THE EFFECT OF AGING ON ELDERLY FEMALE VOICE ONSET TIME AND SEGMENT DURATION

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THE EFFECT OF AGING ON ELDERLY FEMALE

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DURATION

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PREFACE

The following investigation focuses on the effects of aging on phrase durations, fricative durations, voice onset times, and closure durations in elderly females.

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CHAPTER I

INTRODUCTION

The proportionate and numerical size of the elderly population is increasing as Americans enjoy increased longevity. Half the population was under the age of sixteen years in the eighteenth century (Bourliere, 1970). In 1990, the United States population was comprised of more than twelve percent of individuals who were over the age of sixty-five (Statistical Abstracts of the United States, 1992). It is estimated that by the year 2050 at least half the population in America will be 43 years or older (Taebuer & Fino, 1992)

The steady increase in average age is due in part to the advances in a variety of allied biomedical areas. Many individuals will be living longer, fuller lives than ever before. The characteristics of the oldest segment of our population of the twenty-first century will be much different than that same group in our present population (Taeuber, 1992) For instance, it is estimated that approximately 20% of communicatively impaired individuals are now over the age of sixty-five (Fein, 1983). Therefore, is it of great importance for the speech-language pathologist to understand the effects of normal aging when assessing and isolating the effects of pathological problems (Kennedy, 1982)?

Physiological Changes

Alterations in the anatomic and physical dimensions of speech which accompany the aging process are numerous and complex. There are changes in biomechanical efficiency of the respiratory, laryngeal, and articulatory systems These systems are 65 related to muscle atrophy, reduction of muscle tissue elasticity, reduction of neural innervation levels, and ossification of cartilages (Kennedy, 1982).

Changes in lung mechanics and gas exchange are probably related to a decline in the elastic tissues of the lung, a weakening of the respiratory muscles, and added stiffness in the thoracic cage. The respiratory system is hampered due to the decreased volume of air it can supply for driving the speech system (Birren, 1980).

In addition, phrase and sentence lengths and maximum phonation times are reduced. The speaker may stop more often and use shorter speech segments than before The elements within those segments are made more slowly than in the past. In addition, the pausal periods between the segments are longer than before. The resulting contextual speech is uttered in shorter bursts with each burst containing fewer phonemes (Murdoch, 1990).

As part of the aging process, the muscles of the larynx atrophy. The fibers become fewer in number and are reduced in strength. Calcification of the larynx is extensive by the age of sixty-five The mucous membranes are discolored and there is a reduction in submucosal connective tissue There is a general looseness of the membranes covering the vocal folds (Birren, 1980) The loss of elasticity, reduction in muscle strength, and atrophy of the intrinsic laryngeal muscles usually mean that the laryngeal musculature has

a much more difficult time creating what used to be the normal amount of resistance to airflow (Ammerman, 1982).

Changes which also affect speech function occur in the central nervous system because of atrophy of the cerebral cortex. There is approximately a ten to fifteen percent brain mass reduction in the normal aged individual with primary tissue loss occurring in the cortex. There can also be nerve cell degeneration and a reduction of neurotransmitter substance which may affect speech production performances (Kennedy, 1982; Valenstien, 1981; Welford, 1977; Whitborne, 1985).

Those normal aging changes as well as other degenerative diseases that can occur in the central nervous system are often blamed for longer muscle contraction times, slower reflex times, and decreased nerve conduction velocity (Kennedy, 1982). It has been suggested that these factors may have an added impact on sensory and motor performances related to speech production (Kent & Burkard, 1981; Wilder, 1984).

Elderly Speech Characteristics

Many adult speech capabilities peak during the ages of 20 to 30 and then begin to decline (Smith, Wasowicz, & Preston, 1987). Considerable research has focused on the speech production abilities of the elderly population who also have accompanying neurological damage (Murdoch, 1990; Tallal & Piercy, 1975) However, it is critical that the speech-language pathologist take into consideration the potential effects of normal aging when attempting to assess and isolate the effects of a variety of pathological problems (Kennedy, 1982).

However, there is relatively little information available dealing with such effects of normal aging on the speech production skills of adults. Much of what has been reported for normal, elderly subjects has dealt with general voice characteristics such as a hoarse voice quality, reduced pitch range, and tremor (Ryan & Burk, 1974; Shipp & Hollien, 1969; Ryan, 1972). It is also important to obtain information on normal speech motor control for articulation among the normal elderly adult population. Such information provides an improved and more accurate basis for evaluating clinical data for those who demonstrate speech-related neurological impairments (Smith, Wasowicz, Preston, 1987: Nittrouer, 1993; Parnell & Amerman, 1978; Nittrouer & Studdert-Kennedy, 1987).

