Effects of Maximal Articulatory Task Performance in Healthy Kannada-Speaking Elderly Population.

SHASHANK D

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CERTIFICATE

This is to certify that this dissertation entitled "**Effects of Maximal Articulatory Task Performance in Healthy Kannada-Speaking Elderly Population**" is a bonafide work submitted as a part of the fulfilment of the degree of Master of Science (Speech Language Pathology) of the student with Registration Number: 21SLP031. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

September, 2023

Dr. M. Pushpavathi

Director

All India Institute of Speech and Hearing

Manasagangothri, Mysuru-570006

CERTIFICATE

This is to certify that this dissertation entitled "**Effects of Maximal Articulatory Task Performance in Healthy Kannada-Speaking Elderly Population**" has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

September 2023

Dr. B. V. M Mahesh

Assistant professor in Speech Pathology.

All India Institute of Speech and Hearing

Manasagangothri, Mysuru-570006

DECLARATION

This is to certify that this dissertation entitled "**Effects of Maximal Articulatory Task Performance in Healthy Kannada-Speaking Elderly Population**" is the result of my own study under the guidance of Dr. B. V. M Mahesh, Assistant professor in Speech Pathology, Department of Speech-Language Pathology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No: P01II21S0034**

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Dedicated to my Family and to my best friend Deepika.

The world's best Dad & Mum, My wonderful Sister.

Appa….,

When I was born,

You were there to catch me when I fall, whenever and wherever.

When I said my first words,

You were there for me,

to teach me the whole dictionary if need be.

When I took my first steps,

You were there to encourage me on.

When I had my first day at school,

you were there to give me an advice and help me with everything.

I still haven't finished my studies, or walked down the path.

But I know you will be there for me through all these times and more, the good and bad.

There is no possible way I could pay you back for all that you have done for me growing up,

but I greatly appreciate all your hard work raising me..

So I just wrote this to say 'I LOVE YOU APPA!!!'.

All that I am or ever hope to be, I owe to my angel mother and my sister. You both are a blessing sent from God, and I love u amma and anu.

~ Shashank D Gowda

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CHAPTER I

INTRODUCTION

Growing elderly is a natural process that is influenced by both genetics and the environment. Normal aging is characterized by alterations in one's ability to process, understand, and utilize language, alongside physical changes. Aging can be categorized into biological, psychological, and cognitive aging (as defined by Bayles & Kaszniak, 1987; Birren & Renner, 1980; Cohan & Faulkner, 1989; Handler, 1960).

The weakening of physiological processes required for survival and reproduction over time is what is known as ageing (Gilbert, 2000). The ageing process involves a variety of cellular, tissue, and systemic changes that impair function, raise the risk of illness, and finally result in death. These changes are ascribed to "growing older" and are thought to be common in everyone's life. All members of a species experience the consequences of ageing, and the average human life expectancy is around 121 years (Arking, 1998).

World's population is showing a significant rise in elderly individuals. In the western scenario, individuals after attaining the age of 65 years are considered as elderly, whose population is going to expected to raise by 56% from 2030 to 2050 (Noroozain, 2012). India houses the second-largest elderly population in the world. The Census (2011) India identifies the cut-off range of 60 years as the beginning of the elderly age. According to projections, India's old population will rise from 5.6% in 1961 to 22.5% in 2051. As per the census (Census, 2011), India has approximately 53 million females and 51 million males who falls under the category of elderly.

The oral organs undergo numerous changes as we age, which may impair the articulators' capacity for quick, precise movement. Degeneration of the surface epithelium and connective tissue, atrophy of the muscles in the oral cavity which become lean and inelastic (Caruso et al., 1995). Other abnormalities include degeneration and neuronal loss in the nerves reduces somatosensory perception in the oropharyngeal region (Baum & Bodner, 1983; Curtis & Fucci, 1983; Kahane, 1981); mucosal drying secondary to atrophy of the salivary glands (Baum, 1981; Massler, 1971); thickening and scarring of the supraglottal structures due to atrophy thereby leading to reduced speed and range of articulatory movements (Baum, 1981 & Massler, 1971). The movement of the jaw is adversely influenced by the degeneration of the temporomandibular joint and degradation of the alveolar bone in the maxilla and mandible (Zemlin, 1998). This is also accompanied by the atrophy in the driving force of jaw muscles such as pterygoid, masseter, and temporalis (Blackwood 1969; Moffet, et al,1964). Aging-induced muscular changes to the tongue include decreased thickness of the lingual epithelium and reduced muscle fiber diameter (Nakayama, 1991). Increased fatty tissue deposits are thought to compensate for this tissue loss and help maintain the size and shape of the aging tongue (Bässler, 1987). Loss of oral coordination due to the above structural changes has also been reported (Haywood & Getchell, 2014). We hypothesize that these age-related alterations may account for a decline in oral DDK measures as it is a coordinated motor action of lips, jaw and tongue.

Maximal Performance Tasks

Maximum performance tasks help in estimating the physiological deviations more clearly than the routine tasks. Some of the most common maximal performance tasks used across speech subsystems include maximum phonation time, maximum repetition rate, fundamental frequency range, and maximum phonation volume (Ziegler et al, 2019).

With regard to articulatory domain, repeatable speech patterns (such as Diadachokinetic rate) are often used as these are less changeable and easier to assess than spontaneous speech. A slowed articulatory rate which is used as a compensatory strategy in some of the clinical population (e.g., in dysarthria) to enhance the intellilgibilityof spontaneous speech could mask the overall physiological deviations. It is also one of the reasons why these measures are included in certain assessment protocols of compromised speech motor control (e.g RDA, Radboud Dysarthria Assessment, Kunuijt 2017). Additionally, few handful of studies have also supported the use of maiximum articulatory task performance acsoss speech motor disorders like ataxic and hypokinetic dysarthria (Ackermann et al., 1995).

Few studies have measured the maximum articulatory task performance in the elderly population. Knuijt et al., (2019) showed a decreased overall syllabid rate in the single syllable DDK task after the age of 60 years. However, no changes in the syllable rate were observed for the trisyllabic sequences and the variable of gender did not alter the DDK rate in the elderly.   This finding was further supported by another previous study by Kikutani et al. (2009) who showed decreasing articulatory syllabic rates in the four elderly groups ranging from 65 to 69. Boaz et al., (2017) also showed decreased DDK rates in the Hebrew speaking elderly who ranged from 65-86 years compared to middle aged adults. No gender effect was reported from the study. Contradictory evidences on age effect on DDK rate is also reported. Pierce et al. in the year 2013 compared the DDK rate in two groups of elderly (65 to 74 and 75 to 86 years) and found no differences for AMRs and SMR tasks.

Second formant transitions are typically measured in Consonant-Vowel and Consonant-Vowel-Consonant combinations which generally cues for the place of articulation. High F2 is known to indicate the forward tongue position and accordingly low F2 transition also indicate posterior placement of the tongue. High front vowels are known to have high F2 whereas low F2 is common for back consonants. Therefore, by measuring the speed of tongue placement in the vocal tract the assumed positions of the tongue is indirectly inferred through acoustic methods. This information is capitalized in the current study where faster production of vowel /i/ and vowel /u/ will be used to understand the variations in the tongue positions in the vocal tract. Formant transitions are known to indicate the height and movement of the tongue (Savithri et al., 2007; John et al., 2013). In Indian languages, Savithri et al., (2007) have demonstrated change in F1 and F2 formant frequencies across 13 Indian languages. It was reported that Kannada language had Low F1 and middle F2 across the languages studied.

To understand the maximal speech task performances, one can measure a range of 'force physiology' parameters such as Strength, Speed, Range, Tone and Coordination. This could be accomplished by documenting the maximum performance on the above listed parameters across the speech motor subsystems. Among the force physiology parameters listed, speed and range are relatively easier to measure and to numerically quantify with acoustic/instrumental evaluation. The current study explores on the articulatory motor domain of maximal task performance. It is interesting to understand the maximal task performance in the articulatory domain as some of the common motor speech deviations observed in adults are localized to this particular domain. In most cases, except in certain specific brain diseases (e.g., hypokinetic dysarthria), the speed of the articulatory movements are generally compromised and hence slower. Such slower articulatory movements also expected to occur in typical speakers with the increase of age. Therefore, the current study attempts to understand any change that occur in articulatory speed as observed through the diadochokinetic (DDK) rate and second formant transition. DDK rate is tested using the repetition of bilabial, alveolar and velar consonants in isolation or in a combination. As DDK rate measures the articulatory movements in superior inferior dimension, the inclusion of a task that captures the front-back movements of the tongue/lips will provide additional information on overall decline in the speed of the articulatory movements as a factor of age. This study does not target the latero-medial movements of articulators as these are more typical for non-speech movements (e.g., chewing/mastication).

Need for the study

Diadachokinetic rate as a maximal articulatory task performance measure.

With regard to DDK as a maximal task performance, a handful of earlier studies have shown declining syllabic rate after the 6th decade of life (John et al, 2013; Chu et al, 2020) However not all investigations unequivocally agree to the declining trend in DDK rate in the elderly population (Pierce et al., 2013). With regard to Kannada, no published studies are available in the elderly population (across age and gender) to date and the findings of the few handful of western studies cannot be directly applied to Indian context as language and dialectal related changes are known to influence the DDK rate (Icht & Ben-David, 2014). SLPs routinely use the clinical tool oral-DDK to assess patients' oromotor and articulatory systems (Williams & Stackhouse 1998). Oral-DDK methods are quick and simple to administer and don't call for the use of expensive equipment or invasive clinical procedures. Hence, the current study aimed at understanding the DDK rate as one of the maximum articulatory task performance measures in Kannada speaking elderly individuals using Motor Speech Profile (MSP advanced version)

Second formant transition as a maximum articulatory task performance measure

The second formant transition task used in the MSP profile could also be argued as one of the measures that checks maximal articulatory task performance as this involves rapid changes in the tongue and lip movements in the vocal tract. An earlier study by John et al., (2013) which studied the second formant transition in native Kannada speakers between 20 to 60 years showed age and gender specific variations across F2 avergage frequency, F2 magnitude and F2 regularity. As changes were observed in typical adults in the above study, the effect of further aging on the same will be explored in this study.

This study also compares the measures obtained on DDK and F2 formant transtition in the elderly population to that of an already published study (John et al., 2013) on typical adults who were native Kannada speakers. An overall trend in the age-related changes starting in adulthood and ending in elderly age be better appreciated by such comparison. In the current study, participants in the age range of 61-80 years was studied to understand the articulatory motor performance in the elderly. Though few of the studies carried out on elderly population have chosen the minimum age of 65 years and above (as per the WHO classification), the current study used the cut of 61 years which followed the minimum cut off as envisaged in the Census of India (2011).

Regarding Diadochokinetic rate as a maximal articulatory task performance measure, there were only limited studies available on the elderly population, and no clear trend was observed in the decline of DDK rate in the elderly population (Pierce et al. 2013). When it comes to using second formant transition as a measure of maximum articulatory task performance, this involves rapid changes in tongue movement within the vocal tract. Furthermore, there is a lack of age and gender-specific data on second formant transitions in the elderly population. Moreover, both Oral DDK and F2 transition are quick and simple measures that do not require invasive instruments, and they provide insights into typical versus disease-related articulatory changes. Therefore, the study aimed to examine the effects of maximal articulatory task performance in a group of healthy Kannada-speaking elderly individuals.

Aim of the study

The aim of the study was to examine the effects of maximal articulatory task performance in healthy Kannada-speaking elderly adults.

Objectives of the study

1) To investigate the effect of age (61 to 70 and 71 to 80) and gender on maximal articulatory task performance in healthy elderly Kannada speakers using Alternating and Sequential Motion Rates [AMRs (/pə/, /tə/ and /kə/) and SMRs (/pətəkə/)] on selected dependent measures of Motor Speech Profile.

2) To investigate the effect of age (61 to 70 and 71 to 80) and gender on second formant transitions [/i-u/] in healthy elderly Kannada speakers using Motor Speech Profile.

3) To compare the results of the current investigation with a previous study carried out on adults who were native Kannada speakers.

Null Hypothesis of the Study

1) There is no significant effect of age and gender on maximal articulatory task performance of alternating and sequential motion rates [AMRs (/pə/, /tə/ and /kə/) and SMRs (/pətəkə/)] and their measured parameters using the Motor Speech Profile in the Kannada-speaking elderly population.

2) There is no effect of age and gender on maximal articulatory task performance of the second formant (F2) transition and its related parameters on selected dependent measures of the motor speech profile in the Kannada-speaking elderly population.

3) There is no effect of age and gender on the maximal articulatory task performance measures of this study (DDK and F2 transition parameters) with the data reported on young adult population of a previous study using the Motor Speech Profile in Kannada speaking population

Chapter II

Review of Literature

The most common way that people communicate is through speech. It is a technique for turning discretely specified language signals into audible signals that a listener may make sense of. Undoubtedly, the most difficult motor act a human being can perform is speaking. In order to produce speech, one must engage in respiration, phonation, resonance, voice, and speaking. The changes in the pressure and flow form the acoustic signal that we hear when we listen to spoken communication. For this signal to be formed in such a way that it can transmitted into linguistic information, the constituents of the vocal tract must be controlled and coordinated across numerous subsystems, including the respiratory, phonatory, resonatory and articulatory systems. Prosodic alterations that occurs from the interactions between these speech subsystems adds natural intonation and rhythm patterns that finally results in discernible human speech. The speech organs' intricate and deliberate articulatory movements, which produce acoustic signals, are what make speech possible. It calls for more motor fibres than any other mechanical action performed by humans (Fink, 1986). Only the neuromuscular system regulates the articulatory motions required for speech production. The coordinated function of the Central Nervous System is hypothesized by the motor patterns of speech (CNS).

The speech production tasks that measures the highest performance of any speech subsystems are known as maximum performance tasks. The maximum phonation time (MPT), maximum fricative duration, maximum phonation volume, maximum expiratory pressure, fundamental frequency range, maximum sound pressure level, maximum occluding force of the articulators, and diadochokinetic (maximum repetition rate) rate (Knuijt et al., 2017) are a few of the most frequently used tasks in speech production that reflects maximum capacity of specific speech subsystems. A lot of clinicians incorporate at least some of these tasks into their routine clinical evaluation. Very few past studies have measured the task performance across age ranges to understand its natural range and its decline.

Age Effects on Speech Motor Control

Ageing is a complex biological process characterized by the accumulation of neuronal, molecular, and cellular degradation over the course of an individual's lifetime (Lopez-Otin et al., 2013). Brain alterations associated with ageing may be developmental or involutional. During development, a rapid increase in brain mass is accompanied by an increase in synaptic connections and myelination (Dekaban & Sadowsky, 1978; Yakovlev & Lecours, 1967). Involution, which is the gradual shrinkage of an organ, is commonly observed in senior age, where reports indicate a progressive decline in brain plasticity.

Besides neural declines, several local anatomical and physiological changes occur within the speech system with an increase in age. These are known to have an impact on speech motor skills because they affect the speech subsystems of respiration, phonation, resonation, and articulation. Regarding the articulatory system, which is the primary focus of this dissertation, degeneration and neuronal loss in the nerves reduces somatosensory perception in the oropharyngeal region (Baum & Bodner, 1983; Curtis & Fucci, 1983). Further, mucosal drying secondary to atrophy of the salivary glands has also been reported in the oropharyngeal region (Baum, 1981; Massler, 1971). More importantly, with regard to the supraglottic structures, they undergo atrophy and fibrosis (thickening and scarring of the tissues), thereby reducing the speed and range of articulatory movements (Baum, 1981; Massler, 1971). The jaw, one of the principal articulators, undergoes remodeling and gets lengthened with increases in age (Israel, 1971). The movement of the jaw is adversely influenced by the degeneration of the temporomandibular joint and degradation of the alveolar bone in the maxilla and mandible (Zemlin, 1998) accompanied by the atrophy in the driving force of jaw muscles like the pterygoid, masseter, and temporalis (Blackwood, 1969; Moffet et al., 1964). Aging-induced muscular changes to the tongue include decreased thickness of the lingual epithelium and reduced muscle fiber diameter (Nakayama, 1991). Increased fatty tissue deposits are thought to compensate for this tissue loss and help maintain the size and shape of the aging tongue (Bässler, 1987). In sum, alterations to bony structures, muscle fiber type, and cellular composition may underlie the declines in the articulatory subsystem observed in the elderly. In addition, slowness in articulatory movements has been speculated to be a combined influence of reduced nerve conduction and reduction in the levels of neurotransmitters in the elderly (dopamine, serotonin, and norepinephrine) (McNeil et al., 1988; Mortimer, 1988; Peach, 1987).

