult and sluggish (Kahane, 1981). There are changes in dentition as well. The aging adult may have a loss of dentition which may or may not have been replaced with dentures. Weakening and atrophy of the pharyngeal musculature can also alter resonation, while reduced elasticity of the pharyngeal walls will cause more energy absorption (Kahane, 1981). Changes in size of the oral cavity due to resorption of alveolar bone and retrusion of the mandible may change oral resonance as well (Kahane, 1981).

The neuromuscular mechanisms required for articulatory control of the tongue are susceptible to age-related changes as are those controlling tongue movements for swallowing or mastication (Kahane, 1981). Changes in the sensory portion of the trigeminal nerve (Truex, 1940) point to the possibility that there may be reduced sensory feedback from these regions (Mysak, 1959; Ryan & Burk, 1974) which may decrease the precision of articulation as one ages (Kahane, 1981). Kahane (1981) indicates that a momentary loss of velar control may result from neuromotor timing deficits that cause the velum to elevate sluggishly following pauses, junctures, or word boundaries. The slower, less precise articulatory system has increased difficulty maintaining the temporal and prosodic characteristics it once possessed. The delay in the articulatory system causes lengthy segment durations and pauses.

<u>Auditory System</u>

The older adult population constitutes the largest group of people who experience hearing loss, and the number is continually growing (Shadden & Toner, 1997). By age 60, pure tone thresholds are elevated across the frequency range from 250 to 8000 Hz (Shadden & Toner, 1997), but adults may experience hearing loss well before the age of 65 (Schow & Nerbonne, 1996). The physical structure of the outer ear undergoes subtle changes; for instance, the skin becomes less resilient and the pinna increases in size

(Maurer & Rupp, 1990). The changes in the size of the pinna may have an effect on sound transmission. The middle ear undergoes changes as well. Reduced elasticity, atrophy of muscle tissue, and ossification and fixation of the middle ear bones have been found (Goodhill, 1969). A gradual loss of ganglion cells and nerve fibers in the basal ganglia may also result from the aging process (Jorgensen, 1961). Presbycusis, hearing loss due to aging, initially affects the higher frequencies (Schow & Nerbonne, 1996), usually develops gradually, and progresses slowly (Katz, 1994). Schuknecht (1974) discusses four types of presbycusis affecting the older population. Sensory presbycusis develops when there is atrophy of the organ of Corti, which results in high frequency hearing loss. Voiceless consonant sounds in particular are registered in the higher frequencies (Maurer & Rupp, 1990), thereby possibly affecting how well an older adult is able to monitor his/her own speech in this frequency range. It has also been found that adult female voices pose more comprehension difficulties for the person with high-tone loss than do voices of lower pitch (Maurer & Rupp, 1990). Neural presbycusis occurs when there is loss of neurons in the cochlea, which leads to poor speech discrimination abilities. Strial presbycusis occurs when there is atrophy of the stria vascularis in the middle and apical turns of the cochlea. Consequently, there is a flat sensory hearing loss, which negatively influences speech recognition ability. The final type of presbycusis is cochlear conductive, which presents a sloping sensory loss with little degeneration of the sensory or neural mechanism. These changes in the hearing mechanism that occur with the advancement of age may impact the speech of elderly adults, and therefore must be taken into account when working with this population. Previous research has been vague and inconsistent in defining and controlling for hearing loss in the elderly population.

Cognition

Production of normal speech requires the integrity and integration of a number of cognitive, neuromuscular, and musculoskeletal activities (Duffy, 1995). The impact of aging on the central nervous system is of critical importance to all aspects of communicative function (Schow, Christensen, Hutchinson, & Nerbonne, 1978). Loss of brain weight (Brody, 1985; Valenstein, 1981; Kenney, 1989; Schow, Christensen, Hutchinson, & Nerbonne, 1978), and reduction in the number of both central and peripheral neurons (Kenney, 1989; Schow, Christensen, Hutchinson, & Nerbonne, 1978) all occur with age. Neuronal loss (Cotman & Neeper, 1996) and progressive vascular changes are also noted in normal aging (Valenstein, 1981). There is a reduction in cortical areas due to broadening of sulci and a flattening of the gyri, and in some areas, cell loss may be as great as 20% to 40% (Kenney, 1989).

Aging results in decreased cognitive functioning which causes a slowing in mental processes and a decline in circuitry available in the nervous system (Kenney, 1989). Recognition and short-term memory appear to diminish beginning in middle age. When there is a delay in short-term memory the difference between the younger and older population becomes even greater (Kenney, 1989). Changes in neuromuscular and cognitive functioning will impact many areas of speech production. The overall lengths of speech segments are expected to be longer with increased numbers of pauses. Ptacek, Sander, Maloney, & Jackson (1966) reported reduced lingual diadochokinetic rates in geriatric subjects ages 66 to 93 due to reduced comprehension of the task. It is known that older speakers add an abnormally large number of fillers to their utterances as well as a disproportionately large number of repetitions in their oral speech (Harvey, 1990). The increased number of fillers and repetitions appear to be related to a decrease in speaking rate and word finding difficulties (Harvey, 1990).

Elderly Speech Characteristics

An understanding of the effects of advancing age on speech characteristics is important for those who serve the older populations (Liss, Weismer, & Rosenbek, 1990). It is even more critical when a speech-language pathologist works with elderly adults who have experienced a stroke. Knowing what can be realistically expected of older speakers, even those without any apparent physical limitations, is very important. However, there is little information about what should be expected concerning consonant and pause lengths in the elderly.

Smith, Wasowicz, & Preston (1987) found that the older adults consistently produced longer sentence durations, syllable durations, and segment durations in their speech than did the younger adult speakers. Several studies have shown that older subjects produce longer vowel and consonant durations than young adults (Benjamin, 1982; Smith, Wasowicz, & Preston, 1987; Weismer & Fromm, 1983; Liss et al, 1990; Morris & Brown, 1987; Ptacek et al, 1966). Morris & Brown (1994) reported that older women exhibited significantly more variability in comparison to the younger women for consonant duration. Brazeal (1997) found that fricative lengths in blended sounds appeared to have the longest durational times for the 65-75 and 80+ year-old groups. Such differences must be taken into account when attempting to determine whether a speaker is functioning within normal limits.

