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# Development of anticipatory coarticulation of /u/ in typically Malayalam speaking children in the age range of 3-6 years

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**Abstract**

Coarticulation is the articulation of two or more speech sounds together, so that one influences the other. Coarticulation is language dependent and can vary from children to adult. Studies in the past have shown that children have more coarticulation than adults; adults have more coarticulation than children; children and adult have similar coarticulatory patterns. Malayalam is a Dravidian language with extra lip rounding feature and also with five place of nasal articulation. The present study investigated the development of anticipatory coarticulation of /u/ in typically developing Malayalam speaking children in the age range of 3-6 years. The data was collected from 60 participants using bisyllabic meaningful words depicted in flashcards. Data were recorded using Sony audio recorder and analyses were done using PRAAT software. Results showed that children did not follow a particular developmental trend, but 4.6-5 years old children showed a different trend compared to children in other age groups.

**Keywords:** coarticulation, terminal frequency, transition duration, speed of f2, extent of f2

## 1. Introduction

“Coarticulation in broader manner refers to the fact that a phonological segment is not realized identically in all environments, but often apparently varies to become more like an adjacent or nearby segment” (Kuhnert & Nolan, 2000). Physiologically coarticulation is the simultaneous movement of two articulators. Acoustically it is the overlapping acoustic property of one phoneme to another. Perceptually it is a phoneme perceived in anticipation after another phoneme. In adult speakers, Abelin, Landberg, and Persson (1980) found that coarticulation often involves a "look-ahead" strategy, whereas children's labial coarticulation tends to be more time-locked, with the temporal extent of anticipation becoming more prominent with age.

Previous studies on developmental patterns of coarticulation have yielded mixed results. Some studies suggest that children exhibit more coarticulation than adults (Nittrouer, Studdert-Kennedy, & McGowan, 1989; Nittrouer, Studdert-Kennedy, & Neely, 1996; Nittrouer& Whalen, 1989), while others report the opposite, with children showing less coarticulation

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than adults (Hodge, 1989; Repp, 1986; Sereno & Lieberman, 1987). A third set of findings reveals that although children and adults exhibit similar patterns of coarticulation, children tend to show greater variability in their coarticulatory patterns (Goodell & Studdert-Kennedy, 1993; Katz &Bharadwja, 2001; Katz, Kripke, &Tallal, 1991; Nittrouer, 1993; Sereno, Baum, Marean, & Lieberman, 1987; Sharkey & Folkins, 1985; Sussman, Duder, Dalston, & Cacciatore, 1999; Turnbaugh, Hoffman, & Daniloff, 1985).

These mixed findings suggest that coarticulation may be influenced by various factors, including age, linguistic experience, and language-specific characteristics. Importantly, the development of coarticulation is not a uniform process across languages. Some studies suggest that coarticulation patterns can be language-dependent, showing variations both across languages and between adults and children. For example, language-specific phonetic features, such as lip rounding or nasality, may guide the development of coarticulatory patterns in particular ways. However, the claim that coarticulation patterns are language-dependent has not been sufficiently explored in many languages, especially in terms of how they might vary across different developmental stages.

This study focuses on Malayalam, a Dravidian language that exhibits unique phonetic features, such as extensive lip rounding and nasality, which may influence coarticulation development. Malayalam's consonant system is also distinctive, featuring a rare five-place articulation contrast for stops and nasals (Mohanan & Mohanan, 1984), whereas English only has three places of articulation for these consonants. Given these language-specific features, the development of coarticulation, particularly anticipatory coarticulation involving lip rounding, may differ in Malayalam-speaking children compared to those learning other languages, such as English.

The primary aim of the present study is to investigate the development of anticipatory coarticulation in Malayalam-speaking children aged 3–6 years, specifically examining the coarticulatory effects of the vowel /u/ when preceded by various consonants. In particular, the study seeks to:

1. Measure the transition duration of the F2 formant during coarticulation,
2. Assess the terminal frequency of F2, and
3. Evaluate the extent and speed of F2 transitions in this vowel-consonant context.

This research aims to provide insights into the ontogenetic development of coarticulation in a language with distinctive phonetic features, with implications for understanding language-specific and age-related differences in coarticulatory patterns.