Many of the effects of the normal aging process on speech production are manifested in a variety of segmental and suprasegmental, especially temporal, speech dimensions. The dimensions of voice onset time, segment, and phrase durations all provide reasonably stable indicators of the overall maturation and maturity of the neuromuscular system underlying the speech process

When Weismer and Fromm (1983) focused on voice onset time among younger and older subjects, differences were found between the groups for the duration of voiceless intervals. The durations of elderly males were shorter than those of the young adults. In contrast, the elderly females showed longer durations than the young adults. Weismer (1984) also found that 65- to 82-year-olds had a tendency to produce longer vowel and consonant durations than those produced by 21- to 27-year-old speakers

A study by Sweeting and Baken (1982) focused on three groups between the ages of 25 to 39, 65 to 74, and 75+ and found no significant differences in voice onset time

(VOT) across groups. However, they did note that VOT was more variable in the older subjects. Other studies on VOT showed somewhat different results in elderly adults Benjamin (1982) analyzed the speech of 68- to 82-year-olds and 21- to 32-year-old adults. Voice onset time values for the older adults were shorter and there were longer vowel and consonant durations in the speech of 68- to 82-year-olds.

There have also been several studies which report on a variety of durational and other temporal dimensions of aging speech. Ryan & Burke (1974) found that adult male speakers between 40 to 80 years old appeared to become more imprecise in the production of consonants and exhibited a reduced rate of speaking as age increased. Shipp, Qi, Huntley, and Hollien (1992) and Mysak & Hanley (1958) also reported that speech rate slowed with advancing age. Smith, Wasowicz, & Preston (1987) found that older adults produced longer durations in their speech than did younger adults.

It would almost seem, at times, that aging adults tend to reverse the developmental processes and revert to more immature motor speech behaviors. While there may be some common characteristics in elderly and young developing speakers' motor speech patterns, the similarities may or may not end there. Several investigators have attempted to define the changing temporal dimensions of children's immature but developing speech patterns

Children's Speech Characteristics

Smith (1978) investigated word and segment durations among two- to three-year-olds and four- to four-and one-half-year-olds. It was found that both groups of children had word and segment durations which were longer than those of adults Voice onset

time was considerably longer for children than for adults. The duration of /d/ was longer for children than for adults.

Kent and Forner (1980) studied speech segment durations in three sentence recitations by ten college-age adults and ten children in three age groups of four-, six-, and twelve-year-olds. Four-year-olds had longer segment durations and greater variability of segment durations than those of the older children and adults. The amount in which segments were lengthened by the four-year-olds appeared to depend upon segmental, suprasegmental, and linguistic factors. Kent and Forner also reported that there was a substantial correlation between the variability in speech and rate of speech in timing control.

Changes in children's cognition, memory, and certain linguistic processing abilities are also manifested as the child matures. As considerable neuromuscular maturation occurs, gestural movements become more precise and less variable. The child produces shorter segment durations and voice onset time is decreased (Kent & Forner, 1980)

Several of the temporal dimensions which children must work so hard to perfect appear to be very fragile. For example, clusters (blended sounds) are extremely complex and require a high degree of sophisticated precision and coordination among the articulators. The aging process may take an early toll on those temporal dimensions. While only conjecture at this point, it would seem that the highly complex skills of voice onset time, pausal lengths, difficult consonant durations, and combinations of consonants may be very vulnerable to the effects of aging What are considered to be the most complex of the many temporal speech skills may be the first to deteriorate when the normal aging process takes its toll (Ulatowska, 1985)

Little has been reported about the effects of aging on temporal speech features. Yet, many speech-language pathologists who work with a variety of older patients with stroke and other diseases are unable to make meaningful comparisons between their patients and similar aged counterparts with no apparent problems (Smith, Wasowicz, Preston, 1987). The speech-language pathologist is often forced, because of the lack of sufficient data of the normal aging, to compare old "ill" clients with young, virile, healthy ones.

The purpose of the present investigation was to provide information about a variety of temporal parameters including phrase durations, fricative durations, voice onset times, and closure times in older adults who may be especially vulnerable to the effects of the normal aging process.

CHAPTER II

METHOD

Subjects

Subjects are identified as belonging in one of four groups. Group I equals the four-year-old children in the Kent and Forner (1980) study. Group II equals the 18 - 25 year-old college-age group used in this study. Group III equals the 65-75 year-old group used in this study. Group IV equals the 80+ year-old group used in this study.

Approximately forty subjects for the 65-75 year-old group and the 85+ 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 this study.

One group of subjects ranged in age from 65-75 years with a mean age of 70.2 years. The second group ranged from 80-91 years with a mean age of 83.5 years. Eighteen subjects comprised the 65-75 year-old group and 17 subjects comprised the 80+ year-old group. A control group of 23 subjects between the ages of 18-25 with a mean age of 22.3 years were selected from the Oklahoma State University as a third comparison group.

All subjects met the following criteria: First, 65-75 and the 80+ year-old subjects were required to be living independently. Second, 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. Each subject in the two older age groups passed a hearing screening meeting the criterion of a pure tone three-frequency average of 45 dB (ANSI, 1969) or better, in the better ear (See Appendix O). Individuals fitted with amplification were included in this study but were not administered the hearing screening.

