To the Graduate Council:

I am submitting herewith a thesis written by Tammy Kaye Carwile entitled "Comparison of Oral Diadochokinetic Rates in the Normal Young and Aging Population." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the Master's degree, with a major in Speech Pathology.

Gloriajean Wallace

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We have read this dissertation
and recommend its acceptance:

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Accepted for the Council:

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Vice Chancellor and
Dean of The Graduate School

COMPARISON OF ORAL DIADOCHOKINETIC RATES IN THE NORMAL YOUNG AND AGING POPULATION

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Tammy Kaye Carwile
May 1995

DEDICATION

This thesis is dedicated to my parents

Jack and Brenda Carwile

whose generosity and patience

have allowed me to reach yet another goal.

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CHAPTER I

INTRODUCTION, REVIEW OF THE LITERATURE AND STATEMENT OF THE PROBLEM

A. INTRODUCTION

According to the 1993 U.S. Bureau of the Census, there are approximately 32,971,000 Americans who are 65 and older, and it is predicted that this age group will increase to about 65,000,000 over the next couple decades (Fein, 1984). The professionals in the field of speech pathology will most likely incur increases in their geriatric caseload, since a majority of individuals who acquire speech-related, neurological impairments come from this growing population (Smith, Wasowicz, & Preston, 1987). Since there are no specific assessments for speech produced by the elderly, endeavors in research are needed to broaden our understanding of the specific speech changes which can be anticipated from an elderly client (Parnell & Amerman, 1987).

This study was designed to examine differences in oral diadochokinetic (oral repetition) rates between healthy males and females in two different age groups (20 to 30 years and 65 to 75 years), to assess age-related changes (i.e., nonpathologic) in motor-speech coordination. Oral diadochokinesis was employed because it is utilized by Speech Pathologists to differentiate between normal (physically and neurologically) and disordered populations (Fillyaw et al, 1989; Platt, Andrews, Young, & Quinn, 1980; Portnoy & Aronson, 1982; Dworkin, Aronson, & Mulder, 1980; Robb, Hughes, & Frese, 1985; Kreul, 1972; Beam, Gant, & Mecham, 1978).

An evaluation of motor speech integrity encompasses several types of speaking tasks, including oral diadochokinetic (DDK) tasks. This traditional component (Hale, Kellum, Richardson, Messer, Gross, & Sisakun, 1992; Parnell & Amerman, 1987) of most motor speech evaluations requires rapid syllable repetitions, most often utilizing the sounds, /pʌ/, /tʌ/, and /kʌ/, in mono-, bi-, or tri-syllabic combinations. The three consonants in DDK tasks involve motor movement of the lips, front of the tongue, and back of the tongue, and coordination of all three of those movements (Engberg, 1989). These sounds have been selected to represent "different levels of physiologic complexity, as indicated by differences in developmental schedule (speech sound acquisition), articulatory placement, and syllable content" (Fletcher, 1972, p. 764).

Diadochokinesis is used to assess the integrity of the aging articulatory system (Ryan & Burk, 1974; Amerman & Parnell, 1982). It is also frequently used for the screening of motor speech disorders (Kent, Kent, & Rosenbek, 1987), and is used in differentiating normal from disordered populations, particularly those with neuromotor impairments (Fillyaw et al., 1989; Platt, Andrews, Young, & Quinn, 1980; Portnoy & Aronson, 1982; Dworkin, Aronson, & Mulder, 1980; Robb, Hughes, & Frese, 1985; Kreul, 1972; Beam, Gant, & Mecham, 1978). Currently no normative clinical standards have been established for senescent diadochokinetic rates, yet this task is utilized in senescent speech assessments continually.

B. REVIEW OF THE LITERATURE

Aging Stereotypes

Beasley and Davis (1981) found that the ideas that older persons are generally sick, lonely, and depressed have all been questioned by sociological, psychological, medical, and educational researchers, and insist that this stereotypic characterization of senescent individuals is a myth. Foster (1987) states that impairments of mental ability or mobility have been misattributed to the normal course of aging because healthy and active older subjects may often be harder to locate for testing as well as due to the generalized stereotype of the elderly as deteriorating. Naturally, some changes inevitably occur with aging, but not all changes are necessarily deleterious (Ibid.)

Age-related Changes

During senescence, there are immense individual variations in the rate and extent of aging, but certain salient characteristics are manifested -- such as graying and loss of hair, drying of skin and pigment changes (Brown, 1988), diminished visual and auditory acuity (Smith & Sethi, 1975), and reductions in touch, smell, and taste (Lamy & Kitler, 1971). Aging is associated with anatomic and physiologic changes in the speech system effecting respiratory (Kenny, 1988; Hoit & Hixon, 1987; Ptacek, Sander, Maloney, & Jackson, 1966), laryngeal (Kersing, 1986; Kahane, 1981; Hommerich, 1972), pharyngeal (Kahane, 1981; Zaino & Benventano, 1977: Ferreri, 1959), and oral (Baum, 1987; Zemlin, 1968; Ptacek, 1966) structures.

Speech-related Neurologic Changes During Senescence

Neurologic changes normally occur during senescence which may effect speech production (Shadden, 1988), including brain weight and volume reduction due to atrophy of the cerebral cortex, cerebellar cell reduction, nerve cell loss and degeneration, and reduction of neurotransmitter substances (Whitbourne, 1985; Kenny, 1982; Valenstein, 1981). Orlovskaya (1982) states, "Neuronal loss has been viewed as a principle structural substrate of declining brain function with advanced age" (p. 37), and says that changes in contacts between cells also contribute to the decline in neurological functioning with age. Such neurological changes are known to result in longer muscle contraction times, slower monosynaptic reflex times, and decreases in nerve conduction velocity (Kenny, 1982).

Degenerative processes in the neural system related to aging are believed to contribute to a general slowing of neural processing (Smith, Wasowicz, & Preston, 1987; Griew, 1963), which may affect sensory and motor performance capabilities related to speech production (Kent & Burkard, 1981; Wilder, 1984). Because limited experimental work has been done in this area, data on geriatric changes in the neuromuscular control of speech are fragmentary (Kent & Burkard, 1981, p. 57). Additionally, Meyerson (1976) states that speech differences found so far in the aged population are largely unsupported.

Botwinick (1973) found motor performance in older subjects to be characterized by a decrease in muscular strength, slowness and a lack of fine coordination of movement (confounded by the physical activity variable which was not accounted for). However, these characteristics may not necessarily have an effect on the individuals speech processes, because "speech may not be as vulnerable to the effects of aging as are the less frequently performed motor tasks" (Oyer & Deal, 1985, p.109). Anshel (1989), said that "the ability to perform a series of well-learned responses automatically is not dependent upon age" (p. 291), and quotes Spirduso (1987), who concluded that psychomotor speed seems to be maintained in physically active individuals. Rosenbeck and LaPointe (1981) also hypothesize that "a person's age is no more important to motor speech performance than is his or her history of wellness" (p. 176).

Role of Physical Fitness in Aging

It is important to note here that physical fitness and activity play important roles in the efficiency of the central nervous system function (Spirduso & Clifford, 1978). Since activity levels usually decline with age, it is often difficult to attribute the behavioral slowing to aging, or to environmental influences and disease processes. Ramig (1983) found that physical condition has a stronger effect on vocal characteristics than does chronological age. Additionally, Ramig & Ringel (1983) highlighted the role physical fitness plays in the acoustical correlates of speech, demonstrating that healthy senescent speakers had the acoustic characteristics of much younger speakers, and speakers the same age but in poor physiologic condition sounded "old".

Senescent Speech Characteristics

Many studies have been conducted to determine the perceptual acoustic correlates of senescent speech (Ryan & Burk, 1974; Ryan, 1972; Ryan & Capadano, 1978; Hartman 1979; Hartman & Danhauer, 1976; Ptacek & Sander, 1966; Mysak, 1959; Mysak & Hanley, 1959; Parnell & Amerman, 1987; Stewart & Ryan, 1982; Shipp & Hollien, 1969) and found that identifying characteristics of aged speech include slow rate of speech, imprecise articulation of consonants, vocal tremor, tension, lower pitch and hoarseness/breathiness.

Leden (1977) insists that voice changes are virtually inevitable after the age of 50, and many researchers have related them to structural and physiological conditions that occur with senescence (Shindo & Hanson, 1990; Kent & Burkard, 1981; Morrison, Rammage, & Nichol, 1989; Kahane, 1981; Honjo, Tanaka, & Tanabe, 1985; Kahn & Kahane, 1986, Schow, Christensen, Hutchinson, Robinson, & Nerbonne, 1978; Ferreri, 1959; Hommerich, 1972; Sonies, 1987; Geterund, Bake, Berthelsen, Bjelle, & Ejnell, 1991; Moore, 1971; Tucker, 1988; Burzynski, 1987; Honjo & Isshiki, 1980; Hoit & Hixon, 1992; Hirano, 1979; Leden, 1977; Hirano, Kurita & Sakaguchi, 1989). Shadden (1988) says that although reduced articulatory precision is not present in all older speakers, older males are perceived as having more imprecise articulation than older women.

When considering possible causes in age-related articulation differences, some have been attributed to problems in dentition (Kahane, 1981; Kent & Burkard, 1981; Walker, Hardiman, Hedrick, & Holbrook, 1981), peripheral neuromuscular control (Sonies, 1987; Mysak & Hanley, 1958, Mysak, 1959; Ryan, 1972; Hutchinson et al., 1978), reduced salivary secretions (Silverman, 1972; Zemlin, 1968), changes in the oral structures (Kahane, 1981; Hutchinson et al., 1978; Meyerson, 1976; Silverman, 1972), decline in oral sensory perception (Canetta, 1977; Truex, 1940) and reduced auditory feedback (Smith & Sethi, 1975; Shadden, 1988). However, Brookshire and Manthie (1980) posit that articulatory abilities are not usually compromised by aging (unless a pathological condition exists), and Ship (1992) concurs, stating, "speech production appears to be resistant to aging, and there are few data to indicate that the normal (nonpathologic) aging process actually affects movement of the oral articulators (lips, tongue, and jaw) in any appreciable manner" (p. 494). Additionally, Ship (1992) believes that oral physiology is age-stable in healthy individuals, except in the presence of diseases.

Senescent Speech Rate Ability

Reductions in speech rate have been attributed to general neuromuscular slowing which is associated with advancing chronological age (Parnell & Amerman, 1987; Ryan, 1972; Hartman & Danhauer, 1976), and attempts by the aging individual to monitor speech in order to reduce articulation errors (Spirduso & Clifford, 1978; Kent & Burkard, 1981).

Parnell & Amerman (1987), Ramig (1983), Knox (1981), Hartman (1979), Schow et al. (1978), Ryan & Capadano (1978), Hartman & Danhauer (1976), Ryan & Burk (1974), Ryan (1972), Mysak (1959), and Mysak & Hanley (1959), all report speech rate reductions in senescence, but interestingly, none of the subjects from whom the information was gathered were screened for physical fitness and neurological problems. Health status needs to be considered, so that normal senescent individuals ("normal" meaning nondiseased and physically healthy) can be assessed differently than those who have not maintained their physical health. However, it has yet to be determined how aging affects speech in the normal healthy senescent individual.

While perceptual studies may indicate reduced rate in aging speech, objective studies may not. Three objective studies assessing senescent speech rate as compared to younger groups of individuals have been carried out utilizing diadochokinetic rates as a measure (Amerman & Parnell, 1982; Ptacek & Sander, 1966; Kreul, 1972). Two of the three found age-related reductions in diadochokinetic performances (Amerman & Parnell, 1982; Ptacek & Sander, 1966), however physical activity levels and health were not taken into consideration. Blonsky et al. (1975), found normal neuromuscular control of speech in normal geriatric subjects, however, the limited sample size, exclusion of normal young adults for comparison (compared "normal" to disordered aged individuals), and minimal research effort concerning speech production and aging does not render this conclusive. Kreul (1972) also studied differences in diadochokinetic rate of two different age groups, finding no significant results to indicate diadochokinetic rate reduction with age. Actually, the older subjects in this study performed slightly better, however, he did not provide any information, other than age.

Other studies assessing speech of the aging have concluded that normal aging changes may masquerade as a mild motor speech disorder (Ryan & Burk, 1974), observing "mild reductions of oral motor structure and function as a result of age" (Wallace, 1991, p. 108). However, these studies did not consider health status in subject selection.

Oral Diadochokinesis

Oral diadochokinesis (DDK) is used to assess whether a person has the ability to select or alternate place of production and vary in voicing (depending on the syllables selected) (Kent et al., 1987). DDK is a straightforward motor task of articulatory repetition (Tiffany, 1980), which is important in the evaluation of the ability to make consistent articulatory contacts without breakdowns or variations in rate (Peterson & Marquardt, 1990). Bunton and Weismer (1994), suggest that DDK provides useful information about speech production in persons with motor speech disorders.

Kent et al. (1987) posit that DDK specifically investigates coordination of the speech motor subsystems, including laryngeal and labial (during phonation and articulation of /pʌ/), and laryngeal and lingual (both posterior and anterior) (during phonation and articulation of the sounds /tʌ/ and /kʌ/). Utilization of /pʌ/, /tʌ/, and /kʌ/ allows comparison of occlusions in the anterior and posterior superior vocal tract, with typically better performance on anterior plosives compared to posterior plosives (Keller, Vigneux, & Laframboise, 1991).

Amerman and Parnell (1982) found perception (judgements of age from listeners) of oral DDK rate performances to be slower for elderly males as compared to young males (did not include females in this study). Because Amerman and Parnell (1982) conducted a subjective (perceptual) study, other speech characteristics (such as vocal quality) may have influenced the listeners' judgements.

Ptacek et al. (1966) conducted an objective study and also found oral monosyllabic and trisyllabic DDK rate reductions in the aging population. Senescent individuals in their study had DDK rates which ranged anywhere between 3.6 to 5.4 syllables per second, whereas the young adults in their study had DDK rate which ranged from 5.1 to 7.0 syllables per second. Their findings are not applicable to the normal aging population, because physical health or the subjects was not accounted for, and neurological insults were not ruled out.

Although DDK rates are given for the adult population in general, no one has established typical DDK rates for the aging, except to suggest that slower rates may be expected, because normal aging changes may masquerade as a mild dysarthria (Ryan & Burk, 1974). Tiffany (1980), Dworkin et al. (1980), Kreul (1972), Lass and Sandusky (1972), and Sigurd (1973) report consonant-vowel repetition rates (DDK) to average around six to seven syllables per second for young adults or a wide age range of adults (i.e, the mean for adults aged 25-85 years) (Kreul, 1972, only studied monosyllabic tasks).

Articulatory coordination rates (such as DDK) are judged during an oral-motor assessment, such as the Frenchay Dysarthria Assessment(FDA), developed by Enderby & Roworth (1983). Just as in the FDA, the standard approach in the assessment of motor speech has been to measure nonspeech tasks (Darley, Aronson, & Brown, 1975), as well as speech and speech-like tasks (Yorkston, Beukelman, & Bell, 1988; Rosenbek & LaPointe, 1981; Sonies, 1987). The speech-like task (DDK), involving repetition of syllables, "first verifies the patient's capacity to alternate between conditions of an entirely closed [p, t, k] and an entirely opened [ah] vocal tract" (Keller et al., 1991, p. 78). Although DDK is a speech-like task, it is unaffected by prosody and empty of linguistic content, thus syllable stress and dialectal differences should not effect DDK rates (Tiffany, 1980). According to Keller et al. (1991), "many patients with neurologic speech disturbances show excessive difficulties in performing a clearly articulated alternation between the two conditions (open and closed vocal tract)" (p. 78). The ability of quickly selecting or alternating place of articulation involved in oral DDK has been found to be a relatively stable maximum performance, which does not increase with practice (Hale et al., 1992).

Some people feel DDK is a good measure of articulatory abilities (Tiffany, 1980), some identify DDK as a measure of speech rate (Parnell & Amerman, 1987; Ptacek et al., 1966), and perhaps the most pervasive use is to assess the coordination of the articulators (Gentil, 1990; Kent et al., 1987; Fletcher, 1972). At any rate, oral diadochokinesis is designed to provide a way to "contrive a set of such alternated and sequential forms which would approach the form of natural speech articulation without its sense," and that DDK makes it "possible to assess with more clarity the differences between the relatively empty motor tasks (repetition of nonsense syllables) and the natural language tasks" (Ibid). Interestingly, DDK was found to approximate normal reading rates when syllable structure was matched (same vowel and consonant structures) - about 13.5 phones per second, or 6.75 consonant-vowel syllables (e.g., "cookie" = two consonant-vowel syllables) (Tiffany, 1980). According to Kent et al. (1987), the monosyllabic triad /pʌ, tʌ, kʌ/ in DDK "has become a clinical standard, and it is for these syllables that the largest amount of normative data has been reported" (p. 379). However, the normative data on oral diadochokinetic rates has not taken into consideration the effect of aging upon performance on this task.

C. STATEMENT OF THE PROBLEM

Given that many perceive speech as becoming slow with aging, and that several studies have observed diadochokinetic rate reductions (although insufficient screening of subjects), it is of diagnostic importance to determine the presence of reductions due to aging. Rosenbek and LaPointe (1981) believe that senescent individuals "naturally become weaker and slower and that these changes need not to be seen as pathologic nor do they need to be treated" (p. 165). However, the present research endeavor posits that any weakness, slowness, or lack of coordination in motor speech should be indicative of an underlying disorder, not aging.

The purpose of this investigation was to provide an analysis of motor-speech coordination (through utilization of oral diadochokinesis) for young and senescent individuals, as well as male and female, and to investigate the effects of the task (monosyllabic and trisyllabic). Currently, normal age-related changes (i.e., nonpathologic) on speech performance are uncertain, as most of the accepted clinical norms for assessing motor speech processes are based on observations of children and young adults (Parnell & Amerman, 1987).

Parnell & Amerman (1987), state that "a comprehensive database for clinical definition of speech normality in the elderly remains far from complete" (p. 340). A more inclusive profile of speech parameters during aging is needed in order to understand the effect of age upon the speech process, and to facilitate the development of speech norms of the aging to serve as more sensitive indices for clinical evaluation of the aging population (Parnell & Amerman, 1987).

This study addressed age and gender effects upon the speech parameter of oral diadochokinetic abilities. The experimental questions in this study were:

1. Are there significant differences in the oral diadochokinetic (DDK) rates between two age groups (20 to 30 and 65 to 75 years)?

2. Are there significant differences in the DDK rates when comparisons are made between males and females, and are there gender by age interactions?

3. Is there a significant correlation between subject speech rate on monosyllabic DDK tasks and the trisyllabic DDK task?

CHAPTER II

METHODS AND PROCEDURES

A. METHODS

This study investigated oral diadochokinetic monosyllabic and trisyllabic performances of different genders in two different age groups. This was carried out in order to assess maintenance of lip and tongue coordination of both genders throughout senescence. Because it is possible that health and physical fitness plays a role in aging speech, it was a major factor in subject selection.

Subjects

The methods implemented in this study involved the recruiting of fourty volunteer subjects in two different equally distributed age groups (young adults between the ages of 20 to 30 years, and older adults between the ages of 65 to 75 years). Each group consisted of ten males (average age of young males = 25 years; average age of senescent males = 70 years) and ten females (average age of young females = 24 years; average age of senescent females = 70 years) who met the following selection criteria:

1. Native English speaker;

2. Self-reported to be in good physical condition (physically active, without disease and physical impairments);

3. Possessed complete permanent dentition, or sufficient and fitted full or partial dental plates (worn for at least one year);

4. Passed hearing sensitivity screening at 40-dB HL for 500, 1000, 2000, and 4000 Hz (ANSI) in better ear.

5. Recent history (past two years) free from health conditions which required being bed-ridden for more than two-weeks;

6. Past history free from speech or language disorders;

7. Past history free from alcohol or drug abuse;

8. Past history free from debilitating respiratory disease;

9. Past history free from head trauma;

10. Past history free from of paralysis, epilepsy, stroke, or any other neurological disease process;

11. Self-reported to take no medication currently which could affect the nervous system or oral musculature;

12. Maintained independent residences; and

13. Participated in regular exercise or physical activity.

Additional demographic information collected about the subjects included types and frequency of physical activities, as well as type and frequency of social activities. This information was collected for post hoc comparison of subjects.

Experimental Tasks

The syllables chosen for the oral diadochokinetic task are the monosyllables of /pʌ/, /tʌ/, and /kʌ/, and the trisyllabic combination of /pʌ tʌ kʌ/, which Kent et al. (1987) refers to as the clinical standard in speech pathology assessments.

The experimental task consisted of having the subject repeat the syllable or trisyllabic combination (e.g., /pʌ tʌ kʌ/) as fast as possible for six seconds. After a 10 second rest, the subject repeated the task a second time, waited 10 seconds again and repeated the task for a third time. Three trials were given in order to obtain the maximum rate of the subject, and the highest rate (syllables/s) was used in the raw data.

Experimental Data

Data consists of the highest four seconds of syllable rate productions (not including the unrecorded first practice) from each of the four oral diadochokinetic tasks. The total number of syllables during those four seconds were averaged (divided by four) to obtain a syllable per second rate. This syllable per second rate collected for each task was used when evaluating across group performances and across task performances.

B. PROCEDURES

Testing Procedures

Instructions and an unrecorded syllable repetition trial were given before each different syllable task. Each subject was seated in a quiet room (in their home, at the senior citizens center, or in an office at the University of Tennessee Hearing and Speech Annex) in front of a table which supported the microphone and was given the following verbal instructions:

> The following sounds are to be repeated a fast as you can until I instruct you to stop. You will be expected to do the very best you can for at least six seconds on one breath, and I will tell you when to stop. The sounds I want you to say are "___,___,___". Now you repeat that (subject repeats). I want your very best performance, so repeat "___,___,___" as many times as you possibly can when I say go.

Oral diadochokinetic performances were investigated through tape recordings of each subject's productions of /pʌ/, /tʌ/, /kʌ/, and /pʌ tʌ kʌ/ repetitions. A microphone was positioned six to eight inches from the mouth of each subject.

Instrumentation

Recording were made using a Panasonic RQ-323AS recorder and a Shure Brothers, Inc., Model 560, dual impedance, dynamic lavalier microphone. The microphone was positioned on a stand and placed on a table. Each speech task was taped at an input level between 0- to -3-dB VU, and played back for analysis through the same recorder.

To analyze data described below, speech samples were played back and routed into the DSP Sona-Graph, Model 5500 by Kay Elemetrics. The DSP Sona-Graph was set for Spectrographic Time Axis analysis of syllable duration and syllable count. Speech signals from the Panasonic RQ-323AS were played back and recorded on the Sona-Graph scrolling screen, which displayed six seconds of input. The speech syllables were displayed spectrographically, with the stored time cursor placed where the second syllable began (because initiation of the first syllable was sometimes long and seperated from the second syllable), and the active time cursor moved to the four second value on the x-axis. When the active time cursor was placed during a syllable production (at the four second mark), that syllable was measured for length of time, and the syllable time that remained within the four seconds was counted as a fraction to the nearest 1/10th of a syllable. Printouts of all data on screen were collected by using the DSP Sona-Graph Gray Scale Printer, Model 5510.

Data Accuracy Assurance

After compilation of all syllable rates for each subject, a second party (graduate student in speech pathology at the University of Tennessee) randomly checked one-hundred percent of the hard copies acquired from the DSP Sona-Graph printer for accuracy of syllable count, resulting in a 92 percent interscorer reliability. With these disagreements, the principal investigator and the second party jointly reviewed the data and agreed upon syllable count from hard copies. One-hundred percent agreement was obtained after review between the two parties.

Data Analysis

Data obtained were analyzed by three-factor analysis of variance (ANOVA) with repeated measures and the Pearson Product Moment Correlation Coefficient (r), through utilization of the SAS System. Raw data from each subject can be found in table A-1*. Results of statistical analysis will be discussed in the results section.

