

Effect of Age on Formant Frequencies in Kannada Speakers



V. Namitha, V. Namratha, and R. Rajasudhakar

Abstract Formants are the concentration of the acoustic energy around a frequency in the speech wave. Kaur and Narang (1) have noted the variation of pitch and formants in the different age groups in the English language. The current study aimed to find the relation between the aging and formant frequency (F1 and F2) in the Kannada language. The methodology of the study involved eight males and eight females (2 of 8–10 years of age, 2 of 18–20 years of age, 2 of 48–50 years of age, and 2 of above 60 years of age) who were native Kannada speakers. The participants were instructed to repeat the non-sense words V1CV2 in which V2 was /a/always. V1 consisted of three short vowels and three long vowels. The non-sense words used were aka, ika, uka, a: ka, i:ka, and u:ka. The subjects were asked to repeat thrice. In total, 288 tokens were collected for the study. The speech sample is recorded in the Praat software in an acoustically treated room and being the microphone placed 3 cm away from the mouth. The mean of the F1 and F2 of the steady part of the initial vowel (V1) excluding the onset and offset of the three trials is considered. Then, the F1 and F2 were compared across the age group and gender. The present study found that the F1 and F2 decrease as age increases in both males and females.

Keywords Formant frequency · Vowels · Kannada · Acoustic analysis · Aging effect

1 Introduction

Fant (1960) defines formant as the spectral peaks of the sound spectrum $IP(f)$. It corresponds to resonant frequencies or pitch overtones of the vocal tract for articulating different types of voiced sounds, most notably vowels. The first peak in the vowel spectra is referred to as first formant frequency (F1) and the second peak in the spectra is referred to as second formant frequency. The specific formants F1 and F2 are typically evaluated for comparison of different vowels. F1 is the lowest

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formant and is inversely related to vowel height (or how close the tongue is to the roof of the mouth); the difference between F1 and F2 correlates roughly with tongue advancement.

Each human being goes through the process of aging. Our voice and speech patterns change from early childhood to old age. It is well known that acoustic and linguistic characteristics of children's speech are widely different from those of adult speech. Furthermore, characteristics of children's speech vary rapidly as a function of age due to the anatomical and physiological changes occurring during a child's growth and because children become more skilled in co-articulation with age.

Many researchers in the field of speech acoustics have studied the effects of age on the formants. Robb et al. (3) studied the developmental aspects of formant frequency and bandwidth in infants and toddlers. A cross-sectional study was done on 20 children who were in the age range of 4–25 months. The authors concluded that there was a slight rise in F1 at age of 18 months and average F1 and F2 values changed a little while the average bandwidths for F₁ (B₁) and F₂ (B₂) were found to significantly decrease as the age increases.

Sreedevi [6] studied formant frequency in three different age groups from children to adults in Kannada-speaking individuals. The sentences which had meaningful disyllabic test word (C1V1C2V2) with a carrier phrase were used for the study and results revealed that the formant frequencies (F1, F2, and F3) decreased from children to adolescents markedly and there was a further gradual decrease in adults. Further, the author noticed that there was a larger drop in F2 and F3 than in F1 from children to adults.

Mwangi et al. (2) studied the effect of vocal aging on the fundamental frequency and the formant in a longitudinal study wherein the speech of the Queen Elizabeth II's was considered over 50 years of age was considered. The results of this study revealed that vocal aging causes the decline of the fundamental frequency (F0) and first formant frequencies (F1) while second and third formants do not have an influence on aging.

Kaur and Narang [1] had studied the variation of pitch and formants in the different age groups in the English language. They analyzed the first three formants of vowels produced by the child, younger, and older of the same gender. This study showed that the child's formants are found to be higher than adults and it was more scattered. The older speakers had a significantly greater and larger numbers of inflections than the younger persons. The older women exhibit significantly higher minimum and significantly lower maximum intensity than the younger women. The voice of the aged female is characterized by a decrease in fundamental frequency.

Eichhorn et al. (4) aimed to study the effect of aging on vocal fundamental frequency (F0) and the vowel formants in men and women. Authors considered 96 participants (43 males and 53 females) who were in the age range of 20–90. The results indicated that as age increases there was a significant decrease in F0 in women. Significant differences in F1, F2, and F3 were noticed between vowels and gender. No significant differences in women were observed for the highest fourth formant (F4). The authors concluded that the women experience a significant decrease in F0, which is likely related to menopause.