Several studies indicate that listeners perceive the speech of older adults as being distinct from that of young and middle-aged adults (Hartman, 1979; Huntley, Hollien, & Shipp, 1987; Shipp & Hollien, 1969; Ptacek & Sander, 1966). There appear to be several primary characteristics that distinguish the young voice from the aged voice. Hartman & Danhauer (1976) determined primary discriminators of speakers judged to be between 50 and 60 years of age; these characteristics consisted of hoarseness, low pitch, imprecise articulation, breathiness, slow rate, and long pauses. In a study by Mysak and Hanley (1959) the oldest group showed a marked increase in pitch sigma or variability, which may be responsible for the often perceived quavering quality of the aged voice.

The findings regarding the slowing of speech rate from young adulthood through the geriatric years appear to confirm that speech rate is vulnerable to the aging process (Duchin & Mysak, 1987). From a physiological standpoint, this pattern of a general reduction in time measures can possibly be viewed as a function of a general slowing of neuromuscular activity, resulting in the use of fewer words per minute and greater durations of pause time (Mysak & Hanley, 1958).

The nature of phoneme lengths and pause durations will impact the overall temporal parameters of utterances. As normal young adult speakers slow their rate, they tend to lengthen vowels, consonants, and pauses somewhat systematically. When older adults begin to exhibit a slowed rate, it is not clear how they accomplish that reduction. Research would indicate that changes are not accomplished by the organized and systematic reduction in vowels, consonants, and pauses that young mature adults use to slow their rate (Brazeal, 1997; Harvey, 1990). Some pause lengthening appears to occur. It also appears from those reports that certain sound combinations and pausal contexts may be more vulnerable to age related lengthening effects than others. However, little is known about just which types of phoneme combinations may be most vulnerable and which pausal contexts may be lengthened more than others.

It is critical to have a valid frame of reference with which to compare older adults' speech. It is important to know which sound and pausal combinations are most affected so that communication-based therapeutic materials and intervention strategies can be modified appropriately to account for such differences. A better understanding of some of those implications will provide a clearer understanding of the precise nature of the slowed utterances of elderly speakers.

The purpose of this investigation was to determine the magnitude of fricative, blend, and selected pause durations in speakers in different levels of the elderly maturational process. It was hypothesized that the two groups of elderly females would produce fricative, blend, and pause lengths of increased duration when compared to the young group of female speakers. Results of such explorations might help provide a more rational basis for speech-language pathology services in terms of expectation levels and types of contexts used in materials and preventive measures (Mysak & Hanley, 1959).

CHAPTER II

METHOD

Subjects

A total of 45 female subjects participated in this investigation. Subjects were assigned by age to one of three groups: Group I (18-25), Group II (65-75), or Group III (80+). There were 15 subjects in Group I with a mean age of 21.3 years, 15 subjects in Group II with a mean age of 69.8 years, and 15 subjects in Group III with a mean age of 83.1 years.

Existing Database

Subjects for groups II and III were obtained from an existing database (Harris, 1996). Approximately forty subjects for the 65-75 year-old group and the 80+ year-old group were initially sought from community organizations in Stillwater, Oklahoma. Females in the age range of 65-75 years and 80 years plus who were living independently participated in a study conducted by Harris (1996). 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 disorders. Subjects passed a hearing screening meeting the criterion of a pure tone three-frequency average (500, 1000, & 2000 Hz) of 45dB (ANSI, 1969) or better, in the better ear. Only those subjects passing a hearing screening meeting the criterion of a pure tone three-frequency average (500, 1000, & 2000 Hz) of 35dB or better, in the better ear were utilized for the present study. Individuals fitted with amplification were included in this study but were not administered the hearing screening (Harris, 1996; Brazeal, 1997). 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; Brazeal, 1997). Four subjects with monaural or binaural hearing aids were included in this study.

New Database

A control group of 15 subjects between the ages of 18-25 were selected from the Oklahoma State University, and were the only new set of subjects to be studied. The subjects were normal speakers who met the following criteria: each subject demonstrated speech that was 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 (500, 1000, & 2000 Hz) of 20dB (ANSI, 1969) or better, in the better ear (see Appendix C). An interview was conducted with each participant to gather information regarding selection criteria, current medications, and alcohol and tobacco use (see Appendix B).

Materials

The reading task was a large-type version of "The Farm Script" (Crystal & House, 1982) containing 313 monosyllabic words (see Appendix A). The oral readings were recorded using a Nagra reel-to-reel tape recorder, a unidirectional microphone, and studio quality tapes to record each subject's speech samples. The microphone was positioned approximately 15 inches away from the subject. The recorded speech samples of the "Farm Script" from all groups were displayed in 3 second segments at 2,500 Hz using a Kay Elemetrics CSL 4300 spectrum analyzer.

Procedures

Subjects in Groups II & III were assessed either in their homes, the OSU Speech-Language-Hearing Clinic or in a community center (Harris, 1996), while subjects in Group I were assessed in 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 the interview, subjects who did not have hearing aids were administered a hearing screening using a GSI model 17 portable audiometer. Hearing acuity of the subjects fitted with amplification was subjectively assessed during one-on-one conversation with the examiner (Harris, 1996; Brazeal, 1997). All subjects were judged to have hearing within functional limits (Harris, 1996; Brazeal, 1997).

Each subject was asked to orally read the "Farm Script". Large print copies of Crystal & House's (1982) "Farm Script" 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 out loud at your normal speaking rate.".