The 18-25 year-old age group passed a hearing screening meeting the criterion of a pure tone three-frequency average of 20 dB (ANSI, 1969) or better in the better ear

An interview was conducted with each participant to gather information regarding selection criteria as well as information regarding educational level, residential setting, employment history, current medications, and alcohol and tobacco use (See Appendix N) All subjects in this study were rated to have good health status

Procedure

Subjects were assessed either in their homes, the OSU Speech-Language-Hearing Clinic or in a community center 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 prior to testing 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. Five subjects with mono- or binaural hearing aids were included in this study. Hearing of those subjects fitted with amplification was screened during one-on-one conversation with the examiner. All were judged to have hearing within functional limits. General speech behavior was creened during spontaneous conversation with the subjects.

A Nagra reel-to-reel tape recorder, a unidirectional microphone, and studio quality reel-to-reel tapes were used to record each subject's speech samples. The microphone was positioned approximately 15 inches away from the subject. A list of 12 randomly ordered sentences (three different sentences repeated four times each) were spoken by the investigator and repeated by the subjects.

Wide band spectrograms were obtained from the recorded acoustic speech signal and a variety of time intervals were measured from the spectrograms. Measurements made to describe the temporal structure of the sentence productions (as seen in Kent & Forner, 1980) are included in Appendix A. The three sentences used in the Kent & Forner (1980) study were also used for the purposes of this research because indirect comparisons among Kent and Forner's four-, six-, and twelve-year-old groups were made in this study. The sentences were (1) The box is blue and red, (2) I took a spoon and a knife, and (3) We saw you hit the cat (See Appendix A)

All measurements were made in milliseconds For each measurement, calculations were made of the standard deviation, and coefficient of variation as well as the group mean and standard error of the mean

Phrase durations for the following were compared across age groups. The first phrase duration was measured as the interval from the initiation of frication for /s/ in saw to the instant of closure for /t/ in cat. The second phrase duration was measured as the interval from release of /b/ in blue to the steady-state segment of /r/ in red. The third phrase duration was measured as the interval from the release of /t/ in took to the beginning of voicing for the /u/ in spoon.

Fricative durations were also compared across groups. Measurements for the frication for /s/ in box and the duration of frication for /s/ in spoon were taken The duration of closure for /k/ in box was also compared across groups.

Voice onset times were compared across groups for the following: voice onset time for /k/ in cat, voice onset time for /b/ in blue, and voice onset time for /t/ in took.

Mixed design analysis of variance (ANOVA) were used to contrast phrase lengths, fricative lengths, voice onset times, and closure for /k/ across age groups. The age groups formed three levels of a grouping variable. The voice onset time for all the stops formed three levels of a repeated measure. The two fricative durations were also contrasted across the three age groups, as was the closure for /k/. The fricative durations formed two levels of a repeated measure Also, three different phrase durations for parts of three utterances were contrasted across the three age groups.

The Pearson correlation was performed on nine subjects representing each age group using the Systat computer program in order to test for intra- and interjudge reliability The judges were two graduate students in speech-language pathology trained in making temporal dimension measurements. Intrajudge reliability for phrase durations saw you hit the cat, blue and red, and took a spoon averaged 995 Intrajudge reliability

for fricatives /s/ in box and /s/ in spoon averaged .985. Intrajudge reliability for voice onset times of /k/, /b/, and /t/ averaged .981. Intrajudge reliability for closure of /k/ was .994.

Interjudge reliability for phrase durations saw you hit the cat, blue and red, and took a spoon averaged .973. Interjudge reliability for fricatives /s/ in box and /s/ in spoon averaged .943. Interjudge reliability for voice onset times of /k/, /b/, and /t/ averaged .941. Interjudge reliability for closure of /k/ was 982.

CHAPTER III

RESULTS

Phrase Duration

Three different phrase durations for parts of three utterances (measures 1(b), saw you hit the cat; 2(d), blue and red; and 3(c), took a spoon) were contrasted across the three age groups. Table 1 represents the results of the analysis of variance (ANOVA) comparing phrase durations across age groups. There were significant age main effect differences for phrase durations between subjects ($F=13.318$; $df=2$; $p < .01$) and within subjects ($F=6.033$; $df=2$; $p < .01$).

Data for the phrase durations of Groups II, III, and IV are reported in Appendices B, F, and J. Summary statistics for the measures of phrase length are compiled for each age group in Table 2. There were significant differences in duration among the phrases. The durations also differed significantly depending upon the ages of the groups. Finally, the significant age x phrase interaction indicated that the durational patterns were different depending upon the particular phrase and the age group producing it.