Several behavioral and acoustic studies have documented age-related effects on speech production (Amerman & Parnell, 1992; Awan, 2006; Bóna, 2014a, 2014b; Jacewicz et al., 2010; Quené, 2013; Harnsberger et al., 2008; Gosy et al., 2014; Slawinski, 1994; Taschenberger et al., 2019). Most cross-sectional studies provide evidence for a slower speaking rate (Bona, 2014a; Jacewicz et al., 2010) and reading rate (Jacewicz et al., 2010) in older adults compared to the younger population. These studies also report an increase in speech rate till the age of 40, and a decline thereafter. Across various vowel contexts, prior studies suggest an increase in overall syllable duration in older adults compared to younger adults (Amerman & Parnell, 1992; Slawinski 1994). Apart from these metrics, researchers have also examined pause duration and its frequency to better understand how components that comprise speaking rate (i.e., pause time and articulation time) vary as a factor of age. These studies have consistently shown longer pause duration and greater pause frequency in the elderly (Bona, 2014a; Gosy et al., 2014). Except for a few studies that failed to show any consistent changes in speaking rate and pause characteristics in elderly adults (Keszler & Bona, 2019; Quene, 2013), the majority of studies agree on slower speaking /articulatory rate and increased pause duration and frequency in the elderly cohorts.

Diadochokinetic rate (DDK) as a Maximal Articulatory Task

Diadochokinetic rate (DDK) is a measure of how rapidly someone can accurately create a series of rapid, alternating sounds like "pə" (Alternating Motion Rates, AMRs) or " pətəkə" (Sequential Motion Rates, SMRs)" It is a tool used by speech-language pathologists (SLPs) to evaluate individuals' speech-motor skills, particularly when articulatory motor skills are compromised (Fletcher, 1972). It is also known as the Fletcher time-by-count test of diadochokinetic syllable rate. There are two common methods that are manually used to collect and analyse the DDK. In the first method i.e., count-by-time, number of CV combinations produced per second is evaluated whereas in the second method of time-by-count, total time consumed to repeat a predetermined number of mono-, bi-, and trisyllabic consonant and vowel tokens are measured (e.g., /pə/).

Compared to the manual methods, DDK analysis could be performed automatically using software programmes and these methods minimizes the manual errors and adds other related parameters on DDK to understand the same in greater depths. One such is the software protocol of Motor Speech Profile (MSP) by Computerized Speech Lab (CSL, KayPentax), which offers an opportunity to not only gather data on DDK rate, but also related intensity data such as DDK peak and syllabic intensity could also be measured. Whether the DDK is manually or automatically measured, participants are instructed to repeat a target CV at their fastest possible levels which helps in examining the maximal articulatory movements in the vertical plane (superior-inferior motion). With the protocols like MSP, not only the rate measures of DDK, but intensity variations corresponding to the rate variations while producing the CV combinations could also be studied.

DDK task performance and accuracy in typically developing individuals increase with age until around the age of 18 (Fletcher, 1972; Linville, 1996; Weismer & Liss, 1991; William & Stackhouse, 2000; Wohlert & Smith, 1998;). There are normative data for a variety of monosyllabic, bisyllabic, and polysyllabic sequences on DDK rates in English-speakers (Canning, & Rose, 1974; Fletcher, 1972; Robbins, & Klee, 1987). DDK rate specific to languages has been reported wherein English is known to have a wider range of syllable production beginning from 5 to 7 syllables per second (Deliyski & Gress, 1997; Icht, Maltz, & Korecky, 2013; Lass & Sandusky,1971; Ptacek et al., 1966; Robb et al., 1985; and Topbas, 2010). Norms are also available across Portuguese (Louzada et al., 2011; Meurer et al., 2004; Padovani et al., 2009), Greek (Icht & Ben-David, 2014) and Telugu languages (Patil & Manjula, 2013)

Diadochokinetic Measures Reflecting Developmental Changes

MSP has been used in a number of investigations to understand the developmental variations in DDK variations across several cross-sectional cohorts. Wong et al., (2011) used MSP to measure the normative for DDK in English-speaking children between the ages of 4 and 18. The study consisted of 118 participants, 54 girls and 58 males. The subjects were instructed to repeat the phonemes /pa/ and /pa-ta-ka/

as quickly and consistently as they could. For children aged 4 to 8, the DDK rates are: /pa/-4.54 sy/s and /pa-ta-ka/-3.85sy/s; for children aged 9 to 13, /pa/-5.39sy/s and /pa-ta-ka/-4.97sy/s; and for children aged 14 to 18, /pa/-5.62sy/s and /pa-ta-ka/-5. According to the authors, there was no significant difference between males and females in the DDK rate, which increased with age.

Deliyski & Gress (1995) developed normative on healthy participants in the age range of 18 to 60 years (Males = 40.5 years; Females = 34.4 years). All the protocols under MSP (KayPentax) were administered. No effect of age or gender was observed in the adult population for the DDK parameters measured. For second formant transitions, though age differences were not observed, effect of gender was reported for Average F2 (F2aver) and maximum F2 (F2max). In both the above parameters, females had higher average F2 and maximum F2 values compared to male participants.

Deepthy (2015) studied Diadochokinetic (DDK) abilities in 90 Kannada-speaking children aged 4 to 10, recording both Alternate Motion Rates (AMRs) and Sequential Motion Rates (SMRs). Results showed that with the increase in age, DDK parameters like Average DDK Rate (DDKavr), Maximum Intensity of DDK Sample (DDKmxa), Average Intensity of DDK Sample (DDKava), and Average Syllabic Intensity (DDKsla) increased, while Average DDK period (DDKavp) decreased significantly. Gender had no notable impact across age groups. Comparing different age groups, differences in DDK parameters did not differ between ages 4-6 and 6-8, but differences were reported between 6-8 and 8-10 age group

A study by John et al., (2014) measured the variation in DDK between the ages of 20 and 60 for Kannada-speaking adults (n = 300). DDK measurements were carried out on quick iterated productions of /pa/ using MSP. The DDK rate is /pa/-6.33sy/s for ages 20 to 40, /pa/-4.34sy/s for ages 41 to 50, and /pa-2.72sy/s for ages 51 to 60. The researchers noted a declining trend in the DDK rate (DDKrate) and average DDK period (DDKavp) and explained it by changes brought on by ageing. DDKrate decreased and DDKavp reciprocally increased as age increased, particularly in the age range of 51-60 years. Also, they noted a considerable difference between male and female speakers. Males showed significantly higher DDKavp compared to females. In contrast, the coefficient of variation (DDKcvi) was observed to be higher among female speakers. This study's findings regarding DDK can be attributed to male speakers having enhanced respiratory capacity and shorter voice onset time.

By employing MSP, Patil and Manjula (2013) also developed normative for the DDK measures for Telugu-speaking adults between the ages of 20 and 60 on 400 samples. The participants were instructed to quickly and clearly repeat the sounds /pa/, /ta/, /ka/, and /pa-ta-ka/. The DDK rates are as follows: males 4.68sy/s and females 5.23sy/s for those aged 20 to 30; males 5.05 sy/s and females 4.98 sy/s for those aged 30 to 40; males 5.38sy/s and females 5.00sy/s for those aged 40 to 50; and males 5.28sy/s and females 4.67sy/s for those aged 50 to 60. No significant impact of age or gender on DDKavr and DDKavp was observed. The mean Average Syllabic Intensity (DDKsla) was high in both males and females in the 20-30 age group. But this was significant only for female group. No overall effect of gender was observed for DDKsla. For average intensity of DDK sample (DDKava), female group showed higher DDKava in the age 20-30 years compared to other adult subgroups. No gender effect was observed.

Padovani et al. (2009) examined the DDK rate in two groups of healthy subjects using MSP software. Group one consisted of 14 females and 9 males between the ages of 30 and 46, while group two consisted of 14 females and 9 males between the ages of 47 and 94. The participants were instructed to repeat the vowel /a/ the sounds /pa/, /ta/, and /ka/ and the sequence / pətəkə / as fast as possible while maintaining a comfortable pitch and loudness. The MSP module was used to record and analyse the samples. Comparison of individuals AMRs revealed slower rate as the point of articulatory contact moved backward. While the rate did not change considerably with age, the intensity peak varied greatly across all tasks for senior persons. The elderly group displayed high variability, which indicated difficulty in modulating intensity. This was attributed to the age-related deviations including spindled glottal chinks and intrinsic laryngeal muscle atrophy, which reduce the biomechanical efficiency of the laryngeal mechanism.

F2 transition.

The rate of tongue movements in DDK mostly reflects its ability to make quick vertical motions in the oral cavity. The changes that occur in the transitions of tongue in the anterior posterior dimension is missed if only DDK task is included. Therefore, to understand any changes in the tongue movements in the anterio-posterios dimension the second formant (F2) transition could be measured. The second formant (F2) transition indicates the relative position of tongue in the oral cavity. The F2 is known to be higher when tongue advances anteriorly in the oral cavity and decreases as tongue moves back. This information is capitalized in MSP and transition of vowels (i.e., i-u) captures the rapid changes in the tongue and lip movements in the vocal tract. Hence, vowel transition of MSP could also be argued as one of the measures that checks maximal articulatory task performance. As age related variations are known to influence the F2 transitions (Ziegler & Maassen, 2007), the same is examined in the current study. Children appear to coarticulate more than adults, according to research by Turnbaugh, Hoffman, Daniloff & Absher (1985) and Nittrouer (1985), suggesting that younger age groups experience a greater magnitude and slower rate of the F2 transition. According to this study's findings, children's speech had lower second formant values than adult speech.

An earlier study by John et al., (2013) which studied the second formant transition in native Kannada speakers between 20 to 60 years showed age and gender specific variations across F2 average frequency, F2 magnitude and F2 regularity. While F2rate and F2reg decreased somewhat with age, F2aver increased. For instance, F2aver mean values were 1675.3 Hz (20–40 years), 2141.9 Hz (41–50 years), and 2176.4 Hz (51–60 years). Gender effects were also observed for the F2 related measures. F2magn was observed to be higher for female speakers across all age groups compared to male speakers. With regard to F2rate, male speakers had higher values in the 20–40 years, while female speakers had higher values in 41-50 and 51 to 60 years. Male speakers had a higher value for second formant regularity across all age groups, as indicated by a significant difference in F2reg. Female speakers had showed higher F2aver values in the 20–40 age range, while male speakers had a higher average of second formant transition in the 41–50 and 51–60 age ranges. In summary, females showed higher second formant transition (F2magn) and F2rate, while males had increased regularity in F2 (F2reg).

Deepthy (2015) investigated second formant transition (F2 transition) in 90 Kannada-speaking children aged 4 to 10. The results indicated that as age increased, there was a decrease in F2 magnitude (F2magn) and F2 minimum (F2min), while there was a significant raise in the F2 rate. Gender differences were not observed across age groups. The reduction in F2 magnitude and the increase in F2 rate suggest enhanced precision and control over articulatory movements with development. These findings align with the idea that speech motor patterns undergo gradual acquisition and refinement during development. In summary, as children grew older, F2 magnitude decreased, F2 rate increased, and there were no gender differences.

Patil and Manjula (2014) used MSP to establish normative data for second formant transitions in Telugu-speaking adults aged 20 to 60, with a sample size of 400. Participants were instructed to rapidly and clearly repeat the /i-u/ sequence. Variability of F2 magnitude was higher in females compared to males and significant age effects were observed in both genders, with no gender-related impact on F2 magnitude. Regarding F2 rate, gender differences were noted where females had higher mean F2 rate than males while no significant age effect was seen across both genders. Regarding average F2, females had higher average F2.

Deliyski and Gress (1995) reported the F2 transition data on healthy individuals aged between 18 and 60 years (mean age for males = 40.5 years; mean age for females = 34.4 years). Although there were no discernible age-related variations in second formant transitions, gender differences were observed for both Average F2 (F2aver) and maximum F2 (F2max). In these two parameters, females exhibited higher average F2 and maximum F2 values compared to their male counterparts.

CHAPTER III

Method

Participants

A total of 60 native Kannada speaking (Mysore and Mandya dialect) elders in the age range 60 to 80 years participated in the study. The speech samples of elders were collected from Mysore and Mandya regions. Participants were recruited from common social gathering, from park, those who reported to All India institute of speech and hearing as a care taker for the children with speech and hearing problems. Participants were divided into 2 subgroups [61 to 70 years (mean age of 64.76 and SD of 2.25) and 71 to 80 years (mean age of 73.66 and SD of 2.21)]. Each subgroup consisted of 30 participants of fifteen male and fifteen females.

The inclusion criteria of participants were, the subjects should be

(a) Native speakers of Kannada.

(b) No history of speech and language deficits.

(c) Participants with controlled systemic conditions (through medication), such as diabetes mellitus and hypertension.

(d) Participants with amplified hearing and corrected vision.

The exclusion criteria of the participants;

(a) Participants who having cognitive impairment.

(b) Individuals with articulatory errors.

(c) Individuals with a history of neurological disorders affecting articulatory motor control.

(d) Individuals wearing partial or complete dentures affect speech production.

Before the actual recording, informed consent was taken from the participants (APPENDIX-I). And checklist was administered which gather the information regarding deficits in speech, language, hearing, cognition domains and other health related issues like systemic illness, neurological issues. A native Kannada female speaker of age 60years served as a model.

Stimuli

The alternating motion rates (AMRs) of /pə/, /tə/, and /kə/ and the sequential motion rates (SMRs) of /pətəkə/ was used as one of the maximum articulatory task performances. As a second articulatory performance measure of F1-F2 transitions, a vowel sequence of a high front and a high back vowel was used (/i/-/u/).

Maximum performance tasks help in estimating the physiological deviations more clearly than the routine tasks. Some of the most common maximal performance tasks used across speech subsystems include maximum phonation time, maximum repetition rate, fundamental frequency range, and maximum phonation volume (Ziegler et al, 2019). With regard to articulatory domain, repeatable speech patterns (such as Diadochokinetic rate) are often used as these are less changeable and easier to assess than spontaneous speech. A slowed articulatory rate which is used as a compensatory strategy in some of the clinical population (e.g., in dysarthria) to enhance the intelligibility of spontaneous speech could mask the overall physiological deviations. It is also one of the reasons why these measures are included in certain assessment protocols of compromised speech motor control (e.g RDA, Radboud Dysarthria Assessment, Kunuijt 2017). Additionally, few handful of studies have also supported the use of maximum articulatory task performance across speech motor disorders like ataxic and hypokinetic dysarthria (Ackermann et al., 1995).

Formant transitions are known to indicate the height and movement of the tongue (Savithri et al., 2007; John et al., 2013). The second formant transitions also help us in understanding the rate of change of articulatory motions in the vocal tract as high F2 is observed for anterior tongue placement and a low F2 is observed for the posterior placement of the tongue in the vocal tract. In Indian languages, Savithri et al., (2007) have demonstrated change in F1 and F2 formant frequencies across 13 Indian languages. It was reported that Kannada language had Low F1 and middle F2 across the languages studied.

Oral DDK and F2 transition are quick, simple measure and doesn’t require invasive instruments to carry out; also, they provide hint on typical Vs. disease related articulatory changes. Hence, they were considered as stimuli for the study.

