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Speaking Fundamental Frequency Values in Typical Malayalam English Bilingual Speakers

Smriti Joy¹, Dr. Satish Kumaraswamy²

¹Final Post Graduate Student, Dr. M.V. Shetty College of Speech and Hearing, Malady Court, Kavoor, Mangalore-15

²Ph.D. in Speech and Hearing, Dr. M.V. Shetty College of Speech and Hearing, Malady Court, Kavoor, Mangalore-15

Abstract:

Speaking fundamental frequency (SFF) is an important parameter for evaluating vocal characteristics in bilingual populations. This study aimed to establish normative SFF values for Malayalam-English bilinguals, aged 18-25 years, focusing on gender differences and variations across languages (Malayalam and English) and task types (reading vs. spontaneous speech). A total of 40 participants completed both reading and spontaneous speaking tasks in both languages. The findings revealed significant gender differences, with females exhibiting consistently higher SFF values than males. However, no significant differences were observed between languages or task types. These results provide normative SFF data for young Malayalam-English bilinguals, which can serve as a reference for future studies investigating vocal patterns in bilingual populations. The study highlights the need for further research with larger and more diverse samples to enhance understanding of vocal characteristics in different linguistic contexts.

Keywords: Speaking fundamental frequency (SFF), Malayalam English bilinguals, Gender Differences, Reading Task, Spontaneous Speech, PRAAT

1. Introduction:

Communication occurs through various modalities, including speaking, listening, thinking, and writing, all depending on language and speech. During speech production, the articulators and vocal tract actively move, with the type of articulation shaped by both the structure of the vocal tract and the language being spoken (Daniloff & Moll, 1968; Kearney & Guenther, 2019). The human voice serves as a primary means of expression, not only shaping how we communicate and connect but also providing the acoustic foundation for spoken language. Vocal characteristics, such as fundamental frequency (f0), are primarily determined by the length, tension, and mass of the vocal folds, along with subglottic pressure. A higherpitched note is produced when the vocal folds vibrate more quickly due to an increase in tension and a decrease in mass. Conversely, when the vocal folds are relaxed, thicker, and vibrating more slowly, the pitch is lower.

SFF or habitual pitch level in Hertz (Hz), typically varies based on individual characteristics and circumstances (Boone, McFarlane, Von Berg & Zraick, 2019). On average, adult men have an SFF of around 128 Hz, women around 225 Hz, and children approximately 265 Hz (Gelfer & Denor, 2014). Many studies have explored the variation in f0 based on gender and age (Greene & Mathieson, 1992). The average frequency at which we speak is known as the mean SFF, while the range within which typical



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speech occurs is referred to as the mean SFF range, which can significantly be influenced by linguistic factors such as speech content (Behrman, 2013).

Differences in f0 can be observed when subjects vary while speaking. For instance, a highly emotional topic may result in a different f0 compared to a bland topic. Additionally, factors such as unfamiliarity or an uneasy situation can also influence the average f0. Range of f0 is typically assessed through reading or spontaneous speaking tasks. The task appears to have an impact on the frequency values obtained, according to research findings (Zraick, Birdwell & Smith-Olinde, 2005).

Speech tasks provide a sophisticated means of examining how bilingual people interact with their languages, revealing differences in usage and skill in various settings. A diverse group of people with differing degrees of fluency in both languages are bilinguals. According to Grosjean (2012), a bilingual can be someone who can use both languages to suit their own needs. Westby and Costlow (1991) asserts that transitional bilinguals typically utilize English for social contact with the community and others but prefer their mother tongue at home and in close social ties. If a language is not frequently used with other speakers, bilingual people can rapidly lose their ability to speak it, underscoring the fluidity of bilingualism and the changes in fluency that take place in the absence of practice (Kayser, 1995).

Early studies related to SFF such as involving readings of rainbow passage revealed mixed results in SFF patterns, with English-speaking males consistently showing the lowest median SFF (Fairbanks, 1960). Cross-linguistic comparisons, such as those between Japanese and English (Loveday, 1981; Yamazawa & Hollien, 1992), British English and German (Mennen, Schaeffler & Docherty, 2012), and Mandarin and Min (Chen, 2005), emphasize how SFF reflects phonetic structures unique to each language. Chen (1972), in a small study of Mandarin and English speakers, found that Mandarin speakers, particularly women, exhibited wider F0 ranges and larger standard deviations than their English counterparts, while men's mean SFF was similar across languages. These findings suggest that SFF variability may be influenced by linguistic and sociolinguistic factors, making it a key parameter in bilingual and cross-linguistic studies. Recent studies have further explored SFF values in English and other non-Indian languages, highlighting cross-linguistic and task-based variations. For instance, Gelfer and Denor (2014) observed that SFF and pitch sigma values were stable for both African American and Caucasian children aged 6 to 8, indicating that these measurements remain consistent during the prepubescent years. Cavalcanti, Eriksson and Barbosa (2023) found that Brazilian Portuguese-speaking identical twins showed greater f0 differentiation in connected speech compared to sustained vowels, highlighting the significance of long-term f0 measurements for speaker comparison. Similarly, Abu-Al-Makarem and Petrosino (2007) found that Arabic-speaking males had higher SFF values during reading tasks than in spontaneous speech. Also, they exhibited higher SFF values than other linguistic groups.

Cross-linguistic differences in SFF measures between Korean English bilinguals were investigated by (Cheng, 2020), who discovered that F0 was higher in Korean than in English. Additionally, they noticed that spontaneous speech, especially in Korean language, more variation of F0 range was observed. Besides, a slightly higher SFF values were noted by Hollien, Hollien and Gea de Jong (1997) noted in reading tasks compared to spontaneous speech. However, differences were not strong enough for an individual prediction. Sotome, Kanazawa, Konomi, Maeara, Misawa, Takahashi, Fukaura, and Watanabe (2023) demonstrated that reading passages were reliable measurements for spontaneous speech, also making them valuable for therapeutic assessments.

Keating and Kuo (2012) discovered that while the two languages displayed more similar F0 ranges in reading passages, Mandarin speakers had a higher mean F0 and higher maximum and mean F0 values in



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single-word utterances than English speakers. Likewise, Natour and Wingate (2009) found significant differences in F0 and SFF values among adult males, females, and children in the Jordanian Arabic-speaking population. Adult males exhibited F0 values like those of Caucasian and African American males, while females and children had higher SFF values compared to their Western counterparts.

Age and gender are significant factors in determining SFF, and it is crucial to observe any changes in these variables as they can impact vocal characteristics and frequency ranges. Nishio and Niimi (2008) found that SFF decreased significantly in females beginning in their thirties and continuing into old age, with the degree of change being greater in females than in males. Males, on the other hand, just barely altered their SFF throughout the age.

Studies exploring the SFF values among the Indian population are limited. Only few studies like Soni, Jotdar, Kapoor and Singh (2023) reported that the mean f0 in males was 156 Hz (18-25 years) and 141 Hz (26-40 years), while in females, it was 262 Hz (18-25 years) and 253 Hz (26-40 years) in north Indian population. Statistically significant gender differences in SFF were observed across both age groups, with females exhibiting higher mean SFF values than males. A similar study where Indian Hindi speakers and native English speakers were compared by Paramby, Abbott, Turner, Kimble, and DeJonge (2018) in terms of f0 during vowel phonation, reading, and monologue. While the two groups' f0 during prolonged /a/ phonation did not differ considerably, Hindi speakers' f0 during reading and monolog tasks was noticeably greater than that of native English speakers.

Normative data for SFF values in Indian bilingual speakers (Telugu and English) revealed a decline in SFF from 10 to 40 years, followed by a mild increase in males and a significant drop during menopause in females, with a slight increase in later years. The study also found that language (English or Telugu) had no effect on SFF values across age groups for both male and female speakers (Akoju & Didla, 2018). Purpose of this study is to establish normative data for the SFF values in the Malayalam-English bilingual population in India. Given the limited research on this topic, the current study aims to explore gender differences and task-based variations in SFF within this bilingual group.