WSD-T follow-up comparisons of the three phrase durations indicated that saw you hit the cat had the longest durations of the three included in the sample. This finding remained true across all age groups. The phrase blue and red was significantly shorter

TABLE 1

ANOVA RESULTS FOR PHRASE DURATIONS

Source	SS	DF	MS	F	P
Between Subjects					
Category	.852	2	.426	13.318	0.000
Error	1.759	55	.032		
Within Subjects					
a	15.893	2	7.946	601.288	0.000
a category	.319	4	0.080	6.033	0.00
Error	1.454	110	0.013		

Between Subjects: $F=13.318$; $df = 2$; $p < .01$
Within Subjects: $F= 6.033$; $df = 2$; $p < .01$

TABLE 2

STATISTICS ON THE PHRASE DURATION MEASURES 1(B)= PHRASE SAW YOU HIT THE CAT; 2(D)= PHRASE BLUE AND RED; AND 3(C)= PHRASE TOOK A SPOON FOR THE THREE AGE GROUPS OF SUBJECTS. THE DATA ARE IN MS.

Measure	AGE GROUPS 18-25 Years II	65-75 Years III	85+ Years IV
1(b)			
Group Mean	1114	1244	1220
s.d	146	106	163
2(d)			
Group Mean	351	617	598
s.d.	53	229	226
3(c)			
Group Mean	542	615	564
s.d.	46	112	79

CV Between Groups [(.01, 3) = 176]
CV Within Groups [(.01, 3) = 110]

than either of the other two phrases in Group II. The duration for that phrase was also significantly shorter than for the saw you hit the cat duration in Groups III and IV. The phrase took a spoon had the middlemost length in Group II. That same phrase did not differ significantly from the blue and red phrase durations in Groups III and IV.

It appears that the young mature speakers, Group II produced the blue and red phrase in a record short time, while taking considerably longer to produce the took a spoon phrase. Groups III and IV, however, did not make such a distinction. Both the older groups produced the blue and red and took a spoon phrases with almost equal durations making those phrases significantly shorter than the saw you hit the cat phrase.

It also appears that Groups III and IV produced all three phrases with longer durations than Group II. The durations for the blue and red and took a spoon phrases were significantly longer when compared to Group II. Groups III and IV made the saw you hit the cat phrase longer than Group II.

Fricative Duration

There were also significant main effects for fricative durations between subjects ($F=3.757$; $df=2$; $p = .03$) and within subjects ($F=86.084$; $df=1$; $p < .01$). Table 3 represents the results of the ANOVA comparing fricative measures (2(b), /s/ in box and 3(b), /s/ in spoon) across age groups.

Data for the fricative durations of Groups II, III, and IV are reported in Appendices C, G, and K. Summary statistics for the measure of fricative duration are compiled for each age group in Table 4. There were significant age and fricative

TABLE 3

ANOVA RESULTS FOR FRICATIVE DURATIONS

Source	S	DF	MS	F	P
Between Subjects					
Category	0.007	2	0.003	3 757	0.030
Error	0.050	54	0.001		
Within Subjects					
a	0.044	1	0.044	86.084	0.000
Category	0.009	2	0.005	8.986	0.000
Error	0.028	54	0.001		

Between Subjects: $F = 3.757$; $df = 2$; $p = .03$
Within Subjects: $F = 8.986$, $df = 1$; $p < .01$

TABLE 4

STATISTICS ON THE FRICATIVE DURATION MEASURES 2(B)= FRICATIVE /S/ IN BOX AND 3(B)= FRICATIVE /S/ IN SPOON FOR THE THREE AGE GROUPS OF SUBJECTS. THE DATA ARE IN MS

Measure	AGE GROUPS 18-25 Years II	65-75 Years III	85+ Years IV
2(b) Box			
Group Mean	58	58	50
s.d.	23	28	14
3(b) Spoon			
Group Mean	73	111	101
s.d.	34	31	24

CV Between Groups [(.01, 3) = 031]
CV Within Groups [(.01, 2) = 027]

durational differences. The age x fricative interaction indicated that the age groups differed in their durational patterns depending upon which fricative was produced.

The WSD-T follow-up comparisons of pairs of fricative durations across age groups revealed that all three groups, II, III, and IV produced the /s/ in box with a shorter duration that they used to produce the /s/ in spoon.

When the durations of the /s/ in box and spoon were compared across age groups some different patterns emerged. The duration of /s/ in box did not differ significantly across the three age groups. However, the youngest speakers, Group II, produced the /s/ in spoon with the shortest time period. Group III took significantly longer to produce the /s/ than Group II. Group IV took considerably longer than Group II to produce the phoneme, however, the amount of durational increase was just short of being significant on the follow-up statistical tests.

Voice Onset Time

Significant main effect differences for voice onset times (measures 1(a), /k/ in cat; 2(c), /b/ in blue; and 3(a), /t/ in took) were found across subjects ($F= 24.916$; $df= 2$; $p < .01$) and within subjects ($F= 11.041$; $df= 2$; $p < .01$) in the analysis of variance. Table 5 shows the results of the ANOVA.

Data for the voice onset times of Groups II, III, and IV are reported in Appendices D, H, and L. A chart of the statistics for voice onset time can be found in Table 6. The voice onset times, VOT's, differed significantly across age groups and contexts. The age x context interaction indicated that there were different patterns of variability depending jointly upon the age group of the speakers and the context in which they had to execute

TABLE 5

ANOVA RESULTS FOR VOICE ONSET TIMES

Source	S	DF	MS	F	P
Between Subjects					
Category	0.024	2	0.012	24.916	0.000
Error	0.027	55	0.000		
Within Subjects					
a	0.010	2	0.005	11.041	0.000
Category	0.024	4	0.006	13.116	0.000
Error	0.050	110	0.000		

Between Subjects $F = 24.916$; $df = 2$; $p < .01$
Within Subjects $F = 11.041$; $df = 2$; $p < .01$

TABLE 6

STATISTICS ON THE VOICE ONSET TIME MEASURES 1(A)= /K/ IN CAT, 2(C)=/B/ IN BLUE, AND 3(A)= /T/ IN TOOK FOR THE THREE AGE GROUPS. THE DATA ARE IN MS

Measure	AGE GROUPS 18-25 Years II	65-75 Years III	85+ Years IV
1(a) /k/			
Group Mean	38	53	65
s.d.	20	18	24
2(c) /b/			
Group Mean	30	81	88
s.d.	22	34	28
3(a) /t/			
Group Mean	52	46	49
s.d.	13	12	18

CV Between Groups [(.01, 3) = 21]
CV Within Groups [(.01, 3) = 21]

the appropriate VOT It should be noted that VOT was the only measure which had consistently longer durations across the three age groups.

There were no significant differences between the VOT's for cat and took in any of the three age groups. The youngest speakers, Group II did produce significantly shorter VOT's for the blue context than they did for the took context. They also produced noticeably longer VOT's in the took than the cat context.

The older groups (III and IV) followed a slightly different pattern in their VOT's for the blue context. The VOT for the blue context was significantly longer than either the took or cat contexts

Several trends appear when viewing VOT's across age groups for each context First, all three groups produced similar VOT's for the took context Group III had longer VOT's than Group II for the cat context. This difference was not large enough to be significant. However, Group IV had even longer VOT's than either Group II or III. This difference was significant when compared to Group II's VOT's, but was only somewhat longer than those for Group III. In addition, the VOT's for the blue context was significantly longer for the two older groups of speakers (III and IV) than the youngest group (II)

Closure of /k/

Data for closure of /k/ of Groups II, III, and IV are reported in Appendixes E, I, and M. The analysis of variance showed no significant difference across age groups for closure in measure 2(a), /k/ in box ($F = 893$, $df = 2$, $p > 01$) Table 7 shows the ANOVA results

TABLE 7

ANOVA RESULTS FOR CLOSURE OF /K/

Source	S	DF	MS	F	P
Between Subjects					
Category	0.016	2	0.008	0.893	0.415
Error	0.496	55	0.009		

$F = .893$; $df = 2$; $p > .01$

CHAPTER IV

DISCUSSION

Phrase Duration

It almost appears that the older groups (III and IV) seemed to slow down when the phoneme sequences required the production of blends or clusters. The blue and red and took a spoon phrases both require the production of blends (clusters). Both phrases also require a requisite amount of lip rounding for the /u/ vowel and /r/ semivowel. Since the lips are fairly slow articulators compared to the tongue, apparently some of the early toll of neuromuscular aging may well be manifested in the production of phonemes requiring lip manipulation.

The coupling of phonemes together into clusters makes for highly complex neuromuscular coordination and also seems to add to the early and later toll of the process of aging. That is, it simply takes older people longer to execute the movement sequences required in the production of clusters than it does younger mature speakers. It must also be noted that the longest phrase for all groups, saw you hit the cat, contains one lip-rounded sound and no cluster or blended phoneme sounds.

The data from Groups III and IV was compared to interval data found in the Kent and Forner study (1980) with four-, six-, and twelve-year-old children. The data from the

1980 study revealed that children younger than age six also tended to produce longer mean phrase durations than college-age adults. For example, the group mean for the phrase saw you hit the cat for college-age adults was 904 milliseconds. The group mean for four-year olds was 1241 milliseconds. Although the durational values for this phrase was somewhat longer in the older groups, it was not significant.

However, the phrase blue and red revealed an increase in mean value in Groups III and IV compared to Group II. Kent and Forner data also found a mean increase with this phrase in the four-year-olds (Group I). The duration of the phrase took a spoon remained constant across all age groups in the Kent and Forner study. The same phrase was longer in duration for Groups III and IV when compared to Group II.

Fricative Duration

The WSD-T follow-up comparisons of pairs of fricative durations across age groups revealed that all three groups (II, III, and IV) produced the /s/ in box with a shorter duration than they used to produce the /s/ in spoon. The /s/ in final position of the /s/ in box simply requires a release sound after the silent interval in /k/ Also, some of the movements for the /s/ can be coarticulated during the silent interval of the /k/. The release of the /k/ is slowed a bit while the tongue tip, already in position for the /s/ frication, begins that phoneme almost simultaneously with the burst release of /k/.