Instrumentation

The Motor Speech Profile Advanced (MSP) module was used to measure the parameters for the study. It is an integrated software and hardware system from Computerized Speech Laboratory (CSL) Model 4500 (KayPENTAX, Lincoln Park, New Jersey). It provides a reproducible, non- invasive and objective method for assessing motor speech characteristics in subjects. The MSP module consists of various sub-modules such as Diadochokinetic Rate, Second Formant Transition, Voice and Tremor, Intonation Stimulability, Standard Syllabic Rate, Generic Syllabic Rate. For the purpose of this study, the DDK and the F2 transition modules were used.

Procedure

A checklist was prepared by considering the inclusion and exclusion criteria of the study (Appendix-II). The written checklist was initially filled by all the participants before enrolling them into the study. In case of illiterate speakers, the questions were orally asked by the investigator of this study and the responses from the participants were recorded. Those participants who did not meet study's inclusion or exclusion criteria were not included in the study. The samples were recorded in a noise-free room. Before starting the sample recording, a standard instruction for each recording was given to the participants specific to the chosen modules [either DDK or F2 transitions] and before the test begins; two practice trials were given as a familiarization exercise. Participants were asked to listen to the recorded model sample of a native Kannada female speaker, specifically for each parameter. Three voice trials (tokens) were recorded for each voice task. The mic was kept approximately 10-15 centimeters away from the mouth of the participant while recording

Speech Recording

The module of DDK and F2 transition under MSP was used in this study.

Diadochokinetic Rate.

Under DDK, the software captures several aspects such as rate, average period, various measures of perturbations in period and intensity.

Instruction provided for the AMR Task: Repeat the target stimulus (i.e, /pə/, /tə/, /kə/,) as quickly and accurately possible for minimum of 8 seconds in their habitual speaking rate and loudness. In this task, data was collected for /pə/, /tə/, /kə/ separately. The order of each task was counterbalanced across the participants.

Instruction provided for the SMR Task: Repeat the target stimulus (i.e, /pətəkə/) as quickly and accurately possible for minimum of 8 seconds in their habitual speaking rate and loudness. Regardless of the time, samples were taken. however, a 5 second period with good amplitude was used for the analysis. Participants were asked to listen to the recorded model sample of a native Kannada female speaker. Three trials (tokens) were recorded for each voice task.

These variables were measured for DDK.

DDKavp (Average DDK period) /ms/ - This is the client's typical DDK period during this vocalisation. The average period is the typical pause between C-V vocalisations (also known as "pə" vocalisations). The rate and period are negatively connected.

DDKavr (Average DDK rate) /s/ - This represents the client's typical DDK rate throughout this vocalisation. The average rate is the quantity of C-V vocalisations (or "pə") per second. The rate and average period have an opposite relationship. As a result of diminished articulatory motility, many speakers with motor disorders exhibit lower DDK rates.

DDKava (Average Intensity of DDK Sample) /dB/ - This represents the signal's average peak amplitude level.

DDKsla (Average Syllabic Intensity) /dB/ - This is the average level of the syllable.

Table 1

Parameters of Diadochokinetic rate.

Parameters		
Diadochokinetic rate related measures	**Symbol**	**Unit**
1) Average DDK Period	DDKavp	ms
2) Average DDK Rate	DDKavr	/s/
3) Average intensity of DDK Sample	DDKava	dB
4) Average syllabic intensity	DDKsla	dB

Second Formant Transition (F2 transition)

Under this parameter, various aspects of F2 magnitude, rate, and regularity are studied.

Instructions for the task: Participants were instructed to repeat /i-u/ as quickly, regularly and clearly as possible in their habitual speaking rate and loudness.

The following are the variables we looked at for F1-F2 transition.

F2magn (Magnitude of F2 Variations) /Hz/ - This is the extent of the client's second formant's modifications during this vocalisation. The F2 magnitude is decreased if the vocalisation comprises neutralised vowels, a sign of decreased articulator motility.

F2rate (Rate of F2 Variations) /s/ - This is the frequency at which the client's second formant changes during this vocalisation. This evaluates how quickly the speaker can switch between the various vowel positions. A slower pace of changes can be a sign of decreased articulator motility.

F2reg (Regularity of F2 Variations) /%/: This is the consistency of the client's second formant fluctuations throughout this vocalisation. This evaluates the speaker's ability to maintain a regular, periodic transition between the various vowel positions. An irregular vocalization displays lesser regularity while a regular vocalization displays a larger quantity.

Analysis

All parameters underwent analysis using the MSP Advanced module. To analyze each parameter, samples were inputted into the software, and the analysis was conducted using the 'MSP Advanced' within the module. For each parameter, samples were carefully chosen and assessed over a consistent time span of 5 seconds, excluding the initial and final portions of the sample. This 5-second time window was maintained to ensure uniformity in the analysis across different age groups, as older participants typically have a shorter Maximum Phonation Duration (MPD). MSP then compiled the numerical results and presented them in a report format, facilitating the study of changes over time.

For inter-judge reliability, the recorded samples were analyzed by a second speech-language pathologist and dependent variable of the study was documented. 20% of the data were reanalyzed by the study's investigator for intra-judge reliability after a one-week gap. to check the reliability of the calculated dependent variable.

Statistical analysis

SPSS 17 was used for statistical analysis. Descriptive statistics was done to observe the mean and standard deviation across age and gender. All the data were subjected to the normality test across age and gender. The Shapiro-Wilk test was published journal article (John et al) we opted one sample t test to check the age group and gender comparison.

CHAPTER IV

Results

The current study aimed to understand the effects of maximal articulatory performances in Kannada speaking elderly population on selected acoustic measures recorded and analyzed using Motor Speech Profile module of Computerized Speech Lab. Before running the inferential statistical methods, a normality test was performed using Kolmogorov Smirnov test of normality. Results revealed that certain dependent variables were normal whereas few data points were non-normally distributed. Mann-Whitney U test and independent sample-t test were performed to analyze the results of non-normal and normally distributed data respectively. A total of 60 participants in the age range of 61 and 80 years was included. The study population was further divided into two age ranges, i.e., 61 to 70 and 71 to 80 years, with 30 samples in each group with equal gender representation (15 males and 15 females).

Interjudge reliability was assessed using the Kappa coefficient test, which analyzed the agreement between the investigator (judge 1) and another qualified Speech Language Pathologist, both of whom independently assessed samples from 10% of the randomly selected participants (2 from each age group and gender). The results indicated a substantial interjudge reliability, with Kappa coefficients ranging from 0.71 to 0.81 across various parameters.

In order to evaluate intra-judge reliability, the investigator's initial analysis was repeated on a subset of 10% of the participants, two from each age group and two from each gender, with a one-week gap between the two analyses. The Cronbach's alpha test was used to analyse the consistency of scores obtained for various parameters in the investigator's initial analysis. The results revealed strong intrajudge reliability, as indicated by Cronbach's Alpha coefficients ranging from 0.80 to 0.96 for different parameters.

The effect of age and gender on *DDK related* and *Second formant (F2) transition* related measures are discussed separately.

4.1 The effect of age (61 to 70 and 71 to 80) on Alternating and Sequential Motion Rates [AMRs (/pə/, /tə/ and /kə/) and SMRs (/pətəkə/)]

a) Alternating Motion Rate: Syllable /pə/

The four dependent variables were analyzed for the AMRs of syllable /pa/. This include DDK average period (DDKavp), Average DDK rate (DDKavr), Average Intensity of DDK (DDKava), and Average syllabic intensity (DDKsla). As data was non-normally distributed, the median data of DDKavp and DDKsla was analyzed using Mann Whitney U test whereas the Independent t test was used to compare the mean scores of DDKavr and DDKava between the age groups of 61-70 and 71 to 80 years.

DDK*avp* reflected the average time gap between the successive productions of syllable /pa/ whereas DDKsla indicated the average intensity levels of the syllable produced. Results of Mann Whitney U test showed no statistical significant between the age groups for both DDKavp (U = 437; z = 0.19; p = 0.84) and DDKsla (U = 387; Z = 0.931; p = 0.35).

DDKavr reflected the average rate of the CV (Consonant-Vowel i.e., /pa/ in this case) vocalisations per second and DDKava indicated the average peak amplitude of the DDK samples produced by our participants. Analysis of the above two DDK parameters using independent sample t test failed to show any statistical significance between the age groups indicating a comparable performance between the age groups

[DDKavr: t (58) = 0.73; *p* = 0.45); DDKava: t (58) = 0.42; *p* = 0.34]. Descriptive statistical data for the syllable /pa/ is shown in Table 2.

Table 2

Descriptive statistics for the AMR measure of syllable /pə/ across age groups/pə/

Dependent Variable	Unit	Mean	Median	SD	Minimum	Maximum	Range
61-70 years							
DDKavp	ms	195.06	189.56	28.90	156.15	268.70	112.56
DDKavr	/s	5.28	5.35	0.71	3.73	6.40	2.68
DDKava	dB	52.61	51.60	3.91	45.67	60.58	14.91
DDKsla	dB	61.02	61.64	3.22	56.12	66.01	9.89
71-80 years							
DDKavp	ms	192.55	188.24	24.36	161.19	251.86	90.68
DDKavr	/s	5.14	5.04	0.67	3.68	6.20	2.53
DDKava	dB	51.70	51.04	3.50	45.81	58.33	12.52
DDKsla	dB	60.33	60.26	2.88	55.86	67.02	11.16

b) Alternating Motion Rate: Syllable /tə/

Since the data was non-normally distributed, the median data of DDKavp was analyzed using Mann Whitney U test whereas the independent t test was used to compare the mean scores of DDKavr, DDKava, DDKsla between the age groups.

Results of Mann Whitney U test showed no statistically significant difference for DDKavp (U = 414; z = 0.53; *p* = 0.59) whereas the results of independent t test also showed similar trends as none of the compared variables between the age groups were statistically significant [DDKavr: t (58) = 0.61; *p* = 0.85); DDKava: t (58) = 0.13; *p* = 0.51; DDKsla: t (58) = 0.05; *p* = 0.27]. Descriptive statistical data shown in Table 3.

Table 3

Descriptive statistics for the AMR measure of syllable /tə/ across the age groups

Dependent Variable	Unit	Mean	Median	SD	Minimum	Maximum	Range
61-70 years							
DDKavp	ms	220.80	206.12	47.82	164.59	335.27	170.68
DDKavr	/s	4.66	4.85	0.92	2.33	6.08	3.75
DDKava	dB	53.79	54.11	4.53	46.76	64.39	17.64
DDKsla	dB	60.56	60.68	3.71	55.31	67.59	12.28
71-80 years							
DDKavp	ms	225.88	213.25	47.57	153.16	339.61	186.45
DDKavr	/s	4.62	4.71	0.93	2.95	6.53	3.59
DDKava	dB	53.09	52.52	3.63	48.02	63.85	15.82
DDKsla	dB	59.61	59.32	2.86	54.92	67.14	12.22

c) Alternating Motion Rate: Syllable /kə/

As data was non-normally distributed, the median data of DDKavp and DDKsla was analyzed using Mann Whitney U test whereas the Independent t test was chosen to compare the mean scores of DDKavr and DDKava between the age groups.

Table 4

Descriptive statistics for the AMR measure of syllable /kə/ across the age groups

Dependent Variable	Unit	Mean	Median	SD	Minimum	Maximum	Range
61-70 years							
DDKavp	ms	219.07	203.20	46.26	167.07	395.70	228.63
DDKavr	/s	4.81	4.92	0.63	3.54	5.99	2.44
DDKava	dB	52.84	52.83	4.92	45.11	62.90	17.79
DDKsla	dB	60.73	61.45	3.68	55.79	66.58	10.79
71-80 years							
DDKavp	ms	215.46	210.92	41.15	164.15	362.22	198.06
DDKavr	/s	4.82	4.92	0.67	3.67	6.09	2.42
DDKava	dB	52.15	52.09	3.47	46.02	59.08	13.06
DDKsla	dB	59.87	60.16	3.06	50.12	65.07	14.95

Comparison of DDK parameters showed statistically no significant differences either for Mann Whitney [DDKavp (U = 439; z = 0.16; $p = 0.87$); DDKsla (U = 399; $z = 0.75$; $p = 0.45$)] nor for the Independent sample t test [DDKavr: t (58) = 0.58; $p = 0.94$); DDKava: t (58) = 0.02; $p = 0.53$]. Descriptive statistical data is shown in the above Table 4.

***d)* Sequential Motion Rates (/pətəkə/)**

The overall trends were similar for Sequential Motion Rates (SMRs) where analysis conducted using Mann Whitney U test for DDKavp, DDKava, and DDKsla failed to show any statistical significance [(U = 387; z = 0.93; *p* = 0.35), DDKava (U = 445; *z* = 0.07; *p* = 0.94), and DDKsla (U = 444; *z* = 0.08; *p* = 0.93)]. Unequivocal results were also observed for DDKavr when compared between the age groups of 61-70 and 71 to 80 years [t (58) = 0.34; *p* = 0.66)]. Table 5 depicts descriptive statistical data for the above findings.

Table 5

Descriptive statistics for the SMR measure across the age groups

Dependent Variable	Unit	Mean	Median	SD	Minimum	Maximum	Range
61-70 years							
DDKavp	ms	169.73	167.96	30.38	120.41	225.78	105.37
DDKavr	/s	5.75	5.93	0.94	4.00	7.22	3.22
DDKava	dB	52.29	50.76	5.61	45.08	63.36	18.28
DDKsla	dB	60.45	59.63	3.64	55.44	66.83	11.38
71-80 years							
DDKavp	ms	164.08	156.67	31.86	127.44	249.33	121.89
DDKavr	/s	5.85	5.95	0.83	4.01	7.84	3.83
DDKava	dB	53.57	51.44	4.87	45.86	59.05	13.19
DDKsla	dB	59.83	59.98	2.94	55.47	64.29	8.82

4.2 The effect of gender on Alternating and Sequential Motion Rates [AMRs (/pə/, /tə/ and /kə/) and SMRs (/pətəkə/)]

a) Alternating Motion Rate: Syllable /pə/

Table 6

Descriptive statistics of males and females for the average DDK period (DDKavp) for the syllable ***/pə/***

Age Range	Mean (in milliseconds)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	181.40	208.72	20.15	30.41	160.81	156.15	236.25	268.70	75.44	112.56	178.44	199.96
71-80	188.46	196.65	24.60	24.26	161.19	173.92	244.16	251.86	82.97	77.94	186.46	188.80

The results of DDKavp are shown in table 6. Although across both the age groups females showed greater average DDK period than males, Mann Whitney U test revealed high statistical significance only for the 61 to 70 years (U = 47; z = 2.71; p = < 0.01) group with no such differences for 71-80 years age group. (U = 87; z = 1.05; p = 0.29).

Table 7

Descriptive statistics of males and females for the average DDK Rate (DDKavr) for the syllable ***/pə/***

Age Range	Mean (per second)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	5.64	4.91	0.46	0.74	4.76	3.72	6.22	6.40	1.46	2.68	5.81	5.00
71-80	5.40	4.88	0.67	0.58	4.10	3.68	6.20	5.99	2.11	2.31	5.36	4.92

It can be observed from the above table 7 that average DDK rate (DDKavr) was higher for males across the age groups of 61 to 70 (U = 45; z = 2.80; p = <0.01) - and 71 to 80 years (U = 61; z = 2.13; p = 0.03) compared to the age matched female participants These observations were statistically highly significant for the 61-70 years age group.

Comparison of Average Intensity of DDK sample (DDKava) using Independent sample test revealed high statistical significance for the 61 to 70 years [t (28) = 0.14; p = <0.01)] age group whereas the age group of 71-80 years were highly comparable for the same [t (28) = 0.08; p = 0.51]. Descriptive statistics of this is shown in table 8.

Table 8

Descriptive statistics for Average Intensity of DDK sample (DDKava) across gender for syllable /pə/

Age Range	Mean (in dB)		S.D		Minimum		Maximum		Range		median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	54.92	50.29	3.69	2.55	45.67	47.10	60.58	57.39	14.91	10.28	56.58	49.77
71-80	51.27	52.12	2.95	4.04	46.58	45.81	57.16	58.33	10.57	12.52	50.25	51.64

The effect of gender on average syllabic intensity (DDKsla) showed high statistical significance for 61-70 years group (U = 42; *z* = 2.9; *p* = <0.01) where males had higher DDKsla than females. Similar comparisons made for 71-70 years failed to show any statistical significance (U = 103; *z* = 0.39; *p* = 0.69). The descriptive statistical results of DDKsla are shown in table 9.