## 2. Methodology

### *1.1. Participants*

Participants were 60 Malayalam speaking typically developing children in the age group of 3 – 6 years with an age interval of 6 months, that is 3≥ 3.6, 3.7≥ 4, 4 ≥ 4.6, 4.7 ≥5, 5≥ 5.6, and 5.7≥ 6 years. Each group included 10 children with 5 males and 5 females. 3 to 6-year age range period captures crucial developmental changes in speech motor control, including the refinement of coarticulatory patterns. Coarticulation, particularly anticipatory coarticulation, is known to mature through early childhood as children gain better control over their speech articulators.

Inclusion criteria:

1. They shall be native speakers of Malayalam (informally assessed).
2. They shall not have any history of hearing and visual impairment, speech and language impairment, cognitive deficits, or any motor deficits at the time of data collection.
3. All participants should belong to middle class from urban part of Kerala (modified Kuppuswamy socio economic scale, 2023).

*1.2. Data collection and processing*

The material was a list of 14 bisyllabic meaningful words. The structure of the target word was C1V1C2V2, where C1 was /k/ (velar unvoiced stop) /g/ (velar voiced stop), /p/ (bilabial unvoiced stop), /b/ (bilabial voiced stop) /m/ (bilabial nasal), and /j/ (palatal approximant). V1 was either long or short vowel /u/. Pictures depicting the words in a 3 x 3 flash card formed the material. If the child fails in naming the pictures, repetitions were given as prompts. Table 1 shows the material of the study.

Table 1
*Material of the study*

| C1 | Word with V1 as /u/ | Word with V1 as /u:/ |
|---|---|---|
| k | /kuda//kutti//kuppi/ | /ku:də/ |
| g | /guha/ | |
| P | /puli//puttə/ | /pu:və/ |
| b | /bukkə/ | |
| m | /mudi//mutta/ | /mu:ɳa/<br>/mu:kə/ |
| j | /juva/ | |
| | | |

Note: /kuda/means umbrella, /kutti/means child, /kuppi/ means bottle, /ku:də/means nest, /guha/ means cave, /puli/ means tiger, /puttə/means a common breakfast of kerala, /pu:və/means flower, /bukkə/means book, /mudi/ means hair, /mutta/ means egg, /mu:ɳa/ means owl, /mu:kə/ means nose and /juva/ is youth

Participants were seated comfortably and tested individually. Pictures of the target words were presented visually to the participants who were instructed to name the picture five times. The utterances were audio recorded by placing the microphone at a distance of 10 cm from mouth of the speaker at 44100 Hz sampling frequency using a digital tape recorder (Sony ICD-UX533F audio recorder). The audio recorded samples were given to 3 Speech-Language Pathologist for the correctness utterance of C1V1. Speech-Language Pathologists were Post graduates who has at least 2 years of experience in the area of speech sound disorders. Three of the five recordings in which C1V1 are correctly uttered was used for further analysis.

*1.3. Data analysis*

The samples were displayed as waveform and bar type wideband spectrograms using PRAAT (Boersma and Weenink, 2012).The following four parameters were extracted for each word.$F_2$ Transition Duration (ms) is the duration of the formant transition was measured as the time difference in ms between the onsets of F2 transition at the beginning of the vowel till the steady state of the same. Terminal frequency (Hz) was measured as the frequency of $F_2$ at the onset of vowel following the stop. The onset of the steady state of the vowel was defined as the point at which the F2 frequency stabilized and no longer exhibited a significant transition. This was determined manually by inspecting the spectrogram and identifying the point where the frequency of F2 remained relatively constant for a significant duration. Extent of the $F_2$ transition (Hz)was estimated by calculating the difference in frequency between the terminal frequency of $F_2$ and the onset of steady state of the vowel. Speed of $F_2$ transition (Hz/ms) is the rate at which $F_2$ moves and was calculated by the following formula: Speed of $F_2$ transition = E / D, where, E is the Extent of F2 transition and D is the Duration of $F_2$ transition

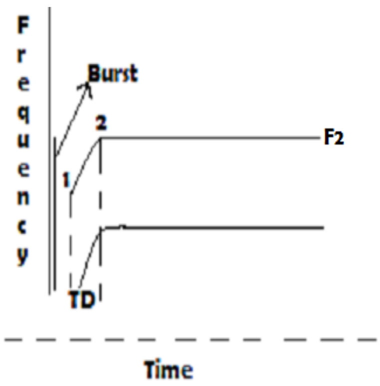


*Figure1.* Illustration of measurement of parameters

- Transition duration of $F_2$ = 2 – 1
- Terminal frequency of $F_2$= 1
- Frequency of steady state at $F_2$ = 2
- Extent of transition of $F_2$ = Frequency at 2 ~ frequency at 1
- Speed of transition of $F_2$ = Extent/ transition duration