The /s/ in spoon must fall into a serial sequence of difficult articulatory moves. The /s/ is a non-rounded, lip-open sequence while the /p/ is a lip-closed phoneme. Plus, the slow process of lip-rounding, even though it can be somewhat coarticulated, impacts the entire sequence. Thus, there are several sounds which place demands on the

articulators which are not present in the production of the /s/ in box. Consequently, the duration of the /s/ in spoon simply takes longer. This increased pattern of duration was similar across all three age groups (II, III, and IV).

Once again, it appears that the combination of the clustering of sounds with dissimilar manners of production along with the anticipatory coarticulation of some lip rounding adds to the length of time speakers will take to produce the sequence. It also appears that the high demands of such sequences placed upon the articulators have differing degrees of impact depending upon the age of the speaker. The older groups of speakers (III and IV) seem to have a less skilled neuromuscular system. They simply must slow down and make many of their phonemes longer to insure accuracy.

Kent and Forner data (1980) also revealed fricative durations for /s/ in spoon to be slightly longer in the four-year-olds (Group I) This finding is comparable to that found in the durations of /s/ in spoon in Groups III and IV. The fricative duration for /s/ in box was found to be constant across Groups II, III, and IV. However, Kent and Forner found the fricative /s/ in box to be slightly longer in the Group I.

Voice Onset Time

Voice onset time is a very delicate maneuver requiring intricate coordination of the phonatory and articulatory systems. All the movements for both systems must be carefully coordinated. While very young children acquire the precision required of VOT, it still remains vulnerable because of its necessity of fine-tuned coordination The burst for the stop must be released and the phonation, if the onset is too early or late, will influence whether the listener will perceive a voiced or voiceless stop sound

This study found that the VOT's for the blue context were significantly longer for Groups III and IV than in Group II. Again, it would seem that the clustering of the two phonemes places unusually difficult demands upon the articulators which perhaps interferes with the onset of the phonation. Phonational onset appears to be held off until the speaker has slowed the processes down in order to insure the production of all the proper movements for both sounds in the cluster.

Apparently Group II had no such need to slow down these processes and are very skilled at making all the necessary moves in a short amount of time. Groups III and IV, with their differing degrees of neuromusculature status appear to have a considerably more difficult time with executing the cluster and onsetting phonation. They slow down everything and simply take longer which increases the voice onset time. Group II has fine-tuned things well enough so that they can make all the movements needed with agility in the shortest amount of time.

Kent and Forner data (1980) also showed that Group I produced longer voice onset times than the six-year-old, twelve-year-old, and the college-age group. However, some four-year-olds fell within the adult range of values for intrasubject standard deviations. The voice onset times for /k/ and /b/ were found to increase in Groups III and IV when compared with Group II in this study. However, voice onset time for /t/ remained constant across the three age groups (II, III, and IV).

CHAPTER V

SUMMARY

The present study compared phrase lengths, fricative lengths, and voice onset times in two groups of older adult females and one group of 18-25 year-old normal female speakers. Subjects were asked to repeat three sentences immediately following the examiner. Reel-to-reel tape recordings were made of the repetitions. Spectral analyses were then conducted on the subjects' sentences.

The phrase lengths, fricative lengths, and voice onset times were compared across groups. The present study indicated main effect differences on all three types of temporal measures. First, phrase lengths were found to be longer in Groups III and IV when compared to Group II. For example, Groups III and IV produced the saw you hit the cat phrase with longer duration than Group II. The phrases took a spoon and blue and red were also considerably longer in duration when compared to Group II. This could be due to the fact that the latter two phrases contain blends, lip rounding and/or the production of a semi-vowel which apparently seems to slow down the phoneme sequence.

Secondly, fricative lengths in blended sounds appeared to have the longest durational time. The utterances with a blend or cluster seemed to increase the durations markedly in the two older groups. For example, the /s/ in spoon was considerably longer in Groups III and IV.

Voice onset times were also found to be longer in Groups III and IV when compared to Group II. The voice onset time for blue was significantly longer than either the took or cat contexts. Here again, the /bl/ cluster seems to delay the onset of voicing in Groups III and IV. The longer voice onset times found among Groups III and IV supports Weismer and Fromm's study which found that elderly females showed longer voice onset time durations than those produced by 21-27 year-olds (Weismer & Fromm, 1983).

It would appear that the blending of sounds causes an increase in the length of time it takes the older speakers to execute the sequence of articulation. Interestingly, the blending of sounds appear to be very complex and difficult for young children to acquire. Thus, clusters appear as a later developing phenomena in younger children.

However, too many generalizations about segment lengthening in the older population should not be made at this point since the present study consisted of a small sample size.

In addition, although significant statistical differences were found between Group II verses Groups III and IV, no significant statistical differences were found between Groups III and IV. Thus, there was no evidence for continued decrease in articulatory skill with increasing age.