Table 9

Descriptive statistics of males and females for Average Syllabic Intensity (DDKsla) for the syllable /pə/

Age Range	Mean (in dB)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	62.71	59.34	2.74	2.81	57.66	56.12	66.01	65.39	8.35	9.27	63.62	59.11
71-80	59.97	60.69	2.38	3.35	55.95	55.86	63.87	67.02	7.92	11.16	59.70	60.56

b) Alternating Motion Rate: Syllable /tə/

Table 10

Descriptive statistics of males and females for the average DDK period (DDKavp) for the syllable ***/tə/***

Age Range	Mean (In milliseconds)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	197.14	244.46	19.00	56.36	164.59	168.95	66.01	335.27	78.17	166.32	198.33	228.44
71-80	204.09	247.68	40.88	44.71	153.16	168.29	298.4	339.61	145.24	171.31	191.98	240.40

Comparison of the median scores of DDKavp between the genders using Mann Whitney U test revealed longer DDKavp for females compared to males across the age groups (U = 49; z = 2.63; p = <0.01) (U = 46; z = 2.75; p = <0.01). This suggested that the time gap between the successive productions of the CV utterances was longer for females compared to males. Results descriptive statistical analysis are shown in table 10. It is also to be noted that the standard deviation and the range were higher for females across the age groups compared to their male counterparts.

Table 11

Descriptive statistics of males and females for the average DDK Rate (DDKavr) for the syllable /tə/

Age Range	Mean (per second)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	5.07	4.26	0.58	1.02	3.54	2.33	6.08	5.92	2.54	3.59	5.03	4.37
71-80	5.05	4.18	0.86	0.80	3.35	2.95	6.53	5.94	3.18	3.00	5.20	4.16

Across both the age groups, men displayed a greater mean DDK rate scores compared to women. This was further confirmed by the Independent sample t test analysis wherein a statistically highly significant differences were observed between the gender across age groups [t (28) = 0.31; p = 0.01)] [t (28) = 0.71; p = <0.01]. Descriptive statistics is represented in the above table 11.

Table 12

Descriptive statistics of males and females for the Average Intensity of DDK Sample (DDKava) for the syllable /tə/

Age Range	Mean (in dB)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	56.37	51.21	4.15	3.34	49.66	46.76	64.39	56.56	14.73	9.78	55.73	50.01
71-80	54.14	52.04	3.86	3.15	50.08	48.02	63.85	56.88	13.76	8.86	53.14	51.05

The effect of gender on DDKava showed high statistical significance only for the age group of 61 to 70 (U = 38; $z = 3.09$; $p < 0.01$) but not for 71 to 80 years (U = 76; $z = 1.51$; $p = 0.13$) despite the median scores were higher for males compared to females across the age ranges. Table 12 displays the descriptive statistics for the DDKava variable's results.

Table 13

Descriptive statistics of males and females for the Average Syllabic Intensity (DDKsla) for the syllable /tə/

Age Range	Mean (in dB)		S.D		Minimum		Maximum		Range		Median	
	M	F	M	F	M	F	M	F	M	F	M	F
61-70	62.20	58.91	3.62	3.09	56.98	55.31	67.59	63.21	10.61	7.9	61.95	57.86
71-80	60.27	58.94	2.74	2.91	56.69	54.92	67.14	63.61	10.44	8.69	59.97	58.35

From the above table it could be observed that males across the age groups showed greater mean/median DDKsla values than females. Inferential statistical results however showed significant difference only for 61 to 70 years (U = 56; z = 2.34; p = 0.01) with no such differences observed for the 71 to 80 year old group (U = 80; z = 1.34; p = 0.17). The descriptive statistics results of DDKsla are reported in table13.

c) Alternating Motion Rates: Syllable /kə/

The effect of gender was examined across DDKavp, DDKavr, DDKava and DDKsla for each age group of the study. For DDKavp, despite the median values were higher in the females, Mann Whitney results did not show any effect of gender either for 61-70 (U = 103; z = 0.39; p = 0.69) or for 71- 80 years group (U = 100; z = 0.51; p = 0.60). Similar results were observed when DDKavr was compared for the effect of gender using independent t test [61-70 years: t (28) = 0.14; p = 0.99); 71-80 years: t (28) = 0.01; p = 0.50]. Comparison of DDKava and DDKsla showed similar trends for the effect of gender. Overall intensity of the sample, i.e., DDKava t (28) = 0.17; p

= <0.01)] and the average syllabic intensity, i.e., DDKsla was highly significant [U = 36; z = 3.17; p = <0.01] for 61-70 years where males showed higher overall intensity while producing the AMR /ka/ compared to females. No such gender differences were seen for the 71-80 year age group [61-70 years: t (28) = 0.17; p = 0.92; 71- 80 years: U = 108; z = 0.18; p = 0.85]. Descriptive statistical data depicting the mean, median, SD, minimum, maximum and range across the chosen parameters for age and gender is shown in table 14.

Table 14

Descriptive statistics of males and females across the AMR parameters for the syllable / **kə** /

Age Range	Mean		S.D		Minimum		Maximum		Median	
	M	F	M	F	M	F	M	F	M	F
DDKavp										
61-70	211.84	226.30	29.20	58.90	176.13	167.07	296.66	395.7	202.31	203.20
71-80	216.18	214.81	53.07	26.26	164.15	168.12	362.22	251.95	199.57	223.21
DDKavr										
61-70	4.81	4.81	0.53	0.74	3.54	3.63	5.68	5.99	4.94	4.92
71-80	4.90	4.74	0.83	0.46	3.67	3.97	6.09	5.55	5.01	4.92
DDKava										
61-70	55.67	50.01	4.71	3.29	47.26	45.11	62.90	56.01	57.18	49.55
71-80	52.09	52.22	4.12	2.82	46.02	48.41	59.08	58.94	50.66	52.39
DDKsla										
61-70	62.70	58.77	3.54	2.69	56.36	55.79	66.58	63.11	64.55	58.54
71-80	60.05	59.68	2.60	3.54	56.61	50.12	64.56	65.07	59.72	60.49

d) Sequential Motion Rates (/pə//tə//kə/)

Table 15

Descriptive statistics of males and females for the SMR parameters

Age Range	Mean		S.D		Min.		Max.		Median	
	M	F	M	F	M	F	M	F	M	F
DDKavp										
61-70	153.37	186.09	23.10	28.36	120.41	127.73	203.35	225.78	153.11	183.53
71-80	157.52	170.64	32.14	31.25	130.26	127.44	249	249.33	142.99	169.1
DDKavr										
61-70	6.24	5.26	0.77	0.86	4.31	4.00	7.22	6.83	6.20	5.29
71-80	6.10	5.60	0.75	0.85	4.02	4.01	6.84	7.84	6.30	5.63
DDKava										
61-70	56.00	48.58	4.66	3.76	46.76	45.08	63.36	57.44	58.42	47.47
71-80	55.90	51.51	4.49	2.99	45.86	46.84	59.05	57.56	50.99	52.06
DDKsla										
61-70	62.43	58.47	3.24	2.93	57.31	55.44	66.83	64.71	64.01	57.45
71-80	61.05	60.11	2.91	2.38	55.76	55.47	64.29	64.78	59.37	60.38

Some intriguing results emerged from comparing SMRs between the 61-70 and 71-80-year age groups as a function of gender. Despite the mean/median values for the females were higher throughout the age groups when compared for DDKavp, the differences were only significant for the former age group (U = 42; z = 2.9; p < 0.01) with no such differences observed for the latter (U = 81; z = 1.30; p = 0.19). Increased SDs for the older age group might have lessened the gender differences. For the comparison of DDKavr, males showed higher overall speed in the production of SMRs compared to females across the age groups [61-70 years: U = 45; z = 2.8; p = <0.01;

71-80 years: U = 57; *z* = 2.30; *p* = 0.02]. Results of DDKava and DDKsla analysis revealed similar trends where both the parameters showed gender effect only for 61-70 years [DDKava: U = 24; *z* = 3.67; *p* = <0.01; DDKsla: U = 46; *z* = 2.75; *p* = <0.01] indicating higher sample and syllabic intensity for males compared to females, with no gender differences emerging for the 71–80 years age group [DDKava: U = 99; *z* = 0.56; *p* = 0.57; DDKsla: U = 97; *z* = 0.64; *p* = 0.52]. It is to be noted that in most cases, the statistical results were highly significant when gender differences emerged.

4.3 To investigate the effect of age (61 to 70 and 71 to 80) and gender on second formant transitions [/i-u/] in healthy elderly Kannada speakers using Motor Speech Profile.

The three dependent variables for the F2 transition were analyzed. This included Magnitude of F2 Variations (F2magn), Rate of F2 Variations (F2rate), and Average F2 (F2aver). As data was non-normally distributed, the median data was compared to understand the effect of age and gender on parameters of F2 transitions.

Magnitude of F2 Variations (F2magn) determines the degree of the vocalization's alterations to the client's second formant. Rate of F2 variation (F2rate) is the frequency at which the client's second formant changes during this vocalisation. Average F2 (F2aver) is the average values of second formant. The Mann-Whitney U test analysis of the F2 transition parameters revealed no age effects. F2magn (U = 320; z = 1.92; p = 0.55), F2rate (U = 444.50; z = 0.08; p = 0.93), and F2reg (U = 351; z = 1.46; p = 0.14) Table 16 represents the data of descriptive statistics on F2 transition parameters across the age groups

Table 16

Descriptive statistics of F2 transitions across the age groups

Dependent Variable	Unit	Mean	Median	SD	Minimum	Maximum	Range
61-70 years							
F2magn	Hz	483.99	507.86	79.31	307.70	591.02	283.31
F2rate	/s/	1.87	1.83	0.26	1.22	2.47	1.25
F2aver	Hz	1491.22	1390.62	210.23	1231.60	1858.24	625.65
71-80 years							
F2magn	ms	438.62	443.31	94.86	230.01	607.18	377.17
F2rate	/s/	1.80	1.88	0.27	1.02	2.20	1.18
F2aver	Hz	1396.63	1373.73	172.62	1039.63	1690.23	650.60

Table 17

Descriptive statistics of males and females across age groups for the F2 transition parameters

Age Range	Mean		S.D		Min.		Max.		Median	
	M	F	M	F	M	F	M	F	M	F
F2magn										
61-70	423.72	544.27	66.34	29.04	307.70	500.73	555.34	591.02	410.19	546.72
71-80	387.01	490.24	59.01	97.21	278.15	230.01	475.02	607.18	398.22	495.12
F2rate										
61-70	1.98	1.76	0.27	0.20	1.63	1.22	2.47	2.13	1.96	1.81
71-80	1.93	1.67	0.12	0.33	1.77	1.02	2.2	2.05	1.92	1.76
F2aver										
61-70	1318.07	1664.38	51.06	157.15	1231.6	1360.3	1398.9	1858.24	1332.44	1722.47
71-80	1340.28	1452.9	182.47	147.0	1039.63	1255.5	1643.35	1690	1351.92	1477.12

Comparison of F2 magnitude (F2magn) and average F2 (F2 aver) between males and females showed similar trends. Mean and median values for both F2 magnitude [(U = 17; z = 3.96; p <0.01) (U = 30; z = 3.42; p <0.01) and F2 average [t (28) = 0.00; p < 0.01) [t (28) = 0.69; p = 0.07] was significantly higher for females compared to males. Inferential statistical analysis using Mann Whitney revealed statistically highly significant differences for gender across age groups for F2 magnitude [61-70 years: U = 17; z = 3.96; p <0.01) and 71-80 years (U = 30; z = 3.42; p <0.01)]. But these differences were limited only for the younger age group (61-70 years) for average F2 [t (28) = 0.00; p < 0.01] and not observed for 71-80 years [t (28) = 0.69; p = 0.07]. With regarding the second formant variations (F2rate), males showed higher F2rate compared to females across the elderly age groups [61-70 years: (U = 64; z = 2.01; p = 0.04); 71-80 years (U = 59; z = 2.22; p = 0.02)].

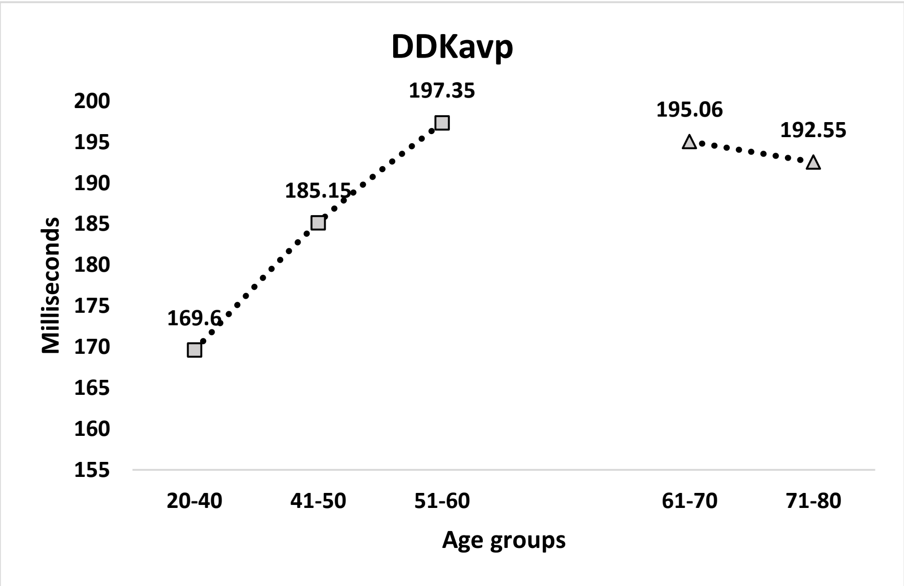
In the third objective, the results of the current study were compared with a similar study conducted on native Kannada speaking individuals by John et al (2014) to understand the overall variations in the maximal task performance as a factor of *age and gender*. In the previous study, adult age groups were subdivided into 3 groups namely 20-40, 41-50 and 51-60 years and the results were reported only for syllable /pə/ and no other data on AMR and SMR measures were reported. Therefore, the current study compares the findings with the previous study only for syllable /pa/ and to the reported variables of average DDK period (DDKavp) and Average DDK rate (DDKavr). The results are discussed separately for DDK and F2 transitions as a factor of *age and gender.*

4.3 a) The effect of age on average DDK period (DDKavp) and DDK rate (DDKavr) between adults and elderly subgroups

The current study's average DDK period was compared to the three young adult age groups from a previous study using a one-sample t test. Our study subgroups (61-70 and 71-80 years) differed mainly with 20-40 years, where the average DDKavp was shorter in the 20-40 years group compared to 61-70 years [t (29) = 4.82; p = 0.01] and 71-80 years [t (29) = 5.16; p = 0.01]. Apart from this, the DDKavp was substantially comparable between the current study subgroups and the prior study's 41-50 years [61-70 years: t (29) = 1.87; *p* = 0.07; 71-80 years: t (29) = 1.87; *p* = 0.10] and 51-60 age groups [61-70 years: t (29) = 0.43; *p* = 0.66; 71-80 years t (29) = 1.07; *p* = 0.29]. This demonstrated that the DDKavp in the native Kannada-speaking population did not change after 40 years. Figure 1 depicts a line graph with descriptive statistical data and comparisons.