Mixed analysis of variance (Mixed ANOVA) was carried out to determine the significant main effect of age (6 age groups), vowel (short and long vowel) and interaction between age and vowel. Multivariate analysis ofvariance (MANOVA) was done to determine the significant difference in age group as a function of each CV syllables, and finally repeated measure analysis of variance (ANOVA) was carried out to determine the significant effect of each CV syllables within each group. Multiple comparisons were accounted for by a Bonferroni adjustment.

## 3. Findings

3.1. *Terminal Frequency of F2 (F2 TF)*

The mean F2 TF was 1618 Hz and 1223 Hz for short and long vowels, respectively. F2 TF was highest in short vowel /u/ when preceded by palatal (approximant) place of articulation and lowest when preceded by velar place of articulation (stop); in long vowel /u:/, it was highest when preceded by bilabial nasal and lowest when preceded by velar stop. Table 2 shows the mean and SD of F2 TF for all age groups, vowels and place of articulation.

Table 2
*Mean and SD of F2 TF (Hz)*

| Age group | /u/ | | | | Avg | /u:/ | | | Avg |
|---|---|---|---|---|---|---|---|---|---|
| | Stops | | Nasal | Approximant | | Stops | | Nasal | |
| | Velar | Bilabial | Bilabial | Palatal | | Velar | Bilabial | Bilabial | |
| 3-3.6 | 1185 (145) | 1277 (188) | 1389 (200) | 2135 (547) | 1497 | 1025 (131) | 1139 (213) | 1368 (178) | 1244 |
| 3.6-4 | 1285 (216) | 1462 (190) | 1398 (230) | 2286 (484) | 1608 | 1245 (244) | 1406 (154) | 1550 (353) | 1401 |
| 4-4.6 | 1238 (129) | 1304 (181) | 1472 (291) | 2980 (473) | 1749 | 1241 (171) | 1243 (247) | 1478 (254) | 1321 |
| 4.6-5 | 1145 (126) | 1244 (131) | 1300 (256) | 2808 (270) | 1624 | 999 (140) | 1208 (232) | 1397 (268) | 1201 |
| 5-5.6 | 1147 (115) | 1179 (90) | 1211 (210) | 3009 (355) | 1637 | 1065 (87) | 1097 (132) | 1177 (222) | 1113 |
| 5.6-6 | 1064 (119) | 1144 (183) | 1263 (276) | 2894 (328) | 1591 | 1006 (151) | 1036 (112) | 1315 (330) | 1119 |
| Avg | 1177 | 1268 | 1339 | 2685 | **1618** | 1097 | 1188 | 1380 | **1233** |

Results of MANOVA showed main effect of age [F (5, 53) = 3.263, P< 0.05], vowel [F (7, 371) = 339.454, P< 0.05] and interaction between age*vowel [F (35, 371) = 5.713, P< 0.05]. F2 TF was significantly higher in 4 – 4.6 years of age and significantly lower in 3 – 3.6 years of age. Results of Post hoc Bonferroni indicated significant difference between F2 TF of 4 – 4.6 years of age and other age groups, 3 – 4 years, 4.6 – 6 years. Further, significant difference between short and long vowels was observed. F2 TF of short vowel was significantly higher than that in long vowel.

### 3.2. *F2 Transition Duration (F2 TD)*

The mean F2 TD was 40.96 and 33.5 for short and long vowels, respectively. F2 TD was longest when preceded by palatal approximant and shortest when preceded by bilabial stop in case of short vowel /u/; in long vowel /u:/, F2 TD was longest when preceded by velar stop and shortest when preceded by bilabial stop. Table 3 shows the mean and SD of F2 TD for all age groups, vowels and place of articulation. Stops Nasal Approximant Palatal Bilabial