*All tables and figures may be found in the appendix.

CHAPTER III

RESULTS

A. AGE EFFECTS

The method for analyzing oral diadochokinetic rate differences between the two age groups was the three-factor design ANOVA with repeated measures.

Age effects was significant (p=>.05). Analysis revealed no differences between the two age groups on the oral diadochokinetic monosyllabic tasks, however, considerable significance was found between the two age groups for the oral diadochokinetic trisyllabic task (table A-2).

B. GENDER EFFECTS

The three-factor ANOVA with repeated measures was used to analyze differences between males and females (table A-3), as well for analysis of age by gender interactions.

Gender effects was significant (p=>.05). Results were that no statistical differences were found between genders on the monosyllabic /pʌ/ task [F (3,36) =, p=.4831], nor on the /kʌ/ task [F (3,36) = 2.51, p= .1218]. Statistical significance was found between the two genders for the performance on the monosyllabic /tʌ/ task [F (3,36) = 5.00, p= .0317], and the trisyllabic task [F (3,36) = 6.47, p= .0154).

Analysis of age by gender interactions revealed non-significance for the monosyllabic tasks, however, the trisyllabic task was closest to .05 significance [F (3,36) =3.32, p=.0768] (table A-4).

C. TASK TYPE PERFORMANCE CORRELATIONS

The method for analyzing correlations between subject performance on monosyllabic and trisyllabic diadochokinetic tasks was the Pearson Product Momemt Correlation Coefficient (r).

Analysis did not reveal strong significance (at the .05 level) between the subjects' performance on the monosyllabic and trisyllabic tasks (table A-5).

CHAPTER IV

DISCUSSION

A. AGE

Oral diadochokinetic performances were measured in syllables per second (SPS) (for performance means on all tasks, see figure B-1). Differences were assessed in two age categories, 20 to 30 years and 65 to 75 years of age (for young and senescent means on all tasks, see figure B-2). During taping of the speech performances, it was noted that the first performance of senescent individuals was typically the highest rate, whereas the highest performance rate of younger subjects varied acorss first, second and third trials. This may indicate that fatigue is a factor for older subjects when collecting data.

Data reveals that the two age groups do not significantly differ on monosyllabic (/pʌ/, /tʌ/, and /kʌ/) performances, with the older group performing at 5.98 to 6.48 SPS and the younger group performing at 6.05 to 6.63 SPS (for means, see table A-6 and figure B-3). This finding is not consistent with Amerman and Parnell's (1987) perceptual study. It is also not consistent with Amerman and Parnell's (1982) and

Ptacek et al.'s (1966) objective studies utilizing mono-, bi- and trisyllabic diadochokinesis (both found significant age differences across all tasks). The means of the senescent group are consistent with one study utilizing only monosyllabic tasks (Kreul, 1972). Kreul's study compared young (mean age 22) and senescent (mean age 70) males and females, finding monosyllabic tasks to be slower in the young and higest for senescent females (see figure B-4). The results from Kreul's study are questionable, since he found that senescent females had higher DDK performances than young males and females, and senescent males. Kreul did not include criteria for subject selection.

Ptacek et al. (1966) found age related diadochokinetic performance reductions (mono- and tri-syllabic) which were much lower than the present study (figure B-5). Portnoy and Aronson (1982) also found monosyllabic performances of 50- to 65-year-old subjects to be slightly lower than the performances of the 65- to 75-year-old subjects studied in this research endeavor (see figure B-6). It is suspected that the reason for the lower performance rates of these slightly younger individuals in Portnoy and Aronson's (1982) study, as compared to this study, is due to the fact that physical health was not taken into consideration in their study. The only criteria for acceptance into their (Ibid.) study was "medical histories free of known neurological disease" (p. 324). As Spirduso and Clifford (1978) and Ramig (1983) found, the physiological aging of the senescent individual must be considered when studying older individuals, for they vary considerably on tasks according to their level of activity and physical condition.

When examining differences on the trisyllabic task (/pʌ, tʌ, kʌ/) between the two age groups, a considerable difference emerged. The younger group performed at 7.145 SPS and the older group performed at 6.115 SPS. This finding appears to be consistent with literature by Ptacek et al. (1966) who found senescent DDK rates to be lower than young rates, however, their findings are questionable since they did not take into account physical health status of the subjects. Ptacek et al. (1966) reported extremely low syllables per second by senescent individuals on the trisyllabic task (male mean = 4.4 SPS; female mean = 3.6 SPS), and reported significantly lower diadochokinetic performances for senescent individuals across all diadochokinetic tasks (figure B-5).

The two age groups in this current study are separated on the trisyllabic task by approximately one entire syllable. When examining the data it is important to note that the younger group performance is skewed by the very high syllable rates (7.8 SPS) of the younger males (figure B-3). The females in the younger group performed a trisyllabic mean of 6.49 SPS, whereas the males in the young group had a mean of 7.79 SPS (table A-7). Although the males in the senescent group performed higher (6.22 SPS) on the trisyllabic task than the females (6.01 SPS) in the same age group (table A-7), their trisyllabic diadochokinetic rate is closer to the performance of the younger females (figure B-3).

No studies have been found that target the effect of aging on monosyllabic, bisyllabic, and trisyllabic diadochokinetic performances, however, since performances on the monosyllabic tasks do not significantly differ between the two age groups, it may be that age has little effect on the more simple oral tasks (such as repetition of single syllables), as compared to more complex tasks. If, in fact, performances are noted to decrease on more complex tasks as age increases, the increases in demands on coordination may have negative effects on the senescent individual's performance.

Another consideration for the lower trisyllabic performances of the older subjects is that mandibular velocity has been found to be lower (about 20 percent) in older individuals in both the opening and closing phases (Karlsson & Carlsson, 1989). Karlsson and Carlsson (1989) found a decrease in vertical mandibular movement of elderly subjects as compared to younger individuals. Each monosyllabic task involves movement of one articulator and some mandibular movement (/pʌ/ requires lip movement, /tʌ/ requires tongue tip movement, and /kʌ/ requires tongue dorsum movement). The trisyllabic task involves all three articulatory movements in succession, which requires more mandibular movement. This may contribute to the lower performances by the elderly on the trisyllabic task. Many senescent subjects in this study reported having arthritis (not severe or crippling), and if affecting the mandibular joint, could also impact trisyllabic rate.

Monosyllabic performance results suggest that isolated lip and tongue movements remain stable across ages. The decrease in trisyllabic performance with age may not necessarily indicate a generalized deterioration in the coordination of the more intricate movements, but instead may suggest a pattern of change in those movements. Decreased oral sensitivity (Canetta, 1977), decrease in muscle fibers of the lip and tongue (Kaplan, 1971), atrophy of the maxillary and mandibular alveolar bone (Ibid.), and dental loss or changes in dentition may result in a change in the articulatory movements, affecting the speed of movement coordination. Changes and compensatory strategies (Baum & Bodner, 1983) in the oral structures with age may be a factor in reduced trisyllabic rates.

B. GENDER

Data reveals that males had higher performance rates than females on one monosyllabic task (/tʌ/) and the trisyllabic task. The total of the male scores may be misleading, however, because the male scores were inflated due to the very high scores of the young males, especially on the trisyllabic test.

Interactions of gender and task were found on the monosyllabic task of /tʌ/ [F(3,36) = 5.00, p= .0317]. Males averaged 6.67 SPS (young males = 6.81 SPS and senescent males = 6.54 SPS) on this task, whereas females averaged 6.18 SPS (young females = 6.215 SPS and senescent females = 6.155 SPS). This difference in performance on the monosyllabic /tʌ/ task may be explained through the differences found by Bunton and Weismer (1994) regarding maximum force production tasks of the tongue between male and female subjects. They (Ibid.) found that maximum hold and maximum tap forces of the tongue (utilizing the /d/ phoneme) were greater in female subjects and that the percent of maximum force produced during reiterant (repeated) force tasks was also greater in this group. Exerting more force during articulation would lead to harder contacts and slow the repetition task. Taking this into consideration, along with the idea that females articulate more precisely than males (Shadden (1988); B. Silverstein, personal communication, March 29, 1995), it stands to reason that speed of articulation may be compromised.

Interactions of gender and task were also found on the trisyllabic task [F (3,36) = 6.47, p= .0154]. Females had a trisyllabic mean of 6.25 SPS and males had a mean of 7.01 SPS.

It is important to consider that young females (mean = 6.49 SPS) performed higher than old males (mean = 6.22 SPS), yet the total of the males scores were .76 higher than the females. Once again, the total score of the males was inflated due to the high scores of the young males. Young males had a trisyllabic mean of 7.79 SPS, which was more than 1.5 SPS faster than the senescent male scores (6.22 SPS).

Males in both age groups had higher trisyllabic performances, which is possibly explained by the articulatory precision and lingual force applied by the females. It is also possible that the slower productions of females is related to levels of activity. It was noted in post hoc observations that the individuals who performed highest in the male and female senescent categories also had the highest levels of physical activities. It was noted that activity levels of the older females involved housecleaning, gardening, and walking, whereas the activities of the older males often involved chopping wood, farming, and mowing. Since all of the young female subjects were currently graduate students and relatively inactive (none engaged in regular exercise), and many of the young males were very active (played basketball, baseball, strength training, etc.), it may be that physical activity levels reflect performance on diadochokinetic tasks.

B. Silverstein (personal communication, March 29, 1995) suggests that the genetic make-up of males allows them more speed in motor activity compared to females. No studies have been found, however, that compare speed and/or coordination of other motor activities with lip and tongue speed and/or coordination between genders. Silverstein's (Ibid.) theory on motor activity and gender is consistent with monosyllabic task performances, however, this theory cannot be applied to the trisyllabic task performance, which requires lip and tongue coordination rather than just speed of movement.

Examination of trisyllabic performances of males and females in each age group (table A-7), brings to light the increased variability of the senescent diadochokinetic rates. Both the females and the males have larger standard deviations in comparison to the same gender in the younger group. Especially variable are the senescent male trisyllabic rate which ranges from 4.8 SPS to 8.275 SPS, with a standard deviation of 1.23. Through personal knowledge of some subjects during post hoc observations, it was noted that the senescent male (#4, pastor, age 67) who had the highest trisyllabic diadochokinetic performance engaged in very high levels of social and physical activities. The senescent male (#1, retired postal worker, age 70) who had the lowest trisyllabic diadochokinetic performance, although healthy and physically active, reported engaging in activities such as mowing occasionally and driving.

C. MONOSYLLABIC AND TRISYLLABIC CORRELATIONS

Analysis of the data revealed correlations did not have strong significance (table A-5) between subject performance on monosyllabic diadochokinetic tasks and the trisyllabic task. This suggests that performance on one type of oral diadochokinetic task is not strongly related to performance on another. No known literature exists regarding relationship of these types of oral tasks.

Performances on the monosyllabic /kʌ/ task appeared to be slightly slower than the other monosyllabic tasks (/pʌ/ and /tʌ/ across age and gender (figures B-1, B-2,and B-3), which is consistent with literature by Keller, Vigneux, and Laframboise (1991). It may be that the inclusion of the oral diadochokinetic bisyllabic (/pʌ, tʌ/) task, which leaves out the slowest syllable /kʌ/, would have resulted in stronger correlations with the other tasks. Tiffany (1980) found that maximum repetition rates on diadochokinetic syllables were highest on the bisyllabic task (group mean 9.3 SPS; 25- to 55-year-old subjects), indicating that the monosyllabic /kʌ/ (utilizing tongue dorsum) is involved with slowing of oral diadochokinetic performances. Although not utilized in this study, the bisyllabic performances (p╬ t╬) have been found to be higher (Tiffany, 1980) than mono- and trisyllabic tasks, and appears to be related to the absence of the slower monosyllabic syllable /kΛ/. With the inclusion of the bisyllabic task, significant correlations may have been found to reflect age, gender, or gender by age interactions. Young males and young females had the lowest means on the monosyllabic /kΛ/ syllable task (compared to all other diadochokinetic tasks), thus, if bisyllabic tasks were included and were strongly correlated with the monosyllabic /kΛ/ or the trisyllabic task (which includes /kΛ/), functions of age might have surfaced.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate differences on oral diadochokinetic performances between gender and age. Monosyllabic (/pʌ/, /tʌ/, and /kʌ/) and trisyllabic (pʌ tʌ kʌ) tasks were utilized to examine speed and coordination of three articulatory movements (lip, tongue tip, and tongue dorsum).

Twenty subjects (10 male, 10 female) aged 20 to 30 years and twenty subjects (10 male, 10 female) aged 65 to 75 years participated in the study. All subjects met the following criteria: native English speaker; self-reported to be in good physical condition and taking no medications which could effect the nervous system; possessed complete permanent dentition, or sufficient and fitted full or partial dental plates (worn for at least one year); passed hearing sensitivity screening at 40-dB HL for 500, 1000, 2000, and 4000 Hz (ANSI) in the better ear; past two-year history free from being bed-ridden for more than two weeks; past history reported free from alcoholism or drug abuse, debilitating respiratory disease, head trauma; past medical history free from paralysis, epilepsy, stroke, or any other neurological disease process; maintain independent residences; and participate in regular exercise or physical activity.

Tape recordings were made of the diadochokinetic performances of each subject, and syllable count was achieved utilizing the DSP Sona-Graph. Subjects performed each task three times and the highest performance (in syllables per second) was used in the data.

The major findings of the investigation were as follows:

1. Diadochokinetic performances on monosyllabic tasks did not significantly differ between the two age groups; however diadochokinetic performances on trisyllabic tasks were significantly different, with the young age group achieving higher syllables rates than the senescent group;

2. Diadochokinetic performances on the monosyllabic /tʌ/ and trisyllabic tasks were significantly different, with males achieving higher syllable rates on both tasks than females in both age groups;

3. Diadochokinetic monosyllabic and trisyllabic task performance correlations were not strongly significant.

In summary, even though monosyllabic performances were comparable across age groups, trisyllabic performances were higher for the young group. Since monosyllabic performances require isolated articulatory movements, and trisyllabic performances require more articulatory movement and coordination along with increased mandible movement, it may be that these motor activities are compromised or altered with age.

Males outperformed females in both age groups on the monosyllabic /tʌ/ and trisyllabic tasks, however, the high scores of the young males appears to skew the results. The articulatory precision and force of the females appears to effect performance of oral diadochokinetic tasks.

Although correlations between mono- and tri-syllabic tasks were not significant ($p=>.05$) , inclusion of the bisyllabic task may have resulted in stronger correlations. Future research needs to include the bisyllabic task, which may impart functions of age and age by gender interactions.

It is important to establish normative data on diadochokinetic performances of different age groups, and normative data according to gender, if we are to continue to utilize this clinical evaluation task. As this study highlights, diadochokinetic performances may vary according to age, and certainly may vary according to gender. Currently oral diadochokinesis is used in speech assessments, but no norms have been compiled for the aging population.

Further studies should include larger groups, a middle-aged group (since differences are not well documented for extreme ages - old and young), the bisyllabic task, an objective measure of physical health status, overall strength and coordination of subjects, and subject selection that enables comparison of more homeogeneous groups (all pastors, or teachers, or postal workers, etc.). Follow up research might include comparison of a nonspeech related diadochokinetic task (e.g., finger tapping) to oral diadochokiesis across age and gender; compare speed on other tasks (such as running) to oral diadochokinesis; and study the effects of fatigue with aging on speech performances.

More studies are needed, not only to investigate issues pertaining to oral diadochokinetic rates, but also to investigate the influence of gender differences in articulation speed and coordination. As this study highlights, gender performances may vary from 1 to 1.5 syllables per second on diadochokinetic tasks. This study also adds to the literature regarding decreased diadochokinetic performances during senescence. Future studies are needed in order to understand the aging process as it relates to speech performance, and as lip and tongue speed and coordination relate to physical health and activeness. Studies examining the cause(s) of decreasing diadochokinetic trisyllabic performances for senescent individuals could also provide important insights into the processes of articulation in the aging population.

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APPENDIX

Table A-1. Oral diadochokinetic performance (measured in syllables per second) on monosyllabic and trisyllabic tasks by male and female subjects of both age categories.

Females, age 20 to 30 years				
Subjects	**/pʌ/ rate (syll/sec)**	**/tʌ/ rate (syll/sec)**	**/kʌ/ rate (syll/sec)**	**/pʌ, tʌ, kʌ/ rate (syll/sec)**
#1 (f)	6.50	6.25	5.83	5.35
#2 (f)	6.55	6.65	6.30	5.55
#3 (f)	6.78	6.55	6.38	7.00
#4 (f)	6.75	6.05	6.00	6.33
#5 (f)	6.93	6.93	6.25	7.25
#6 (f)	6.13	5.35	5.25	6.13
#7 (f)	6.50	6.2	6.00	7.20
#8 (f)	6.00	5.98	5.60	6.25
#9 (f)	6.50	5.85	5.73	6.75
#10 (f)	6.73	6.35	5.28	7.13
Mean	6.54	6.22	5.86	6.49

Table A-1 (continued)

Males, age 20 to 30 years				
Subjects	/pΛ/ rate (sull/sec)	/tΛ/ rate (syll/sec)	/kΛ/ rate (syll/sec)	/pΛ, tΛ, kΛ/ rate (syll/sec)
#1 (m)	6.10	5.63	5.35	7.25
#2 (m)	6.75	6.75	6.05	7.78
#3 (m)	7.03	7.13	7.00	6.70
#4 (m)	7.25	8.00	7.05	7.83
#5 (m)	5.78	6.13	5.25	7.13
#6 (m)	6.75	7.00	6.50	7.88
#7 (m)	6.03	5.33	5.28	6.70
#8 (m)	7.30	7.00	6.33	8.78
#9 (m)	8.38	8.25	7.03	9.75
#10 (m)	6.00	6.93	6.75	8.23
Mean	6.74	6.81	6.26	7.80

Table A-1 (continued)

Females, age 65 to 75 years				
Subjects	**/pʌ/ rate (syll/sec)**	**/tʌ/ rate (syll/sec)**	**/kʌ/ rate (syll/sec)**	**/pʌ, tʌ, kʌ/ rate (syll/sec)**
#1 (f)	6.20	5.45	5.50	4.73
#2 (f)	5.95	5.88	5.48	5.75
#3 (f)	6.28	6.05	5.13	5.83
#4 (f)	7.75	7.25	7.00	7.45
#5 (f)	6.33	6.00	6.25	5.50
#6 (f)	6.00	5.88	5.88	6.03
#7 (f)	6.05	6.03	5.20	5.75
#8 (f)	6.50	5.95	6.03	5.68
#9 (f)	6.28	6.05	5.25	6.00
#10 (f)	7.05	7.03	7.00	7.38
Mean	6.44	6.16	5.87	6.01

Table A-1 (continued)

Males, age 65 to 75 years				
Subjects Age: 65-75	**/pʌ/ rate (syll/sec)**	**/tʌ/ rate (syll/sec)**	**/kʌ/ rate (syll/sec)**	**/pʌ, tʌ, kʌ/ rate (syll/sec)**
#1 (m)	4.83	5.35	5.05	4.80
#2 (m)	6.50	5.88	5.90	5.00
#3 (m)	7.50	6.98	6.85	7.98
#4 (m)	7.50	8.20	7.00	8.28
#5 (m)	6.00	6.25	6.03	5.50
#6 (m)	5.70	6.23	5.50	5.25
#7 (m)	6.00	6.53	6.00	6.70
#8 (m)	7.38	7.00	6.25	5.38
#9 (m)	6.65	6.50	6.20	6.88
#10 (m)	7.28	6.50	6.15	6.48
Mean	6.53	6.54	6.09	6.22

Table A-2. Analysis of age differences on diadochokinetic tasks utilizing the repeated measures multivariate ANOVA.

Variable	Degrees of Freedom	Mean Squares	F Value	p
/pʌ/	3,36	.23104	.50	.4831
/tʌ/	3,36	.27556	.57	.4556
/kʌ/	3,36	.06084	.16	.6915
/pʌ tʌ kʌ/	3,36	10.61930	11.85	.0015

Table A-3. Analysis of gender differences on the monosyllabic and trisyllabic tasks utilizing the non-repeated measures multivariate ANOVA.

Variable	Degrees of Freedom	Mean Squares	F Value	p
/pʌ/	1	.21316	.50	.4831
/tʌ/	1	2.4206	5.00	.0317
/kʌ/	1	.95481	2.51	.1218
/pʌ tʌ kʌ/	1	5.7988	6.47	.0154

Table A-4. Analysis of age by gender differences on the diadochinetic tasks utilizing the repeated measures multivariate ANOVA.

Variable	Degrees of Freedom	Mean Squares	F Value	p
/pΛ/	1	0.02916	0.06	0.802
/tΛ/	1	0.11449	0.24	0.630
/kΛ/	1	0.07744	0.20	0.655
/pΛ tΛ kΛ/	1	2.97570	3.32	0.077

Table A-5. Analysis of correlations between monosyllabic and trisyllabic tasks, age, and gender utilizing the Pearson Product Moment Correlation Coefficient (r).

	/pΛ/	/tΛ/	/kΛ/	/pΛ,tΛ,kΛ/
/pΛ/	1.0	.7951	.7603	.6279
/tΛ/	.7951	1.0	.8524	.7074
/kΛ/	.7603	.8524	1.0	.5902
/pΛ,tΛ, kΛ/	.6279	.7074	.5902	1.0

Table A-6. Oral diadochokinetic performances (in syllables per second) on monosyllabic and trisyllabic tasks according to age and gender group.

Age/ Gender Group	Variable	Mean	Std. Dev.	Minimum	Maximum
20-30 (m)	/pʌ/	6.635	0.7977	5.775	8.375
20-30 (m)	/tʌ/	6.812	0.9283	5.325	8.250
20-30 (m)	/kʌ/	6.257	0.7394	5.250	7.050
20-30 (m)	/pʌ,tʌ,kʌ/	7.799	0.9507	6.700	9.750
20-30 (f)	/pʌ/	6.535	0.2887	6.000	6.925
20-30 (f)	/tʌ/	6.215	0.4461	5.350	6.925
20-30 (f)	/kʌ/	5.860	0.4016	5.250	6.375
20-30 (f)	/pʌ,tʌ,kʌ/	6.493	0.6843	5.350	7.250
65-75 (m)	/pʌ/	6.530	0.8998	4.825	7.500
65-75 (m)	/tʌ/	6.540	0.7602	5.350	8.200
65-75 (m)	/kʌ/	6.092	0.5700	5.050	7.000
65-75 (m)	/pʌ,tʌ,kʌ/	6.222	1.2340	4.800	8.275
65-75 (f)	/pʌ/	6.438	0.5581	5.950	7.750
65-75 (f)	/tʌ/	6.155	0.5492	5.450	7.250
65-75 (f)	/kʌ/	5.870	0.6994	5.125	7.000
65-75 (f)	/pʌ,tʌ,kʌ/	7.146	1.0483	5.350	9.750

Table A-7. Oral diadochokinetic trisyllabic performances (in syllables per second) of males and females in each age group.

Age	Gender	Mean	Std. Dev.	Minimum	Maximum
20-30	F	6.49	0.684	5.350	7.250
20-30	M	7.79	0.951	6.700	9.750
65-75	F	6.01	0.825	4.725	7.450
65-75	M	6.22	1.234	4.800	8.275

Table A-8. Oral diadochokinetic performances on monosyllabic tasks (measured in syllables per second) for males and females in each age group.

Variable	Young Female	Young Male	Senescent Female	Senescent Male
/pΛ/	6.535	6.735	6.438	6.530
/tΛ/	6.215	6.813	6.155	6.540
/kΛ/	5.860	6.258	5.870	6.223

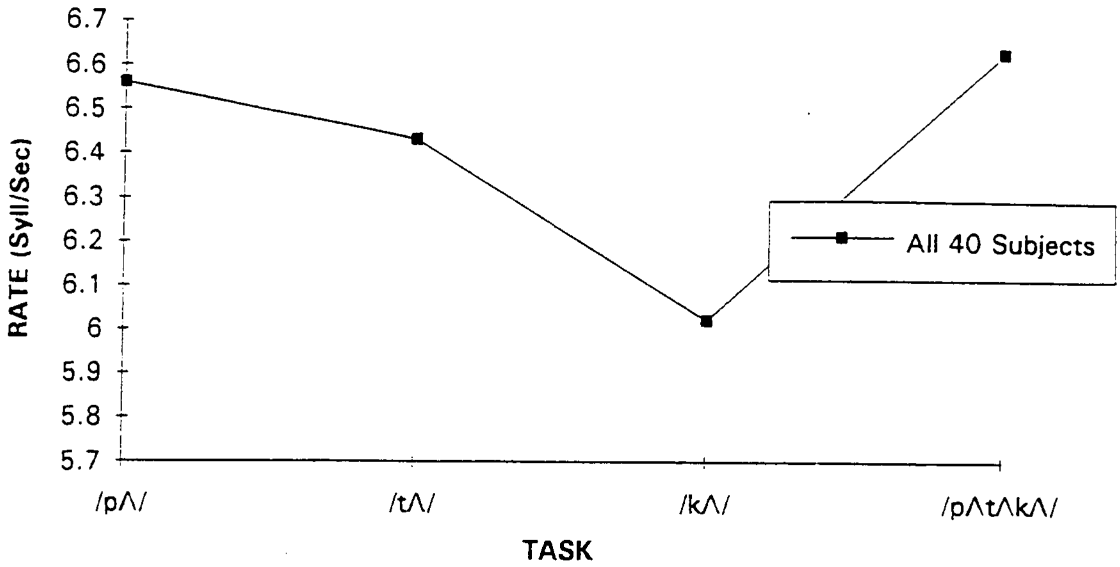


Figure B-1. Monosyllabic and trisyllabic rate means of all forty subjects.

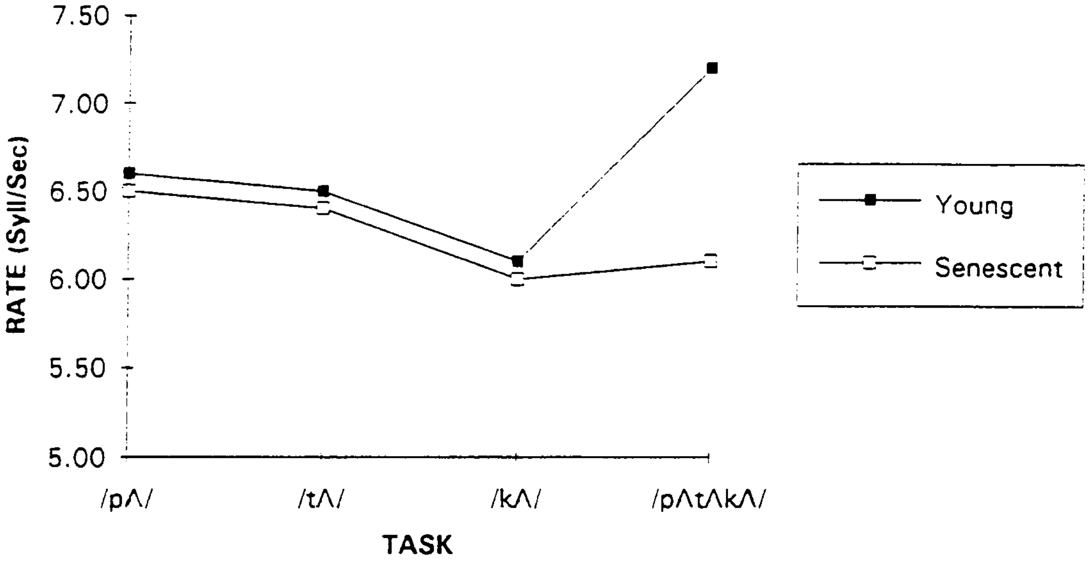


Figure B-2. Monosyllabic and trisyllabic rate means of each age group.

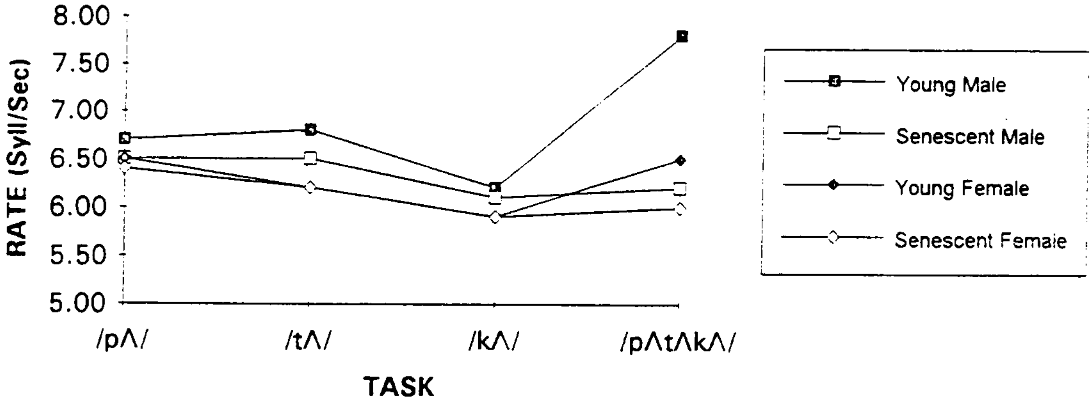


Figure B-3. Monosyllabic and trisyllabic rate means of each gender in each age group.

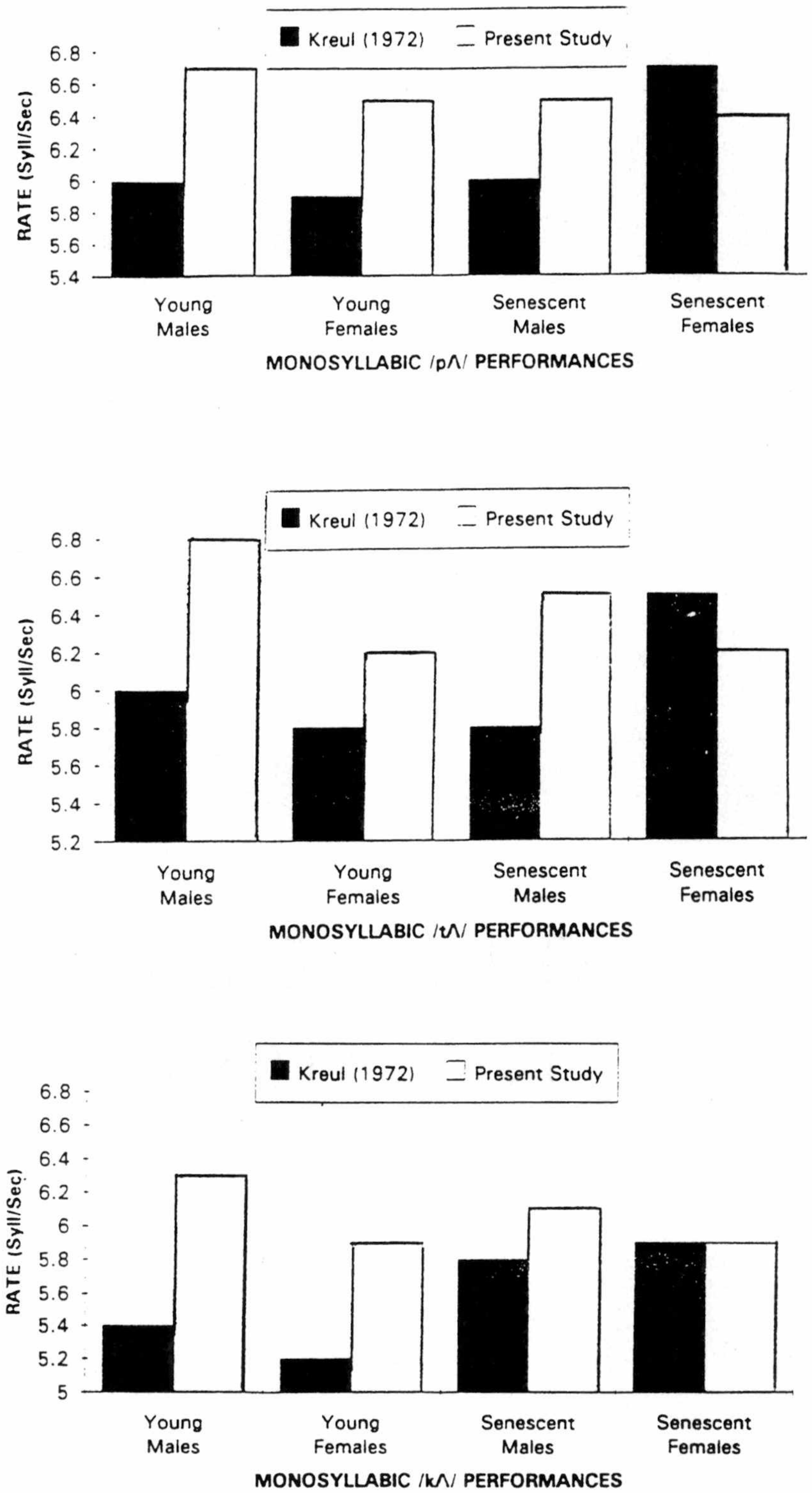
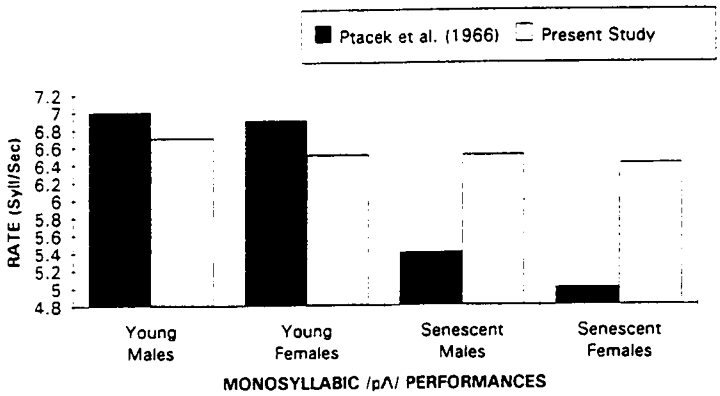


Figure B-4. Comparison of age and gender performances on monosyllabic tasks from Kreul (1972) and present study.



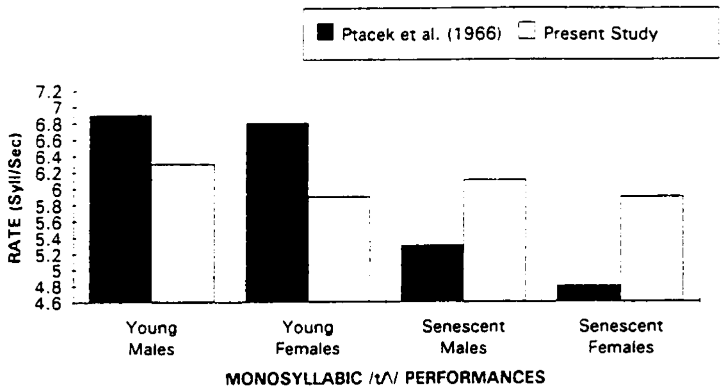
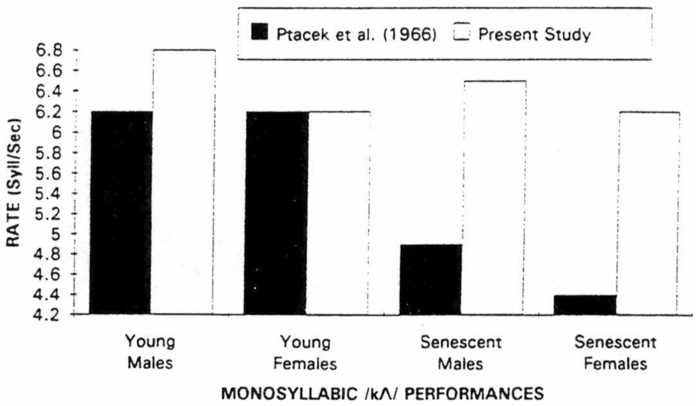
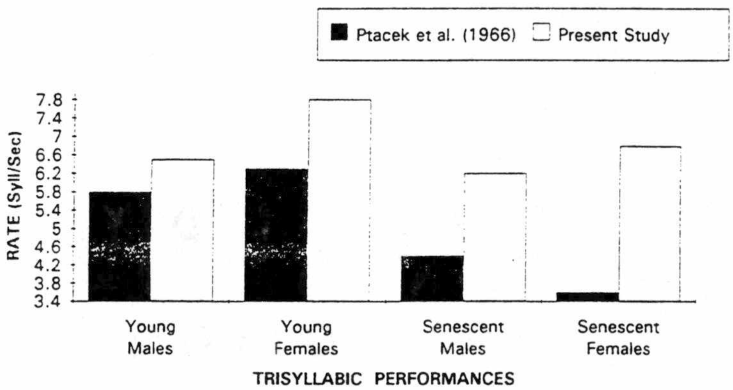


Figure B-5. Comparison of age and gender performances on monosyllabic and trisyllabic tasks from Ptacek et al. (1966) and present study.

Figure B-5 (continued).





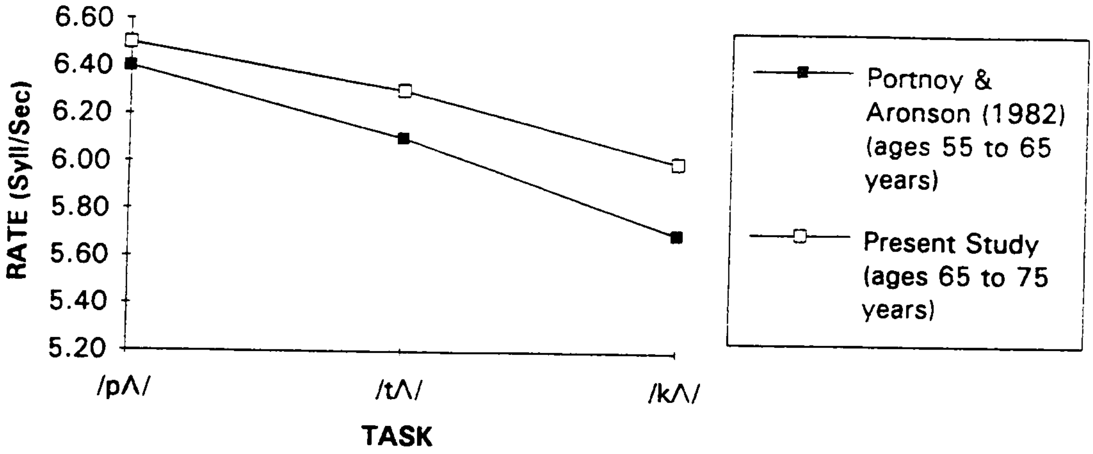


Figure B-6. Comparison of diadochokinetic monosyllabic performances from Portnoy and Aronson (1982) and present study.

VITA

Tammy Kaye Carwile was born in Gainesboro, Tennessee on October 11, 1964 to Mr. and Mrs. Jack L. Carwile. She resided in Gainesboro, Tennessee until graduation from Jackson County High School in May, 1982. The following September she entered Middle Tennessee State University in Murfreesboro, Tennessee. After receiving a Bachelor of Science degree in Mass Communications in December, 1986, she accidentally became a flight attendant. In September, 1987 she attended Tennessee Technological University in Cookeville, Tennessee, acquiring teaching certification and became then a secondary education speech and drama teacher. After teaching speech communications, she decided to continue her education in speech pathology. In January, 1993 she moved to Knoxville, Tennessee and attended the University of Tennessee in the area of Speech-Language Pathology. She completed the requirements for the Master of Arts degree in Speech-Language Pathology in May, 1995. After graduation, she moved to Florida and began work in a health care facility. Future plans include pursuing a Doctoral degree in a related field.