From the above studies, it is clear that the effect of aging and development on formant frequencies in Indian languages are very few. Hence, the need of the present study arise.

2 Aim of the Study

The present study made an attempt to determine the effect of age on formant frequencies (F1 and F2) in Kannada-speaking individuals.

2.1 Method

Participants: The study involved eight males and eight females. They were divided into four age groups. Group I included four children of 8–10 years of age; Group II included the young adolescents of four in number whose age was between 18 and 20 years; Group III consisted of four subjects of 48–50 years of age; and Group IV consisted four subjects of above 60 years of age who were native Kannada speakers. Each group had two males and two females. Also, all the participants had Kannada as their mother tongue. Also, the participants did not report of any speech, language, and hearing difficulty at the time of study.

Material: The participants were instructed to repeat the non-sense words (V1CV2) in which V2 was always /a/. V1 consisted of three short vowels and three long vowels (aka, ika, uka, a: ka, i: ka, u:ka). V1 was succeeded always by the consonant /k/in the middle of the non-sense word. Hence, a total of six non-sense words were considered as material for the study.

Procedure: The objectives of the study were explained to the participants and informed written consent was obtained from them. All the participants were tested individually in a noise-free room. Participants were asked to repeat each non-sense word thrice in a normal rate. PRAAT software was used to record the samples by using a laptop (Lenovo G500). The microphone to mouth distance was maintained as 10 cm constantly for all the participants. A total of 288 tokens (16 participants × 6 vowels × 3 repetitions) were made for the study.

Analysis: The first (F1) and second (F2) formant frequencies were extracted by using PRAAT software. The steady portion of the vowel (V1) was selected to measure F1 and F2, excluding the onset and offset of the vowels. The average of the F1 and F2 was calculated by averaging the three repetitions for each participant and each of the vowels. Then the F1 and F2 were compared across the age groups and gender.

3 Results and Discussion

The results of the present study are discussed under the following three sub-headings:

- (a) First formant frequency (F1) across different age groups,
 - (b) Second formant frequency (F2) across different age groups,
 - (c) Gender difference in F1 and F2, and
- (a) F1 across different age groups.

Table 1 shows the average F1 values for both short and long vowels between males and females across different age groups. From Table 1, the average F1 values were higher for low vowel /a/when compared to vowels /i/and /u/(high vowels). Also, average F1 values tend to decrease from Group I to Group IV, that is, as age increases, the F1 value decreases.

The present study found that low vowel (/a/) had high F1 value compared to high vowels (/i/& /u/). This was observed in both short and long vowels and across both genders. The results of the present study are in consonance with the findings of Fant (1960) study who reported F1 is inversely proportional to tongue height. That is, when the height of the tongue is low, F1 would be higher and when the tongue height is high, the F1 would be lower. The results of present study are in consonance with the findings of Abolhasanizadeh, Karimabadi, Ayazi, and Moghadam’s (2014) where they found that F1 decreases with age.

- (b) F2 across different age groups

Table 2 shows the average F2 values for both males and females across different age groups. From Table 2, it can be observed that F2 values were lower for back vowel (/u/) when compared to mid and front vowels /i/. The front vowel (/i/) had the highest F2 value compared to mid /a/and back vowel (/a/). This was observed in both short and long vowels and in both genders. Also, average F2 values tend to

Table 1 Average F1 of short and long vowels across different age groups and genders

Groups	Gender	F1 value in Hz					
		Short vowels			Long vowels		
		/a/	/i/	/u/	/a:/	/i:/	/u:/
Group I	M	1004	405	475	1125	395	439
	F	1105	375	485	1173	326	526
Group II	M	683	336	748	1377	2129	876
	F	895	420	467	946	373	490
Group III	M	642	470	453	765	400	464
	F	950	464	501	1092	398	504
Group IV	M	664	324	440	820	332	383
	F	740	367	427	760	406	464

Table 2 Average F2 of short and long vowels across different age groups and genders