Table 3

*Mean and SD of F2 TD*

| Age group | /U/ | | | | AVG | /U:/ | | | AVG |
|---|---|---|---|---|---|---|---|---|---|
| | Stops | | Nasal | Approximant | | Stops | | Nasal | |
| | Velar | Bilabial | Bilabial | Palatal | | Velar | Bilabial | Bilabial | |
| 3-3.6 | 20 (7) | 17 (3) | 17 (5) | 72 (24) | 31.5 | 31 (23) | 23 (6) | 23 (3) | 25.67 |
| 3.6-4 | 31 (8) | 26 (6) | 33 (9) | 78 (40) | 42 | 40 (11) | 35 (11) | 40 (11) | 38.33 |
| 4-4.6 | 30 (6) | 28 (6) | 32 (8) | 107 (18) | 49.25 | 42 (6) | 38(14) | 45 (11) | 41.67 |
| 4.6-5 | 32 (7) | 27 (5) | 32 (7) | 99(24) | 47.5 | 39 (10) | 36 (11) | 40 (6) | 40.63 |
| 5-5.6 | 19 (4) | 17 (3) | 19 (3) | 82 (23) | 34.25 | 24 (6) | 26 (9) | 25 (6) | 25 |
| 5.6-6 | 24 (7) | 20 (6) | 27(1) | 94 (21) | 41.25 | 33 (8) | 32 (6) | 31 (6) | 32 |
| | | | | | | | | | |
| AVG | 26 | 22.5 | 26.67 | 88.67 | **40.96** | 34.83 | 31.67 | 34 | **33.5** |

Results of MANOVA showed main effects of age [F (5, 54) = 10.669, P< 0.05], vowel [F (7, 378) = 247.011, P< 0.05] and interaction between age*vowel [F (35, 378) = 1.557, P< 0.05]. F2 TD was significantly higher in 4 – 4.6 years of age and significantly shorter in 3 – 3.6 years of age. Results of Post hoc Bonferroni indicated significant difference between 3 – 3.6, 5 – 5.6 years of age and other age groups, 3.6 – 5 years. Further, significant difference between short and long vowels was observed. F2 TD of short vowel was significantly longer than that in long vowel.

### *3.3. Extend of F2 Transition*

The results indicated that mean extent of F2 transition was 439 ms and 205 ms for short and long vowel, respectively. Extent of F2 transition was highest when preceded by palatal approximant and lowest when preceded by velar stop for short vowel /u/ and more when preceded by bilabial nasal and less when preceded by velar stop. Table 4 shows the mean and SD of extent of F2 transition for all age groups, vowels and place of articulation

Table 4

*Mean (Hz) and SD of extent of F2 transition*

| Age group | /U/ | | | | AVG | /U:/ | | | Avg |
|---|---|---|---|---|---|---|---|---|---|
| | Stops | | Nasal | Approximant | | Stops | | Nasal | |
| | Velar | Bilabial | Bilabial | Palatal | | Velar | Bilabial | Bilabial | |
| 3-3.6 | 188 (49) | 177 (54) | 183 (64) | 682 (269) | 307.5 | 142 (34) | 168 (54) | 175 (31) | 161.7 |
| 3.6-4 | 252 (60) | 247 (70) | 224 (70) | 689 (352) | 353 | 248 (70) | 300 (88) | 260 (66) | 269.3 |
| 4-4.6 | 214 (85) | 217 (58) | 219 (63) | 1252 (397) | 475.5 | 210 (61) | 229 (82) | 257 (45) | 232 |
| 4.6-5 | 200 (43) | 195 (40) | 219 (65) | 1439 (321) | 513.3 | 191 (20) | 205 (38) | 242 (34) | 212.7 |
| 5-5.6 | 141 (30) | 195 (52) | 203 (69) | 1439 (421) | 494.5 | 147 (39) | 183 ((49) | 192 (51) | 174 |
| 5.6-6 | 165 (44) | 201 (52) | 195 (63) | 1394 (290) | 488.8 | 165 (61) | 186 (45) | 186 (35) | 179 |
| AVG | 193.3 | 205.3 | 207.2 | 1149.2 | **438.8** | 183.8 | 211.8 | 218.7 | **204.8** |

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Results of MANOVA showed main effects of age [F (5, 54) = 9.217, P< 0.05], vowel [F (7, 378) = 361.513, P< 0.05] and interaction between age*vowel [F (35, 378) = 9.188, P< 0.05]. Extent of F2 transition was significantly longer in 4.6 – 5 years of age and significantly shorter in 3 – 3.6 years of age for short vowel /u/; it was significantly longer in 5.6-4 years of age and significantly shorter in 3-3.6 years of age in long vowel /u:/. Results of Post hoc Bonferroni indicated significant difference between 3 – 3.6 years of age and other age groups, 4 – 6 years of age and other age groups. Further, significant difference between short and long vowels was observed. Extent of F2 transition short vowel was significantly longer than that in long vowel.

*3.4. Speed of F2 Transition*

The results indicated that mean speed of F2 transition was 9.5 ms and 6.7 ms for short and long vowel, respectively. Speed of F2 transition was highest when preceded by palatal approximant and lowest when preceded by velar stop in short vowel /u/; it was highest when preceded by bilabial nasal and lowest when preceded by velar stop in long vowel /u:/. Table 5 shows the mean and SD of speed of F2 transition for all age groups, vowels and place of articulation

Table 5
*Mean (Hz/ms) and SD of speed of F2 transition*

| Age group | /u/ | | | | Avg | /u:/ | | | Avg |
|---|---|---|---|---|---|---|---|---|---|
| | Stops | | Nasal | Approximant | | Stops | | Nasal | |
| | Velar | Bilabial | Bilabial | Palatal | | Velar | Bilabial | Bilabial | |
| 3-3.6 | 8 (2) | 11 (4) | 9 (2) | 9 (2) | 9.25 | 7 (2) | 7 (4) | 9 (5) | 7.7 |
| 3.6-4 | 8 (2) | 10 (2) | 8 (3) | 9 (3) | 8.75 | 7 (2) | 10 (4) | 7 (2) | 8 |
| 4-4.6 | 7 (2) | 9 (2) | 6 (2) | 12 (2) | 8.5 | 5 (1) | 8 (4) | 6 (1) | 6.3 |
| 4.6-5 | 6 (1) | 8 (1) | 7 (1) | 13 (4) | 8.5 | 5 (1) | 6 (2) | 6 (1) | 5.7 |
| 5-5.6 | 9 (2) | 11 (4) | 10 (3) | 16 (2) | 11.5 | 6 (1) | 7 (2) | 8 (2) | 7 |
| 5.6-6 | 6 (2) | 11 (4) | 9 (3) | 15 (3) | 10.25 | 5 (2) | 6 (2) | 6 (2) | 5.7 |
| Avg | 7.3 | 10 | 8.2 | 12.3 | **9.5** | 5.8 | 7.3 | 7 | **6.7** |

Results of MANOVA showed main effects of age [F (5, 54) = 5.247, P< 0.05], vowel [F (7, 378) = 15.834, P< 0.05] and interaction between age*vowel [F (35, 378) = 2.181, P< 0.05]. Speed of F2 transition was significantly less in 4.6 – 5 years of age and significantly high in 5.6 - 6 years of age in short vowel /u/ and significantly low in 4.6 – 5 years of age and significantly high in 3.6 - 4 years of age in long vowel /u:/. Results of Post hoc Bonferroni indicated significant difference between 5 – 5.6 years and other age groups; 3 – 5 and 5.6 – 6 years. Further, significant difference between short and long vowels was observed. Speed of F2 transition of short vowel was significantly high than that in long vowel.

## 4. Discussion

The primary objective of this study was to examine the development of anticipatory coarticulation in Malayalam-speaking children, specifically focusing on the effects of consonant context on the F2 characteristics of the vowel /u/ in both short and long vowel contexts. Our study aimed to measure the terminal frequency, transition duration, extent, and speed of F2 transitions, and to investigate developmental changes across different age groups.

*4.1. Language-Specific Effects: The Role of Lip Rounding*

Our first key finding relates to the influence of lip rounding on F2 characteristics. We found that the mean terminal frequency of F2 was significantly higher in short vowels compared to long vowels. This result may be interpreted in the context of articulatory dynamics: in short vowels, there is a need for the articulator (likely the tongue) to transition more quickly between positions. This faster articulatory movement might contribute to the observed higher terminal frequency of F2. However, it is important to clarify that this observation likely pertains to tongue movement rather than lip movement, as the primary articulatory feature of interest in this study was lip rounding. The F2 distinctions associated with tongue positioning (e.g., anterior-posterior tongue movements) may better account for this finding, which underscores the importance of considering tongue displacement rather than speed when interpreting F2 transitions.