Figure 1

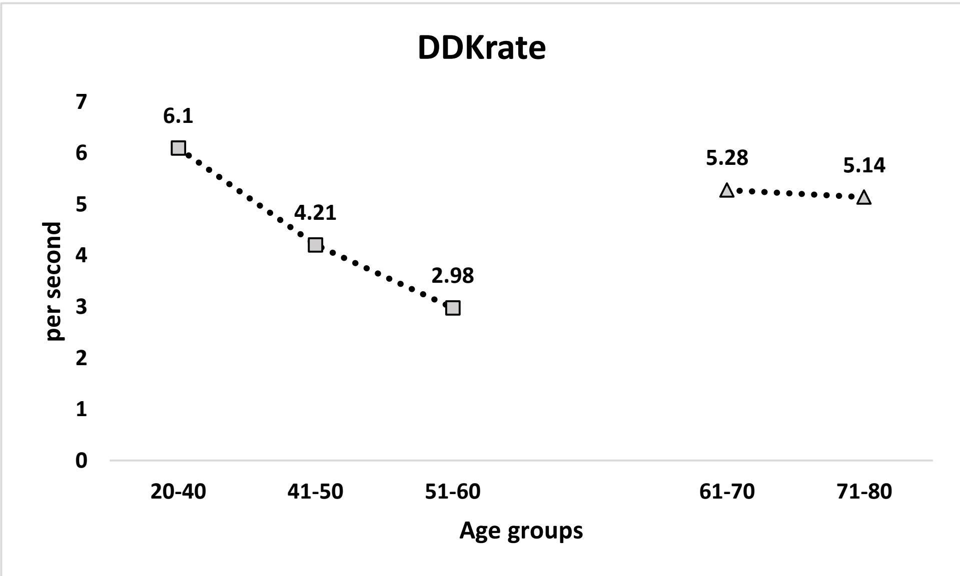
Mean DDK Period (DDKavp) as a Factor of Age in Adult and Elderly Subgroups.



With regard to DDK rate, it was observed that 20–40-year-olds had a higher mean DDK rate compared to 61–70-year-olds [t (29) = 5.12; p <0.01] and the 71–80-year-old age group [t (29) = 6.49; p <0.01]. DDK rate differences were significant when 41–50-year participant data were compared with the current study subgroups [61–70 years: t (29) = 8.20; p < 0.01; 71–80 years: t (29) = 7.58; p <0.01]. This trend was maintained when current research data was compared to data from a previous study of 51-60 years [61-70 years: t (29) = 17.61; $p < 0.01$; 71-80 years: t (29) = 17.54; $p < 0.01$]. It is important to note that the DDK rate was lower for 41-50 and 51- 60 years compared to the data obtained on the elderly population of this study.

Figure 2

Mean DDK Rate (DDKrate) as a Factor of Age in Adult and Elderly Subgroups



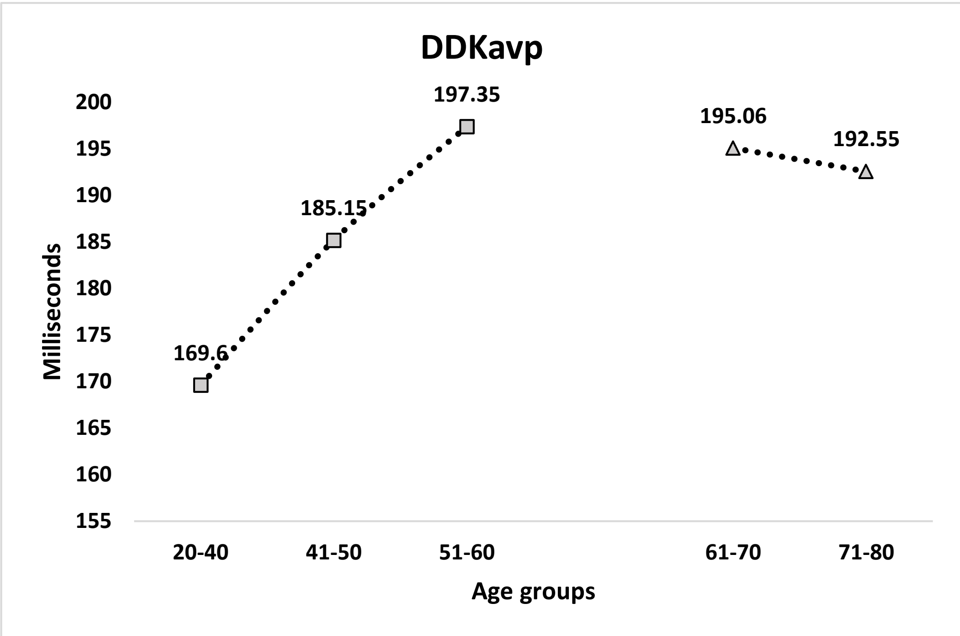
4.3 b) The effect of gender on average DDK period (DDKavp) and DDK rate (DDKavr) between Adults and Elderly Subgroups

One sample t test was used to compare the current study results of average DDK period (DDKavp) for the effect on gender on the production of syllable /pa/. For *males*, the DDKavp of 20-40 years differed statistically (highly significant) compared to 61-70 [t (14) = 3.15; p <0.01] and 71–80-year-old age groups [t (14) = 3.68; p <0.01]. Here, the elderly age group had longer overall DDKavp compared to the young adult group of the previous study. Significant differences were also observed when 41–50-year-old age groups were compared for the mean DDKavp with 61-70 years [t (14) =

0.63; *p* = <0.01] and 71- 80-year-old elderly cohorts [t (14) = 0.59; *p* = <0.01]. Here, the average DDK period of 41-50 years was in between the 61-70 and 71–80-year-old age groups. For 51-60 year group, the differences were apparent for the DDKavp for 61-70 [t (14) = 4.18; *p* = <0.01] and 71 to 80 year old males [t (14) = 2.31; *p* = <0.01]. Findings were intriguing as the 51–60-year-old participants had longer DDKavp compared to the elderly subgroups of this study. The results of the overall comparison are visually represented as a descriptive statistic in figure 3

Figure 3

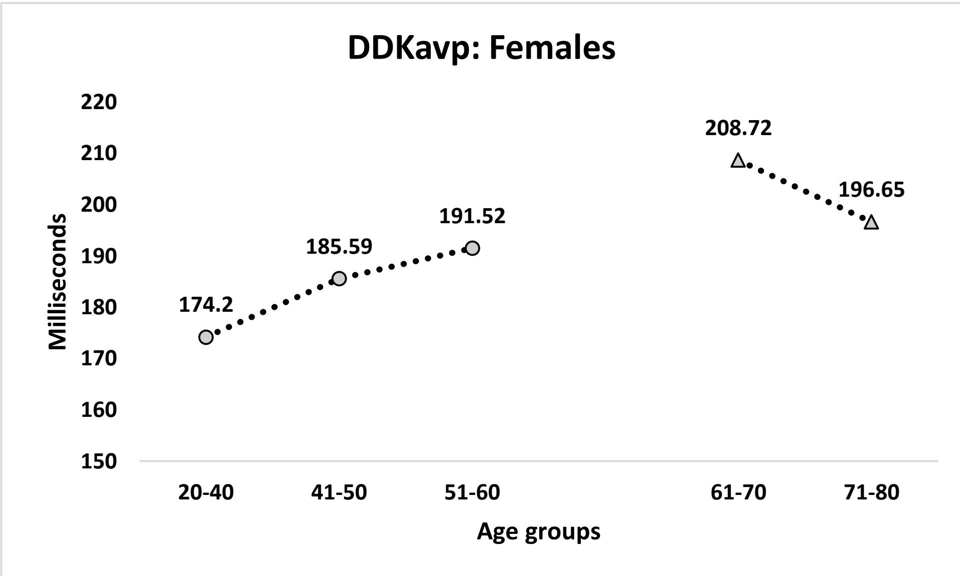
Comparison of the Mean DDK Period (DDKavp) for Males in Adults and Elderly Subgroups



For *females*, the DDKavp of 20-40 years differed highly significantly compared to 61-70 [t (14) = 4.39; *p* = <0.01] and 71–80-year-old age groups [t (14) = 3.58; *p* = <0.01]. Here, the elderly age group had longer overall DDKavp compared to the young adult group of the previous investigation. Significant differences were also observed when 41–50-year-old age groups were compared for the mean DDKavp with 61-70 years [t (14) = 2.94; *p* = <0.01] and 71- 80-year-old elderly cohorts [t (14) = 1.76; *p* = <0.01]. For 51–60-year group, the differences were apparent for the DDKavp for 61-70 [t (14) = 2.19; *p* = <0.01] and 71- to 80-year-old females [t (14) = 0.81; *p* = <0.01]. Overall differences revealed that the DDKavp of the elderly group for females were significantly longer than the younger age groups reported in the previous study. The observed variations across genders revealed that the overall trends were consistent in females comapred to the male counterparts. The mean data that were compared between the female groups across the studies are represented in figure 4.

Figure 4

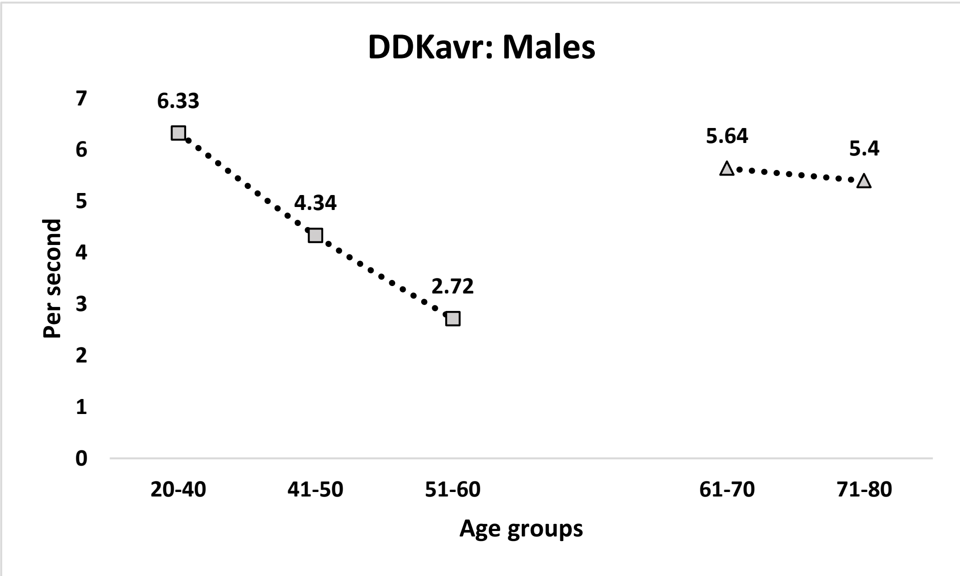
Comparison of the Mean DDK Period (DDKavp) for Females in Adult and Elderly Subgroups



The average DDK rate (DDKavr) was found to be higher in males of 20 to 40 years of age when compared to males of 61 to 70 years of age [t (14) = 5.66; *p* = <0.01] and 71 to 80 years [t (14) = 5.28; *p* <0.01]. Interestingly, compared to 41 to 50 years, males of 61 to 70 years [t (14) = 10.76; *p* <0.01] as well as 71 to 80 years had a higher average DDK rate [t (14) = 6.14; *p* < 0.01]. This trend continued for male groups in the age range of 51 to 60 years, where they showed a lower average DDK rate than male groups of 61 to 70 years [t (14) = 24.14; *p* = 0.01] and 71 to 80 years [t (14) = 15.44; *p* = 0.01]; the observed differences were statistically highly significant. The mean data across the age groups for male participants of the two studies are shown in figure 5.

Figure 5

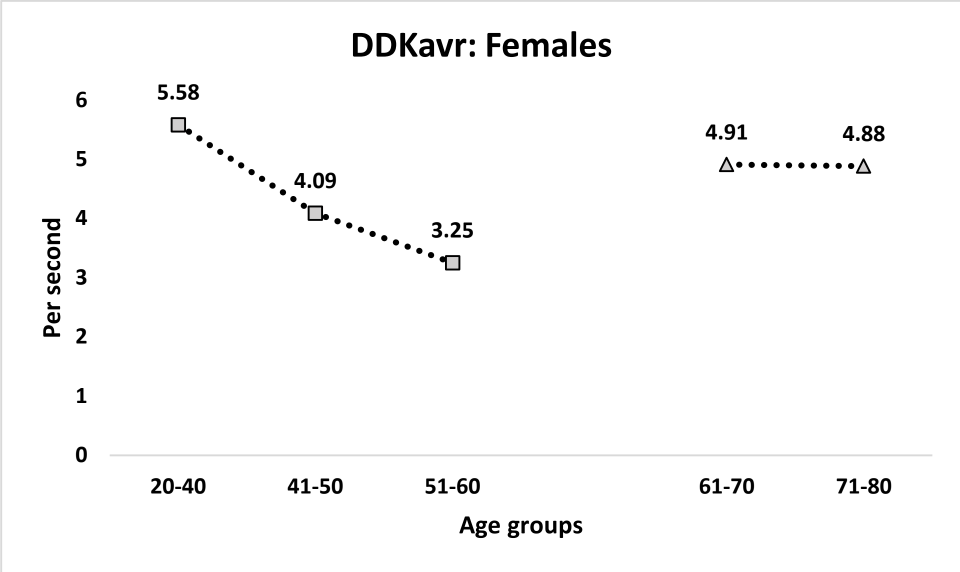
Comparison of the Average DDK Rate (DDKavr) for Males in Adult and Elderly Subgroups



With regard to females, all the subgroups of the previous study were found to be statistically significant compared to the current subgroups of elderly individuals in this study. Significant differences for DDKavr were observed between 20–40 years and 61–70 [t(14) = 3.43; *p* = 0.01] and 71–80 years [t(14) = 4.58; *p* = 0.01]; between 41–50 years and 61–70 [t (14) = 4.29; *p* = 0.01] and 71–80 years [t (14) = 5.23; *p* = 0.01]; and between 51–60 years and 61–70 [t (14) = 0.77; *p* = 0.01] and 71–80 years [t(14) = 8.65; *p* = 0.01]. Although differences were observed across the age groups of both studies, the overall average DDK rate declined from 20 to 60 years. Interestingly, the average DDK rate was higher for the elderly aged 60–80 years compared to adults in the age range of 41–60 years. The mean data for the average DDK rate is shown in Figure 6.

Figure 6

Comparison of the Average DDK Rate (DDKavr) for Females in Adult and Elderly Subgroups.

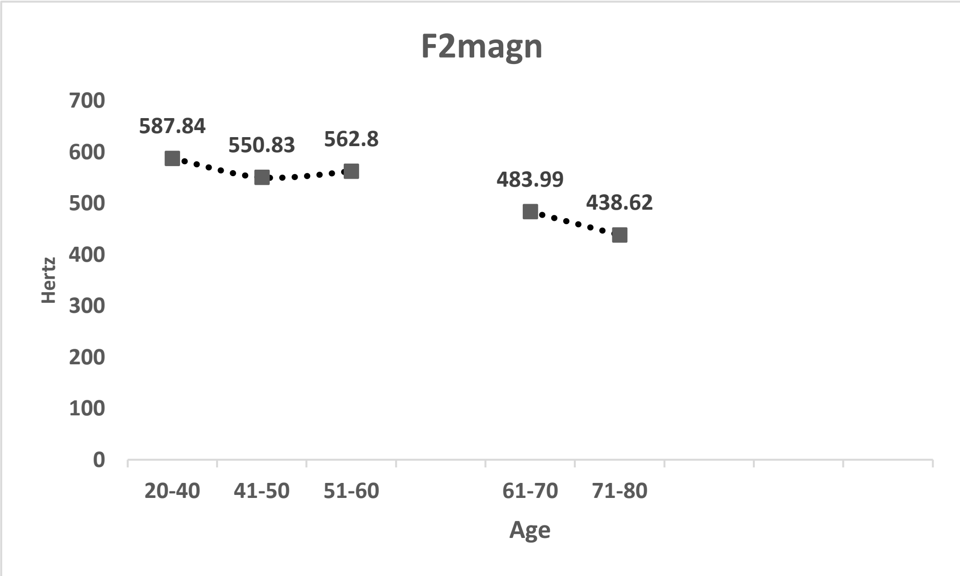


4.4 a) The effect of age on Magnitude of F2 Variations (F2magn), Rate of F2 Variations (F2rate), Average F2 (F2aver) between Adults and Elderly Subgroups.