Data Analysis

Wide band spectrograms were obtained from the recorded acoustic speech signal and a variety of durations were measured from the spectrograms. The second, third, sixth, tenth, eleventh, twelfth, and fifteenth sentences of the "Farm Script" were utilized for analysis of the fricative /s/, the s-blend /st/, and two pauses (see Table 1). The second sentence in the passage contains the fricative /s/ in the word *sun*. Recording was started at the beginning of each target sentence until the 3 second window of the spectrum analyzer was filled. The same was done with the third sentence which contains the fricative /s/ in *us*. The sixth sentence in the passage contains the /st/ blend in the word *stays*, and the tenth sentence contains the /st/ blend in *stove*, while the eleventh sentence contains a final position /st/ blend in the word *most*. The first pausal pattern to be analyzed, which is indicated by a comma, is found in the twelfth sentence, "When served hot, (pause) ham and beans...". The twelfth sentence also contains a final /st/ blend in the word *taste*. The second pausal pattern, which is not indicated by a comma, is found in the fifteenth sentence, "...fresh milk with rich deep (pause) cream on top". The lengths of the phonemes and pauses were recorded in milliseconds.

Table 1
Measured Items

Sentence	Word	Phonemes/Pauses
Second sentence	"The *sun* shone all day,..."	Fricative /s/
Third sentence	"...there to greet *us*..."	Fricative /s/
Sixth sentence	"The sky *stays* light..."	Blend /st/
Tenth sentence	"...had lit the *stove*..."	Blend /st/
Eleventh sentence	"with *most* of the food..."	Blend /st/
Twelfth sentence	"served hot, *(pause)* ham.."	Pause
Twelfth sentence	"ham and beans *taste*..."	Blend /st/
Fifteenth sentence	"rich deep *(pause)* cream.."	Pause

The lengths of the phonemes and pauses were compared across age groups using four, two-way mixed-design analyses of variance. Three age groups made up three levels of a between-groups factor. Comparison 1 was made between the fricative /s/ in initial and final positions in the words *sun* and *us*. The second association was made between the blend /st/ in initial and final positions in the words *stays* and *taste*. The third comparison was made between the blend /st/ in initial and final positions in the words *stove* and *most*. The final comparison was made between the two pausal lengths, "deep *(pause)* cream" and "hot, *(pause)* ham". An analysis of variance was conducted to determine whether phoneme and pause lengths differed significantly with age.

Reliability

Interjudge reliability in determining phoneme and pause lengths for the oral reading samples were determined. An independent observer, a graduate student in speech-language pathology, repeated the analysis procedures for one eleventh of the subjects. The Pearson product moment correlation coefficient was calculated using independent observer and examiner measures. The Pearson product moment correlation coefficient was .99 for phoneme and pause length durations during oral reading samples. Intrajudge reliability was determined by the examiner re-evaluating one eleventh of the subjects. Pearson product moment correlation coefficients were calculated with the examiner's initial measurements. The Pearson product moment correlation was .916 for phoneme and pause lengths during oral reading samples. Results of both inter- and intra-judge measures indicated a high level of reliability for test measures.

Independent samples t-tests were conducted between six subjects with hearing levels above 30dB and six subjects with hearing levels below 30dB in order to determine if hearing levels above 30dB affected scores on any of the dependent variables. No significant differences were found between these two groups.

CHAPTER III

RESULTS

Four, two-way mixed-design analyses of variance were conducted between the fricative /s/ in initial and final positions in the words *sun* and *us,* the /s/ in the blend /st/ in initial and final positions in the words *stays* and *taste*, the /s/ in the blend /st/ in initial and final positions in the words *stove* and *most*, and the two pausal lengths, "deep *(pause)* cream" and "hot, *(pause)* ham."

The first comparison was made between initial position /s/ in *sun* and final position /s/ in *us*. Significant differences in fricative duration were found across age groups, $\underline{F}$ (1, 42) = 37.25, $\underline{p} < .02$ and within age groups across fricative contexts, $\underline{F}$ (2, 42) = 15.49, $\underline{p} < .02$. The interaction was also found to be significant, $\underline{F}$ (2, 42) = 4.53, $\underline{p} < .02$ (see Table 2). A table of means for initial and final position /s/ for each group is contained in Table 3.

The next comparison was made between the initial position /s/ in the /st/ blend in *stays* and later position /s/ in /st/ in *taste*. Significant differences were not found in the main effects for context, or age group (see Table 4). Means for initial and final position /s/ in the /st/ blend for each group are included in Table 5 and Figure 1.

A third comparison was made between the initial position /s/ in the /st/ blend in *stove* and the later position /s/ in the /st/ blend in *most*. Significant differences in blend duration were found across age groups, $\underline{F}$ (1, 42) = 113.96, $\underline{p} < .02$, in age group across

Table 2
Analysis of Variance Source Table
Comparison 1 – *Sun* and *Us*

Source	df	SS	MS	F	p
Between Subjects					
Group	2	2133.50	1066.75	15.49	0.000
Between Subjects Error	42	2891.94	68.86		
Within Subjects					
Condition	1	3083.54	3083.54	37.25	0.000
Group X Condition	2	749.36	374.68	4.53	0.017
Within Subjects Error	42	3476.79	82.78		

Table 3
Group Means and Standard Deviations (msec)
Sun and *Us*

		Age Groups	
	18-25 years	65-75 years	80+ years
Condition	I	II	III
Sun			
Mean	35.17	35.52	39.55
s. d.	7.19	7.59	11.36
range	20.80 – 46.40	20.80 – 46.40	25.60 – 71.60
Us			
Mean	42.67	43.28	59.41
s. d	7.15	7.40	10.51
range	30.80 – 56.40	30.80 – 56.00	36.00 – 76.80

Critical value between groups = 9.22
Critical value within groups = 21.11

Table 4
Analysis of Variance Source Table
Comparison 2 – *Stays* and *Taste*

Source	df	SS	MS	F	p
Between Subjects					
Group	2	5.68	2.84	.03	0.968
Between Subjects Error	42	3703.38	88.18		
Within Subjects					
Condition	1	271.79	271.79	2.86	0.098
Group X Condition	2	151.82	75.91	.80	0.456
Within Subjects Error	42	3988.95	94.98		