Furthermore, we observed that the mean terminal frequency of F2 was highest when preceded by a palatal approximant and lowest when preceded by a velar stop, especially for the short vowel /u/. This finding is consistent with previous research that reports higher F2 frequencies for palatal consonants compared to other places of articulation (e.g., Liberman et al., 1972; Kent & Read, 2002). Additionally, the fact that velar stops yielded the lowest terminal frequency in /u/ was intriguing and warrants further exploration. We hypothesize that the consonantal constriction in the lip region (as seen in both bilabials and vowels like /u/) might mitigate the effects of vowel-consonant interactions when compared to the stronger articulatory influence of velar constrictions. This suggests that the coarticulatory effects of vowel lip rounding may interact differently depending on the specific consonantal context, further emphasizing the language-specificity of coarticulation.

*4.2. Consonantal and Vowel Context Effects*

Next, we found that the mean transition duration of F2 was significantly longer in short vowels compared to long vowels, even after excluding the palatal approximant. This finding aligns with the idea that articulators need to "traverse" a greater distance more quickly in short vowels, which likely results in shorter transition durations in comparison to long vowels. The result is also consistent with previous studies (Savithri, 1989) that reported transition durations in the same range (approximately 33.5 ms).

The transition durations were notably longer when the vowel was preceded by a palatal approximant and shorter when preceded by bilabial stops, particularly in the short vowel /u/. This could be due to the fact that approximants typically involve the articulation of two vowel sounds (/i/ and /a/ in this study), leading to a longer transition duration due to vowel modification. In contrast, bilabial stops and nasals, which involve constrictions at the lip end, might not be influenced as strongly by the vowel's lip rounding, resulting in shorter transition durations.

*4.3. Developmental Trends in Coarticulatory Behavior*

Our results also suggest age-based differences in coarticulatory behavior, with significant developmental changes observed across the three age groups. The terminal frequency of F2 was significantly higher in children aged 3.6–4 years and significantly lower in children aged 5–5.6 years, even when excluding the palatal approximant. Interestingly, these results do not align with findings from Repp (1986), where a 4-year-old speaker showed no systematic differences in coarticulatory patterns across different linguistic contexts. Our results are more in line with Perumal (1993), who reported no linear developmental trend for coarticulation. These findings suggest that coarticulatory patterns in younger children may be influenced by different factors, such as vocal tract size and speech motor maturation.

Moreover, while Sereno and Lieberman (1987) suggested that coarticulatory patterns become more consistent with the fine-tuning of speech motor patterns as children mature, our study did not reveal a clear developmental trend in F2 terminal frequency, further emphasizing the complexity of coarticulation development.

*4.4. Transition Speed and Age Effects*

Transition speed, calculated as the extent of F2 transition divided by the transition duration, was significantly higher in short vowels compared to long vowels. This finding could be explained by the combination of greater extent and shorter duration in short vowels. The speed of F2 transition was highest when preceded by palatal approximants and lowest when preceded by velar stops in short vowels, and highest when preceded by bilabial nasals and lowest when preceded by velar stops in long vowels. These patterns reflect the interaction between consonantal and vowel contexts, where the presence of palatal constrictions leads to higher F2 frequencies, while velar stops lead to lower F2 frequencies, consistent with the effects of lip rounding and articulatory timing.

Significant differences in transition speed were also observed across age groups. Children aged 4.6–5 years exhibited significantly lower speeds in the short vowel /u/, while those aged 5.6–6 years showed significantly higher speeds. This may reflect increased control over speech motor patterns with age, particularly in terms of articulatory adjustments related to lip rounding and transition planning.

*4.5. Comparison with Previous Studies*

Finally, we must consider the findings of previous studies, such as those by Repp (1986) and Perumal (1993). Our results diverged from Repp's, who found no systematic differences in younger children's coarticulation, and Perumal's, who reported an increase in transition duration with age. Our findings, which showed no clear developmental trend in terminal frequency or transition duration, suggest that coarticulatory patterns in Malayalam-speaking children might be influenced by unique phonetic features of the language, such as lip rounding and the complex consonant system, which may not follow the same developmental trajectory as seen in languages like English.