Groups	Gender	F2 value in Hz					
		Short vowels			Long vowels		
		/a/	/i/	/u/	/a:/	/i:/	/u:/
Group I	M	1703	1636	1329	1782	1853	1147
	F	1378	1651	876	1497	1729	1008
Group II	M	723	2289	384	1256	2253	1519
	F	1478	2679	1008	1387	2610	1005
Group III	M	1347	2274	963	1355	2452	807
	F	1574	2501	1096	1444	2180	1088
Group IV	M	1225	2386	1002	1214	2420	799
	F	1394	2266	941	1390	2348	950

decrease from group I to group IV. That is, as age increases, the F2 value decreases. The results of present study are in consonance with the findings of Abolhasanizadeh, Karimabadi, Ayazi, and Moghadam (2014), where they also reported reduced F2 values as a function of age (increase in age leads to decrease in F2 values).

The present study found that front vowel (/i/) had higher F2 value compared to back vowel (/u/). The F2 value of mid vowel (/a/) occurs between vowels /i/and /u/. This was observed in both short and long vowel counterparts. The results of the present study are in agreement with the findings of Fant (1960) where study reported that F2 is directly proportional to tongue advancement in the oral cavity. That is, more the tongue advanced/placed front as in case of high vowel (/i/), higher the F2 value.

The present study also found that average F1 and F2 values reduce (from group I) when age is increased further. The formant frequency depends on the size of the oral cavity. When the oral cavity size is small (in children), the resonance/formants would be higher. As the person grows further, the volume/size of the oral cavity becomes matured and increased, thereby reducing the resonance/formant frequency values.

(c) Gender difference

From Tables 1 and 2, the values of F1 and F2 were relatively higher for females compared to males. This was observed for both short and long vowels. The higher F1 and F2 values in females can be attributed to the source characteristics, that is, the fundamental frequency of voice is higher in females compared to males and further the resonance peaks would accordingly have amplified higher in them due to smaller vocal cavity (in females). The results of this study are in agreement with findings of Abolhasanizadeh et al. (5) and Sreedevi [6] which showed F2 values of vowels in females are more than that in males.

4 Summary and Conclusion

The present study aimed to analyze the change in formant frequencies across different age groups. The study considered four group of participants including children, adolescents, adults, and geriatric people as Group I, Group II, Group III, and Group IV, respectively. Subjects were asked to read six non-sense words. Using PRAAT, first formant frequency (F1) and second formant frequency (F2) were measured from the initial vowel of the non-sense word. The results showed that F1 and F2 were higher in females and as age increases F1 was reduced considerably than F2. As age increases, the anatomical structure of the vocal tract undergoes modifications and accordingly F1 and F2 values change. The results of the present study are not in consonance with results of previous study due to methodological differences.

5 Limitations

The present study considered less number of participants so to generalize the present findings will be difficult to whole population. Hence, more number of participants can be included in future study.

6 Future Direction

1. Study can be repeated with more number of subjects and different age groups.
2. Methodology can be adopted to study the formant changes in other Indian languages.

Acknowledgments We would like to thank Dr. Asha Yathiraj, Director, AIISH, Mysuru, for permitting us to carry out this study. Our heartfelt thanks to all participants in the study.

References

1. Kaur J, Narang V (2015) Variation of pitch and formants in different age group. *Int J Multi Res Modern Edu* 1:517–521
2. Mwangi S, Spiegl W, Honig F, Haderlein T, Maier A, Noth E (2009) Effects of vocal aging on fundamental frequency and formants. In: Marinus M. Boone (ed) *Proceedings of the international conference on acoustics NAG/DEGA 2009*. N.A.G, Rotterdam, pp 1761–1764
3. Robb MP, Chen Y, Gilbert HR (1997) Developmental aspects of formant frequency and bandwidth in infants and toddlers. *FoliaPhoniatica etlogopaedica* 49:88–95
4. Eichhorn JT, Kent RD, Austin D, Vorperian HK (2017) Effects of aging on vocal fundamental frequency and vowel formants in Men and Women. *J Voice*. ISSN 0892-1997

5. Abolhasanizadeh V, Karimabadi H, Ayazi E, Sharifi Moghadam A (2014) The effect of age and sex on the acoustic characteristics of speech, *language design* 16:105–116
6. Sreedevi N (2000) Acoustic characteristics of vowel in Kannada. Submitted to the University of Mysore, Mysuru, Karnataka