Table 5
Group Means and Standard Deviations (msec)
Stays and *Taste*

	Age Groups		
Condition	18-25 years I	65-75 years II	80+ years III
Stays			
Mean	43.44	39.92	41.31
s. d.	7.45	9.47	10.53
range	30.80 – 61.60	25.60 – 61.20	30.40 – 61.60
Taste			
Mean	43.36	45.97	45.76
s. d.	7.67	9.68	11.87
range	25.60 – 56.40	25.60 – 61.20	20.40 – 61.60

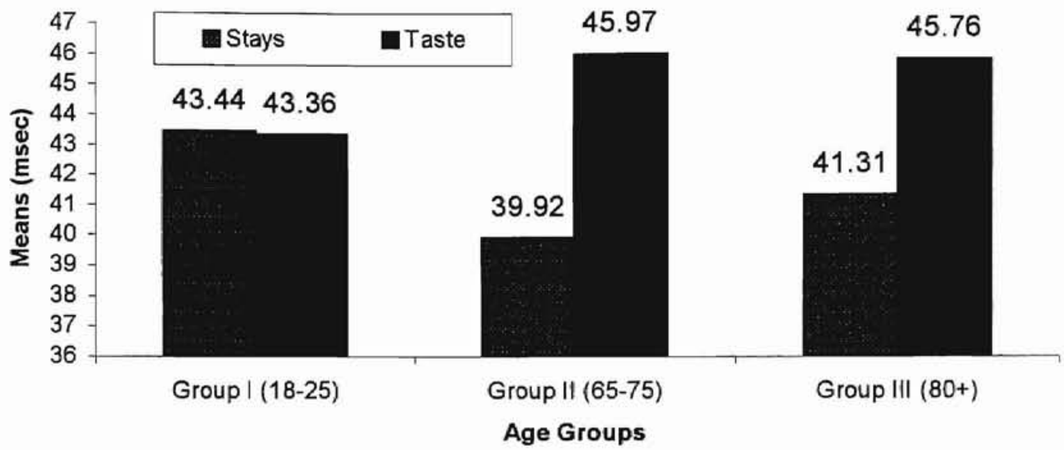

Figure 1. Mean durations for *Stays* and *Taste* for Groups I, II, and III of Female Speakers

contexts, $\underline{F}$ (2, 42) = 10.31, $\underline{p}$ < .02 and for the interaction, $\underline{F}$ (2, 42) = 7.22, $\underline{p}$ < .02 (see Table 6). Means for the initial and final position /s/ in the /st/ blend are provided in Table 7.

The final comparison was made between the durations of the pause following *deep* and the pause following *hot*. Significant differences in pause duration were found across age groups, $\underline{F}$ (1, 42) = 6.27, $\underline{p}$ < .02. However, there were no significant differences across the two different durations and there were no significant interactions (see Table 8). The comparison between the pausal patterns showed that the pause following *hot* was shorter in duration than the pause following *deep*. A table of means for the two pauses are provided in Table 9.

Additional statistical analyses were completed to determine where significant differences occurred. Tukey HSD follow-up comparisons of the durations of /s/ in *sun* and *us* revealed no statistical differences between groups for the fricative /s/ in initial position but did reveal significant differences between groups I and III, and II and III for /s/ in final position. Mean durations for *sun* and *us* across age groups are presented in Figure 2.

Tukey comparisons for *stays* and *taste* revealed no significant differences between groups as indicated by previous ANOVA results. Follow-up comparisons between *stove* and *most* revealed that the oldest group of speakers (Group III) had significantly longer /s/ blend durations in the word *stove* than the two younger groups of speakers. There were no differences in duration for the /s/ in the /st/ blend in the word *most*. Mean durations for *stove* and *most* across age groups are shown in Figure 3.

Table 6
Analysis of Variance Source Table
Comparison 3 –*Stove* and *Most*

Source	df	SS	MS	F	p
Between Subjects					
Group	2	992.56	496.28	10.32	0.000
Between Subjects Error	42	2020.63	48.11		
Within Subjects					
Condition	1	6071.30	6071.30	113.97	0.000
Group X Condition	2	769.32	384.66	7.22	0.002
Within Subjects Error	42	2237.46	53.27		

Table 7
Group Means and Standard Deviations (msec)
Stove and *Most*

	Age Groups		
	18-25 years	65-75 years	80+ years
Condition	I	II	III
Stove			
Mean	44.69	39.57	54.53
s. d.	11.26	5.99	5.97
range	15.20 – 61.60	30.40 – 51.20	46.00 – 71.60
Most			
Mean	28.80	30.03	30.69
s. d.	7.62	5.05	4.69
range	20.40 – 51.20	25.60 – 40.80	25.60 – 40.80

Critical value between groups = 25.11
Critical value within groups = 7.21

Table 8
Analysis of Variance Source Table
Comparison 4 – Deep *(Pause)* Cream and Hot, *(Pause)* Ham

Source	df	SS	MS	F	p
Between Subjects					
Group	2	149829.90	74914.93	3.58	0.037
Between Subjects Error	42	878921.50	20926.70		
Within Subjects					
Condition	1	65761.29	65761.29	6.27	0.016
Group X Condition	2	47864.16	23932.08	2.28	0.115
Within Subjects Error	42	440285.90	10483.00		

Table 9
Group Means and Standard Deviations (msec)
Deep *(Pause)* Cream and Hot, *(Pause)* Ham

Condition	Age Groups 18-25 years I	 65-75 years II	 80+ years III
Deep (*Pause*) Cream			
Mean	99.65	153.60	253.65
s. d.	74.47	110.92	223.78
range	35.60 – 312.40	36.00 - 332.80	20.40 – 624.80
Hot, (*Pause*) Ham			
Mean	93.20	114.35	137.17
s. d.	22.76	31.07	157.54
range	56.40 – 133.20	66.40 – 169.20	30.80 – 691.20