The current study's magnitude of F2 transition was compared to the three young adult age groups from a previous study using a one-sample t test. With regard to magnitude of F2 transition, it was observed that all the subgroups in the earlier study differed significantly with the elderly subgroups of the current study [*20–40-year* vs. 61–70- [t (29) = 7.17; *p* = <0.01] and 71–80-year-old groups [t (29) = 8.61; *p* = <0.01]; *41–50-years* vs. 61–70 -[t (29) = 4.61; *p* = <0.01] and 71–80 years: [t (29) = 6.4; *p* = <0.01]; 51-60 years vs. 61-70 years- [t (29) = 5.44; *p* = <0.01] and 71-80 years – [t (29) = 7.17; *p* = <0.01]. It is important to note that the magnitude of F2 transition was lower for elderly population compared to the young adults of the previous study. The mean data of F2 magnitude across studies is shown as figure 7.

Figure 7

Mean Magnitude of F2 Variation (F2magn) as a Factor of Age in Adult and Elderly Subgroups



With regard to rate of f2 variations, it was observed that 20–40-year-olds had a higher mean F2 rate compared to 61–70-year-olds [t (29) = 10.59; *p* = <0.01] and the 71–80-year-old age group [t (29) = 11.4; *p* = <0.01]. F2 rate differences were significant when 41–50-year participant data were compared with the current study subgroups [*61–70 years*: t (29) = 8.11; *p* = <0.01; *71–80 years*: t (29) = 9.05; *p* = <0.01]. This trend was when the current elderly subgroups were compared to 51-60 year age participants of the previous study[61-70 years: t (29) = 1.93; *p* = <0.01; 71-80 years: t (29) = 3.18; *p* = <0.01]. In the observed differences, elderly subgroups showed lower F2 rate variations compared to the adult subgroups of the previous study. The mean Rate of F2 variations across adults and elderly population is shown in figure 8.

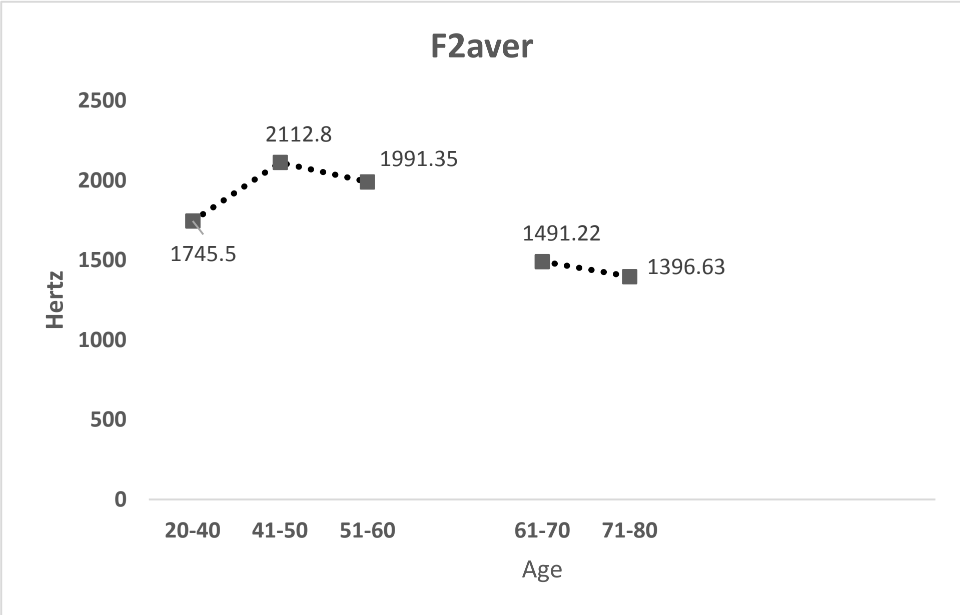
Figure 8

Mean Rate of F2 (F2 Rate) as a Factor of Age in Adult and Elderly Subgroups

As far as Average F2 were concerned, it was observed that 41 to 50-year-olds had a higher average F2 compared to 61–70-year-olds [t (29) = 16.19; *p* = <0.01] and the 71–80-year-old age group [t (29) = 22.72; *p* = <0.01]. Average F2 differences were significant betwen 20 to 40-year group and 61–70 years: [t (29) = 6.6; *p* = <0.01] and 71–80 years [t (29) = 11.06; *p* = <0.01]. Differences were also statistically highly significant between 51-60 years and 61-70 years [t (29) = 13.03; *p* = <0.01] and 71-80 years [t (29) = 18.8; *p* = <0.01]. Compared to any other adult group, the average F2 was higher for 41–50-year-old participants. When the findings are observed across studies, a steep decline in average F2 values were seen after the age of 50, and the elderly group had the lowest average F2 values.

Figure 9

Average F2 (F2aver) as a Factor of Age in Adult and Elderly Subgroups.

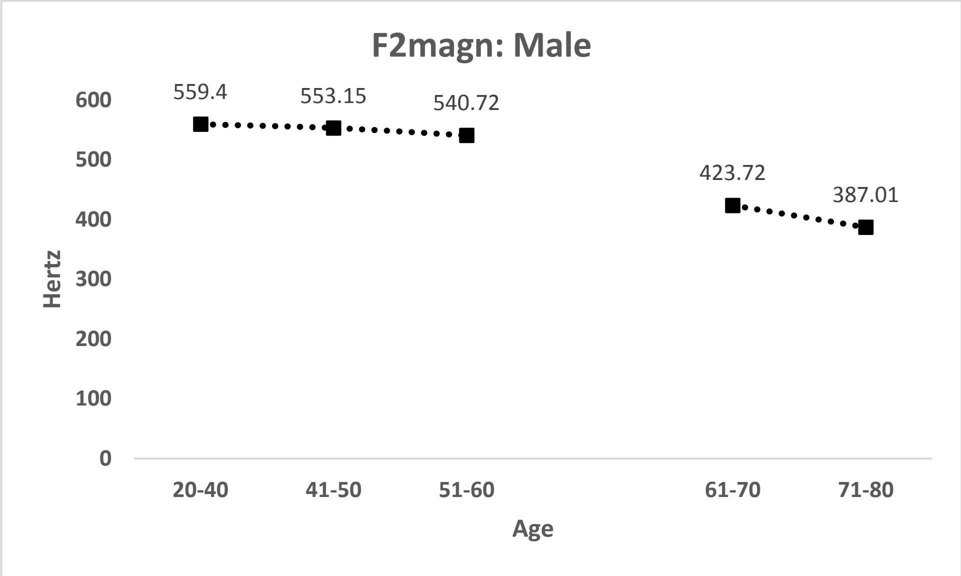


4.4 b) The effect of gender on Magnitude of F2 Variations (F2magn), Rate of F2 Variations (F2rate), Average F2 (F2aver) between Adults and Elderly Subgroups

The current study's results of the amount of F2 variation for the effect of gender on the production of /i-u/ were compared using a one sample t test. For males, the F2magn of 20-40 years differed statistically compared to 61-70 [t (14) = 7.92; p = <0.01] and 71-80-year-old age groups [t (14) = 11.31; p = <0.01]. Significant difference was also observed when 41-50-year-old age groups were compared for the mean F2magn with 61-70 years [t (14) = 7.55; p = 0.01] and 71- to 80-year-old elderly cohorts [t (14) = 10.90; p = 0.01]. For 51–60-year group, the difference was significant for F2magn for 61-70 [t (14) = 6.83; p = 0.01] and 71- to 80-year-old males [t (14) = 10.08; p = 0.01]. Cumulatively, it could be observed that the male participants in the adult group had higher mean F2 magnitude values than the elderly cohorts. A gradual decline in the average F2 values was seen in the male population from 20 to 60 years, and there was a sharp decline after the age of 60. Figure 10 shows the average magnitude of F2 variations between adults and elderly subgroups.

Figure 10

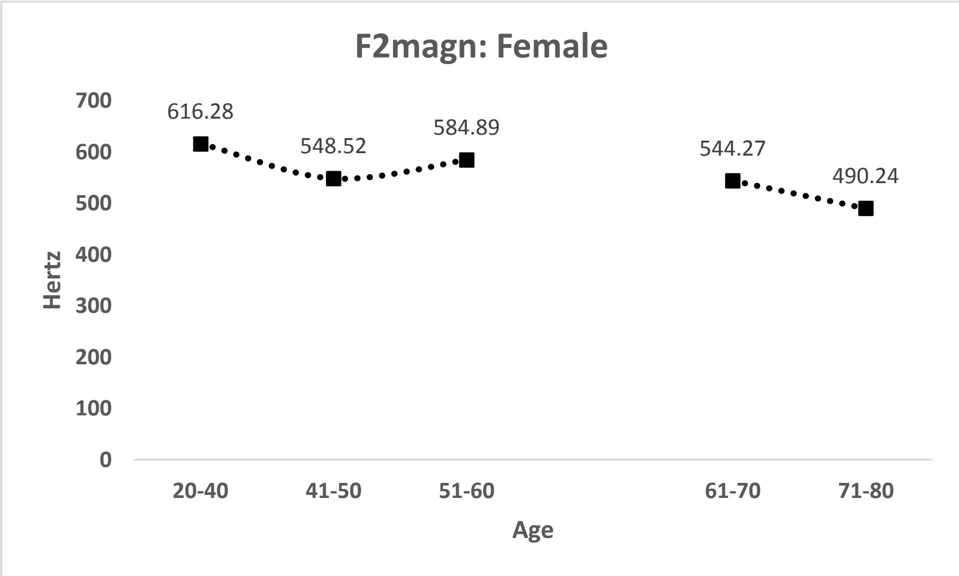
Comparison of the Magnitude of F2 Variation (F2magn) for Males in the Adult and Elderly Subgroups.



For *females*, the F2magn of 20-40 years differed highly significantly compared to 61-70 [t (14) = 9.60; *p* = <0.01] and 71–80-year-old age groups [t (14) = 5.02; *p* = <0.01]. Here, the elderly age group had lesser overall F2magn compared to the young adult group of the previous investigation. Significant differences were also observed when 41–50-year-old age groups were compared for the mean F2magn with 61-70 years [t (14) = 0.56; *p* = 0.01]and 71- 80-year-old elderly cohorts [t (14) = 2.32; *p* = 0.01]. For 51–60-year group, the differences were apparent for the F2magn for 61-70 [t (14) = 3.77; *p* = 0.01] and 71- to 80-year-old females [t (14) = 5.41; *p* = 0.01]. Overall differences revealed that the F2magn of the elderly group for females were significantly lesser than the adult subgroups reported in the previous study. The mean F2 magnitude in females across the age groups are shown in figure 11.

Figure 11

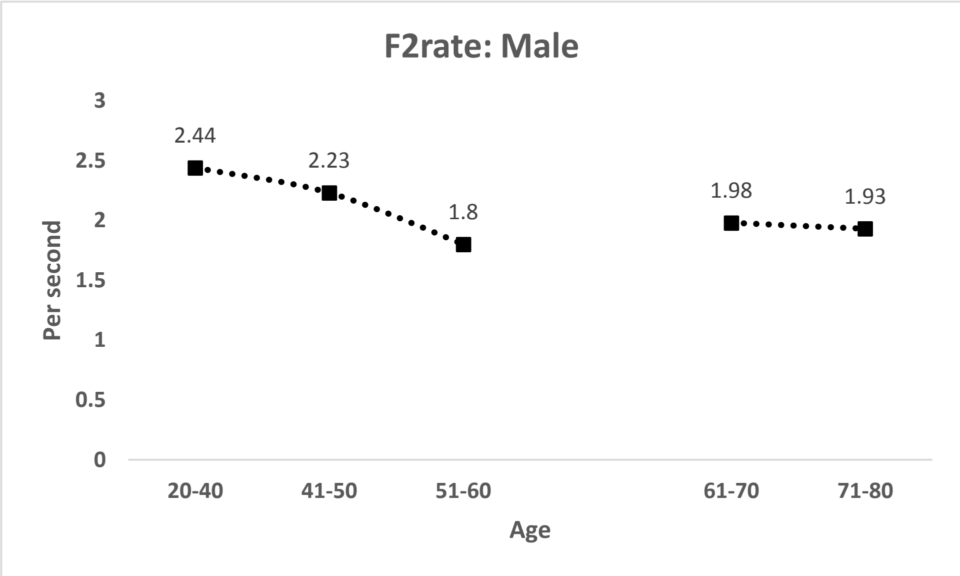
Comparison of the Magnitude of F2 Variation (F2magn) for Females in the Adult and Elderly Subgroups.



The average F2 rate (F2avr) was found to be higher in males of 20 to 40 years of age when compared to males of 61 to 70 years of age [t (14) = 6.30; p = 0.01] and 71 to 80 years [t (14) = 15.3; p = 0.01]. F2 magnitude was was higher for 41 to 50 year old adults compared to the elderly groups [61 to 70 years [t (14) = 3.36; p = 0.01] and 71 to 80 years [t (14) = 8.96; p = 0.01] Interestingly, 61 to 70 years [t (14) = 2.64; p = 0.01] and 71 to 80 years [t (14) = 4.14; p = 0.01] had greater F2rate compared to 51 to 60 years. Here we can observe that the rate of F2 transition decreased gradually from 20 to 60 years but slightly increased from 61 to 80 years.

Figure 12

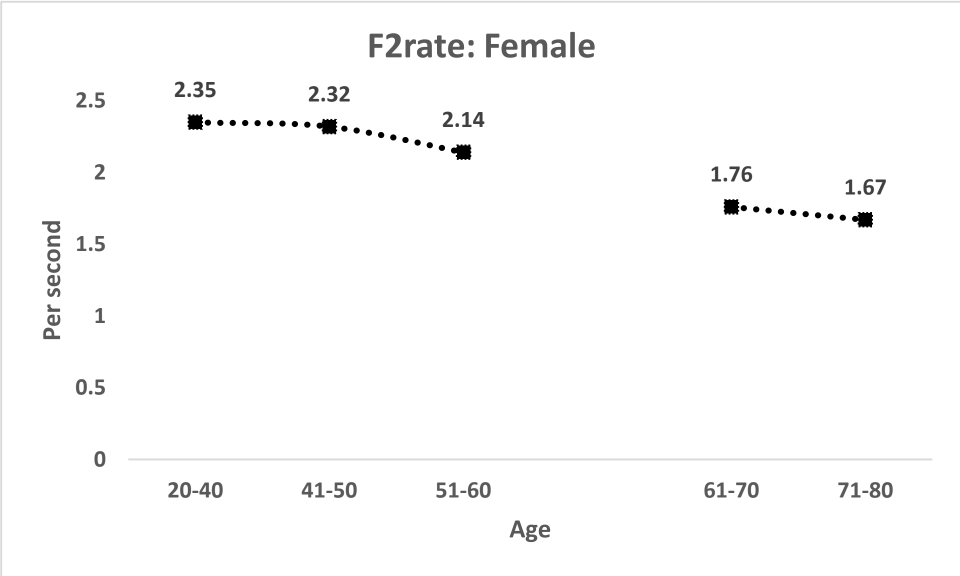
Comparison of the Rate of F2 Variation (F2rate) for Males in the Adult and Elderly Subgroups.



For *females*, the F2 rate of 20-40 years differed highly significantly compared to 61-70 [t (14) = 7.82; p = 0.01] and 71–80-year-old age groups [t (14) = 11.06; p = 0.01]. Here, the elderly age group had reduced overall F2 rate compared to the young adult group of the previous investigation. Significant differences were also observed when 41–50-year-old age groups were compared for the mean F2rate with 61-70 years [t (14) = 10.49; p = 0.01] and 71- 80-year-old elderly cohorts [t (14) = 7.47; p = 0.01]. For 51–60-year group, the differences were apparent for the F2rate for 61-70 [t (14) = 7.10; p = 0.01] and 71- to 80-year-old females [t (14) = 5.37; p = 0.01]. Overall differences revealed that the rate of F2 transition declined from 20 to 80 years. Younger females showed faster transition from one vowel to another vowel compared to females in the elderly group. However, as per the frist objective of this study, the age difference was negligible within elderly subgroups. The mean F2 rate for females across the age groups is shown in Figure 13.

