A Cross-Language Pitch and Durational Properties of Indian English Diphthongs: Uniformity and Diversity in Indo-Aryan and Dravidian Speakers

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Abstract
Studies have shown that the influence of L1 diphthongs on L2 results in acoustic variation of diphthongs in Indian English (IE) in terms of duration (ms) and fundamental frequency (F0 Hz). This study provides an acoustic analysis of 8 English diphthongs (/eə/, /ɪə/, /aɪ/, /eɪ/, /ɔɪ/, /əʊ/, /aʊ/, /ʊə/) produced by Indo-Aryan and Dravidian speakers. PRAAT software was used to extract the duration (ms) and fundamental frequency (F0 Hz) of IE diphthongs. Results showed that the F0 frequency of diphthongs was higher in the Dravidian speakers than in the Indo-Aryan IE speakers. Also, IE speakers preserved the homogeneity in the adaptation of three IE diphthongs as long monophthongs (/eɪ/>[eː], /əʊ/>[oː] and /ʊə/>[uː]). The findings suggest homogeneity in terms of duration (ms), and diversity in terms of F0 (Hz). This also exemplifies the characteristic unity-in-diversity of Indian English.
Key words: Duration, fundamental frequency, diphthongs, Indian English, Indo-Aryan, Dravidian

Introduction

The current study investigates the acoustic features, such as duration (ms) and fundamental frequencies (F0 Hz), of eight English diphthongs produced by Indian English (IE) speakers belonging to Indo-Aryan (Hindi, Chhattisgarhi) and Dravidian (Telugu, Malayalam) families. Diphthongs are produced when there is a qualitative change or transitional movement from one monophthongal vowel to another or to a semivowel (Ladefoged, 1982). In this study, we assume that a unit comprising two steady states, V1V2 (V1-vowel 1; V2-vowel 2), may vary typologically in duration (in milliseconds) and fundamental frequency (F0 in Hz) among native L1 (first language) speakers of Indo-European languages. Studies have shown that the variation in L2 can be predicted on the basis of L1 features (Bansal, 1970; Pickering & Wiltshire, 2000; Wiltshire & Moon, 2003; Wiltshire & Harnsberger, 2006), referring to the examples of Malayalam English (MalE) (Mohanan & Mohanan, 2003), Hindi English (HinE) (Pandey, 1980), Punjabi English (PunE) (Sethi, 1980) and Telugu English (TelE) (Babu, 1976). However, these studies rarely consider variation in the duration of IE diphthongs with respect to time-sensitive syllabic and mora features of L1, such as Hindi and Telugu, which are classified as syllable-timed and mora-timed, respectively (Dauer, 1983; Murty et al., 2007). Further, the accentual identity markers of diphthongs, which are primarily based on F0 characteristics (Mennen et al., 2012; Andreeva et al., 2014), have been typologically overlooked in IE. F0 values of diphthongs may, however, point to identity markers associated with the genetic families of L1. These research gaps have motivated us to examine the similar and dissimilar patterns of duration (ms) and F0 (Hz) of IE diphthongs across and within the genetic families of L1.

The current study is significant as India is a micro-linguistic region of South Asia (Masica, 2005). Almost all the native languages here share a few common features due to intense language contact and convergence, despite their distinctive genetic

identities. For example, the IE spoken by three L1 speakers of the Tibeto-Burmese language family showed many segmental similarities (Wiltshire, 2005). Along similar lines, we investigated whether there was uniformity and diversity in the durations and F0 values of IE diphthongs across the (Indo-Aryan and Dravidian) genetic families of L1 speakers. Accordingly, this study addressed the important questions: What are the identical acoustic markers of IE diphthongs among the four languages selected for the investigation? Does the genetic family of L1 determine unity and diversity in IE? Both these questions are largely grounded in the recent study conducted by Wiltshire (2020). Her study raised the question of what characteristics marked the unity in IE? What characteristics marked the diversity in IE? Interestingly, these questions have been persistently raised in the domain of second language phonology to define specific, unique and universal patterns of L2 in a bi-multilingual context. For example, Mohanan and Mohanan (2003) raised the following question in the context of MalE: what properties distinguish one variety of English from another? What are the unique properties of MalE? Interestingly, their inquiry led them to observe that the alveolar-retroflex pattern exhibits the idiosyncratic property of MalE. MalE speakers changed the native English diphthongs /eɪ/ and /əʊ/ too long monophthongs [eː] and [oː] (Mohanan & Mohanan, 2003). The monophthongization of English diphthongs is widely observed in the regional varieties of African, Southeast Asian and the Pacific Englishes (Schneider, 2004; Maxwell & Fletcher, 2009; Sailaja, 2009). However, it is interesting to trace the process of monophthongization of IE diphthongs across the L1 of Dravidian and Indo-Aryan speakers. Based on previous findings that Punjabi speakers exhibit greater phonetic variation in diphthongs than Hindi speakers (Maxwell and Fletcher, 2009, 2010), it could be hypothesized that the acoustic characteristics of IE diphthongs produced by Dravidian speakers may differ statistically from those of Indo-Aryan English speakers. We, therefore, assume that IE speakers with homogeneous educational backgrounds and ages may produce minimum acoustic differences of diphthongs within a family of languages, whereas the acoustic differences of diphthongs will be larger between families of languages.

Acoustic studies on IE diphthongs

A large body of literature has described the acoustic properties, especially formant frequencies of vowels and diphthongs of IE (Wiltshire, 2005; Wiltshire & Harnsberger, 2006; Maxwell & Fletcher, 2009) and compared those with the native L1, native BrE and AmE. For example, studies on IE have described six diphthongs /aɪ/ 'price', /ɔɪ/ 'choice', /aʊ/ 'mouth', /ɪɔ/ 'near', /eə/ 'square' and /ʊə/ 'tour' (Nihalani et al., 2004; Trudgill & Hannah, 2008; Sailaja, 2012). The monophthongization of diphthongs /eɪ/>[e] and /əʊ/>[o] in words like 'face' and 'goat,' which are considered as long monophthongs in place of diphthongs, is widely present in varieties of IE (Maxwell & Fletcher, 2009; Sailaja, 2009). Though the adaptive feature of [e] in the place of /eɪ/ is observed in some Tibeto-Burman varieties of IE, it is realized as [ɪ] in Angami and Miso speakers of English (Wiltshire, 2005). Maxwell and Fletcher (2010) have also reported that IE /eɪ/ as in 'face' is recognized as a variant of /ɪ/ by Punjabi L1 speakers, which is similar to the Tibeto-Burman speakers of English, but is contradictory to the many Hindi L1 speakers, who produce the long [eː]. However, Sirsa and Redford (2013) observed very few differences in the pronunciation of diphthongs produced by IE-educated speakers from English-medium backgrounds with four different L1s. In this respect, the duration of diphthongs and long monophthongs is considered an inter-and intra-speaker variation (Gargesh, 2004). Given the fact that cross-language variation exists in IE, an attempt, therefore, is made here to find out the similarities and differences in terms of the duration (ms) and F0 (Hz) values of IE diphthongs and long monophthongs produced by L1

speakers belonging to Indo-Aryan (HinE, ChatE) and Dravidian (TelE, MalE) families.

L1's vowels and diphthongs
Indo-Aryan family of languages: Hindi and Chhattisgarhi

Hindi has seven short (/ɪ, e, ɛ, a, o, ə, ʊ/) and three long vowel phonemes (/ɪː, əː, uː/) (Narang, 1981), and two diphthongs (/əɪ/ and /əʊ/). These two diphthongs are considered as vowel clusters (Ohala, 1994). Many dialects of Hindi spoken in Saharanpur, Agra, Mathura, and Moradabad districts of the state of Uttar Pradesh in India retain the sequence of vowels as diphthongs /əɪ/, /ʊɪ/, /oɪ/ and /ʊə/. A few relevant examples are: /səɪt/ 'with', /moɪl/ 'price', /dʊɪr/ 'far' and /sʊər/ 'pig'. Like Hindi, Chhattisgarhi, which is largely spoken in the state of Chhattisgarh and classified as an eastern variety of the Indo-Aryan language, has seven short vowels: /ɪ, e, ɛ, a, o, ə, ʊ/, three long vowels /ɪː, əː, uː/ and two diphthongs /əɪ/ and /əʊ/ (Verma, 1973).

Dravidian family of languages: Telugu and Malayalam

Telugu has five short vowels /ɪ, e, o, a, ʊ/ and corresponding five long vowels /ɪː, eː, oː, aː, uː/ (Reddy, 1988). Telugu has two diphthongs /aɪ/ and /aʊ/, the durations of which are equivalent to those of monophthongs (Bai, 1985). However, Malayalam has a total of eleven vowels, of which six are short /ɪ, e, a, o, ʊ, ə/, and five are long /ɪː, eː, aː, oː, uː/ (Nayar, 1970). Like Telugu, Malayalam has two diphthongs: /aɪ/ and /aʊ/. These diphthongs are largely restricted to CV1V2C positions (Nayar, 1970). Most of the descriptive studies discussed above have shown that Indo-Aryan and Dravidian families have a limited number of diphthongs, with /aɪ/ and /əʊ/ being the most common (Pandey, 2015). Diphthongs have almost the same duration as long vowels (Reddy, 1988). Also, metrically, diphthongs are treated as long vowels because they contain two morae in duration (Krishnamurti, 2003). This reinforces the point that the duration of diphthongs is equivalent to that of long monophthongs in most Indian languages, with Malayalam being an exception (Velayudhan & Howie, 1974).

The current study

The current study compares the duration (in ms) and fundamental frequency (F0 in Hz) of English diphthongs produced by Indo-Aryan and Dravidian speakers to test the following hypothesis.

Ho1: F0 differences of IE diphthongs would be highly significant with greater statistical effect between Indo-Aryan and Dravidian families, whereas the differences of F0 would be negligible or significant with lesser effect within a family of L1. Thus, the F0 value of IE may be influenced by the L1 accentual patterns of Indian speakers.

Ho2: Within the Dravidian family, Telugu speakers may produce a longer duration of IE diphthongs than Malayalam speakers because the duration of native Telugu diphthongs is similar to that of long vowels (Velayudhan & Howie, 1974; Reddy, 1988). The L1 rhythmic patterns of duration may influence the pronunciation of IE.

Ho3: Almost all speakers of Indo-Aryan and Dravidian families maintain homogeneity in the process of monophthongization of a few IE diphthongs, following

the findings of the previous studies in IE (Mohanan & Mohanan, 2003; Maxwell & Fletcher, 2009, 2010).

Methodology

Participants

The study was conducted in a laboratory condition. The study included IE speakers from Indo-Aryan (HinE, ChatE) and Dravidian families (TelE, MalE). A total of 32 male students, comprising eight students from each language category (8□□=32), were included in this study. They fall in the age group of 18 to 24 years (mean age of 21 ± 2.03 years). Participation was voluntary, and written consent was obtained from those who agreed to participate in the study. All the participants had either studied English as a subject or had English as the medium of instruction in their schools from the 4th standard onwards, which are located in their home states. At the time of data collection, all the participants were pursuing the Bachelor of Technology (B.Tech) degree at the National Institute of Technology Raipur, Chhattisgarh. The participants varied in their home states and mother tongues, while the level of education (i.e., 12th standard) was largely homogeneous across all. Further, all participants were functionally bilingual, speaking English for academic purposes at the college and their respective mother tongues at home. All of them were healthy adults, and none of them reported having any pathological disorder or language impairment issues. Also, we took the utmost care to maintain the confidentiality of participants' demographic information.

Recording materials

Target English words (N=44), which were monosyllabic and contained eight diphthongs (e.g., /eə/, /ɪə/, /aɪ/, /eɪ/, /ɔɪ/, /əʊ/, /aʊ/, /ʊə/) were selected from the English dictionary and the phonetic textbooks (Balasubramanian, 1992; Suzana, 2017). Six monosyllabic word tokens for each target diphthong were selected on the basis of closed syllabic words without onset (i.e., word-initial V_1V_2C), closed syllabic words with onset (i.e., word-medial CV_1V_2C) and open syllabic words with onset (i.e., word-final CV_1V_2) (Table:1).

Table 1: List of English words used for the recording of target diphthongs

Target diphthongs	Monosyllabic words **- onset +coda (V_1V_2C)**	**+onset, +coda ($C_1(C_2)V_1V_2C$)**	**+onset, -coda ($C_1(C_2)V_1V_2$)**
/eɪ/	/eɪd/ 'aid' /eɪm/ 'aim'	/greɪt/ 'great' /heɪt/ 'hate'	/seɪ/ 'say' /deɪ/ 'day'
/aɪ/	/aɪl/ 'isle' /aɪs/ 'ice'	/draɪv/ 'drive' /baɪt/ 'bite'	/draɪ/ 'dry' /kraɪ/ 'cry'
/ɔɪ/	/ɔɪ□/ 'oil' /ɔɪnk/ 'oink'	/bɔɪl/ 'boil' /vɔɪs/ 'voice'	/kɔɪ/ 'coy' /tɔɪ/ 'toy'
/aʊ/	/ aʊt/ 'out' / aʊst/ 'oust'	/baʊnd/ 'bound' /daʊs/ 'douse'	/plaʊ/ 'plough' /kaʊ/ 'cow'
/əʊ/	/əʊn/ own' /əʊld/ 'old'	/bləʊn/ 'blown' /ləʊd/ 'load'	/bləʊ/ 'blow' /fləʊ/ 'flow'
/ɪə/	/ɪər/ 'ear'	/bɪəd/ 'beard' /pɪəs/ 'pierce'	/fɪə(r)/ 'fear' /klɪə(r)/ 'clear'
/ʊə/		/kjʊəd/ 'cured'	/tʊə(r)/ 'tour' /ljʊə(r)/ 'lure'
/eə/	/eər/ 'air' /eər/ 'are'	/leəd/ 'laird' /beən/ 'bairn'	/beə(r)/ 'bare' /jeə/ 'yeah'

The printed target words were randomized to avoid any regular rhythmic patterns at the time of recording.

Recording Instruments, Procedures and Tasks

The recording sessions were conducted in a sound-attenuated booth at NIT Raipur, using a low-noise external microphone (Sony-ECM-CS3) channeled directly to a laptop. Praat software (version 5.3.61) was used to record and digitize the sound at a 44.1 kHz sampling rate. A practice session was conducted for all participants, in which they were instructed to read the target words before the recordings. This was done to ensure their familiarity with the task. After the practice session, participants were asked to read all the words from the lists, provided one at a time. All the recording files were saved in the dot-wave format.

Segmentations and acoustic measurements of diphthongs

Speech wave files were segmented using the visual spectrogram of diphthongs. The diphthongs were isolated from consonants. During segmentation, a steady-state of diphthongs, including the onset of V^1 and offset of V^2, was included in the segmentation process. For example, the segmentation of diphthong /ɔɪ/ as in 'oil' was made by isolating the final continuant murmur feature 'l'. The steady-state of /OI/ was measured as soon as it occurred in the onset-less closed-monosyllabic word (ɔɪl) 'oil' (Fig.1). First, the mean acoustic values of duration (ms) and F0 (Hz) of diphthongs were extracted between the onset and offset points of diphthongs. Next, the mean duration and F0 of eight diphthongs were tabulated for each speaker according to their families of languages i.e., Indo-Aryan and Dravidian.

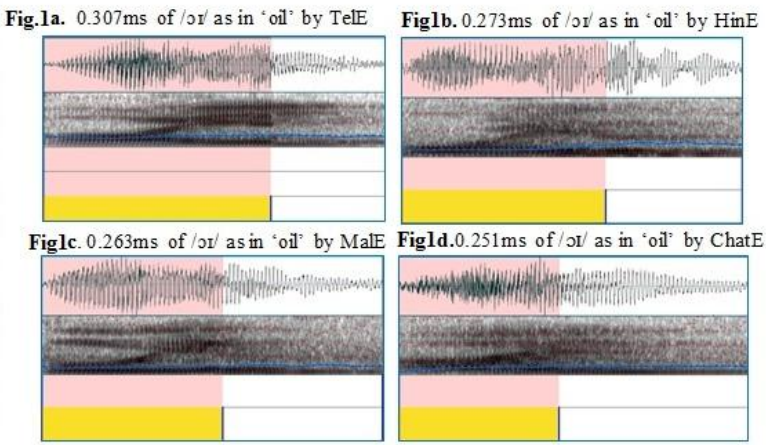


Figure 1 illustrates the segmental procedures and measurement criteria applied for extracting the mean duration of diphthong /ɔɪ/ as in 'oil' produced by (1a) TelE, (1b) HinE, (1c) MalE and (1d) ChatE speakers. Although the red dotted lines from the bottom to the top signify the formant frequencies, i.e., F1, F2, F3 and F4, this does not display a clear transitional change in F2 and F3. On the other hand, the spectrogram demonstrates the transitional change of formant frequencies. The blue curved line indicates the F0 contour, which shows fluctuations from low to high when the tongue moves from /ɔ/ to /ɪ/.

Procedures for Analysis

Mean values of F0 (Hz) and duration (ms) of diphthongs of each speaker were submitted to a two-way ANOVA among 4 languages (HinE, ChatE, TelE and MalE) and 3 positions (i) initial: closed syllable without onset, (ii) medial: closed syllable with onset and (iii) final: open syllable with onset). This was done to examine the effects of language and positions, as well as their interactions. ANOVA results were computed by using the SPSS (Version 20) software. The significant main effect (p<.05) of languages and positional occurrences of diphthongs, including their interaction effects, established the intra-speakers' variability associated with diphthongs spoken by Indo-Aryan and Dravidian speakers. The grand average duration (ms) and fundamental frequencies (F0 in Hz) of diphthongs and long monophthongs were presented to find out the differences between speakers of Indo-Aryan and Dravidian families.

Results

Analysis of duration (ms) and F0 (Hz) of /eɪ/

The /eɪ/ is produced as long [e:] among the English speakers of both Indo-Aryan and Dravidian languages (Fig.2 & Fig.3). Two-way ANOVA factors 4 languages (HinE, ChatE, TelE and MalE) × 3 positions (initial, medial and final) showed a significant main effect of language, F (1, 7) =11.190, p=.012, η^2p = .870, suggesting the long duration of [e:] for Dravidian (0.255) than Indo-Aryan (0.228) speakers (Fig. 3). Further, the main effect of diphthong positions was significant, F(1, 7) =33.034, p=.001, η^2p = .956, revealing the length of [e:], which is longer in the final (CV1V2) than initial (V1V2C) and the medial (CV1V2C) positions. This effect suggests that the duration of diphthongs without onset was shorter than the duration of diphthongs with onset. Further, the interaction between language and positional occurrence of /eɪ/>[e:] was significant, F (1, 7) =1.178, p=.027, η^2p = .991, indicating the longer duration of [e:]in the initial and final than medial position of words across languages (Fig.5).

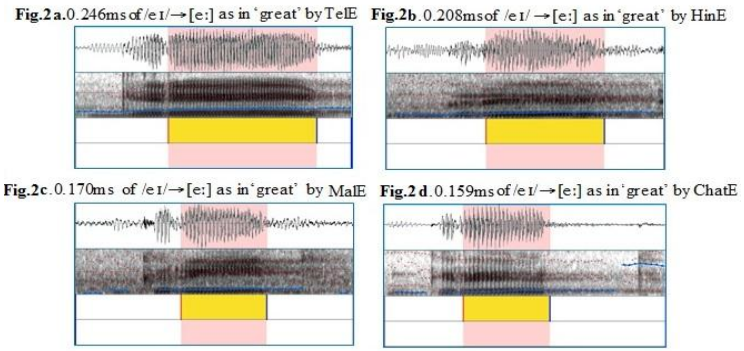
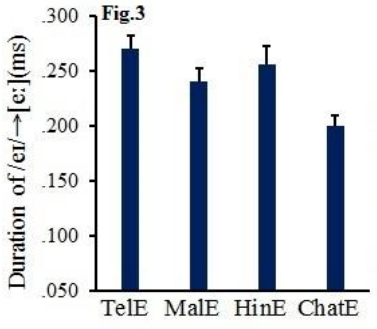
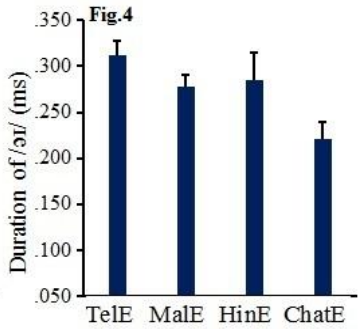


Figure 2 shows the duration of long monophthongization [e:] of English diphthong /eɪ/ (/eɪ/> [e:]) as in 'great' produced by (2a) TelE, (2b) HinE, (2c) MalE and (2d) ChatE speakers. The selected yellow indicates the duration of /eɪ/>[e:]. The blue curved line indicates the F0 contour, which shows no fluctuation.

ANOVA analysis of F0 of /eɪ/>[e:] across 4 languages and 3 positions showed a significant main effect of languages, F(1, 7) = 10.217, p=.014, η^2p = .860, displaying a continuous gradation of higher F0 values for TelE and MalE speakers in comparison to that of HinE and ChatE (i.e., TelE>>MalE>>HinE>>ChatE) (Fig.9A). While there

was a continuous degree of variation and dissimilarity of F0 for monophthong [eː] across L1 speakers, the genetically-related L1s of the Dravidian family showed higher F0 than L1s of the Indo-Aryan family (Table 2). As per the findings, neither the frequencies of positional occurrences of [eː] (p>.99), nor the interaction effect between languages and positional occurrences was significant (p> .86).

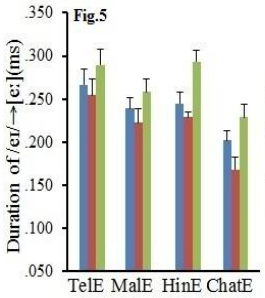


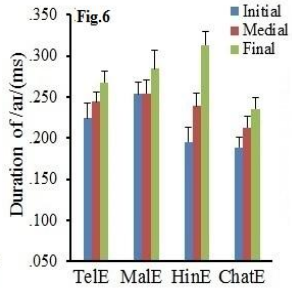


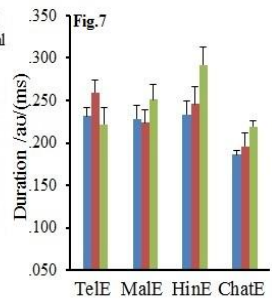
Figures 3 & 4 show that the mean duration (ms) of /eɪ/> [eː] and /OI/ statistically differed across languages. It represented the duration of (Fig.3) monophthong /eː/ and (Fig.4) diphthong /ɔɪ/in TelE, MalE, HinE, and ChatE.

Analysis of duration (ms) and (F0-Hz) of /aI/

Two-way factors ANOVA among 4 languages and 3 positions demonstrated significant durational differences of /aɪ/ across positions, F(1, 7) = 41.969, p=.001, η^2p=.940, presenting longer duration in the final than the medial and initial positions (CV1V2 >> CV1V2C >> V1V2C) (Fig.6). However, the main effect of durational differences across languages (p>.25) was not significant, which revealed a degree of durational uniformity of /aɪ/ across L1 speakers (Table 3). The interactional effect among 4 languages and 3 positions was close to significant, F(1, 7) = 4.195, p=.062, η^2p= .375 (Fig.6).







Figures 5, 6 and 7 show the Mean duration (ms) of diphthongs, which significantly differ across languages and positions, suggesting (Fig.5) a higher duration of /eɪ/>[eː], (Fig.6) [aɪ] and (Fig.7) [aʊ] in the HinE and ChatE final.

A two-way ANOVA between 4 languages and 3 positions on F0 showed a significant main effect of languages, F (1, 7) =9.700, p=.056, η^2p=.581, revealing a continuous degree of gradation of higher F0 values for TelE and MalE than HinE and ChatE speakers (i.e., TelE>>MalE>>HinE>>ChatE) (Fig.9B). Here the degree of continuity in F0 differences of /aɪ/ across IE speakers marked the genetic relation of L1s, revealing a higher F0 for Dravidian than Indo-Aryan speakers (Table 2). However, the main effect of F0 (Hz) across positions (p>.82) and the interactional effect between languages and positions were not significant (p>.77).

Analysis of duration (ms) and F0 (Hz) of /ɔɪ/

Two-way ANOVA between 4 languages and 3 positions on the duration of /ɔɪ/ established an effect of languages, F (1, 7) = 5.615, p=.047, η^2p=.771, signifying the longest duration for TelE and HinE than MalE and ChatE speakers (TelE>>HinE>>MalE>>ChatE) (Fig.4 & Table 3). Similarly, the main effect of positional occurrences of the duration of /ɔɪ/ was significant, F (1, 7) =7.039, p=.027, η^2p=.701, representing longer duration in final and medial positions than in the initial position (CV1V2 >> CV1V2C >> V1V2C). However, the durational effect of interactions between languages and positions was not significant (p >.162).

Two-way ANOVA on F0 of /OI/ showed the significant effect of languages, F (1, 7) = 4.195, p=.060, η^2p= .746, revealing a higher F0 value for TelE and MalE than HinE and ChatE speakers (i.e., TelE>>MalE>>HinE>>ChatE) (Fig.9 C). This revealed that the higher F0 of /ɔɪ/ was observed in Dravidian than in Indo-Aryan speakers (Table 2). The main effect of positional occurrence was significant, F (1, 7) =13.486, p=.006, η^2p= .818, suggesting higher frequency in the initial than final and medial positions (V1V2C>>CV1V2>>CV1V2C). On the contrary, the interactional effect between languages and positional occurrence was not significant (p>.339).

Analysis of duration (ms) and F0 (Hz) of /aʊ/

Two-way ANOVA between 4 language and 3 positions showed significant main effect of positional duration of /αʊ/, F(1, 7) = 12.344, p=.007, η^2p= .804, yielding longer duration in the final and medial than initial position (CV1V2 >> CV1V2C >> V1V2C) (Fig.7). This means that the duration of monosyllabic word without onset was produced much faster and quicker than the monosyllabic word with onset. However, the main effect of language was not significant (p >.09) (Table 3). This revealed a degree of durational uniformity of /αY/ like /aɪ/ across L1 speakers of Indo-Aryan and Dravidian families. Further, the interactional effect between languages and positions was significant, F(1, 7) = 3.341, p=.043, η^2p = .985, revealing a longer duration of /aʊ/ in the final and medial positions for HinE and ChatE than in final and medial positions for TelE and MalE (Fig.7).

Two-way ANOVA on F0 of /aʊ/ across languages and positions showed the main effect, F (1, 7) =6.073, p=.040, η^2p= .985 of languages, signifying the higher frequency for MalE and TelE than HinE and ChatE speakers (i.e., MalE>>TelE>>HinE>>ChatE) (Fig. 9D). Here, the F0 of /aʊ/ across speakers was sharply differentiated between genetic families of L1, suggesting higher F0 for Dravidian than Indo-Aryan IE speakers (Table 2). Neither the main effect of positional occurrences of F0 (p>.204) nor the interactional effect of F0 between language and positional occurrence was significant (p>.374).

Analysis of duration (ms) and F0 (Hz) of /əʊ/

English speakers of both Indo-Aryan and Dravidian families speak diphthong /əʊ/ as long monophthong [oː] (/əʊ/>[oː]) (Fig.8). Two-way ANOVA on 4 languages and 3 positions on the duration of /əʊ/ manifested the positional differences, $F(1,7) = 4.837$, $p = .056$, $\eta^2p = .617$, which was significantly longer in the initial than final and medial positions (V1V2C >> CV1V2 >> CV1V2C). The durational effect across languages failed to reach significance ($p > .142$), just like the interaction effect between languages and positions ($p > .478$) (Table 3). The lack of significant variation in the duration of monophthongs [oː] in place of /əʊ/ indicated a higher degree of uniformity of IE across L1S irrespective of their genetic affiliations (Table 3).

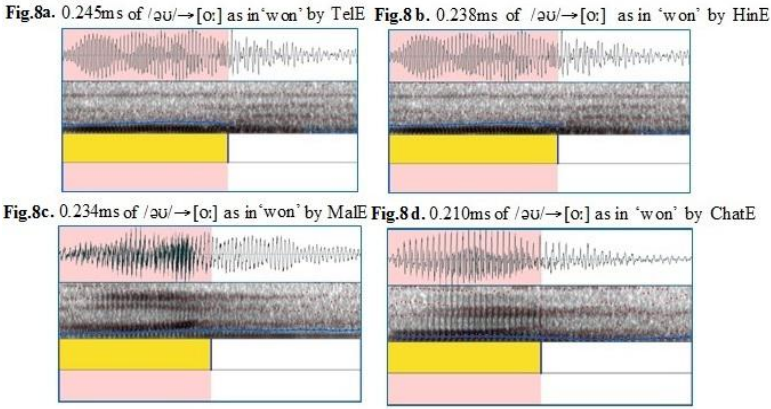


Figure 8 demonstrates the long monophthongization [oː] of English diphthong /əʊ/ (/əʊ/> [oː]) as produced in the word 'own' by (8a) TelE, (8b) HinE (8c) MalE and (8d) ChatE English speakers. Selected yellow color shows the duration of /əʊ/□[oː] in ms. The blue curved line indicates the F0 contour, which shows no fluctuations.

Two-way ANOVA on F0 /əʊ/> [oː] demonstrated the main effect of languages, $F(1, 7) = 6.057$, $p = .041$, $\eta^2p = .784$, showing a continuous degree of gradation of higher F0 values for TelE and MalE than that of HinE and ChatE speakers (i.e., TelE>>MalE>>HinE>>ChatE) (Fig. 9E). Also, some degree of F0 differences of monophthong [oː] was found across L1 speakers. This variation sharply fell between genetic families of L1S, suggesting a higher F0 for Dravidian than Indo-Aryan speakers (Table 2). No significant F0 effect for /əʊ/ was found of either positional occurrence($p > .691$) or the interaction between language and positional occurrences ($p > .192$).

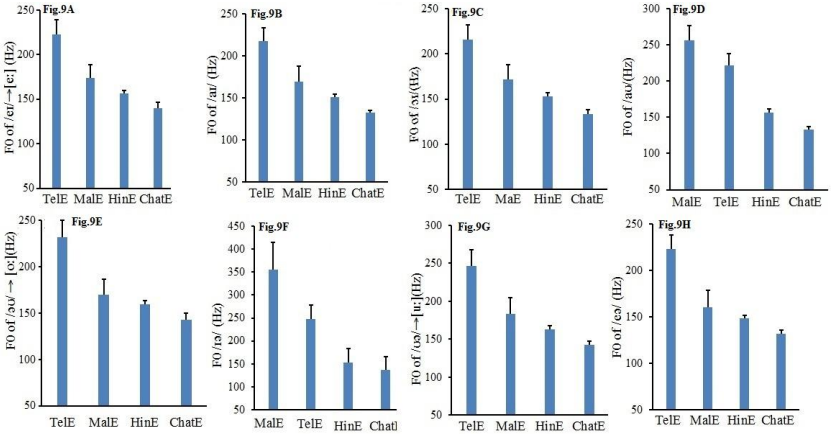


Figure 9 shows the mean values of F0 (Hz) of the long monophthongs (9A) /eɪ/>[eː], (9E) /əʊ/> [oː], and (9G) /ʊɔ/> [uː], and diphthongs (9B) /aɪ/, (9C)/ɔɪ/, (9D) /aʊ/, (9F) /ɪɔ/ and (9H) / eɔ/ of IE. It shows higher F0 in Dravidian (TelE, MalE) than in Indo-Aryan (HinE, ChatE) speakers.

Analysis of duration (ms) and F0 (Hz) of /ɪə/

Two-way ANOVA on 4 and 3 positional occurrences on the duration of /ɪə/ did not reveal the effect of language (p>.365) (Table 3) and of positional differences (p>.111). Even the interactional effect between language and positional occurrences was not significant (p>.319). Therefore, the lack of durational variation in/ɪə/ revealed a greater degree of uniformity of IE across L1S, irrespective of their genetic families (Table 3).

Further, two-way ANOVA between language and positional occurrences on F0 of /ɪə/ did not show any significant interaction (p>.865) and the main effect of positional occurrences (p>.602). However, the main effect on F0 across languages was significant, F(1, 7) =5.405, p=.050, η^2p= .764, obtaining higher F0 for MalE and TelE than HinE and ChatE (i.e., MalE>>TelE>>HinE>>ChatE) (Fig.9F & Table 2).This systematic variation in F0 of /ɪə/ demonstrated a dissimilarity between genetic families of L1s, suggesting a higher F0 for Dravidian than the Indo-Aryan IE speakers (Table 2).

Analysis of duration (ms) and F0 (Hz) of /ʊə/

Speakers from Indo-Aryan and Dravidian families speak /ʊə/ as long /uː/ (Fig.10). A two-way factorial ANOVA on 4 languages (HinE, ChatE, TelE and MalE) × 2 positions (medial and final) on duration/ʊə/ as [uː], neither revealed the significant main-effect of languages (p>.576) nor showed the significant interactional effect between language and positions (p>.296) (Table 3). Here, the monophthongization of /ʊə/to [uː] demonstrated greater uniformity across L1S, irrespective of their genetic affiliations (Table 3). Further, the main effect of positional occurrence was significant, F (1, 7) =29.471, p=.001, η^2p= .808, representing a longer duration of /uː/ in the final than medial positions of words (i.e., CV1V2 >> CV1V2C).

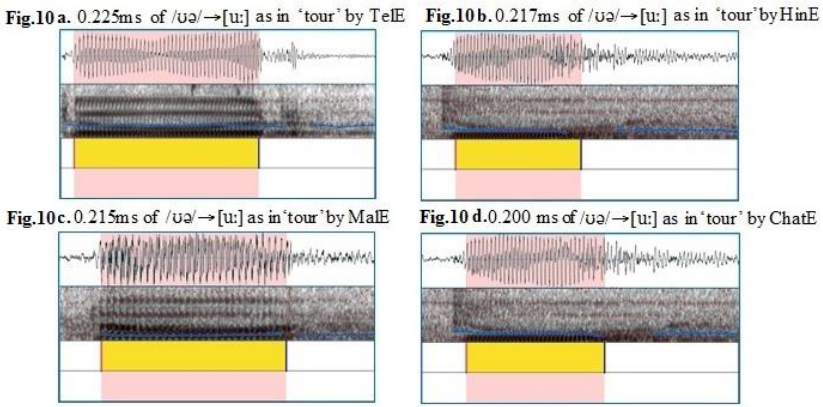


Figure 10 validates the long monophthongization [u:] of English diphthong /ʊə/ (/ʊə/□[u:]) as in 'tour' produced by (10a) TelE, (10b) HinE, (10c) MalE and (10d) ChatE English speakers. Selected yellow color shows the duration of /ʊə/>[u:] in ms. The blue curved line indicates the F0 contour, which shows no change across a language.

Two-way ANOVA on 4 languages and 2 positions (medial and final) on F0 (Hz) of /ʊə/ as [u:] revealed the main effect of language, which was close to significant, F (1, 7) =4.686, p=.065, η^2p= .738, indicating higher frequency for TelE and MalE than Hindi and Chhattisgarhi speakers (i.e., TelE>>MalE>>HinE>>ChatE) (Fig. 9G & Table 2). These variations of F0 for long monophthong [u:] demonstrated a genetic affiliation of L1s, suggesting a higher F0 for L1 speakers belonging to Dravidian than Indo-Aryan languages (Table 3). The main effect of positional occurrence (p>.277) and the interaction between languages and positions (p>.812) were, however, not significant.

Analysis of duration (ms) and F0 (Hz) of /eə/

ANOVA of two-factor 4 languages and 3 positions on the duration of /eə/ neither showed the main effect of language (p>.162) nor revealed any significant interaction (p>.741) between language and positions. The lack of significant differences in the duration of /eə/ suggests a greater uniformity in IE of both the genetic families of L1S (Table 3). However, the main effect of positional differences were significant, F (1, 7) =8.368, p=.018, η^2p= .736, confirming the longer duration of /eə/ in the initial than medial and final positions (V1V2C >> CV1V2C >> CV1V2) words.

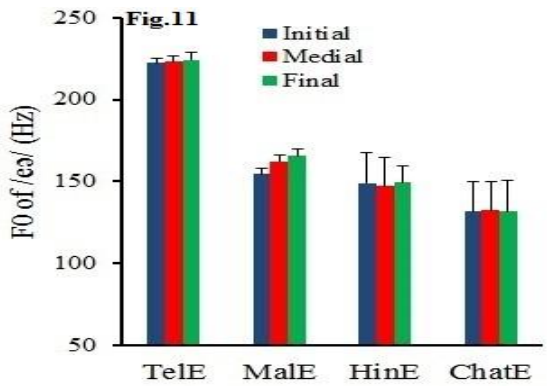


Figure 11 shows the mean F0 (Hz) values of IE /eə/, which significantly interacted across languages and positions, indicating higher F0 for word-initial, medial and final of TelE than MalE, HinE and ChatE speakers.

ANOVA results on F0 (Hz) of /eə/ showed the main effect of language, which was significant, F (1, 7) =7.798, p=.025, η^2p= .824, indicating a higher F0 value for TelE and MalE than HinE and ChatE speakers (i.e., TelE>>MalE>>HinE>>ChatE) (Fig.9 H). This reveals that the F0 of /eə/ was higher for Dravidian (TelE, MalE) than for Indo-Aryan (HinE, ChatE) speakers (Table 2). There was no significant main effect of F0 related to the positional occurrence (p>.647) of /eə/. However, the interaction between language and positional occurrences was significant, F(1, 7) =9.208, p=.017, η^2p= .994, suggesting a higher F0 of /eə/ for Dravidian (TelE, MalE) than Indo-Aryan speakers (HinE, ChatE) in the initial, medial and final positions (Fig.11).

F0 differences of diphthongs and adapted long monophthongs of IE

To examine the F0 differences of IE diphthongs and adapted long monophthongs, a t-test of F0 values between two families (Dravidian and Indo-Aryan) of languages revealed a significant difference with a higher effect, [t (7) = 9.188, p=.0001 <.05], suggesting higher mean F0 values for Dravidian (208.744Hz) than Indo-Aryan (145.778Hz) family. Further, a simple t-test of F0 values between two languages of the Dravidian family (Telugu and Malayalam) revealed a significant difference with a lesser effect, [t (7) = 2.541, p=.039 <.05], suggesting a higher mean of F0 values for Telugu (225.962Hz) than Malayalam (191.530Hz). The mean difference of F0 within the Dravidian family (Telugu and Malayalam) is relatively lesser (34. 432Hz) than the mean differences of F0 between the two families (62.965Hz). A simple t-test of F0 values between two Indo-Aryan languages (Hindi and Chhattisgarhi) revealed a significant difference with a small effect size [t(7) = 18.643, p = .013 < .05], suggesting a higher mean F0 for Hindi (154.936Hz) than for Chhattisgarhi (136.611Hz). The mean difference of F0 within the Indo-Aryan family (Hindi and Chhattisgarhi) is relatively lesser (18.235Hz) than the mean differences of F0 values between the two families (62.965Hz). These statistical differences support our hypothesis-1, reporting a significant difference with a greater effect between Dravidian and Indo-Aryan families. However, there is a significant difference in the effect between the languages in the same family.

Duration of diphthongs and adapted monophthongs of IE

A t-test of durational length of IE diphthongs between two families (Dravidian and Indo-Aryan) of language revealed a significant difference with a higher effect, [t (7) = 6.945, p=.0001 <.05], suggesting higher durational mean values of diphthongs and adapted monophthongs for Dravidian (0.252ms) than Indo-Aryan (0.227ms) family. Similarly, a t-test of durational length values between two languages of the Indo-Aryan family (Hindi and Chhattisgarh) revealed a significant difference with a lesser effect, [t (7) = 5.781, p=.001 <.05], suggesting a higher mean of durational values of diphthongs for Hindi (0.247ms) than Chhattisgarh (0.208ms). Further, a simple t-test of durational length values of diphthongs and adapted monophthongs between two languages of Dravidian family (Telugu and Malayalam) revealed a significant difference with a lesser effect, [t (7) = 2.722, p=.030 <.05], suggesting a higher mean of durational values of diphthongs for Telugu (0.261ms) than Malayalam (0.242ms). This result supports our hypothesis-2 that, within the Dravidian family, Telugu

speakers produce a longer duration of IE diphthongs and adapted monophthongs than Malayalam speakers.

Discussion

IE speakers maintain homogeneity in the adaptation of three IE diphthongs as long monophthongs (/eɪ/>[eː], /əʊ/> [oː] and /ʊə/> [uː]). The variation in the duration of long monophthongs [eː] and diphthongs [ɔɪ] of IE was longer for Hindi and Telugu L1 speakers (Table 3). This is due to the influence of time-sensitive L1 rhythmic features of Telugu and Hindi. While Hindi is syllable-timed, Telugu is a mora-timed language. Speakers of both these languages preserve the L1 features of syllables and of the mora weight while producing the L2 words. The syllable-timed language does not have reduced vowels and tends to provide rhythmic prominence of syllables in an equal space (Dankovicova & Dellwo, 2007). However, in mora-timed language, the rhythm falls according to the occurrence of morae in a syllable (Dauer, 1983). The vowel duration is higher in mora-timed and syllable-timed languages than in stress-timed languages like English (Liu & Takeda, 2021). In this direction, our study demonstrates that the duration of diphthongs was higher for mora-timed language like Telugu than the duration of diphthongs of syllable-timed language like Hindi. Our results also demonstrate that Telugu speakers produce longer IE diphthongs and adapted monophthongs than Malayalam speakers. This is a resultant feature of the duration of native Telugu diphthongs, which is similar to that of long vowels (Velayudhan & Howie, 1974; Reddy, 1988). This indicates that the pronunciation of IE diphthongs is influenced by L1 patterns of duration.

F0 was higher for Dravidian (TelE and MalE) than Indo-Aryan (HinE and ChatE) L1 speakers (Table 2). Thus, it is established that greater homogeneity in terms of duration (ms) (except the duration of [eː] and [ɔɪ]) and greater diversity in terms of F0 (Hz) define the characteristics of unity in diversity of IE.

Table 2 represents the F0 (Hz) results of IE diphthongs and long monophthongs across
L1 speakers of Dravidian and Indo-Aryan families

IE Diphthongs & adapted Monophthongs	F0 (Hz) of Dravidian family			F0 (Hz) of Indo-Aryan family			p	$\eta^2 p$
	TelE	MalE	Dravidian	HinE	ChatE	Indo-Aryan		
	Mean	Mean	G. Avg.	Mean	Mean	G. Avg.		
/ʊə/> [uː]	246.34	183.36	214.85	162.57	142.15	152.36	< .06*	.738
/əʊ/> [oː]	231.38	170.05	200.71	159.62	142.68	151.15	< .04**	.784
/eɪ/> [eː]	222.55	173.83	198.19	156.04	139.97	148.05	< .01**	.860
/aɪ/	217.39	169.77	193.58	151.06	132.21	141.63	< .05**	.581
/ɔɪ/	215.82	171.24	193.53	152.49	133.65	143.07	< .06*	.746
/aʊ/	221.51	255.80	238.65	156.39	132.65	144.52	< .04**	.785
/ɪə/	229.47	247.48	238.47	152.92	137.68	145.30	< .05**	.764
/eə/	223.24	160.71	191.975	148.40	131.90	140.15	< .02**	.824
* p<.06 (close to significant), **p< 0.05(significant) Grand Average (**G. Avg.**)								

Adaptation of diphthongs as long monophthongs: Uniformity in IE

Indo-Aryan and Dravidian speakers produced three diphthongs, i.e. /eɪ/, /əʊ/ and /ʊə/ as long monophthongs, i.e. [e:], [o:] and [u:]. This is consistent with the results of recent research, which establishes that Punjabi-Urdu-English speakers often assimilate IE diphthongs /eɪ/, /əʊ/ and /ʊə/ as long monophthongs [e:], [o:] and [u:] (Wiltshire &Harnsberger, 2006; Maxwell & Fletcher, 2010). Speakers of Telugu, Tamil, Kannada and Malayalam tend to monophthongize the IE diphthongs/eɪ/> [e:] and /əʊ/> [o:] (Ganta, 2014).

Duration of adapted long monophthongs in IE

The duration of diphthongs equates with the duration of long monophthongs, as the native Telugu diphthongs have a similar duration to that of long vowels (Velayudhan & Howie, 1974; Reddy, 1988). However, MalE speakers tend to produce a shorter duration of long monophthong [e:] because the duration of native Malayalam diphthongs is largely equivalent to monophthong (Bai, 1985). So, this study confirms that the mean duration of [e:] is higher for speakers of TelE and HinE than that of MalE and ChatE (Table 3). This observation supports our argument that the duration of diphthongs of L1 influences the duration of diphthongs and adapted monophthongs in L2, as it was found in the case of Telugu and Malayalam.

Table 3 lists the mean duration (ms) results of IE diphthongs and long monophthongs across L1 speakers of Dravidian and Indo-Aryan families

IE Diphthongs & adapted Monophthongs	Duration (ms) produced by Dravidian speakers			Duration (ms) produced by Indo-Aryan speakers			*p*	η^2 *p*
	TelE	MalE	Dravidian	HinE	ChatE	Indo-Aryan		
	Mean	Mean	G. Avg.	Mean	Mean	G. Avg.		
/ʊə/>[u:]	0.222	0.209	0.225	0.223	0.189	0.206	=.57*	.305
/əʊ/> [o:]	0.252	0.226	0.239	0.232	0.187	0.209	=.14*	.634
/eɪ/> [e:]	0.270	0.240	0.255	0.256	0.200	0.228	=.01**	.870
/aɪ/	0.245	0.264	0.254	0.249	0.212	0.230	=.25*	.525
/ɔɪ/	0.312	0.278	0.295	0.285	0.221	0.253	=.04**	.771
/aʊ/	0.237	0.234	0.235	0.257	0.201	0.229	=.09*	.688
/ɪə/	0.286	0.242	0.264	0.240	0.231	0.235	=.36*	.443
/eə/	0.267	0.245	0.256	0.241	0.224	0.232	=.16*	.612
* *p*= .09to 0.5 (not significant), ***p*= 0.05 to 0.04 (significant), Grand Average (**G. Avg**.)								

Except for the long monophthong [e:], the other two long monophthongs of IE: /əʊ/> [o:] and /ʊə/> [u:] do not show any significant variation of duration across HinE, ChatE, TelE and MalE speakers (Table 3). Therefore, the monophthongization of three English diphthongs (/eɪ/> [e:], /əʊ/> [o:] and /ʊə/>[u:]) clearly demonstrates phonetic uniformity in IE. Furthermore, the duration of long monophthongs [e:] and

[uː] was higher in the final than in the medial positions of words (i.e., open syllable with onset (final) >> closed syllable with onset (medial) >> closed syllable without onset (initial). This confirms the findings of an earlier study, which suggested that IE diphthongs and monophthongs are stressed in word ending (open) and word medial (closed) monosyllabic contexts, thereby increasing their lengths more than their occurrences in the initial positions (onset less) (Pandey, 1992). To sum up, the current results support the argument that IE speakers with homogeneous educational backgrounds and the age at which exposure to English as a second language is initiated show a similar trend with less variation (Sirsa & Redford, 2013).

IE speakers often assimilate diphthongs /eɪ/ and /əʊ/ as long /eː/ and /oː/ monophthongs (Trudgill & Hannah, 2008; Sailaja, 2009; Mukherjee, 2010). This assimilation can be considered an adaptive process of IE (Olaizola, 2019). In contrast to the earlier observation that IE has six diphthongs (Fuchs, 2015), the current study has classified five diphthongs and three long-monophthongs of IE (Table 3). These affinities of producing diphthongs as long monophthongs have been observed in many sub-varieties of Englishes across the globe. For instance, like IE, Vietnamese, Australian, Japanese and Thai English speakers also produce monophthong in place of diphthongs /eɪ/ as in 'face' and /əʊ/ as in 'goat' (Nguyen & Ingram, 2004; Tsukada, 2008; Gardiner &Deterding, 2020). Under the theoretical framework of natural phonology (Donegan &Stampe,1979), the variation and change of diphthongs as monophthong comes under the process of lenitions. Lenitions minimize the syntagmatic difficulty of producing the complexity of the sequence of vowels in the context of diphthongs (Dziubalska-Kołaczyk, 1990). Further, applying the moraic theory of phonology, a study on Urhobo English, which is a variety of Nigerian English, has shown that the speakers of a regional variety of English always need to preserve the moraic weight of the deleted V2, i.e., /ɪ/ of /eɪ/ and /ə/ of /ʊə/ through the compensatory lengthening of V1 (Utulu, 2014). Hyman (2019) points out that the use of the non-syllabic feature in a second vowel in a diphthong indicates the relative prominence of the first vowel, thereby increasing its length. This phonological process of compensatory lengthening (Hayes, 1989) of monophthong, which is seen as the smoothing of complex gestures, is evident during the simplification of diphthongs in IE.

Uniformity and diversity in duration (ms) of IE diphthongs

Except the diphthong /ɔɪ/, the remaining four: /eə/, /ɪə/, /aɪ/, /aʊ/ did not show any significant variation of duration across HinE, ChatE, TelE and MalE speakers. These similarities and dissimilarities support the arguments made by earlier studies that IE demonstrates a homogeneous uniformity among speakers despite the phonological variations of their L1s (Sirsa & Redford, 2013). Comparing the acoustic characteristics of Indo-Aryan speakers, Maxwell and Fletcher (2009, 2010) argue that the acoustic differences are due to persistent influences of speakers of L1 on IE. Like MalE, ChatE exhibits a shorter duration of diphthongs than other Englishes varieties (Table 3). This happens because the timing of the transition is not constant for all diphthongs (Lindauet al., 1990; Ladefoged & Johnson, 2011). Studies have found that the duration of diphthongs across Northern and Southern Welsh English does not show any significant cross-dialectal differences, though the mean duration of /ɔɪ/ is significantly shorter than other diphthongs (Mayr and Davies, 2011). On the contrary, the mean duration of /ɔɪ/ is higher than that of other diphthongs across IE speakers, irrespective of the genetic affiliation of L1 (Table 3). Moreover, four non-significant durational variations of diphthongs (/eə/, /ɪə/, /aɪ/ and /aʊ/) are considered homogeneous, spoken by Indo-Aryan (HinE & ChatE) and Dravidian (TelE & MalE)

speakers in India. This argument is associated with the statement that L2 speakers of English may not show the variability in all diphthongs following their L1 backgrounds (Vaughn et al., 2019).

F0 of long monophthongs and diphthongs: Diversity in IE

Analysis of F0 (Hz) of English diphthongs /eə/, /ɪə/, /aɪ/, /ɔɪ/, /aʊ/ and adapted long monophthongs /eɪ/> [eː], /ʊə/>[uː] and /əʊ/>[oː] revealed higher F0 frequency for Dravidian (TelE & MalE) than Indo-Aryan (HinE & ChatE) L1 speakers (Fig.9 & Table 2). Within the genetic affiliation of the Dravidian family, TelE speakers produced higher F0 than MalE speakers. Similarly, within the genetic family of Indo-Aryan L1s, HinE speakers produced higher F0 than ChatE speakers (Table 2). Thus, the F0 differences of IE diphthongs were very high between Dravidian and Indo-Aryan language speakers. However, the F0 differences were low within the family Indo-Aaryan and Dravidian language speakers (Fig. 9 & Table 2). This finding confirmed our hypothesis-1 that F0 differences of IE diphthongs and adapted long monophthongs are highly significant with greater effect between Indo-Aryan and Dravidian families of L1, whereas the differences of F0 are negligible or significant with lesser effect within a family of L1. Overall, this study has shown that Dravidian (TelE, MalE) IE speakers produce a higher mean of F0 than Indo-Aryan IE speakers (HinE, ChatE) (Table 2).

Conclusions and recommendations

We conclude that the fundamental frequency (F0) of IE diphthongs and adapted long monophthongs appear higher for Dravidian than Indo-Aryan L1 speakers. Furthermore, the minimal F0 variation of IE is observed within a language family, whereas the F0 variation is larger between families of languages. Firstly, we prove that F0 difference of IE diphthongs is significant between Indo-Aryan and Dravidian families of L1, whereas the differences of F0 is negligible or significant with lesser effect within a family of L1. Secondly, we also prove that almost all IE speakers belong to Indo-Aryan and Dravidian families, and maintain homogeneous uniformity in the process of monophthongization of three diphthongs (/eɪ/> [eː], /əʊ/> [oː] and /ʊə/> [uː]). IE is one of the varieties of English that characterizes the unity in diversity across Indian linguistic boundaries (Wiltshire, 2005; Sirsa & Redford, 2013). Therefore, within the Dravidian family, Telugu speakers produced a longer duration of IE diphthongs than Malayalam speakers because the duration of native Telugu diphthongs is similar to that of long vowels (Velayudhan & Howie, 1974; Reddy, 1988). The L1 rhythmic patterns of duration influence the pronunciation of IE. Finally, we demonstrate that greater variation in duration enhances the presence of identical markers, whereas lesser variation accelerates homogeneity in IE.

These phonetic variations and similarity of diphthongs may be considered to maintain a distinctive identity of Indian English like British, American, Australian and New Zealand Englishes. Further, these findings can be considered when designing acoustic likelihood measures for automatic speech recognition and text-to-speech software in IE. Moreover, the findings of this study are restricted to controlled laboratory experiments and to the reading style of isolated-word speech. A comprehensive study is needed to investigate the typological features of monophthongization (/uː/ and /oː/) of English diphthongs/ʊə/ and /əʊ/ across Indian languages. Therefore, our future study will be focused on the sociolinguistic variations of Indian English, correlating the acoustic features of diphthongs with social variables such as gender and age.

Acknowledgements
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Ethical Approval
The research was conducted in full compliance with the ethical standards outlined in the Declaration of Helsinki, and all research procedures adhered to the ethical principles commonly upheld in social science research. Additionally, the Head of Research (NIT, Raipur) and the Deanship of Scientific Committee (PSAU) at our institutions were aware of and informed about this research study.
Informed consent was obtained in written from all participants included in the present study.

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