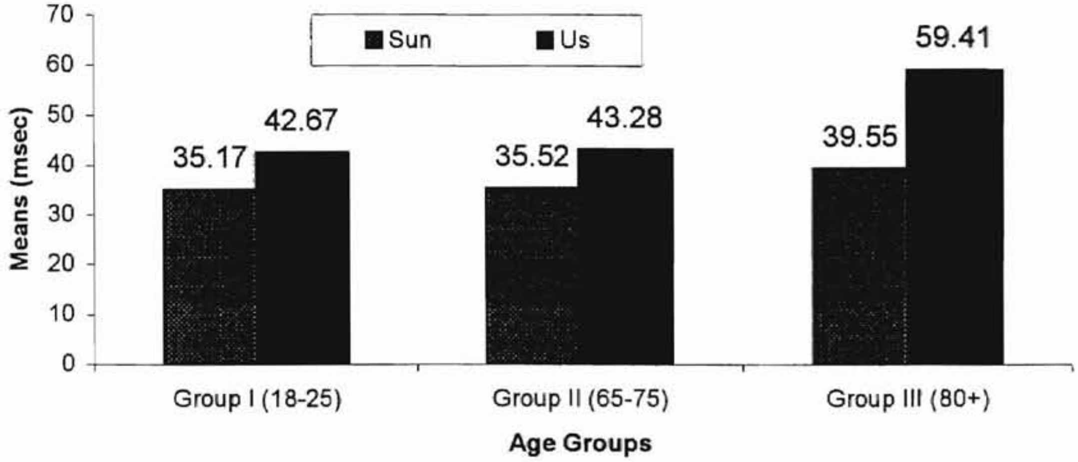

Figure 2. Mean durations for *Sun* and *Us* for Groups I, II, and III of Female Speakers

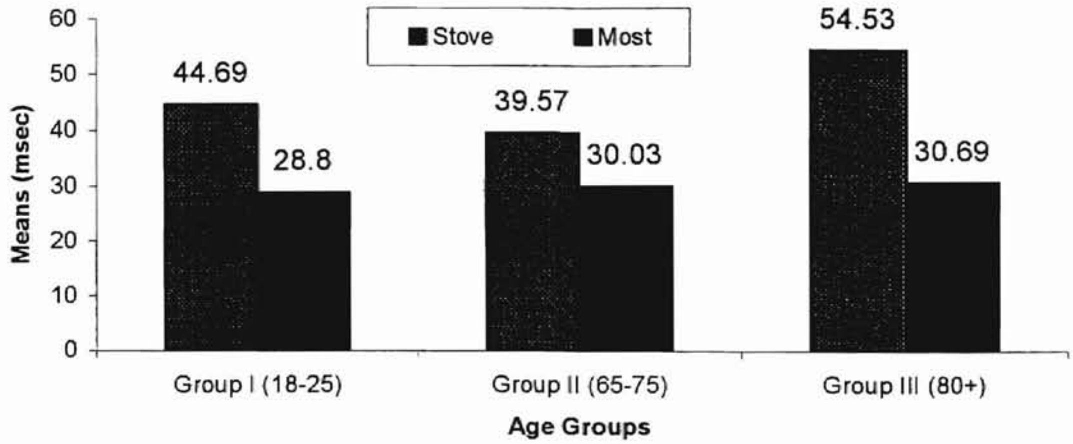

Figure 3. Mean durations for *Stove* and *Most* for Groups I, II, and III of Female Speakers

The durations of the pauses following *hot* and *deep* were significantly different in the initial analysis. The absence of any age main effect and any significant interaction would indicate that the same pattern of difference was present across age groups. Follow-up comparisons revealed significant differences between Groups I and III for the variable *hot*. Mean durations for *hot* and *deep* are provided in Figure 4. The pauses following *deep* were significantly longer than those following *hot* in Group III.

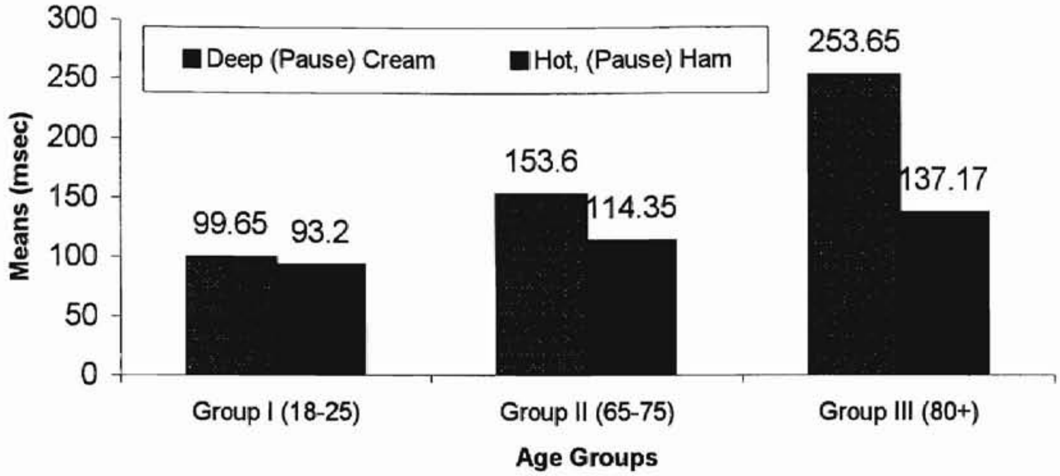

Figure 4. Mean durations for Deep (*Pause*) Cream and Hot, (*Pause*) Ham for Groups I, II, and III of Female Speakers

CHAPTER IV

DISCUSSION

The purpose of this investigation was to determine and compare the magnitude of certain fricative, blend, and pause durations in speakers across two groups of older adult females (65-75 and 80+) and one group of young adult females (18-25). Subjects were asked to read the "Farm Script". The oral readings were recorded using a Nagra reel-to-reel tape recorder. Fricative and pause durations were then determined.

The present study contrasted the durations of the /s/ fricative sounds across speakers in different age groups in an effort to determine if any fricative combinations took significantly longer for older speakers to produce. The comparison of the durations of the /s/ fricative in the words *sun* and *us* revealed significant age and fricative position differences. A significant age x position interaction also indicated that the initial and final durational patterns varied depending upon the ages of the groups of speakers.

All the groups produced the /s/ in the initial position in a shorter time than the one in the final position. However, follow-up Tukey tests comparing the initial and final position /s/ durations across all the groups revealed some additional insight. The two younger groups tended to make their initial position sounds somewhat shorter than the final position /s/ sounds. The oldest group followed that same trend, but the final position sounds were significantly larger than the initial position phoneme. The initial position sound is produced following a neutral position vowel (e. g. "The *sun*...") which did not appear to be difficult for the older speakers to produce. There is only a modest amount of articulatory adjustment necessary, possibly causing the speed with which the /s/ was produced to be shorter in duration than the final position /s/ in *us*.

A comparison of both initial and final durations for each age group indicated that the two younger groups' initial position sounds had similar durations. The older groups' initial fricative durations were significantly longer than those for either of the younger groups. Both younger groups produced their final position fricative with about the same durations. However, the oldest group made their final phonemes significantly longer than either of the younger groups. The increase in consonant duration of the elderly speakers could be a result of atrophy of the articulatory musculature (Honjo & Isshiki, 1980) and/or slowed neuromotor timing (Kahane, 1981) due to the aging process.

The early sounds in a phrase tend to be shorter than those in the later positions. In this particular instance the /s/ in *us* is right at the end of the phrase and phrase-final lengthening appears to become a major influence. Apparently the oldest group adds a considerably larger amount of phrase-final lengthening than the younger groups. The precise reason for that is not clear. The process of phrase-final lengthening in older adults is relatively undefined. Little is known about how older speakers execute the phrase-final lengthening process.

The findings in the present study appear to be in contrast to Brazeal (1997) and Morris and Brown (1987). Brazeal (1997) found that the /s/ in the word *box* was shorter than that for the /s/ in *spoon*. But, the obvious differences in the context of the fricatives and their phrasal positions (e.g. *The box is red.* and *He took a spoon and a knife*.) make appropriate comparisons with the present data virtually invalid. Morris and Brown (1987) reported that consonants in the initial position were longer than those in the final position. That report used carrier phrases as the stimulus material. The impact of that type stimulus on durations as opposed to the present oral reading sample also makes accurate comparisons with those results at best, very tenuous.

It was believed that the two older groups of females would produce blends of increased duration when compared to the young group of female speakers. In comparison 2 (*stays, taste*) no main effect differences were found. These comparisons showed that all three groups produced the /s/ in the /st/ blend in *stays* and *taste* with similar durations. The similarity in durations between *stays* and *taste* may be due to the neutral, non-rounded vowel utilized in both words.

The third comparison contrasted the duration of the /s/ in the /st/ blend across speakers in each age group to determine whether the initial or later position /s/ in the /st/ blend appeared more vulnerable to the aging process. The comparison of the /s/ in the words *stove* and *most* indicated significant age and blend position differences. A significant age x position interaction also indicated that the initial and final durational patterns varied depending upon the ages of the groups of speakers.

All the groups produced the /s/ in the /st/ blend in the later position in a shorter duration than the blend in initial position. Further analysis of the initial and later position /s/ durations across all groups provided additional information. The two younger groups of speakers made their later position sounds somewhat shorter than the initial position /s/ sound. The oldest group revealed similar findings but with larger differences between the initial and later production of the /s/ blend. The arresting consonant in the word *most* may have influenced the duration of the /s/ blend, causing it to be shorter in duration than the initial position blend. The final blend combination appears to be made with similar speeds by all ages of speakers.

These findings were similar to those for final position /s/ in *us*. The differences appear to occur between Groups I and III and Groups II and III, but none shown between Groups I and II as would have been expected. That would indicate that /s/ in the /st/ blend remains somewhat stable from age 25 to 65, with more significant increases in duration occurring between the two older groups of female speakers. The /s/ blend in *stove* seems to be a more difficult articulatory sequence for the older groups of speakers to perform. The /s/ in *stove* is a non-rounded, lip-open sequence while the /o/ is a lip-rounded sequence. The older speakers may hold the /st/ blend while preparing to round the lips for production of /o/. This slower process of lip-rounding may impact the duration of the /st/ blend.

The two pauses were compared across speakers in different age groups in an effort to determine which pausal patterns are most affected as speakers move through the aging process. While there were significant differences in the average lengths of the two pauses, there were no significant age differences. The comparisons revealed no significant age x position interaction for the two pauses.

Comparisons of the pausal durations across age groups revealed that all three groups produced the pause following *hot* with a shorter duration than used to produce the pause following *deep*. An increase in duration was seen across age groups for both pausal patterns, however, significance was only found for the pause following *hot*. The oldest group of speakers had significantly longer pausal durations after *hot* than either of the younger groups.

An extremely large variability was seen for both of the pausal durations within all three age groups of female speakers. That variability may have obscured any real age-related pausal durations. A review of the variances across age groups indicates a rather clear pattern of increase as the age of the speakers increase.

Changes in cognitive functioning may impact various areas of speech production, resulting in longer speech segments and an increased number of pauses. Word finding difficulties could have been a factor for some, which may have caused an increase in the pausal durations as compared to others within the group.

Another factor to be examined is the use of repetition versus reading. Many studies have utilized sentences or carrier phrases to analyze duration of consonants and vowels (Kent & Forner, 1980; Morris & Brown, 1987; Liss, et al, 1990; Smith, Wasowicz, & Preston, 1987). Liss et al (1990) simultaneously presented a spoken model of the sentence and corresponding written stimuli to assure the task was understood and the subject was familiar with the sentence.