Figure 13

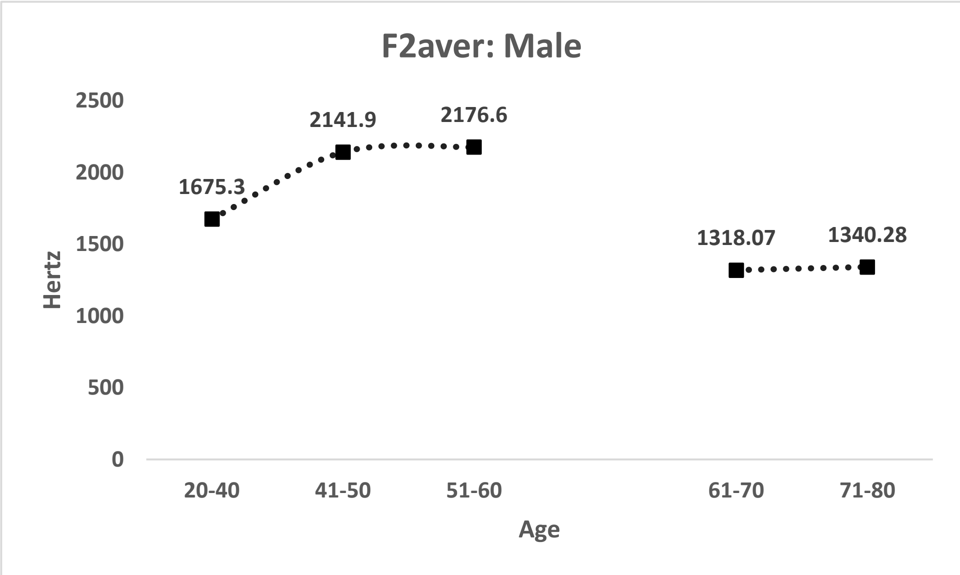
Comparison of the Rate of F2 (F2rate) for Females in the Adult and Elderly Subgroups.



The average F2 (F2aver) was found to be higher in males of 20 to 40 years of age when compared to Males of 61 to 70 years of age [t (14) = 27.09; p = 0.01] and 71 to 80 years [t (14) = 7.11; p = 0.01]. Significant differences were noted when it was compared between 41 to 50 years with 61 to 70 years [t (14) = 62.48; p = 0.01] and 71 to 80 years [t (14) = 17.01; p = 0.01]. Average F2 values differed from 61 to 70 years [t (14) = 65.11; p = 0.01] and 71 to 80 years [t (14) = 17.75; p = 0.01] with 51 to 60-year-old participant groups. There was a remarkable decrease in the average F2 of the elderly subgroup of this study compared to the values of adults reported in a previous study.

Figure 14

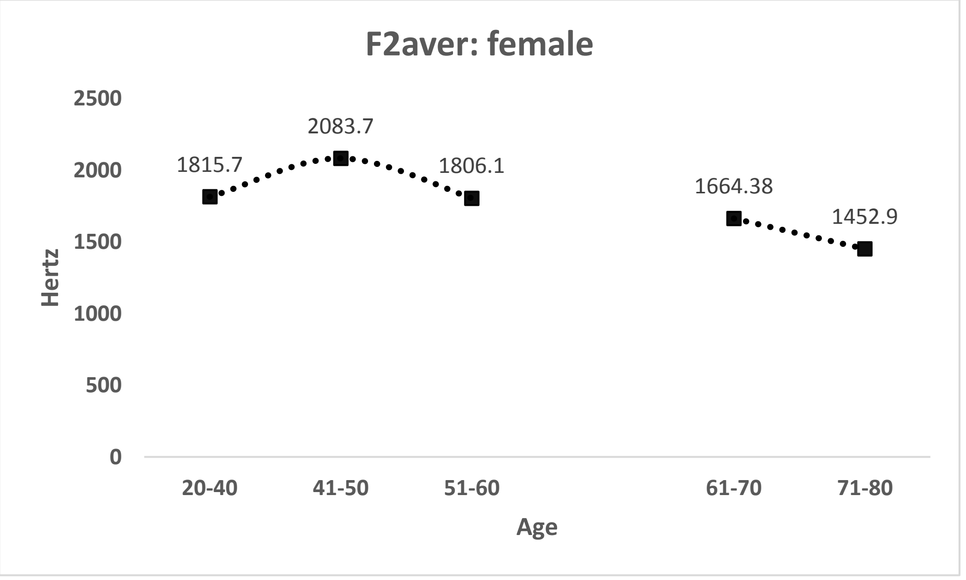
Comparison of the Average F2 (F2aver) for Males in the Adult and Elderly Subgroups.



For *females*, the average F2 of 20-40 years differed significantly compared to 61-70 [t (14) = 3.72; *p* = 0.01] and 71–80-year-old age groups [t (14) = 9.55; *p* = 0.01]. Here, the elderly age group had reduced overall average F2 compared to the young adult group of the previous investigation. Significant differences were also observed when 41–50-year-old age groups were compared for the average F2 with 61-70 years [t (14) = 10.33; *p* = 0.01]and 71- 80-year-old elderly cohorts [t (14) = 16.61; *p* = 0.01]. For 51–60-year group, the differences were apparent for the average F2 for 61-70 [t (14) = 3.49; *p* = 0.01] and 71- to 80-year-old females [t (14) = 9.30; *p* = 0.01]. Overall differences revealed that the average F2 of the elderly group for females were significantly lower than the younger age groups reported in the previous study. Average f2 was more in 41-to-50-year females compare to all other groups. The average F2 values across the age groups are represented in figure 15.

Figure 15

Comparison of the Average DDK Rate (F2aver) for Males in the Adult and Elderly Subgroups.



CHAPTER V

Discussion

It is important to understand the age-related changes that occur on maximal articulatory task performances such as DDK and F2 transitions for several reasons. Importantly, it helps in revealing the articulatory changes as a factor of age and this in turn would help in differentiating the acoustic changes that reflect the articulatory control in normal versus the pathological conditions. Additionally, DDK is a time saving measure that is sensitive for neurological breakdown in the articulatory control and this is minimally influenced by the language related characteristics. Using DDK as the only measure would provide age related changes on the articulatory task performance mostly in the vertical plane. Hence, this study supplements this with by measuring F2 transitions to understand the articulatory changes in the horizontal plane as well (/i/ - /u/ movements). The main goal of the current investigation was to examine the effect of maximal articulatory task performance in healthy Kannada speaking elderly population in the age range of 61-70 and 71 to 80 years and compare the results to an earlier investigation which studied the DDK and F2 transitions in the adult subgroups.

1. A) Effects of age on AMRs and SMRs

As per the results, there was no effect of age on the measured dependent variable of AMR [/pə/, /tə/ and /kə/] and SMRs /pətəkə/, and hence the null hypothesis is accepted.

The current findings go against a handful of studies that measured the DDK rate in adults and elderly population (Deyliski & Gress, 1997; John et al., 2014; Padovani et al., 2009). According to Padovani's 2009 study, DDK was measured across two age groups i.e., 30 to 46 (young adults) years and an elderly group between the age range of 47 to 94 years (median age 70). DDK rate varied between the two age groups compared where the elderly cohorts showed a decreased overall DDK rate (ranged between 5.52 to 6.13). Additionally, sounds that had posterior articulatory constriction (e.g., /ka/) had slower rate than the other placements. High variability in the intensity control was also seen in the elderly group suggesting of poor intensity control in them. Age related abnormalities including intrinsic laryngeal muscle atrophy and spindled glottal chinks, were attributed to the decreased intensity control.

Deyliski & Gress (1997) showed decrease in DDK rate as the age increases in the adult population (age range: 18- to 60-years). This was supported by John et al., (2014) who also showed decreased trend for DDK measured for /pə/ and they noted 6.33 syl/sec for 20- to 40-year-old group, 4.43 syl/secfor 41- to 50-year-olds and 2.72 in 51- to 60-year-old group. According to previous studies, DDK declines with age, however in our study, which included participants ranging in age from 61 to 80 years, we found no evidence of an age difference in DDK. The current finding is mostly counterintuitive to the notion that the DDK rate will progressively decline with the increase of age even in elderly. The trends clearly showed that between the ages of 61 to 80 years, there were no appreciable decline in AMRs and SMRs. This may indicate that the articulatory control to perform AMR and SMR tasks does not decline in the elderly and this might be due to a resilient articulatory motor system that may compensate for age related decline in the motor performance of other speech subsystems. The current acoustic finding of unchanged DDK rate in the subgroups of the elderly population needs to be further researched, replicated and confirmed with physiological studies to understand the age specific decline in the articulatory motor control.

The current study's findings showed that there was no statistically significant difference between DDKava and DDKsla as a factor of age. The findings are not in consonance with the previous reports of DDK measurement in adults (John et al., 2014; Padovani et al., 2009). In their 2009 study, peak intensity coefficient of variation (DDKcvi%), Padovani et al. reported that there were no differences between the groups in terms of rate variability, which is likely a result of the individuals' good health. However, when peak intensity was taken into account, the elderly adults group showed significant variability (/p/=2.38, /t/=2.24, /k/=2.42, / pətəkə /=3.23). This might suggest a difficulty in controlling intensity and is likely caused by age-related deviations like spindled glottal chink and intrinsic laryngeal muscles atrophy, which reduce the biomechanical efficiency of the entire system. When the characteristics of DDK are compared across age groups, it is shown that DDKcvi are in an ascending trend for both genders with the growing age band, according to a study done by John et al. (2014). these Age-related voice differences are predicted by an increasing trend in the coefficient of variance in disturbance and intensity.

1. b) Effect of gender on AMRs and SMRs.

As per the results, there was an effect of gender on AMRs and SMRs and hence the null hypothesis was rejected. The average DDK rate (DDKavr) was higher for men in the age ranges of 61 to 70 and 71 to 80 years compared to age-matched female participants. However, it was significant only for the 61-70 age group, but not for 71-80 years. Findings of the current investigation has been supported from a previous study carried out on adult population (Deyliski & Gress, 1997; John et al., 2014). Deyliski & Gress

(1997) studied 18- to 60-year-old and found that there was a significant difference in gender for DDK tasks. John et al., (2014) also showed gender effect for both DDKavr and DDKavp in 51–60 years, with males showing higher values than females.

The findings were in dissonance with another study by Patil and Manjula (2014), who reported no effect of gender on AMRs and SMRs. They conducted a study on 400 participants, in the age range of 20-60 years. Results revealed that the Average DDK Period (DDK avp) results indicate no differences across the various age groups in either men or females, and no impact of gender as evidenced by no statistically significant differences between males and females. Similar to DDK avp, DDK avr also did not significantly differ by age or gender. It is to be noted that none of the earlier studies have investigated the DDK variations across subgroups of elderly population (> 60 years) and the results of this study is being supported only from those investigations which were carried out on adult population upto the age of 60 years.

In the current study, it was discovered that the intensity parameters, DDKava and DDKsla, were higher in males than in females across all assessed AMRs (/p/, /t/, and /k/). This is further supported by John et al (2014) and Deyliski et al. (1997) who also showed such trends when DDK was compared for its intensity variation (for e.g., DDKcvi). This indicated that males had poor overall control of intensity compare to females while repeating rhtymic sequences such as that of DDK.

2. a) Effects of age on F2 transition

The current findings of this study did not show any effects of age on the parameters measured for F2 transitions such as F2magn and F2rate. This indicated that the articulatory movements that occur on a horizontal plane while transiting for the vowels did not change as a factor of age. By this, it could be inferred that speed and extent of articulatory motions remain consistent even in the elderly population studied in this investigation. However, in case of F2 average there was a gender effect with females having an increased F2 compared to males. The findings are in consonance with Deliyski and Gress (1997). Deliyski and Gress (1997) reported to no age effect for F2mang and F2rate. But differences were reported for F2average where the trend was similar to our study. An increased F2 average is naturally expected given a longer vocal tract of females compared to males. The current findings goes against the data reported by Patil and Manjula (2014) where age effect was reported for F2 magnitude and average F2 values. Younger adult group had higher overall F2 magnitude and F2 average in their study.

2. b) Effects of gender on F2 transitions

In our study, gender effect was observed for all the measured parameters wherein females showed higher F2 magnitude and males showed higher F2 rate. With regard to the F2 average values, females showed higher F2 averaged compared to males. As per Patil and Manjula (2013), in adults, F2 rate was observed to be higher for females compared to males. However, here we have obtained a reverse trend where males showed higher F2 rate. These differences in findings may hint for possible language related variations of articulatory movements. Nevertheless, the data which we are comparing here is with regard to adult population and not for the elderly as there are no contemporary investigations that have studied the formant frequency variations in elderly using vowel transition task. The current findings are in line with John et al., (2014) study where females were observed to have higher F2magn than male speakers. Male speakers did show higher F2rate in the young adult group, but a decreased F2rate was seen with increase in age. F2aver revealed higher values for females compared to male.

In the third objective, the results of the current investigation with a previous study carried out on adults who were native Kannada speakers (John et al., 2014)

3.a) Effect of age on DDK parameters between young adults and elderly group.

Only the younger group of the previous study differed in their DDKavp compared to the elderly participants of our study. After 50 years the average DDK period did not change between the adults and elderly population. This might suggest that the DDKavp in the native Kannada-speaking population has not changed after 50 years. This indicated that the time taken to produce the repetitive syllables was comparable between older adults and the elderly population.

With regard to the DDK rate, there was a significant deviation compared to the previous study. The earlier study showed a decrease overall trend of DDK rate, however, a higher DDK rate was seen across the elderly subgroup of this study. The trend of our study's findings is supported by Patil and Manjula's (2014) report that the DDK rate in telugu adult groups did not change with age. The difference could be attributed to the differences in the recording procedure of our study with the study of John et al., (2014) where they have used both live as well as offsite recording to measure the DDK parameters.

3. **b) Effect of gender on DDK parameters between young adults and elderly group**

In our study, gender effect was observed for DDKavp and DDKrate. Wherein, females showed higher DDKavp and males showed greater DDKrate. For males, Findings were intriguing as the 51–60-year-old participants had longer DDKavp compared to the elderly subgroups of this study. whereas for females, Overall differences revealed that the DDKavp of the elderly group for females were significantly longer than the younger age groups reported in the previous study. With respect to DDK rate, the past study revealed a declining trend across the genders. However, in our study there was no much decline in DDK rate. This finding needs further replication with larger samples. However, the current finding of our study aligns with Patil & Manjula (2014) where age effect of declining DDK rate was not observed in their participants who were native telugu speakers. We hypothesize that dialectal variations between ours and John et al's study (Udupi/Mangalore Kannada dialect-though not specified in their study) may be one of the covarying factors that might have led to these differences.

4. **a) Effects of age on F2 transition parameters between young adults and elderly group**

The current findings of this study did not show any effects of age on the parameters measured for F2 transitions such as F2magn, F2rate and F2aver. The magnitude of F2 transition was lower for elderly population compared to the young adults of the previous study and showed decreasing trend in F2magn. With regard to F2 rate, elderly subgroups showed lower F2 rate variations compared to the adult subgroups of the previous study and declined trend was noted in F2 rate as the age increases. Average F2 was higher for 41–50-year-old participants. When the findings are observed across studies, a steep decline in average F2 values were seen after the age of 50, and the elderly group had the lowest average F2 value compare to adult groups.

4.a) **Effects of gender on F2 transition.**

In our research, we observed gender effects across all the measured parameters. Specifically, females exhibited a higher F2 magnitude, while males demonstrated a higher F2 rate. In terms of the F2 average, females exhibited a higher F2 average compared to males.

With regard to F2 magnitude, both genders in the elderly cohort displayed lower F2 magnitudes in comparison to the adult group. This suggests that the articulatory movements involved in transitioning between vowels on a horizontal plane remain consistent regardless of age.