## 5. Conclusion

In sum, this study provides a detailed examination of the development of anticipatory coarticulation in Malayalam-speaking children, shedding light on the complex interplay of linguistic factors, developmental age, and articulatory processes. While some of our findings align with previous studies, others suggest that Malayalam-specific phonetic features, such as lip rounding and nasality, play a significant role in shaping coarticulatory patterns in young children. Future studies should further explore the developmental trajectory of coarticulation in Malayalam, with particular attention to the interaction between language-specific phonological features and age-related motor development. A future extension of this study could involve comparing the coarticulatory behavior of adults with the current child participants to better understand the development of mature coarticulatory patterns in this language.

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## References

Abelin, Å., Landberg, I., Persson, L. (1980). A study of anticipatory labial coarticulation in the speech of children. *Perilus*, 2, 2–18.

Goodell, E. W., & Studdert-Kennedy, M. (1993). Acoustic evidence for the development of gestural coordination in the speech of 2-year-olds: A longitudinal study. *Journal of Speech and Hearing Research,* 36, 707-727.

Hodge, M. (1989). *A comparison of spectral-temporal measures across speaker age: Implications for an acoustic characterization of speech maturation.* Unpublished doctoral dissertation, University of Wisconsin-Madison.

Katz, W. F., & Bharadwja, S. (2001). Coarticulation in fricative-vowel syllables produced by children and adults: A preliminary report. *Clinical Linguistics and Phonetics,* 15, 139-143.

Katz, W. F., Kripke, C., & Tallal, P. (1991). Anticipatory coarticulation in the Speech of adults and young children: Acoustic, perceptual, and video data. *Journal of Speech and Hearing Research,* 34, 1222-1232.

Kent, R. D., & Read, C. (2002). *The acoustic analysis of speech*, (2nd Ed.). University of Wisconsin – Madison: singular press.

Kuhnert, B., & Nolan, F. (1999). *Coarticulation: Theory, Data and Techniques.* W.J. Hardcastle and N. Newlett, Cambridge: Cambridge University Press.

Mohanan, K. P., & Mohanan, T. (1984). Lexical phonology of the consonant system in Malayalam. *Journal of Linguistic Inquiry,* 4, 575 – 602.

Nittrouer, S. (1993). The emergence of mature gestural patterns is not uniform: Evidence from an acoustic study. *Journal of Speech and Hearing Research,* 36, 959-972.

Nittrouer, S., & Whalen, D. H. (1989). The perceptual effects of child-adult differences in fricative-vowel coarticulation. *Journal of the Acoustical Society of America*, 4, 1266-1276.

Nittrouer, S., Studdert-Kennedy, M., & McGowan, R. S. (1989). The Emergence of Phonetic Segments: Evidence from the spectral structure of fricative-vowel syllables spoken by children and adults, *Journal of Speech and Hearing Research*, 32, 120-132.

Nittrouer, S., Studdert-Kennedy, M., & Neely, S. T. (1996). How children learn to organize their speech gestures: Further evidence from fricative-vowel syllables. *Journal of Speech and Hearing Research,* 39, 379-389.

Perumal, G., & Savithri, S. R. (1993). Development of production of coarticulation in children. *Jayaram, M., & Savithri, S. R. (Eds.). Dissertation abstracts*. Mysore: All India Institute of Speech and Hearing.

Radhakrishnan M., & Nagaraja SB. (2023). Modified Kuppuswamy socioeconomic scale stratification and updates. *International Journal of Community Medicine and Public Health*, 10, 4415-8.

Repp, B. H. (1986). Some observations on the development of anticipatory coarticulation. *Journal of the Acoustic Society of America,* 79, 1616-1619.

Savithri, S. R. (1989). Acoustic and physiological correlates of speech. *Journal of the Acoustic society of India,*17, 1-8.

Sereno, J. A., & Lieberman, P. (1987). Developmental aspects of lingual coarticulation. *Journal of Phonetics,* 15, 247-257.

Sereno, J.A., Baum, S. R., Marean, G. C., & Lieberman, P. (1987). Acoustic analyses and perceptual data on anticipatory labial coarticulation in adults and children. *Journal of the Accoustical Society of America,* 2, 512-519.

Sharkey, S. G., & Folkins, J.W. (1985). Variability in lip and jaw movements in children and adults: Implications for the development for speech motor control, *Journal of Speech Hearing Research,* 78, 8–15.

Turnbaugh, K. R., Hoffman, P. R., & Daniloff, R. G. (1985). Stop-vowel coarticulation in 3-year-old, 5-year-old, and adult speakers. *Journal of the Acoustic Society of America,* 77, 1256-1257.