That method was chosen in part because subjects had some degree of hearing loss and visual impairment. Hearing loss and visual impairment are additional factors that need to be considered when older subjects are being utilized. The subjects in the current study were not given a vision screening while hearing was screened. Although a large type version of the "Farm Script" was utilized by the subjects in the present study, vision might still have influenced the rate at which the passage was read by the two older groups of speakers. Repetition of sentences and/or phrases might be beneficial in that the speakers do not have to read, thereby eliminating visual difficulties. However, repetition of sentences may have an impact on the subject's performance if any degree of hearing loss is present. In the current study, comparisons were made between subjects with hearing levels above 30dB and those with hearing levels below 30dB. No significant differences were found between these two groups. The examiner's rate of speech could also influence the rate at which the subjects repeat the sentences. Although all methods have some bias, it is important to use methods consistent across studies to ensure that proper comparisons can be made.

The particular passage utilized may have impacted the lengths of durations as well. The "Farm Script" is a monosyllabic passage, which may prove more difficult for readers. Future research may want to utilize a passage that uses polysyllabic words as opposed to one containing only monosyllabic words.

Because significant statistical differences were not found between Groups I and II, but statistical differences were found between Groups I and III, and Groups II and III, this provides evidence that a decrease in the rate of execution of articulation does occur with increasing age. However, those execution rates vary among different contexts and structures. It also appears that even difficult /s/ blend structures may be produced by all the groups with equal speed and agility. It appears that other combinations, especially those requiring large articulation movements and adjustments, may negatively impact older speakers articulatory speed and accuracy.

The data presented shows that further investigation of blends, fricatives, and additional pausal durations need to be pursued. It remains unclear what effect pausal durations have on the speech of elderly speakers. However, there is an indication that the speech of elderly females is affected by the particular sequences being used. In particular, blends seem to be difficult for the aging articulators of older groups of speakers (Groups II and III).

In conclusion, the present study indicated no significant differences for initial position /s/ in *sun* across age groups, however, an increase in duration was seen for final position /s/ in *us* between Groups II and III, and Groups I and III. Although the initial position /s/ in the /st/ blend in *stove* revealed significant differences between Groups II and III, and Groups I and III, no significant statistical differences were found for the final position /s/ in the /st/ blend in *most* or for initial and final position /s/ in the /st/ blends in *stays* and *taste*. Finally, no statistical differences were found for the pause following *deep*, however significant differences were found between Groups I and III for the pause length following *hot*.

The present study suggests that further investigation in these and other areas are merited. This investigation has supplemented the current normative database concerning durational characteristics in the elderly population. However, there is still a need for additional research on the effects of aging on the communication of the elderly population. Continuing research concerning the aging population should provide speech-language pathologists with additional information with which to compare normal aging speech production to disordered speech production.

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APPENDICES

APPENDIX A

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 ham 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, ham 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 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

INTERVIEW QUESTIONNAIRE

Interview Questionnaire

Name: ________________________ Age: ______ Date of Birth: ____________

Current Medications:

____

____

Check any of the following that apply:

Hearing loss_____ Hearing Aids_____

Speech Problems_____ Cardiovascular Accident (Stroke)_____

Chronic Laryngitis_____ Brain injury_____

Neurological diseases_____ Cleft Palate and/or lip_____

Cerebral Palsy_____ Smoker_____

Paralysis_____

Any formal speech training?

Any previous speech therapy?

How many alcoholic drinks do you have in a typical week?

_____ (<2) _____ (3-7) _____ (7+)

On a weekly basis, how often do you have five or more drinks in a row?

_____ 0 _____ 1-2 _____ 3-5 _____ 6-10 _____ 11 +

APPENDIX C

SCREENING MEASURES

Subject #:_____
Date:_____
Site:_____

SCREENING MEASURES

Hearing Screening

	R	L
500 Hz	______	______
1000 Hz	______	______
2000 Hz	______	______
Three Frequency Ave.	______	______

20 dB or better in better ear Pass/Fail

HEARING AIDS? Yes/No

General Speech Behavior Rating

1 = Adequate/Within Normal Limits 2 = Deviation which D/N Hamper Cmmctn

3 = Deviation which Hampers Communication

Pitch: 1 2 3
-too high/low
-monotonous
-pitch breaks
-other

Loudness: 1 2 3
-too loud/soft
-monotonous
-loudness pattern
-other

Rate: 1 2 3
-too rapid/slow
-monotonous
-rate pattern
-other

Voice Quality: 1 2 3
-breathiness
-harshness
-hoarseness
-glottal attack
-hyper/hyponasal
-other

Fluency: 1 2 3
-disfluencies of any type
(list)
-other

Articulation: 1 2 3
-general misarticulations
(describe)
-other

OVERALL GENERAL ADEQUACY: 1 2 3

COMMENTS:____

APPENDIX D

INDIVIDUAL SUBJECT SCORES

GROUP I (18-25 YEARS)

Individual Subject Scores for Phoneme and Pause Lengths
Group I (18-25 years)