2. Need of the study:

SFF value, the average pitch in Hz of an individual's speech, varies based on language, task type (e.g., reading vs. spontaneous speech), and sociolinguistic factors. These variations can provide valuable insights into how bilingualism influences voice characteristics. Akoju and Didla (2018) investigated SFF in Telugu and English-speaking Indian bilinguals. They discovered differences in SFF values between age groups and the impact of spoken languages, specifically Telugu and English, on SFF value. Examining SFF in bilingual populations, particularly among Malayalam-English speakers in India, is crucial for understanding the distinct vocal patterns within this linguistic group and addressing the limited research in this area. This highlights the need for further exploration into how bilingualism affects vocal parameters, especially in the Indian context. Establishing comprehensive SFF profiles for bilingual populations is essential for enhancing clinical voice assessments and understanding the nuances of bilingual speech patterns.

3. Methodology:

3.1 Aim:

The purpose of the current study was to investigate the gender differences in SFF values among Malayalam-English bilinguals (aged 18-25) across reading and spontaneous speaking tasks in both



languages, examining how language context (Malayalam vs. English) and task type (reading vs. spontaneous speaking) influence SFF values among males and females.

3.2 Participants:

A total of 40 Malayalam-English bilingual participants (20 males and 20 females) were included in the study.

3.3 Inclusion criteria:

Participants were native speakers of Malayalam, aged between 18 and 25 years, who were proficient in English reading and writing.

3.4 Exclusion criteria:

Individuals with any known speech, language, or hearing impairments, as well as participants who do not meet the required language proficiency in English, was excluded from the study.

3.5 Procedure:

Each participant completed two speech tasks—reading and spontaneous speaking—in both Malayalam and English. For the reading task, participants read an 80-word passage in Malayalam and a 97-word English passage (Rainbow Passage). For the spontaneous task, they were asked to speak freely for 3 minutes on a given topic in both languages. All speech samples were recorded in a quiet environment using a high-quality microphone. The recordings were then analyzed using PRAAT software to extract SFF values. This analysis provided mean SFF measurements for each participant across the four conditions: Malayalam Reading, Malayalam Spontaneous speech, English Reading, and English Spontaneous speech. These values were later used for comparison across gender, language, and task type.

3.6 Statistical Analysis:

The collected data were summarized by using the Descriptive Statistics: frequency, percentage, mean, and standard deviation (SD). The Independent sample "t" test was used to compare the SFF values; between males, and females. The Paired "t" test was used to compare the SFF values between Malayalam and English. Also, to compare the SFF values of Malayalam and English; between reading and speaking as according to gender, the Paired "t" test was used. Data were analyzed by using the SPSS software version 29.0.10.

4. Results and discussion

SFF values among males and females were analyzed based on the language and task type and results and discussed below.

Table shows the gender distribution of the participants								
		Frequency	%					
Gender	Female	20	50					
	Male	20	50					

Table 4.1Table shows the gender distribution of the participants

Table 4.2

Comparison of the SFF values between males and females

	Gender	n	Mean	S.D.	"t"	p value	Significance
Malayalam-	Female	20	220.68	23.26	15.54	< 0.001*	Sig.
reading	Male	20	118.76	17.86			



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Malayalam-	Female	20	220.13	22.85	15.69	< 0.001*	Sig.
speaking	Male	20	119.20	17.49			
English-reading	Female	20	215.67	24.33	14.44	< 0.001*	Sig.
	Male	20	120.92	16.43			
English-	Female	20	215.09	24.33	13.87	< 0.001*	Sig.
speaking	Male	20	122.31	17.40			

"t" = Independent sample "t" test; * Sig = Significance

Above table summarize the comparison of SFF values based on gender. An independent sample t-test was conducted, revealing a significant difference (p < 0.05) in the SFF values for Malayalam reading, Malayalam speaking, English reading, and English speaking between males and females.