It should also be stated that the style of presentation mode may affect durational aspects in the aging voice. For the purpose of this study, the examiner presented the stimulus phrase which was then followed by an immediate repetition of the phrase by the subject Regional dialect of the subjects, including the style of pronunciation and stress pattern may also affect durational aspects in the aging voice. However, efforts were made

to insure that potential subjects with strong or marked regional dialect were excluded from the sample. The presence of regional dialects would certainly have to be considered in light of the present or other related studies.

The data presented here should raise future questions and cautions about research for speech production in the aging population. There is still a need to look at pause lengths and vowel lengths along with durational dimensions in spontaneous conversation. In addition, further investigation of phrase durations, fricative durations, and voice onset times will help the speech-language pathologist when treating and diagnosing motor speech disorders.

In conclusion, there is a great need to develop a normative database of durational patterns in normally aging individuals. Further investigation on aging and the speech processing characteristics among the elderly would provide data which would aid in identifying pathological aging from disordered speech in differing age groups. These data would also provide information in distinguishing normal aging on speech processes from disordered speech processes. Therefore, research focusing on the variability of phrase durations, fricative durations, and voice onset times within the aging population is needed in order to make further conclusions about the changing speech productions in the elderly population.

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APPENDIXES

APPENDIX A

SENTENCE LIST

1. "We saw you hit the cat."
    (a) voice onset time for /k/ in cat;
    (b) phrase duration, measured as the interval from the initiation of frication for /s/ in saw to the instance of closure for /t/ in cat.
2. "The box is blue and red."
    (a) duration of closure for /k/ in box.
    (b) duration of frication for /s/ in box.
    (c) voice onset time for /b/ in blue.
    (d) phrase duration, measured as the interval from release of /b/ in blue to the steady-state segment of /r/ in red.
3. "I took a spoon and knife."
    (a) voice onset time for /t/ in took.
    (b) duration of frication for /s/ in spoon.
    (c) phrase duration, measured as the interval from the release of /t/ in took to the beginning of voicing for the /u/ in spoon.

The voice onset time will be omitted in 2(d) whenever voicing is carried over from the preceding phonetic segment.

APPENDIX B

PHRASE DURATION DATA: 18 - 25

YEAR-OLD FEMALES, GROUP II

SUB	b-r	s-t	t-u
2501	387	972	523
2202	296	942	595
2203	297	1096	544
2104	384	1121	574
2305	447	1285	629
2306	364	1072	555
2407	272	1115	592
2408	418	1229	502
2109	427	1235	559
2410	309	1068	485
2411	428	1549	512
2512	278	1111	531
2013	411	1005	611
1914	329	1047	495
2015	290	1186	548
2216	355	945	543
2417	394	1268	574
2118	332	1062	524
2119	360	958	431
2120	348	1118	528
2321	305	877	478
2122	300	1150	560
2323	342	1219	578

APPENDIX C

FRICATIVE DURATION DATA: 18 - 25

YEAR-OLD FEMALES, GROUP II

SUB	/s/ box	/s/ spoon
2501	49	107
2202	47	99
2203	47	88
2104	76	113
2305	104	150
2306	102	107
2407	89	85
2408	34	53
2109	77	56
2410	41	27
2411	33	34
2512	57	139
2013	64	90
1914	66	47
2015	100	64
2216	57	43
2417	36	56
2118	39	76
2119	45	45
2120	41	50
2321	29	76
2122	49	37
2323	50	43

APPENDIX D

VOICE ONSET TIME DATA: 18 - 25 YEAR-OLD FEMALES, GROUP II

SUB	VOT /k/	VOT /b/	VOT /t/
2501	11	91	70
2202	14	13	61
2203	16	30	30
2104	44	11	50
2305	25	31	67
2306	34	10	53
2407	26	25	47
2408	30	25	30
2109	26	26	63
2411	70	15	55
2310	57	31	45
2512	25	15	46
2013	17	22	62
1914	17	27	37
2015	32	10	37
2216	64	26	64
2417	35	27	66
2118	69	21	38
2119	26	42	48
2120	56	28	65
2321	69	32	35
2122	49	30	55
2323	67	23	61

APPENDIX E

CLOSURE FOR /K/ DATA: 18 - 25

YEAR-OLD FEMALES, GROUP II

SUB	/k/
2501	78
2202	47
2203	57
2104	53
2305	80
2306	81
2407	74
2408	71
2109	83
2411	78
2310	55
2512	39
2013	41
1914	63
2015	35
2216	34
2417	42
2118	68
2119	127
2120	46
2321	87
2122	76
2323	44

APPENDIX F

PHRASE DURATION DATA: 65 - 75

YEAR-OLD FEMALES, GROUP III

SUB	/s/-/t/	/b/-/r/	/t/-/u/
6501	1129	734	602
7402	1358	512	609
6606	1411	1106	746
7204	1306	1071	643
7208	1402	762	697
7510	1357	953	865
7013	1147	534	647
7012	1157	439	481
6715	1292	680	591
7416	1207	473	555
6917	1289	397	594
6918	1150	419	653
7219	1340	628	765
6620	1169	658	521
7021	1295	459	681
6822	1173	444	487
7123	1094	421	433
7338	1111	422	493

APPENDIX G

FRICATIVE DURATION DATA: 65 - 75

YEAR-OLD FEMALES, GROUP III

SUB	/s/ box	/s/ spoon
6501	119	112
6606	90	107
7204	74	133
7208	39	181
7510	53	92
7013	87	99
7012	33	67
6715	48	144
7416	36	86
6917	34	140
6918	44	59
7219	37	163
6620	33	111
7021	56	112
6822	78	115
7123	99	115
7338	26	76

APPENDIX H

VOICE ONSET TIME DATA: 65 - 75

YEAR-OLD FEMALES, GROUP III

SUB	VOT /K/	VOT /B/	VOT /T/
6501	49	162	40
7402	69	35	53
6606	58	120	61
7204	50	74	45
7208	114	107	67
7510	46	96	50
7013	61	58	56
7012	33	42	21
6715	44	77	33
7416	32	77	38
6917	36	82	37
6918	51	120	53
7219	62	75	65
6620	41	43	43
7021	61	32	53
6822	56	81	33
7123	52	106	35
7338	46	68	35

APPENDIX I

CLOSURE FOR /K/ DATA: 65 - 75

YEAR-OLD FEMALES,

GROUP III

SUB	/k/
6501	17
7402	89
6606	93
7204	126
7208	54
7510	59
7013	72
7012	104
6715	81
7416	27
6917	48
6918	74
7219	60
6620	72
7021	91
6822	56
7123	81
7338	39

APPENDIX J

PHRASE DURATION DATA: 80+

YEAR-OLD FEMALES,

GROUP IV

SUB	/s/-/t/	/b/-/r/	/t/-/u/
8005	1110	1110	434
8603	1201	451	622
8007	1195	850	561
8109	1394	973	540
8611	1507	476	554
8124	989	376	544
8325	1112	494	523
8026	1536	660	647
8227	1252	403	495
9128	1141	654	538
8729	1256	447	628
8330	1145	456	597
8431	973	414	467
8132	1116	433	524
8736	1395	888	759
8234	1306	452	506
8637	1116	623	645

APPENDIX K

FRICATIVE DURATION DATA:

80+ YEAR-OLD FEMALES,

GROUP IV

SUB	/s/ box	/s/ spoon
8005	44	66
8603	72	107
8007	31	114
8109	53	66
8611	58	108
8124	33	70
8325	68	78
8026	74	148
8227	41	98
9128	40	109
8729	50	123
8330	42	117
8431	48	87
8132	33	76
8736	37	106
8234	59	118
8637	61	131

APPENDIX L

VOICE ONSET TIME DATA: 80+

YEAR-OLD FEMALES,

GROUP IV

SUB	VOT /k/	VOT /b/	VOT /t/
8005	37	92	29
8603	66	23	42
8070	64	67	45
8109	57	111	66
8611	98	61	34
8124	40	86	49
8325	60	108	40
8026	98	86	76
8227	57	88	37
9128	126	88	37
8729	58	69	71
8330	67	72	49
8431	68	95	34
8132	73	93	28
8736	41	131	67
8234	48	81	41
8637	46	148	88

APPENDIX M

CLOSURE FOR /K/ DATA: 80+

YEAR-OLD FEMALES,

GROUP IV

SUB	/k/
8005	77
8603	26
8007	14
8109	62
8611	83
8124	69
8325	78
8026	43
8227	63
9128	71
8729	44
8330	27
8431	113
8132	40
8736	84
8234	74
8637	68

APPENDIX N

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 __

Paralysis __ Neurological Diseases __

Cleft Palate and/or Lip __ Cerebral Palsy __

Smoker __

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 O

HEARING SCREENING FOR

65 - 75 AND 80 + YEAR-OLDS

Subject #:_____
Date:_____
Site:_____

	R	L
500 Hz	_____	_____
1000 Hz	_____	_____
2000 Hz	_____	_____
Three frequency average	_____	_____

45 dB or better in better ear? Pass/Fail

Hearing aids? Yes/No

APPENDIX P

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 03-19-97 **IRB#: AS-97-051**

Proposal Title: THE EFFECTS OF AGING ON ELDERLY FEMALE VOICE ONSET TIME AND SEGMENT DURATION

Principal Investigator(s): Arthur Pentz, Vickie Brazeal

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:  Date: March 27, 1997

Chair of Institutional Review Board

cc: Vickie Brazeal

VITA[2]

Vickie D. Brazeal

Candidate for the Degree of

Master of Arts

Thesis: THE EFFECT OF AGING ON ELDERLY FEMALE VOICE ONSET TIME AND SEGMENT DURATION

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