Age	Subject Number	*Sun*	*Us*	*Stays*	*Taste*	*Stove*	*Most*	Deep (*Pause*) Cream	Hot, (*Pause*) Ham
20	10	30.80	46.00	41.20	36.00	46.00	25.60	35.60	71.60
21	25	20.80	46.00	46.40	40.80	46.00	38.00	66.40	56.40
21	30	30.40	36.00	41.20	46.00	36.00	30.80	82.00	117.60
22	35	46.00	40.80	61.60	25.60	51.20	25.60	51.20	71.60
22	45	40.80	40.80	36.00	36.00	35.60	51.20	56.40	66.40
21	50	30.80	30.80	46.00	46.00	51.20	20.40	35.60	92.40
22	60	30.80	56.40	51.20	35.60	40.80	30.80	158.80	92.40
21	80	46.40	35.60	36.00	36.00	61.60	25.60	92.00	82.00
22	90	46.00	40.80	40.80	51.20	61.60	30.80	128.00	82.00
19	95	36.00	46.00	46.00	46.00	40.80	25.60	61.60	133.20
22	100	36.00	56.40	51.20	46.00	15.20	20.40	184.40	133.20
21	105	35.60	41.20	41.20	56.40	51.20	30.40	56.40	97.20
19	110	30.80	46.00	41.20	41.20	46.00	25.60	46.00	102.40
23	115	36.00	41.20	40.80	46.00	41.20	25.60	128.00	102.40
23	120	30.40	36.00	30.80	51.20	46.00	25.60	312.40	97.20

APPENDIX E

INDIVIDUAL SUBJECT SCORES

GROUP II (65-75 YEARS)

Individual Subject Scores for Phoneme and Pause Lengths
Group II (65-75 years)

Age	Subject Number	*Sun*	*Us*	*Stays*	*Taste*	*Stove*	*Most*	Deep (*Pause*) Cream	Hot, (*Pause*) Ham
72	7204	30.40	30.80	35.60	51.20	40.80	25.60	317.60	66.40
66	6606	20.80	36.00	30.80	51.20	30.40	25.60	132.80	112.40
74	7416	30.80	46.00	61.20	56.40	30.80	25.60	56.40	87.20
69	6917	46.00	40.80	51.20	46.00	41.20	36.00	317.20	72.00
69	6918	40.80	46.00	35.60	46.00	36.00	35.60	92.00	153.60
68	6822	30.80	40.80	46.00	40.80	46.00	25.60	61.60	122.80
71	7123	35.60	51.20	41.20	40.80	40.80	30.40	40.80	87.20
70	7012	25.60	40.80	40.80	61.20	46.40	25.60	102.40	133.20
67	6715	46.40	40.80	40.80	40.80	51.20	25.60	66.40	92.00
72	7219	35.60	30.80	30.80	40.80	35.60	30.80	332.80	118.00
66	6620	46.00	51.20	51.20	25.60	46.00	30.80	36.00	122.80
75	7510	30.80	51.20	25.60	61.20	35.60	40.80	164.00	92.00
70	7013	41.20	40.80	36.00	51.20	40.80	25.60	164.00	169.20
73	7338	36.00	56.00	41.20	40.80	36.00	30.80	312.40	153.60
65	6501	36.00	46.00	30.80	35.60	36.00	36.00	107.60	132.80

APPENDIX F

INDIVIDUAL SUBJECT SCORES

GROUP III (80+ YEARS)

Individual Subject Scores for Phoneme and Pause Lengths
Group III (80+ years)

Age	Subject Number	*Sun*	*Us*	*Stays*	*Taste*	*Stove*	*Most*	Deep *(Pause)* Cream	Hot, (*Pause*) Ham
80	8005	51.20	66.40	51.20	30.80	56.40	40.80	71.60	76.80
83	8330	40.80	36.00	56.40	51.20	51.20	25.60	378.80	112.40
84	8431	46.40	56.40	30.40	46.00	56.00	30.80	46.00	117.60
80	8007	40.80	51.20	30.80	20.40	51.20	30.40	97.60	97.20
81	8109	30.40	56.40	30.80	51.20	46.00	25.60	41.20	40.80
81	8124	40.80	51.20	36.00	51.20	56.00	30.80	266.40	86.80
86	8611	30.80	66.40	36.00	61.60	51.20	30.80	624.80	61.60
86	8637	46.00	51.20	30.80	30.80	56.40	30.80	583.60	143.20
86	8603	30.80	56.40	30.80	46.00	51.20	30.80	30.80	102.40
83	8325	25.60	76.80	61.60	51.20	51.20	40.80	588.80	691.20
82	8227	30.80	66.40	51.20	36.00	71.60	30.40	20.40	30.80
80	8026	36.00	61.60	35.60	40.80	61.20	30.80	256.00	158.80
81	8132	71.60	61.60	46.00	56.40	56.00	25.60	384.00	82.00
82	8234	35.60	56.40	46.00	61.60	51.20	30.80	41.20	143.60
91	9128	35.60	76.80	46.00	51.20	51.20	25.60	373.60	112.40

APPENDIX G

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 10-02-97 **IRB#:** AS-98-019

Proposal Title: THE EFFECTS OF AGING ON PHONEME AND PAUSE LENGTHS IN ELDERLY FEMALES

Principal Investigator(s): Arthur L. Pentz, Julie S. Stone

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: John H. Wyckoff
Chair of Institutional Review Board

Date: October 17, 1997

cc: Julie S. Stone

VITA

Julie S. Stone

Candidate for the Degree of

Master of Arts

Thesis: THE EFFECTS OF AGING ON PHONEME AND PAUSE LENGTHS IN ELDERLY FEMALES

Major Field: Speech Pathology

Biographical:

Personal Data: Born in Amarillo, Texas, May 18, 1974, the daughter of Bill and Susan Browning. Married to Jeb Stone on December 31, 1996.

Education: Graduated from Frederick High School, Frederick, Oklahoma in May, 1992; received Bachelor of Science degree in Speech-Language Pathology from Oklahoma State University, Stillwater, Oklahoma in May, 1996. Completed the requirements for the Master of Arts degree in Speech-Language Pathology at Oklahoma State University, Stillwater, Oklahoma in May, 1998.

Professional Experience: Graduate clinician at Oklahoma State University Speech-Language-Hearing Clinic, August, 1996 to December, 1997; LIFE Center Adult Day Facility, June, 1997 to July, 1997; internships at Drumright Public Schools, October, 1997 to December, 1997; and Kaiser Rehabilitation Center, March, 1998 to May, 1998.

Professional Memberships: National Student Speech-Language-Hearing Association.