Figure 4.2 shows the comparison of the SFF values between males and females

The figure illustrates the comparison of SFF values between male and female participants during Malayalam reading, Malayalam speaking, English reading, and English-speaking tasks. Female participants consistently demonstrated higher SFF values across all conditions. The visual representation emphasizes these gender-based differences, which were statistically significant (p < 0.05) as revealed by an independent samples t-test.

Table 4.3						
Comparison of the SFF values between languages (Malayalam and English)						

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		n	Mean	S.D.	"t"	p value	Significance
Reading	Malayalam	40	169.72	55.52	0.66	0.515	NS
	English	40	168.30	52.17			
Speaking	Malayalam	40	169.66	54.91	0.41	0.681	NS
	English	40	168.70	51.41	0.41		

("t" = paired "t" test), NS = non significance



Above table and figure shows the comparison of SFF values between Malayalam and English using a paired "t" test and found that no significant difference (p > 0.05) in the SFF values of both reading and speaking; between Malayalam and English.



Figure 4.3 shows the comparison of the SFF values between languages (Malayalam and English)

The figure represents the comparison of SFF values between Malayalam and English during both reading and speaking tasks. It shows a close similarity in mean SFF values across languages, with no significant difference observed (p > 0.05). This indicates that language (Malayalam vs. English) did not significantly influence the SFF in either reading or speaking contexts.

		n	Mean	S.D.	"t"	p value	Significance
Malayalam	Reading	40	169.72	55.52	0.03	0.98	NS
	Speaking	40	169.66	54.91			
English	Reading	40	168.30	52.17	-0.21	0.837	NS
	Speaking	40	168.70	51.41			

 Table 4.4

 Comparison of the SFF values based on tasks (reading and speaking)

("t" = paired "t" test), NS = non significance

Above table shows the results of the paired 't' test comparing SFF values between two task types—reading and speaking in both Malayalam and English. The findings indicate no significant difference (p > 0.05) in SFF values for either language across the two tasks.

5. Discussion

The present study aimed to establish normative data for SFF among Malayalam-English bilingual speakers aged 18–25 years and examine the influence of gender, language, and task type (reading vs. spontaneous speaking). A total of 40 participants, comprising an equal number of males (n = 20) and females (n = 20), were assessed, and their SFF values were analyzed using PRAAT software. Findings from the current



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study revealed significant gender-based differences in SFF, with females consistently exhibiting higher mean SFF values across both Malayalam and English, as well as across reading and speaking tasks. These results align with existing literature that attributes such differences to anatomical and physiological variations in vocal fold mass and length between genders (Gelfer & Denor, 2014; Nishio & Niimi, 2008). The consistency of these findings across both languages and task types further reinforces the reliability of gender as a key variable influencing SFF. The present study's outcomes are in accordance with previous research that similarly reported notable gender-based variations in SFF, while finding minimal impact of language and task type on f0 (Akoju, & Didla, 2018; Gelfer & Denor, 2014).

6. Summary and conclusion

SFF also known as habitual pitch level, usually fluctuates according to personal traits and situations (Boone, 2019). In the current study, 40 Malayalam-English bilingual participants (20 males and 20 females) aged 18–25 years were included. PRAAT software was used to analyze the recordings and derive SFF values. This analysis provided mean SFF measurements for each participant across four conditions: Malayalam Reading, Malayalam Spontaneous Speech, English Reading, and English Spontaneous Speech. These values were used for comparison across gender, language, and task type. Findings from the current study revealed significant gender-based differences in SFF, with females consistently exhibiting higher mean SFF values across both Malayalam and English, as well as across reading and speaking tasks. Nevertheless, the study discovered that language and task type had little effect on f0 (Akoju & Didla, 2018; Gelfer & Denor, 2014). These findings support the notion that gender is a reliable predictor of SFF, while language and speaking context exert less influence in this demographic.

7. Limitation:

- A small sample size of 40 participants has been used
- Randomly selected bilingual participants (English and Malayalam only)
- Limited age range of 18 25 years

8. Future direction:

- Comparison of other language bilinguals can be done with the same study
- Study can be done using broader age group
- Comparison of different age groups can be done
- Study can be conducted in multilinguals

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