With regard to rate F2 variations, females showed a declining F2 rate compared to young adult group. This indicated that the rate of tongue movements was slower in the female elderly population. In males, though adult group showed slower F2 rate with increase in age till 60 years, but further increase in age, which is in our study, did not show a decline in F2 rate. This indicated that male population still maintained the rate of tongue movements even when the age is increasing. This is an intriguing finding and goes against the trend observed for females where F2 rate showed decline even in the elderly cohorts. Jacewicz (2009) found that men spoke on an average with a slightly higher articulatory rate than women which is in agreement with the current findings.

Notably, among males, the elderly subgroup in our study displayed a significant decrease in average F2 compared to values reported in a previous study for adults. Similarly, among females, the average F2 of the elderly group was significantly lower than that of the younger age groups reported in the previous study.

CHAPTER VI

Summary and Conclusions

The aim of the current study was to determine the effectiveness of maximal articulatory task performance in healthy Kannada speaking elderly population who were 61 to 80 years old (61-70 and 71- 80 years). The subject group consisted of 60 healthy participants, equally split between males and females. In order to exclude any communication issues, preliminary evaluations of speech, hearing, and voice were performed. Following the Motor Speech Profile's recommended protocol both Diadochokenetic rate (DDK) and second formant transition (F2) parameters were analysed for the elderly participants of this study. Following were the conclusion drawn from this study using the MSP protocol.

The key inferences that may be made from the findings are:

1) Diadochokenetic Rate:

A. AMR /Pə/:

- The mean Average DDK Period **(**DDK avp) was higher in 61-70 years age group than 71 to 80 years. However, no significant effect of age was seen statistically. Significant gender difference was seen where females had higher mean DDKavp compared to males was observed. No age effect was observed for the mean DDK rate (DDKavr) however, male participants showed higher DDKavr than female cohorts. No age effect was noted even for average Intensity of DDK sample (DDKava). But males showed higher values of DDKava in 61 to 70 years and the trend was reversed for females in 71 – 80 years of age. Average syllabic intensity (DDKsla) was more in 61 to 70 group than 71 to 80 year group but no age effect was observed. For gender, males had higher DDKsla than females and the gender effect was highly significant.

- AMR /Tə/: The Average DDK Period **(**DDK avp) was more in 61-70 years age group than 71 to 80 years. For gender, females showed longer DDKavp than males. However, no significant effect of age was seen but significant gender difference was observed for average DDK period. The Average DDK rate **(**DDKavr) was more in 61-70 years age group than 71 to 80 years. With regard to gender, DDK rate was found to be higher for males than females, however, no significant effect of age was seen but significant gender difference was noted. The Average Intensity of DDK sample (DDKava) was more in 61-70 compared to 71- to 80-year-old group but failed to show statistical significance. The effect of gender on DDKava showed high statistical significance only for the age group of 61 to 70 but not for 71 to 80 years despite the median scores were higher for males compared to females across the age ranges. Average syllabic intensity (DDKsla) was more in 61-to-70-year group than 71 to 80 years. For gender, males across the age groups showed greater DDKsla values than females and this was significant only for 61 to 70 years but not for 71-to-80-year elderly group.

- AMR /Kə/: The Average DDK Period **(**DDK avp) was more in 61-70 years age group than 71 to 80 years but not statistically significant. With regard to gender, despite the median values were higher in the females, did not show any effect of gender across the age groups. The mean DDK rate (DDKavr) was more in 71-to-80-year group than 61-to-70-year group but failed to show age effects. There was no gender effect too across the age ranges. The Average Intensity of DDK sample (DDKava) was found to be more for 61-70 than 71–80-year-old group but age effect was not significant. Gender effect was highly significant where males had higher DDKava than females. The Average syllabic intensity (DDKsla) was more in 61-to-70-year group than 71- to 80-year-old group, but age effect was insignificant. With regard to gender, males had higher DDKsla than females.

Sequential Motion Rates (/pə//tə//kə/)

- The mean of the Average DDK Period **(**DDKavp) was more in 61-to-70-year group than 71-to-80-year group but no age effect was seen. For gender, Despite the median values for the females were higher throughout the age groups when compared for DDKavp, the differences were only significant for the former age group with no such differences observed for the latter.

- The mean DDK rate (DDKavr) was higher for 71 to 80 years than 61 to 70 years, but did not reach statistical significance. For gender, comparison of DDKavr, males showed higher overall speed in the production of SMRs compared to females across the age groups and gender effect was significant.

- The Average Intensity of DDK sample (DDKava) was more in 71 to 80 years than 61 to 70 years but it was not significant. DDKava showed gender effect only for 61-70 years indicating higher sample intensity for males compared to females, with no gender differences emerging for the 71–80 years age group.

- Average syllabic intensity (DDKsla) was found to be more in 61 to 70 years than 71-to-80-year group but age effect was not seen. DDKsla analysis showed gender effect only for 61-70 years indicating higher syllabic intensity for males compared to females, with no gender differences emerging for the 71–80 years age group.

a) Second Formant Transition:

- The mean magnitude of F2 variation (F2magn) was found to be higher in 61- to 70-year-old age group than 71 to 80 years but no age effect was seen. Gender effect was observed and females showed higher F2magn than males.

- Rate of F2 variation (F2rate) was found to be more in 61 to 70 years than 71 to 80 years, but the age effect was not present. With regard to gender effect, males showed higher F2rate compared to females across the elderly age groups, which was statistically significant.

- Average F2 was more in 61 to 70 years than 71 to 80 years. However, age effect was not observed. With regard to gender, statistically highly significant differences for gender across age groups was seen, But these differences were limited only for 61-70 but not observed for 71-80 years.

Limitations of the study:

1. Number of participants considered in the current study was 60 and therefore future studies can increase the sample size and develop the normative for the elderly.

2. The speaking rate was not correlated with DDK measures undertaken in this study.

3. The measured parameters of this study cannot be assessed without using Motor speech profile protocol.

Future Directions:

1. The current study was done on individuals between the age range of 61 to 70 and 71 to 80 years, inclusion of elders above 80 years could have yielded more information on the deterioration.

2. Future research must look at dialect-specific variations in the DDK after seeing some disparities between our study and a previous study, which is covered in the third objective.

3. To distinguish the articulatory control with regard to age-related differences, the current findings must be compared with impaired speech motor control.

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APPENDIX I

ಅಖಿಲ ಭಾರತ ವಾಕ್ ಮತ್ತು ಶ್ರವಣ ಸಂಸ್ಥೆ, ಮೈಸೂರು-06.

ಒಪ್ಪಿಗೆ ಪತ್ರ.

ಭಾಗವಹಿಸುವವರಿಗೆ/ಪಾಲಕರಿಗೆ ಮಾಹಿತಿ.

ನಾನು, ಕುಮಾರ ಶಶಾಂಕ್ ಡಿ, ದ್ವಿತೀಯ ವರ್ಷದ ವಾಕ್ ಮತ್ತು ಭಾಷಾ ತಜ್ಞ ವಿದ್ಯಾರ್ಥಿ, ನನ್ನ ಮಾಸ್ಟರ್ಸ್ ಸಂಶೋಧನಾ ಕಾರ್ಯಕ್ರಮದ ಭಾಗವಾಗಿ, ಆರೋಗ್ಯವಂತ ವಯಸ್ಕರಲ್ಲಿ "ಆರೋಗ್ಯಕರ ಕನ್ನಡ-ಮಾತನಾಡುವ ಹಿರಿಯ ಜನಸಂಖ್ಯೆಯಲ್ಲಿ ಗರಿಷ್ಠ ಉಚ್ಚಾರಣಾ ಕಾರ್ಯ ನಿರ್ವಹಣೆಯ ಪರಿಣಾಮಗಳು", ಡಾ. ಬಿ, ವಿ, ಎಂ, ಮಹೇಶ್. ಸ್ಪೀಚ್ ಪೆಥಾಲಜಿಯಲ್ಲಿ ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕ. ವಾಕ್-ಭಾಷಾ ವಿಭಾಗ, ಅಖಿಲ ಭಾರತ ವಾಕ್ ಮತ್ತು ಶ್ರವಣ ಸಂಸ್ಥೆ, ಮೈಸೂರು. ಅವರ ಮಾರ್ಗದರ್ಶನದಲ್ಲಿ ಈ ಅಧ್ಯಯನವನ್ನು ತೆಗೆದುಕೊಳ್ಳಲಾಗಿದೆ. ಅಧ್ಯಯನವು ಪ, ಟ, ಕ, ಪ ಟ ಕ, ಇ-ಉ, ಎಂದು ಗರಿಷ್ಟ ಉಚ್ಚಾರಣೆಯಲ್ಲಿ ಹೇಳಬೇಕು ಹಾಗೆ ಒಂದು ಉಸಿರಿನಲ್ಲಿ ಆ... ಎಂದು ದೀರ್ಘವಾಗಿ ಹೇಳಬೇಕು. ಕಾರ್ಯವಿಧಾನವು ಹಾನಿಕರವಲ್ಲ ಮತ್ತು ಕೇವಲ ಸಂಶೋಧನಾ ಪ್ರಯೋಜನಗಳನ್ನು ಹೊಂದಿದೆ ಮತ್ತು ಭಾಗವಹಿಸುವವರು ಅದರಿಂದ ಯಾವುದೇ ಹಣಕಾಸಿನ ಪ್ರಯೋಜನಗಳನ್ನು ಪಡೆಯುವುದಿಲ್ಲ. ಮೌಲ್ಯಮಾಪನ ಅವಧಿಗಳನ್ನು ಆಡಿಯೋ ರೆಕಾರ್ಡ್ ಮಾಡಲಾಗುತ್ತದೆ ಮತ್ತು ಅದನ್ನು ಶೈಕ್ಷಣಿಕ ಉದ್ದೇಶಗಳಿಗಾಗಿ ಬಳಸಲಾಗುವುದು. ಆದ್ದರಿಂದ ನಿಮ್ಮ ಗುರುತು ಮತ್ತು ಈ ಡೇಟಾವನ್ನು ಗೌಪ್ಯವಾಗಿಡಲಾಗುತ್ತದೆ ಎಂಬ ಭರವಸೆಯೊಂದಿಗೆ ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ನಾನು ನಿಮ್ಮನ್ನು ವಿನಂತಿಸುತ್ತೇನೆ. ನಿಮ್ಮ ಭಾಗವಹಿಸುವಿಕೆಗೆ ತನಿಖಾಧಿಕಾರಿ ಅಥವಾ ತನಿಖಾ ಸಂಸ್ಥೆಯಿಂದ ಯಾವುದೇ ರೀತಿಯ ಪ್ರಭಾವ ಅಥವಾ ಒತ್ತಡವಿಲ್ಲ.

ಅಧ್ಯಯನದಲ್ಲಿ ನಿಮ್ಮ ಸಹಕಾರವು ವಯಸ್ಸಾದ ವಯಸ್ಕರಲ್ಲಿ ಗರಿಷ್ಠ ಉಚ್ಚಾರಣಾ ಕಾರ್ಯ ನಿರ್ವಹಣೆಯ ಪರಿಣಾಮಗಳು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ನಮಗೆ ಸಹಾಯ ಮಾಡುತ್ತದೆ.

ಭಾಗವಹಿಸುವಿಕೆಗೆ ಸಮ್ಮತಿ ಪತ್ರ

ಅಧ್ಯಯನದ ಗುರಿಗಳು, ಉದ್ದೇಶಗಳು ಮತ್ತು ಕಾರ್ಯವಿಧಾನದ ಬಗ್ಗೆ ನನಗೆ ತಿಳಿಸಲಾಗಿದೆ. ಅಧ್ಯಯನದಲ್ಲಿ ಮಾನವ ವಿಷಯವಾಗಿ ನನ್ನ ಭಾಗವಹಿಸುವಿಕೆಯ ಸಂಭವನೀಯ ಅಪಾಯ-ಪ್ರಯೋಜನಗಳನ್ನು ನಾನು ಸ್ಪಷ್ಟವಾಗಿ ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ. ಯಾವುದೇ ಸಮಯದಲ್ಲಿ ಭಾಗವಹಿಸುವಿಕೆಯನ್ನು ನಿರಾಕರಿಸುವ ಅಥವಾ ನನ್ನ ಸಮ್ಮತಿಯನ್ನು ಹಿಂತೆಗೆದುಕೊಳ್ಳುವ ಹಕ್ಕನ್ನು ನಾನು ಹೊಂದಿದ್ದೇನೆ ಎಂದು ನಾನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ನಾನು ಈ ಮೂಲಕ ನನ್ನ ಸಂಪೂರ್ಣ ಸಮ್ಮತಿಯನ್ನು ನೀಡುತ್ತೇನೆ.

ನಾನು, ____, ಕೆಳಗೆ ಸಹಿ ಮಾಡಿದ್ದೇನೆ, ಈ ಅಧ್ಯಯನದಲ್ಲಿ

ಭಾಗವಹಿಸಲು ನನ್ನ ಒಪ್ಪಿಗೆಯನ್ನು ನೀಡುತ್ತೇನೆ.

ಭಾಗವಹಿಸುವವರ/ಆರೈಕೆದಾರರ ಸಹಿ   ಪರಿಶೋಧಕನ ಸಹಿ

ಹೆಸರು, ವಿಳಾಸ, ಮತ್ತು ದೂರವಾಣಿ ಸಂಖ್ಯೆ:   ದಿನಾಂಕ:

APPENDIX II

ಅಖಿಲ ಭಾರತ ವಾಕ್ ಮತ್ತು ಶ್ರವಣ ಸಂಸ್ಥೆ. ಮೈಸೂರು

ಪರಿಶೀಲನಾಪಟ್ಟಿ

ಹೆಸರು: ದಿನಾಂಕ:

ವಯಸ್ಸು: ಭಾಷೆ:

ಸ್ಥಳ:

1. ನಿಮಗೆ ಯಾವುದೇ ರೀತಿಯ ಮಾತು ಅಥವಾ ಭಾಷೆಯ ತೊಂದರೆ ಇದೆಯೇ?

   ಹೌದು/ಇಲ್ಲ.

2. ನಿಮಗೆ ಯಾವುದೇ ರೀತಿಯ ಅರೋಗ್ಯ ಸಮಸ್ಯೆ ಇದೆಯೇ?

   ಹೌದು/ಇಲ್ಲ.

   ನಿಮ್ಮ ಉತ್ತರ ಹೌದು ಎಂದಾದರೆ, ವಿವರಿಸಿ.

   ನಿಮ್ಮ ಆರೋಗ್ಯ ಸಮಸ್ಯೆಗೆ ಸೂಕ್ತ ಚಿಕಿತ್ಸ/ಔಷದ ತೆಗೆದುಕೊಳ್ಳುತಿದೀರಾ?

   ಹೌದು/ ಇಲ್ಲ'

3. ನಿಮಗೆ ಯಾವುದೇ ರೀತಿಯ ಮರೆವಿನ ಸಮಸ್ಯೆ ಇದಿಯೇ?

   ಹೌದು/ಇಲ್ಲ.

4. ನಿಮಗೆ ಕಿವಿ ಕೇಳಿಸಿಕೊಳ್ಳುವುದರಲ್ಲಿ ಸಮಸ್ಯೆ ಇದಿಯೇ?

   ಹೌದು/ಇಲ್ಲ.

5. ನಿಮಗೆ ಹಲ್ಲಿನ ಸಮಸ್ಯೆ ಇದಿಯೇ?

ಹೌದು/ಇಲ್ಲ.

ನಿಮ್ಮ ಉತ್ತರ ಹೌದು ಎಂದಾದರೆ, ವಿವರಿಸಿ.

ಅದಕ್ಕೆ ಸೂಕ್ತವಾದ ದಂತಕವಚ ವಸ್ತುಗಳನ್ನು ಬಳಸುತ್ತಿದ್ದೀರಾ?

ಹೌದು/ಇಲ್ಲ.

6. ನಿಮಗೆ ಯಾವುದೇ ರೀತಿಯ ನರ ಸಂಬಂಧಿತ ಸಮಸ್ಯೆ ಇದಿಯೇ?

ಹೌದು/ಇಲ್ಲ.

ಯಾವುದೇ ಸಂಬಂಧಿತ ಇತಿಹಾಸ: