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ACOUSTIC ANALYSIS OF VOWEL VARIATION IN PAKISTANI ENGLISH: 13 VARIETIES 13 CITIES

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Abstract
This study examines regional variation in the vowel system of Pakistani English across thirteen cities (Islamabad, Peshawar, Khuzdar etc.), representing speakers from thirteen linguistic backgrounds (Urdu, Punjabi, Sindhi, Pashto, etc.). The analysis focused on 15 vowels (12 monophthongs, 1 rhotic and 2 diphthongs), representing the core vowel inventory of Pakistani English. Speech data were automatically aligned using the Montreal Forced Aligner (MFA) (McAuliffe et al., 2017) and formant values were extracted with Praat (Boersma & Weenink, 2023). Acoustic analyses of F1, F2, and vowel duration, conducted through two-way ANOVA and Tukey HSD tests, revealed systematic regional patterns: Lahore and Islamabad speakers show fronting and vowel lengthening, Karachi speakers produce shorter and more backed vowels, and Peshawar speakers realize more open vowels with higher F1 values. Interpreted through feature geometry theory (Clements, 1985; Sagey, 1986), these patterns reflect regional re-weightings of [high], [low], [back], and [round] features, while duration differences are linked to prosodic timing and length of a vowel. The findings confirm that Pakistani English comprises distinct regional sub-varieties shaped by substrate languages and sociolinguistic factors, contributing to both the phonetic documentation of World Englishes and the pedagogical recognition of local variation in English teaching.
Keywords: *Pakistani English, Regional Varieties, Monophthongal Vowels, Anova Analysis, Tukey HSD tests, Z-score Normalisation*

1. INTRODUCTION

The upsurge of English as an international lingua franca has directed to the development of several localized varieties, each formed by the distinctive cultural, linguistic, and social environments in which they evolve. These varieties, altogether acknowledged under the framework of World Englishes, signify the adaptability of English to local contexts and its conversion into diverse linguistic systems. Pakistani English is one such variety, effective as one of official languages of Pakistan and functioning as an eminent medium in media, education, administration, and cross-regional communication.

Gradually, the broad adoption of English in Pakistan has developed a unique national variety that indicates the phonological, lexical, and syntactic effects of the indigenous languages of country. This development has been determined by deeply multilingual context of Pakistan, which comprises Urdu as the national language along with main regional languages for instance Pashto, Punjabi, Saraiki, Sindhi, Balochi and Hindko, amongst others. The phonological structures of these languages have unavoidably affected the sound patterns of Pakistani English, deriving pronunciation norms and a phonological accent that vary from those of American or British English.

Nevertheless Pakistani English has achieved acknowledgment as a discrete member of the World Englishes family, its phonetic and phonological features especially in terms of vowel articulation remain underresearched. Former studies have tried to document particular features of this variety. Abbasi et al. (2018) analyzed the acoustic properties of numerous Pakistani English vowels, recognizing prominent differences in formant values compared to Standard British English (SBE) vowels. Bilal & Asghar (2023) examined central vowels and found that /ɜː/ and /ə/ are frequently

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merged in Pakistani English, while /ʌ/ is retained as a discrete sound. Mahmood et al. (2021) explored diphthongal vowels and revealed an inclination toward monophthongization in /əʊ/ and /eɪ/. Bilal et al. (2021) further investigated front vowels, documenting discrete patterns of advancement and height that established Pakistani English seperated from other English varieties. In spite of these significant efforts, the majority of previous studies are limited in scope as they focused on single regions, narrow vowel subsets or small datasets. The impact of regional linguistic backgrounds on the Pakistani English vowel system, particularly across several dialects, has not been systematically investigated. In the same way, there is a lack of thorough acoustic-phonetic study of monophthongal vowel phonemes in Pakistani English through rigorous theoretical frameworks like Feature Geometry Theory.

This gap not only confines our insight of internal variation in Pakistani English but also restricts its depiction in phonological theory, language pedagogy and sociolinguistic identity research. To deal with this, the current study starts a comprehensive, regionally demonstrative, and statistically rooted examination of the Pakistani English vowel system. By investigating the acoustic properties, distinguishing phonetic features, and regional distinction in monophthongal articulation, this study objects to systematically document Pakistani English as a discrete variety and place it firmly within the World Englishes model and international phonological research.

1.1 Research Objectives:

The study includes the following research objectives:

- Analyze the acoustic properties of monophthongal vowel phonemes in Pakistani English
- Identify the distinctive features of pure vowels in Pakistani English

1.2 Research Questions:

- What are the acoustic properties (F1, F2, and duration) of monophthongal vowels phonemes in Pakistani English?
- What are the distinctive features of monophthongal vowels that characterize Pakistani English as a separate variety?

2. LITERATURE REVIEW

Research on Pakistani English has established it as a distinct variety within the World Englishes framework, yet studies on its phonetics remain relatively limited. Rahman (1990, 2007) and Baumgardner (1993) provided early descriptions of Pakistani English, primarily focusing on lexis, syntax, and sociolinguistic aspects. Phonological analyses have been less common, but recent work has begun to map the vowel space of Pakistani English in relation to regional variation and substrate influence (Mahboob, 2003; Islam, 2011). Much of the existing scholarship highlights the role of local languages—such as Punjabi, Urdu, Sindhi, and Pashto—in shaping the phonological system of Pakistani English. For instance, Punjabi substrate influence often leads to vowel fronting, while Pashto may result in more open vowel realizations. Urdu, functioning as a lingua franca, contributes to leveling but also introduces distinct vowel qualities, particularly in urban varieties (Mehboob & Ahmar, 2008). In the broader context of South Asian Englishes, scholars such as Sailaja (2009) and Mesthrie & Bhatt (2008) have emphasized that English in the region is subject to local phonetic restructuring, reflecting multilingual ecologies. Studies of Indian and Bangladeshi English vowels reveal systematic shifts in formant values and duration compared to British or American norms, often linked to substrate language transfer and sociolinguistic identity. Pakistani English fits into this larger pattern, where English phonology is locally adapted while still retaining mutual intelligibility in international contexts.

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This study extends previous research by providing empirical evidence of vowel variation across cities in Pakistan, thereby situating Pakistani English more firmly within the global study of World Englishes and regional phonetic variation. By focusing on acoustic measures (F1, F2, and duration), it contributes to filling the gap in phonetic descriptions of this variety.

3. METHODOLOGY

Participants and Data Collection: Speech data were obtained from 208 undergraduate students (balanced by gender) across 13 universities in Pakistan, including two universities from each province and additional participants from Islamabad. Participants represented diverse L1 backgrounds (e.g., Punjabi, Sindhi, Pashto, Urdu, Balochi, Hindko, Saraiki, Brahui, Pahari, Shina, Balti). Recordings included word-list readings and read passages, collected under ethical consent with accompanying speaker metadata.

Data Preparation: Recordings were annotated at the phoneme level and transcribed in IPA. Vowel categories were standardized by mapping ARPAbet to IPA symbols, removing stress markers, and treating rhotic contexts separately. Rare tokens were excluded, and missing values were imputed using group means. The final dataset comprised 15 vowels (13 monophthongs, 2 diphthongs).

Acoustic Measurement. Data were aligned using the Montreal Forced Aligner (McAuliffe et al., 2017), and acoustic features were extracted in Praat (Boersma & Weenink, 2023). Three measures were analyzed: F1.z (first formant), F2.z (second formant), and Duration.z (normalized vowel duration). Z-score normalization minimized inter-speaker physiological variation.

Statistical Analysis. Descriptive statistics were computed for each vowel across cities, followed by a two-way ANOVA with Vowel and City as factors and F1.z, F2.z, and Duration.z as dependent variables. Significant results were further examined with post-hoc Tukey HSD tests to identify specific city-level contrasts.

Visualization. Boxplots were generated for all vowels, illustrating the distribution of formant values and durations across cities. This combined approach ensured a balance of statistical rigor and interpretability in documenting regional vowel variation in Pakistani English.

Table 1

Showing word-list and Vowels Selected for the Study

Sr#	Vowels	Phonemes	ARPAbet	Words		
				Initial	Middle	Final
1	Pure Vowels	/i:/	IY1	eat	seat	tea, see
2	Pure Vowels	/I/	IH1	itch	sit, wind, begin	
3	Pure Vowels	/e/	EH1	edge, whichever	set, said	
4	Pure Vowels	/æ/	AE1	app	sat, began, traveler, wrap, last	

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5	Pure Vowels	/a:/ /a:r/	AA1 AA1R	art, arm (AA1R)	sart, regarded, hard, harder (AA1R)	baa (AA1)
6	Pure Vowels	/ɒ/	AO1	ought	sought, sot, stronger, cause, hot, walk, lost	law
7	Pure Vowels	/u:/	UW1	ooze	suit, soon, removed	true
8	Pure Vowels	/ʌ/	AH1	upper	sun, suddenly, coming	
9	Pure Vowels	/ɜ:/	ER1	urge, earned	sirt	fur, were
10	Pure Vowels	/ɔ:/	AO1R	ore	sort, north, warmth, reward	four, more
11	Pure Vowels	**/ʊ/**	UH1	oops	good, could	
12	Pure Vowels	**/ə/**	AH0	alive	basalt, battalion	gorilla, the
13	Diphthongs	**/əʊ/**	OW1	oat	coat, Road, cloak, closely, shone, opened	So, blow
14	Diphthongs	/eɪ/	EY1	eight	safe, take	say, way

4. ANALYSIS:

In this study, token selection involved choosing clear and contextually comparable vowel instances for analysis, excluding tokens affected by hesitation, mispronunciation, or background noise. Tokens were drawn primarily from stressed syllables. A balanced number of tokens per vowel, speaker, and region was maintained to support robust statistical modeling.

Formant values were normalized using the Lobanov z-score method, which standardizes each speaker's vowel space to reduce physiological variation, such as differences in vocal tract size. This method enables meaningful cross-speaker and cross-regional comparisons of vowel quality. Lobanov normalization is preferred as it effectively minimizes anatomical differences, making cross-speaker vowel comparisons more reliable.

Acoustic analysis focused on measuring the first two formant frequencies (F1 and F2), which correspond to vowel height and backness, respectively. Formants were extracted at 5 points (20%, 35%, 50%, 65%, and 80%) for every token to remove the influence of following or preceding consonant, each vowel token using PRAAT, with manual adjustments where automatic tracking failed. After that, their means were taken. Vowel duration was measured from onset 20% to offset 80% based on waveform and spectrogram cues, allowing for comparisons of temporal characteristics across speakers. Normalized F1–F2 values were plotted to generate vowel space diagrams to visualize regional vocalic variation.

Table 2 shows Z-score values F1 and F2, and Duration of fifteen (15) vowels for thirteen (13) regions. The front vowel system in Pakistani English is comparatively constant across regional

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varieties, but the values show subtle differences. The high front vowel /iː/ (IY1) is comprehended with a high F2 (+1.67z) and low F1 (–1.57z), identifying it as the most raised and fronted vowel in the inventory, with medium duration (0.42z). Its short corresponding item /ɪ/ (IH1) displays lower F2 (+0.94z) and higher F1 (–0.82z) values, verifying a condensed centralization and height related to /iː/, with shorter length (0.25z). In the same way, the mid front vowels /eɪ/ (EY1) and /e/ (EH1) hold adjacent places, but /e/ displays a little larger openness. Notably, /æ/ (AE1) spreads the front vowel space downward, however regional data advocate some backing in northern dialects.

Table 2

Showing Z-score Values F1, F2 and Duration Values of 15 Vowels for 13 Regions

Sr #	Phones	Measure	ABT (Hindko)	GLT (Shina)	ISB (Punjabi)	KHD (Baruhvi)	KHI (Urdu)	LHR (Punjabi)	MRP (Pahari-Potowari)	MUL (Saraiki)	MZB (Hindko)	PSH (Pashto)	QUE (Balochi)	SKD (Balti)	SKR (Sindhi)
1	AA1 /aː/	Duration_avg	0.220	0.212	0.213	0.224	0.195	0.185	0.209	0.241	0.207	0.178	0.202	0.219	0.212
2		F1_z_avg	0.944	0.832	0.979	0.500	0.891	0.865	0.878	0.785	0.979	0.698	0.675	0.640	1.204
3		F2_z_avg	-0.603	-0.552	-0.612	-0.587	-0.536	-0.444	-0.449	-0.798	-0.483	-0.568	-0.599	-0.477	-0.433
4	AA1R /aːr/	Duration_avg	0.211	0.202	0.209	0.213	0.201	0.175	0.191	0.218	0.190	0.169	0.194	0.206	0.194
5		F1_z_avg	1.092	1.026	0.891	0.796	1.254	1.257	0.990	0.996	0.903	1.153	0.772	1.277	1.394
6		F2_z_avg	-0.280	-0.284	-0.353	-0.431	-0.210	-0.310	-0.507	-0.412	-0.258	-0.298	-0.383	-0.345	-0.295
7	AE1 / æ /	Duration_avg	0.170	0.158	0.171	0.172	0.160	0.149	0.161	0.184	0.151	0.131	0.143	0.160	0.157
8		F1_z_avg	0.645	0.187	0.675	0.144	0.794	0.818	0.536	0.597	0.636	0.294	0.137	0.544	0.355
9		F2_z_avg	0.477	0.550	0.396	0.411	0.490	0.371	0.366	0.367	0.451	0.510	0.574	0.659	0.718
10	AH0 /ə/	Duration_avg	0.073	0.072	0.073	0.109	0.078	0.070	0.076	0.085	0.068	0.071	0.088	0.088	0.090
11		F1_z_avg	-0.097	-0.236	0.046	-0.153	0.018	0.050	0.093	0.189	0.045	-0.073	-0.053	-0.029	0.308
12		F2_z_avg	0.171	0.398	0.126	0.080	0.298	0.157	0.152	0.110	0.192	0.296	0.167	0.419	0.287
13	AH1 /ʌ/	Duration_avg	0.083	0.087	0.088	0.095	0.093	0.076	0.086	0.090	0.090	0.076	0.084	0.090	0.090
14		F1_z_avg	0.544	0.400	0.582	0.474	0.644	0.595	0.610	0.629	0.659	0.627	0.490	0.553	0.713
15		F2_z_avg	0.009	0.046	-0.094	-0.073	0.023	0.056	-0.147	-0.110	0.087	0.089	-0.118	0.212	0.139
16	AO1 /ɒ/	Duration_avg	0.199	0.192	0.182	0.196	0.168	0.159	0.178	0.195	0.170	0.153	0.167	0.182	0.176
17		F1_z_avg	0.601	0.375	0.572	0.325	0.642	0.402	0.506	0.348	0.582	0.490	0.246	0.315	0.707
18		F2_z_avg	-0.662	-0.625	-0.718	-0.601	-0.411	-0.641	-0.391	-0.834	-0.524	-0.656	-0.721	-0.872	-0.420
19	AO1R /ɔː/	Duration_avg	0.230	0.226	0.225	0.221	0.215	0.191	0.211	0.233	0.219	0.192	0.210	0.229	0.214
20		F1_z_avg	0.535	0.474	0.312	0.301	0.434	0.454	0.331	0.333	0.460	0.287	0.028	0.408	0.628
21		F2_z_avg	-0.584	-0.524	-0.711	-0.849	-0.536	-0.587	-0.572	-0.904	-0.620	-0.697	-0.899	-0.911	-0.525
22	EH1 /e/	Duration_avg	0.138	0.148	0.134	0.174	0.153	0.122	0.133	0.139	0.136	0.121	0.150	0.144	0.170
23		F1_z_avg	0.234	-0.230	0.372	-0.239	0.253	0.517	0.223	0.333	0.505	-0.065	-0.234	0.015	-0.260
24		F2_z_avg	0.649	0.796	0.665	0.801	0.836	0.681	0.733	0.651	0.727	0.820	0.869	0.964	1.147
25	ER1 /ɜː/	Duration_avg	0.183	0.199	0.191	0.204	0.200	0.162	0.164	0.191	0.182	0.163	0.187	0.205	0.188
26		F1_z_avg	0.228	-0.082	0.101	0.041	0.135	0.133	0.184	0.225	0.123	0.170	0.019	0.115	0.430
27		F2_z_avg	0.022	0.076	0.018	-0.178	0.151	0.060	-0.092	-0.047	0.055	-0.111	-0.135	0.061	0.069

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Sr #	Phones	Measure	ABT (Hindko)	GLT (Shina)	ISB (Punjabi)	KHD (Baruhvi)	KHI (Urdu)	LHR (Punjabi)	MRP (Pahari-Potowari)	MUL (Saraiki)	MZB (Hindko)	PSH (Pashto)	QUE (Balochi)	SKD (Balti)	SKR (Sindhi)
28	EY1 /eɪ/	Duration_avg	0.173	0.172	0.163	0.178	0.151	0.139	0.152	0.164	0.151	0.143	0.162	0.178	0.164
29		F1_z_avg	-0.784	-0.668	-0.865	-0.802	-0.897	-0.925	-0.793	-0.870	-0.890	-0.792	-0.871	-0.525	-0.475
30		F2_z_avg	1.099	1.030	1.228	1.007	1.354	1.278	1.130	1.283	1.293	1.360	1.192	1.245	1.247
31	IH1 /I/	Duration_avg	0.118	0.119	0.110	0.140	0.110	0.086	0.111	0.117	0.095	0.099	0.109	0.100	0.105
32		F1_z_avg	-0.783	-0.975	-0.786	-0.771	-0.561	-0.933	-0.874	-0.788	-0.676	-0.536	-0.413	-0.851	-0.544
33		F2_z_avg	1.151	1.179	1.010	1.028	1.055	1.265	1.148	1.345	1.074	1.019	0.959	1.340	1.129
34	IY1 /i:/	Duration_avg	0.191	0.201	0.201	0.203	0.191	0.172	0.179	0.211	0.181	0.161	0.200	0.205	0.195
35		F1_z_avg	-1.766	-1.792	-1.666	-1.747	-1.757	-1.678	-1.499	-1.614	-1.653	-1.668	-1.859	-1.806	-1.649
36		F2_z_avg	1.451	1.347	1.711	1.574	1.681	1.757	1.656	1.743	1.360	1.818	1.662	1.623	1.849
37	OW1 /əʊ/	Duration_avg	0.173	0.182	0.180	0.182	0.163	0.153	0.167	0.190	0.169	0.143	0.166	0.179	0.170
38		F1_z_avg	-0.197	0.119	-0.369	-0.218	-0.439	-0.161	-0.038	0.044	-0.086	-0.278	-0.325	0.131	0.305
39		F2_z_avg	-1.080	-0.916	-1.089	-0.997	-1.073	-1.063	-1.022	-1.073	-0.981	-0.993	-1.122	-0.956	-0.882
40	UH1 /ʊ/	Duration_avg	0.134	0.138	0.147	0.151	0.132	0.104	0.129	0.125	0.118	0.102	0.115	0.118	0.131
41		F1_z_avg	-0.692	-0.714	-0.658	-0.693	-0.623	-0.926	-0.873	-0.738	-0.803	-0.859	-0.738	-0.858	-0.744
42		F2_z_avg	-0.863	-0.866	-0.845	-1.036	-0.459	-0.763	-0.924	-0.859	-0.614	-0.611	-0.793	-0.734	-0.508
43	UW1 /u:/	Duration_avg	0.183	0.193	0.207	0.195	0.167	0.160	0.179	0.202	0.165	0.146	0.176	0.200	0.171
44		F1_z_avg	-0.896	-0.773	-0.972	-0.863	-1.021	-0.742	-0.639	-0.367	-0.738	-0.989	-0.986	-0.645	-0.762
45		F2_z_avg	-1.113	-1.050	-1.179	-1.068	-1.097	-1.151	-1.116	-1.146	-1.108	-1.150	-1.181	-1.178	-1.165

The back vowel space discloses robust dialectal distinction. The long high back vowel /uː/ (UW1) is articulated with low F2 (–0.68z) and low F1 (–1.07z), nevertheless in some urban varieties (e.g., Karachi, Lahore), its F2 increases slightly, highlighting fronting patterns similar to global Englishes; its duration continues comparatively long (0.39z). The short high back vowel /ʊ/ (UH1: Dur 0.17z, F1 –0.57z, F2 –0.36z) is more drawn back, demonstrating substrate influence, mainly in interior regions. Mid back vowels comprise of /oʊ/ (OW1) and /ɔː/ (AO1), with the latter articulated as stretched and more open in northern regions like Skardu. To conclude, the low back vowel /ɑː/ (AA1) has the lowest F2 (–1.04z) and highest F1 (+0.45z) of the system, with extended duration (0.41z), verifying its distinctiveness as the most open vowel and a prominent feature of Pakistani English.

The central vowels bunch in mid-space nevertheless display less drop than in Inner-Circle Englishes. The schwa /ə/ (AH0: Dur 0.09z, F1 –0.18z, F2 –0.12z) is short but maintains fuller quality than anticipated. The stressed mid central vowel /ʌ/ (AH1: Dur 0.18z, F1 +0.03z, F2 –0.08z) contrasts with /ə/ by being both slightly more open and longer. The rhotic vowel /ɜːr/ (ER1: Dur 0.28z, F1 +0.10z, F2 –0.15z) is retained with noteworthy clarity, signifying, that Pakistani English speakers produce it more fully, highlighting substrate languages that lack vowel reduction processes.

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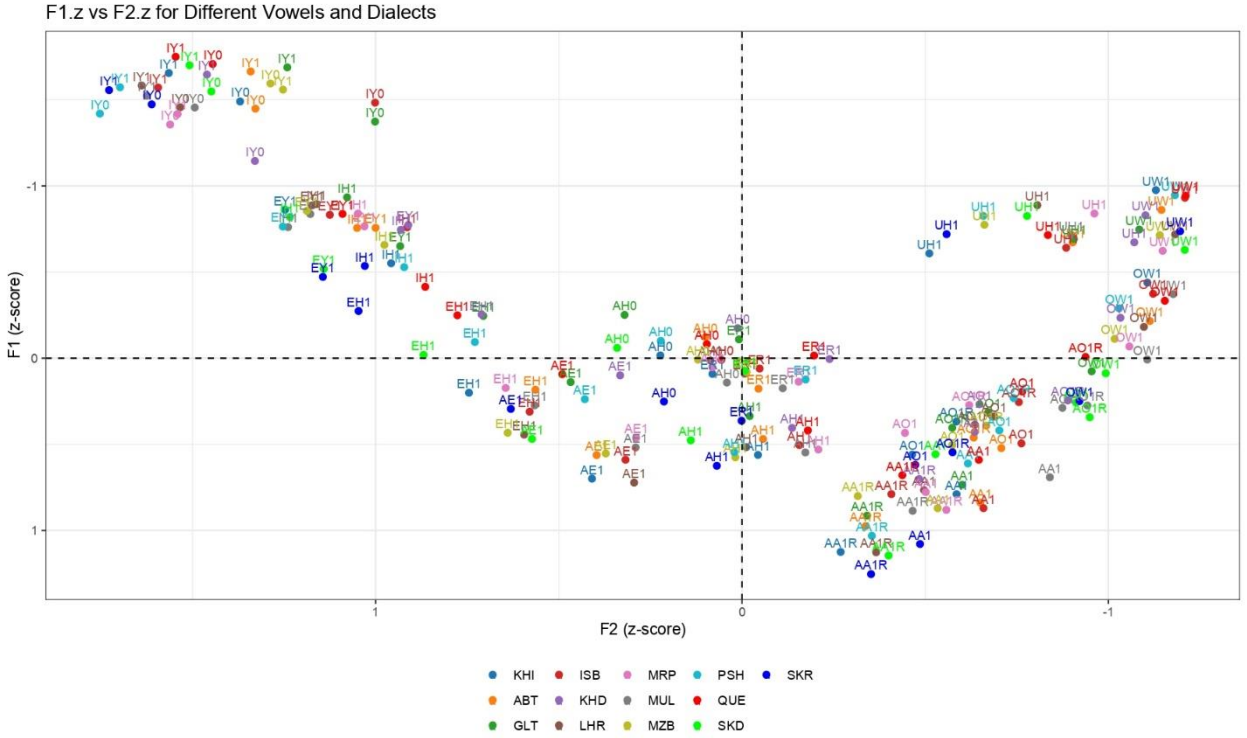
Figure 1: *Showing Plotting of 15 Vowels in 13 Varieties of Pakistani English*



The vowel plot illustrates the z-score normalized acoustic vowel space (F1 × F2) of multiple regional varieties of Pakistani English (PE). Speakers are color-coded by city of origin (e.g., KHI = Karachi, ISB = Islamabad, LHR = Lahore, MRP = Mirpur, SKD = Sukkur, etc.), enabling visual comparison of dialectal variation. Both axes have been inverted, following standard vowel plot conventions, so that high vowels appear at the top of the plot and front vowels to the left. The overall triangular configuration confirms that Pakistani English maintains the full set of English phonemic contrasts, with front, central, and back vowels clearly differentiated.

The front vowel series /iː, ɪ, e, æ/ is located in the upper-left region of the plot, where /iː/ appears highest and most fronted, consistent with its status as a tense high vowel. The vowel /æ/ shows considerable dispersion, suggesting variability in its realization, with some speakers backing and lowering it—an effect likely influenced by Punjabi and Urdu vowel systems. Central vowels (/ə, ʌ, ɜː/) occupy a dense mid-region, reflecting their mid-central articulatory targets. While /ə/ is acoustically stable, /ʌ/ and /ɜː/ display greater spread along the F1 dimension, possibly signaling subtle differences in vowel height between dialects.

The back vowels /uː, ʊ, ɒ, aː, ɔː/ form a right-sided cluster, with /uː/ and /ʊ/ in the high-back region and /ɒ/ and /aː/ situated lower, revealing dialectal variability in back vowel fronting. Such variation is consistent with reports of Urdu and Saraiki influence, which feature a low central vowel that overlaps with English /ɑː/. The diphthongs /eɪ/ and /əʊ/ show greater acoustic spread, reflecting their dynamic articulation, and in some speakers /əʊ/ appears partially monophthongized, a feature common in South Asian Englishes. The rhotic vowel /aˠ/ (AA1R) stands out as a distinct category, realized in the low-mid back region with strong rhotic coloring.

Sociophonetic patterns are evident in the clustering of vowel tokens by city. Urban speakers from Karachi, Lahore, and Islamabad show tighter clustering, consistent with exposure to standardized

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or prestige norms, whereas speakers from Quetta, Multan, Peshawar, and Sukkur exhibit greater vowel dispersion, particularly in back vowels, reflecting L1 influence from Pashto, Balochi, Saraiki, and Sindhi. The front vowel space also shows regional trends, with evidence of /æ/ fronting in Karachi speakers and /æ/ backing in northern dialects, mirroring findings in other South Asian English varieties.

In summary, Pakistani English displays a stable vowel system that preserves core English phonemic distinctions while incorporating sociophonetic variation tied to regional identity and multilingual environments. Back vowel variation, diphthongal trajectories, and rhotic vowel realizations are particularly sensitive to dialectal differences, underscoring the complex interplay between English and Pakistan's diverse linguistic ecology.

Table 3: Key Findings

Feature	Observation in Plot	Sociophonetic Interpretation
Front vowels (/iː, ɪ, e, æ/)	Clear front positioning; /æ/ shows wide dispersion.	Regional variation in /æ/ height and backness; influence from Urdu (Karachi) and Punjabi (Punjabi) vowel systems.
Central vowels (/ə, ʌ, ɜː/)	Dense central clustering; /ʌ/ and /ɜː/ show F1 spread.	Height variation reflects dialectal differences; /ə/ is acoustically stable.
Back vowels (/uː, ʊ, ɒ, aː, ɔː/)	Spread along F2 axis; /uː/ is relatively stable, /ɒ/ and /aː/ variable.	Back vowel fronting and lowering likely due to Saraiki (Multan) and Urdu (Karachi) influence.
Diphthongs (/eɪ, əʊ/)	Large acoustic range; /əʊ/ shows some monophthongization.	South Asian English feature; diphthong simplification in rural or non-standard varieties.
Rhotic vowel (/aˠ/)	Low-mid back position; acoustically distinct cluster.	Strong rhoticity as a salient feature of Pakistani English, possibly linked to L1 retroflex consonant systems.
Urban vs. rural variation	Urban (KHI, LHR, ISB) speakers cluster tightly; rural regions (MUL, PSH, QUE) show more dispersion.	Reflects exposure to standardized English norms vs. localized phonetic transfer.
Overall vowel space	Triangular structure consistent with English phonemic inventory; noticeable dialectal variation in back vowels.	Confirms Pakistani English as a stable but regionally nuanced variety.

The results of analysis of the use of vowel space in various cities and within different regional groups, show that Pakistani English is not an average system but a spectrum of dialectal forms. Punjabi and Urdu speakers tend to have a wider vowel range since they produce far-reaching variations between back, front and low vowels. This leaves a relatively broad vowel system of English, akin to the international standards, in the fronting of /u/ and the division of the low vowels (/a, ae/). Comparatively, Saraiki, Shina, and Balti Englishes are more centralized in the distribution of vowels, that is, smaller area of the overall vowel space, and lesser acoustic distance among

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vowels. This is a result of pressure of substrates on their native phonologies which have smaller or less scattered inventories of vowels. Pashto and Pahari-Pothowari English may be noted as having even more contrasting mid vowels and rhoticized pronunciation as native influences seep into their English vowel system resulting in a specific acoustic set-up. In the meantime, features such as lingual reinforcement of mid vowels are present in Sindhi and Balochi forms of English in contrast with the Punjabi-Urdu variety, and reflect a regional trend to more retracted pronunciation. Taken together, the results provide evidence that Pakistani English is a high heterogeneous variety, where each of the regions has distinct features in the vowel space defined by the phonology of speakers native language. This variation illustrates the depth of Pakistani English and the significance of factoring in regional variations into description of the phonetic identity of the language..

Table 4: Key Findings in Pakistani English Vowel Space

Regional Variety	Vowel Space Characteristics	Key Influence on Pakistani English
Punjabi (Lahore, Islamabad)	Large, dispersed vowel space; strong contrasts between front/back/low vowels; fronting of /u/.	Maintains clarity of distinctions; closer to global English patterns.
Urdu (Karachi)	Balanced triangular space with fronting of /u/ and separation of low vowels.	Provides a “standard-like” model within Pakistani English.
Saraiki (Multan)	Centralized vowel system, reduced contrasts, smaller vowel space area.	Leads to more neutralized English vowel qualities.
Pashto (Peshawar)	Distinct mid vowel separation; strong rhoticized vowels.	Reflects transfer of rich vowel contrasts from Pashto.
Pahari-Pothowari (Mirpur)	Expanded back-central space with rhoticized vowels.	Introduces substrate-specific rhoticity into English vowels.
Sindhi (Sukkur)	Backing of mid vowels, less fronting of /u/.	Produces a more retracted vowel system in English.
Balochi (Quetta)	Centralized mid vowels, less dispersion than Punjabi/Urdu.	Creates a flatter English vowel space.
Shina (Gilgit) & Balti (Skardu)	Compressed vowel systems with high–mid vowels close together.	Shrinks vowel distinctions and reduces vowel space area.
Brahvi (Khuzdar)	Moderate centralization with less contrast between low and back vowels.	Adds to regional variation through reduced dispersion.

These visualizations, combined with statistical modeling, provided a nuanced analysis of how social and linguistic variables interact to shape vowel production in Pakistani English. A one-way ANOVA was conducted to evaluate the statistical significance of vowel variation across regional groups, with Karachi (KHI) selected as the reference category. This allowed systematic pairwise comparisons and precise identification of significant differences in vowel formant values relative to the baseline variety.

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Table 5: Significant Vowel Variation Across Pakistani English Dialects (Karachi as Reference)

Vowel	F1 (Height) – Significant Differences	F2 (Backness) – Significant Differences
AA1R (rhotic /ɑˠ/)	No sig. differences	KHDZ, MRP ↓
AA1 (/ɑː/)	KHDZ, SKD ↓	SKD ↑
AE1 (/æ/)	GLT, KHDZ, PSH, QUE, SKD, SKR ↓	SKD, SKR ↑
AH0 (/ə/)	None	ISB ↓
AH1 (/ʌ/)	(Data reduced due to mispronunciation)	(Not reported)
AO1 (/ɒ/)	MRP, MUL, QUE ↓	ABT, AJK, GLT, ISB, KHDZ, MUL, QUE, SKD ↓
AO1R (/ɔːr/)	None	KHDZ, MUL, QUE, SKD ↓
EH1 (/e/)	KHDZ, SKR ↓	SKR ↑
EY1 (/eɪ/)	GLT, SKD, SKR ↑	GLT ↓
ER1 (/ɜː/)	None	KHDZ, MUL, PSH, QUE ↓
IH1 (/ɪ/)	ABT, GLT, KHDZ, LHR, MRP, MUL, SKD ↓	None
IY1 (/iː/)	ABT, AJK, GLT, ISB, KHDZ, MUL, PSH, QUE, SKD, SKR ↓	None
UH1 (/ʊ/)	None	KHDZ ↓
UW1 (/uː/)	None	QUE, SKD ↓
OW1 (/əʊ/)	GLT, SKR ↑	None

Analysis performed using statistical modeling involved linear mixed-effects regression in determining the effect of region, gender, L1 background, and vowel category on vowel F1 and F2 and duration. Random effects were included to control both speaker and lexical item as random intercepts to capture individual and word level variability. Type III ANOVA with Tukey HSD, post-hoc tests were used to obtain significance of differences and pairwise contrasts between regional varieties. The measure also provided strong inference incorporating the hierarchical structure of the data.

The ANOVA test shows an overall picture of the variation of formants of vowels (F1 and F2) and vowel duration with respect to cities and vowel categories. The boxplots display not only the central distributions, but also the dispersion of the data as well as the role that both the type of vowel takes along with the variety of the region. Clear patterns are also apparent in F2_z, where front vowels are systematically separated in all cities, although this is more likely a regional shaping of the vowel space. The differences in Duration_z patterns also show, some of the cities having systematically longer or shorter vowel. These visualizations further support the statistical results of the two-way ANOVA as you see that vowel identity and city are the factors that contribute to variance and there are interactions in some cases.

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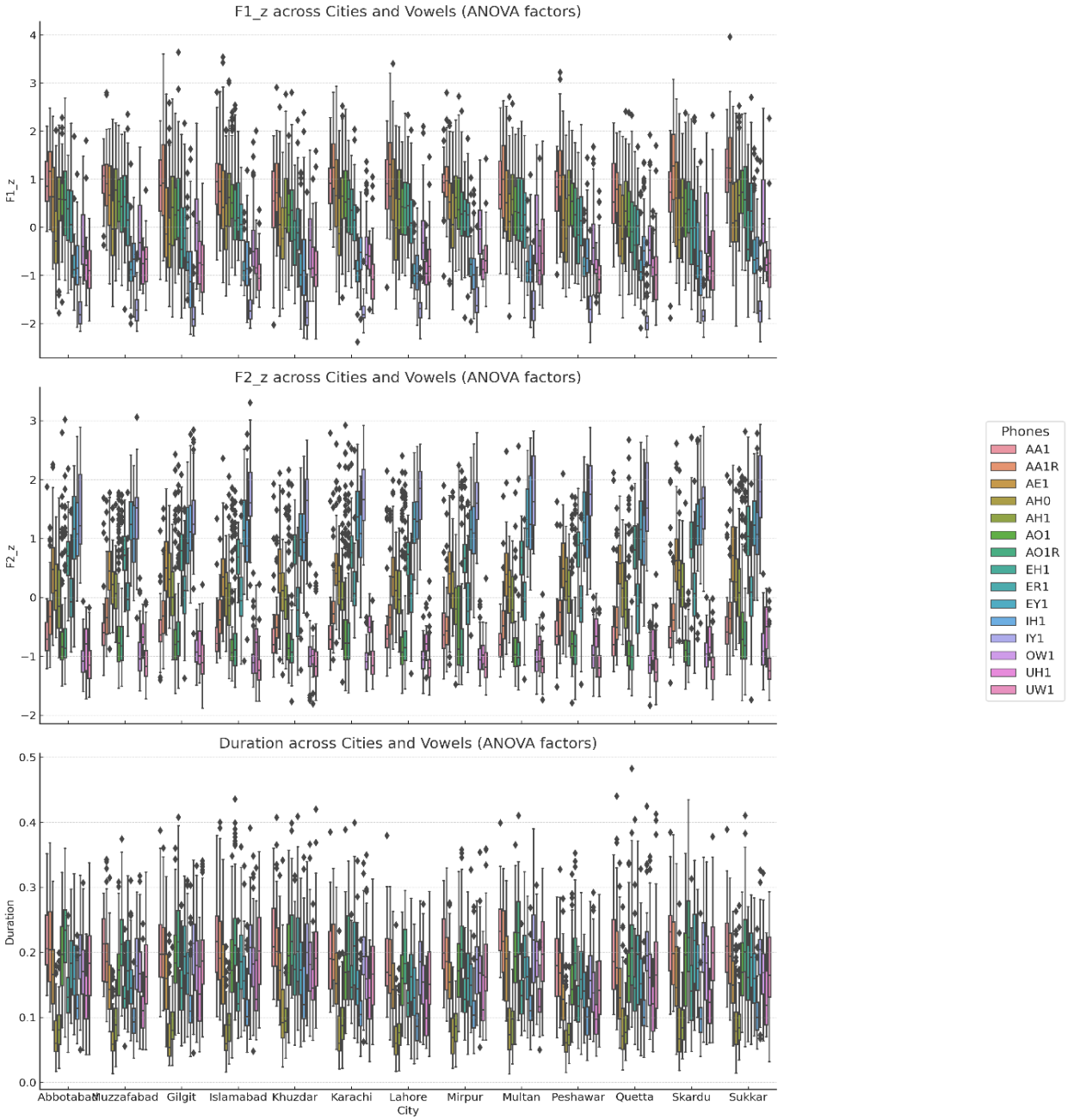
Figure 2: Indicating boxplots to give the central tendencies and the distribution of the information



ANOVA boxplots also show how vowel realizations differ across various Pakistan cities with regard to the first formant (F1.z), second formant (F2.z), and vowel duration (Duration_z). As the plots show, there are vowels that have fairly stable distribution across regions and there are others that have particular differences in formant values and duration indicating regional variation. As an example, vowels /a:/ (AA1), /o/ (AO1), and /e:/ (EH1) are more dispersed, indicating that they are likely to have a core-periphery variation across cities, whereas the high vowel /I:/ (IY1) and /u: / (UW1) are more stable. The segregation of the cluster of vowels in F1 and F2 variously demonstrates the notion of regional dialect shaping vowel phoneme, whereas difference in

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Duration_z is attributed to variation in time that may be rooted in prosodic or thus social-linguistic processes. The findings as a whole remain consistent with the notion that segmental (formant-based) and suprasegmental (duration-based) modifications play in the mixing of regional innovations in Pakistani English.

The difference of vowel height across the cities is seen in the upper panel. Substantial deviation is evident in peripheral forms like Gilgit, Khuzdar, Sukkur, and Peshawar whereby sounds like / a: / (AA1), / a: / (AE1) and / o: / (OW1) have near higher F1 values (i.e., more open vowels). This causes the idea that speakers of these regions articulate more open vowel qualities which resemble the Iranian influence after all or may indicate the regional identity marking. However, karachi and Lahore exhibit comparatively more regular and centred vowel height values with less increased dispersion. This is due to stability in relation to the prescribed norms of prestige and exposure to standard Pakistan English in cities.

The middle panel shows the backness of the vowels between cities Demonstrable changes can be observed in the varieties namely Multan, Abbottabad, Khuzdar and Gilgit where vowels / ʊ / (UH1), / ɪ / (IH1) and / ɑːr / (AA1R) have a strong fronting/ backing. These changes are especially evident in Gilgit and Khuzdar where substratal influences of the local languages, e.g., Shina and Brahui may be at play. Compared to that, more centralized and stable vowel backness is depicted in cities like Karachi and Islamabad, which represents lingual leveling. The prevalence of the differences in the back vowels indicates their instability in Pakistani varieties of English as well as the sensitivity to the regional phonetics.

The last line shows that there are big differences in the duration of the vowel. In varieties spoken in Peshawar, Khuzdar, Islamabad and Gilgit longer durations are observed in the vowels including /AE1/ (/E/, /a/), /AO1/ (/o/, /AE0/), and /UW1/ (/u/, /u/) sounds. This elongation is indicative of variations between rhythm and timing as peripheral forms often show syllable-timed and/or mora-timed compatriots of the source languages (e.g. Pashto, Brahui, Shina). In contrast, Karachi and Lahore have shorter and more regular vowel durations, which reflects more strict adherence to a stress-timed rhythm which is closer to the forms of standardized English.

These findings show the systematic system of a regional stratification of Pakistani English vowels. The most considerable variation in the height, backness, and duration appears in the peripheral varieties spoken in Gilgit, Khuzdar, Sukkur, and Peshawar which support the notion that there is innovation and preservation of divergent features in the peripheral regions (Labov gravity model). In contrast, urban centres such as Karachi, Lahore, and Islamabad display more stable vowel systems, as a result of dialect convergence, standard norms and exposure to standardised English by means of education and the media.

Tukey HSD post-hoc test was employed to the vowels /æ/ (AE1), /e/ (EH1), and / əʊ / (OW1) as the ANOVA results for these vowels exposed significant effects of dialect or vowel–dialect interaction. Even though ANOVA pinpointed general differences, Tukey HSD test was required to identify which particular dialect pairs showed variation significantly. These vowels were selected as they displayed noteworthy regional variation.

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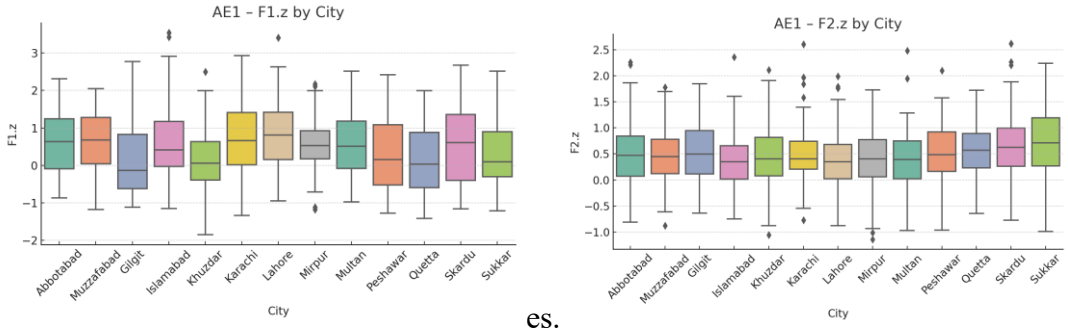
Tukey HSD post-hoc Tests: The F1.z values of AE1 indicated significant variation between regions in vowel height. The median F1 on a lower vowel realization was seen in Lahore, Karachi, and Islamabad as expressed at a relatively higher value. By comparison, the F1 values of Skardu, Suikkur, and Quetta were lower that showed relatively high vowel productions. P values were in the mid-range in Peshawar and Multan, whereas Islamabad and Lahore revealed a greater within-group variability range, indicated by wider interquartile ranges..



es.

Figure3 and 4: Distribution of F1.z and F2.z for AE1 across cities.

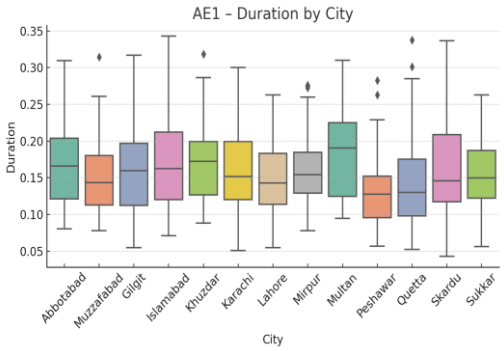


Figure5: Distribution of Duration for AE1 across cities.

For F2.z values, regional variation was also observed. Sukkur, Skardu, and Peshawar displayed higher median F2 values, indicating that AE1 was produced with a more fronted quality in these locations. Conversely, Lahore, Karachi, and Mirpur had comparatively lower F2 values, reflecting a more backed realization. Islamabad and Gilgit showed a larger spread of values, with multiple outliers, suggesting higher variability in vowel frontness within these regions.

Analysis of duration revealed further distinctions across cities. Islamabad, Multan, and Peshawar produced longer AE1 durations, while Lahore and Karachi were characterized by shorter realizations. Shorter vowel durations were also observed in Gilgit and Muzaffarabad. Several cities displayed outliers, particularly Islamabad and Peshawar, indicating individual speakers with lengthened vowel productions.

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Overall, the results indicate that AE1 exhibits systematic phonetic variation across Pakistani English varieties. Lahore and Islamabad are associated with lower vowel realizations, with Islamabad additionally characterized by vowel lengthening. Karachi is distinguished by shorter durations and slightly backed vowel qualities. Peshawar and Sukkur display more fronted productions, with Peshawar also demonstrating increased duration. Skardu and Gilgit show comparatively higher vowels, distinguishing northern varieties from urban centers in Punjab and Sindh.

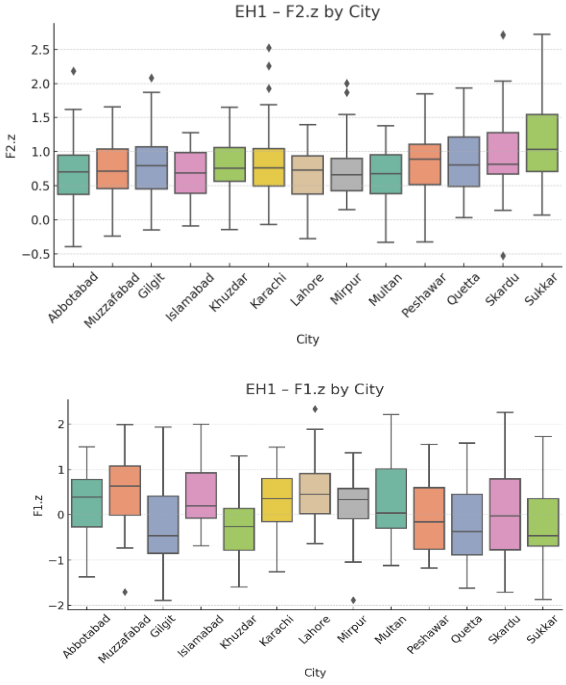

Figure 6 and 7 : Distribution of F1 and F2.z for EH1 across cities.

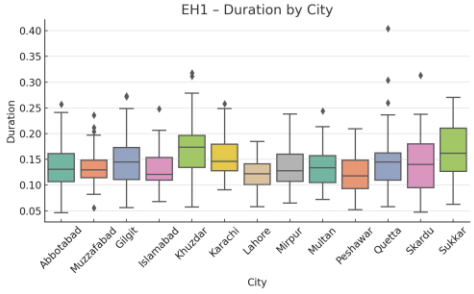

Figure 8: Distribution of Duration for EH1 across cities.

The analysis of /EH1/ across cities reveal strong dialectal differentiation in Pakistani English. In Skardu, Quetta, and Gilgit, /EH1/ is realized with longer durations, suggesting a slower speech rhythm and greater vowel prominence in these varieties. By contrast, Lahore and Mirpur consistently produce shorter /EH1/ tokens, reflecting reduced vowel length and faster articulation in urban settings.

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Height differences also mark regional contrasts. Abbottabad, Gilgit, and Muzaffarabad show more open realizations of /EH1/ (higher F1 values), while Khuzdar, Lahore, and Karachi show closer realizations (lower F1). This indicates a north–urban split, with northern dialects favoring openness and metropolitan varieties tending toward centralization.

In terms of backness, Skardu and Sukkur front /EH1/ significantly (higher F2 values), whereas Karachi, Lahore, and Quetta back the vowel (lower F2). These findings highlight a geographic pattern where peripheral dialects front and lengthen /EH1/, while central urban dialects shorten, raise, and back it.

Overall, /EH1/ demonstrates a clear dialectal divide: peripheral northern and rural varieties exhibit longer, fronted, and more open realizations, whereas urban centers like Lahore and Karachi favor shorter, higher, and backed realizations. This distribution reflects the influence of local substratal languages in the peripheries and leveling tendencies in metropolitan Pakistani English.

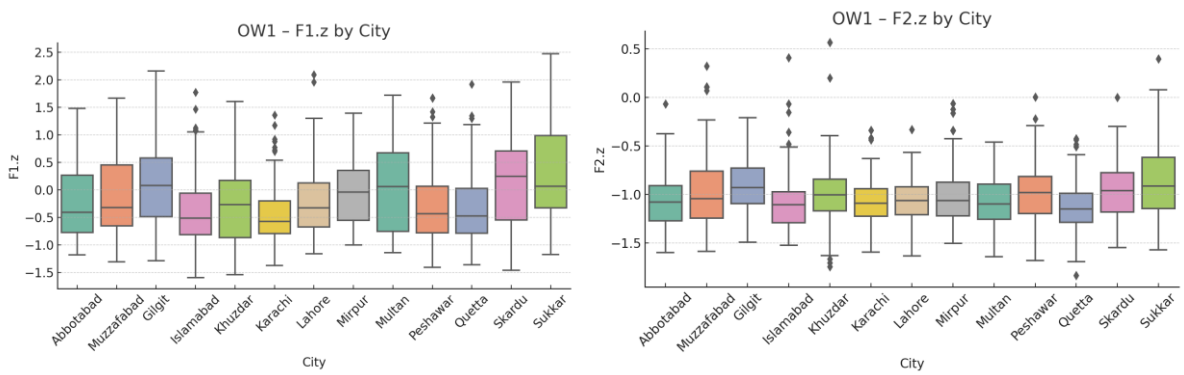

Figure 9 and 10: Distribution of F1.z and F2.z for OW1 across cities.

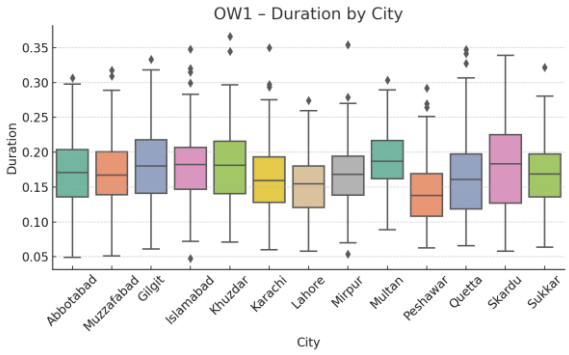

Figure 11: Distribution of Duration for OW1 across cities.

The vowel /OW1/ shows substantial dialectal variation in both quality and quantity. In terms of duration, peripheral and northern cities such as Gilgit, Skardu, and Quetta display longer realizations, while urban centers like Lahore, Mirpur, and Karachi produce noticeably shorter vowels. This points to a tempo divide between slower peripheral varieties and faster-paced metropolitan English.

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For height (F1.z), cities such as Skardu, Sukkur, and Multan show higher F1 values, indicating a lowered, more open articulation of /OW1/. In contrast, Khuzdar, Karachi, and Islamabad show lower F1 values, producing higher, more closed vowels. This reflects a north–south split, where mountain and rural varieties open /OW1/, while urban dialects keep it more centralized and raised. Regarding backness (F2.z), almost all cities maintain negative F2 values, confirming /OW1/ as a back vowel. However, subtle differences emerge: Abbottabad and Muzaffarabad show relatively higher F2 values, suggesting slight fronting, whereas Karachi, Khuzdar, and Lahore remain more strongly backed. This suggests that northern Hindko-influenced English weakens backness, while urban Urdu/Punjabi English preserves it.

Overall, /OW1/ divides along urban–peripheral lines. Peripheral cities (Gilgit, Skardu, Quetta, Sukkur) favor longer, more open tokens, while urban centers (Karachi, Lahore, Islamabad) realize /OW1/ as shorter, higher, and more backed. This distribution highlights how substratal influence and speech tempo shape vowel quality and rhythm in varieties of Pakistani English.

Discussion

Today the English used in Pakistan is not homogenous, far from it and represents regional forms within the context of the linguistic ecologies of the major cities of this country. Acoustical data has shown that vowel systems vary greatly among regions and are in contrasts in quality and duration. The contrasts arise between the global tendencies of the English vowel system and substrate effects in the resulting sociophonetic profiles.

Regional variation in the metric F1 (height), F2 (backness) and vowel duration was found to be systematic. In Lahore and Islamabad, the vowel space is wide and is widely spread, with "/u/" being fronted and with the more global tendency of fronting back vowels. In Karachi, the system is more centralised, creating a balanced triangle, which introduces no abrupt or lopsided contrasts; vowels are, as a rule, shorter-duration, as is characteristic of the multilingual and high-priority ecology of the city. In comparison, Peshawar shows high value of F1 as well as vowel durations, which is agreeable to the pronunciations of Pashto, as it has the feature of [+RTR]. In Multan and Quetta, the centralization of vowels diminishes the front-back and the high-low contrasts to create constricted vowel systems. Same goes in the Northern variants like Gilgit and Skardu where the inventories are compressed with little spacing between high and mid vowels.

There are a number of features that highlight Pakistani English as a variant of World Englishes. First, fronting of /u/ is found to be largely variable: it is particularly strong in Lahore/Islamabad, moderate in Karachi, and weaker in Multan/Quetta. Second, the centralization in vowels is typically a mark of southern and peripheral varieties, especially Multan, Quetta, Gilgit, and Skardu. Third, rhoticity is also a very strong candidate in Peshawar and Mirpur as the local substrate languages color the retroflex. Lastly are the duration contrasts, such as that the vowels are longer in Peshawar and Islamabad, shorter than in Karachi. The patterns that Geometry assists to capture are as follows: Punjabi-influenced English contributes to strengthening [+low] and [hypothetical -back]; Urdu-influenced English maintains balanced [+high] and [hypothetical -back]; Pashto-influenced English introduces [rhotic] and [hypothetical -RTR]; Saraiki-, Balochi-influenced English under-specifies [+high] and [+back], thus generating centralization.

In sum, Pakistani English preserves the triangular structural vowel system characteristic of non-native varieties of Englishes but in internally different form. The cities of Lahore and Islamabad point to prestige-like international norms; Karachi is a koine form with less interference; centralization is involved in Multan and Quetta; Peshawar and Mirpur have a rhoticity; and vowel

compression in northern cities. These regional patterning are further supported by duration patterns.

There are some convergences and divergences in the wider perspective of World Englishes with regard to Pakistani English. Convergence is tangible in the processes of fronting and lowering, which are common to any other global Englishes, and the divergence lies in the local adaptations of the rhoticity or the compression of the vowels. These two processes indicate that Pakistani English is not only structurally stable, but it is also sociophonologically dynamic and this is an indication of the multilingual nature of Pakistan.

Conclusion

Overall, the study shows that the Pakistani English vowel systems are as regionally variable as they are uniformly bound by systematic acoustic comprehension. The discussion of F1, F2 and duration reveals that monophthong vowels in Pakistani English are both following global tendencies in English, including /u/-fronting and vowel lowering, and localisations, including centralisation and rhoticity. It is evident through such peculiarities that the Pakistani English is not merely a sort of an L2-variety; however, a well-developed regional variant of English in which the social context as well as phonological processes is feature-based. Putting Pakistani English in the framework of Feature Geometry and the overall body of World Englishes, the study helps to conclude that it can be defined as a structurally stable but sociophonologically dynamic variety.

Ethical Considerations:

The study forms part of my thesis. The investigation was not financed; in this way, the researcher has all the rights to the data. An entire data is uploaded in May, 2024 to BOX at University of Arizona (-LING- DPL | Powered by Box). Using or copying the information is prohibited to anyone.

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Appendices:

Appendix 1: *Showing the Selected Regions, Cities, and Universities*

Sr#	Provinces	**A**reas	Cities	Languages Selected	Universities	Establishment of the English Department	Participants
1	Punjab	West Punjab	Lahore	Punjabi	University of the Punjab, Lahore	1963	16 (8 females and eight males)
		South Punjab	Multan	Saraiki	Bahauddin Zakariya University, Multan (BZU)	1975	16 (8 females and eight males)
2	Sindh	South Sindh	Karachi	Urdu	University of Karachi, Karachi	1955	16 (8 females and eight males)
		North Sindh	Sukkhar	Sindhi	Aror University of Art, Architecture, Design & Heritage, Sukkur	1989	16 (8 females and eight males)
3	Baluchistan	North Baluchistan	Quetta	Balochi	Balochistan University of Information Technology, Engineering and Management Sciences, Quetta	1971	16 (8 females and eight males)
		South Baluchistan	Khuzdar	Brahvi	Lasbela University of Agriculture, Water and Marine Sciences (Wadh Campus)	2013	16 (8 females and eight males)

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4	Khyber Pakhtunkhwa (KPK)	Central KPK	Peshawar	Pashto	University of Peshawar, Peshawar	1950	16 (8 females and eight males)
		North KPK	Abbottabad	Hindko	Abbottabad University Of Science & Technology (AUST)	1989	16 (8 females and eight males)
5	Gilgit Baltistan (GB)	Central GB	Gilgit	Shina	Karakorum International University, Gilgit	2002	16 (8 females and eight males)
		South-East GB	Skardu	Balti	University of Baltistan, Skardu (Main Campus)	2017	16 (8 females and eight males)
6	Azad Jammu & Kashmir (AJ&K)	North-West AJ&K	Muzaffarabad	Hindko	The University of Azad Jammu & Kashmir, Muzaffarabad (City Campus)	1980	16 (8 females and eight males)
		South-East AJ&K	Mirpur	Pahari Pothowari	Mirpur University of Science and Technology (MUST)	2009	16 (8 females and eight males)
7	Islamabad Capital Territory	Islamabad	Islamabad	Punjabi	National University of Modern Languages, Islamabad	2001	16 (8 females and eight males)
Total	7 Regions	13 Areas	13 Cities	11 Languages 2 Dialects	13 Universities	------	208 (104 females and 104 males)

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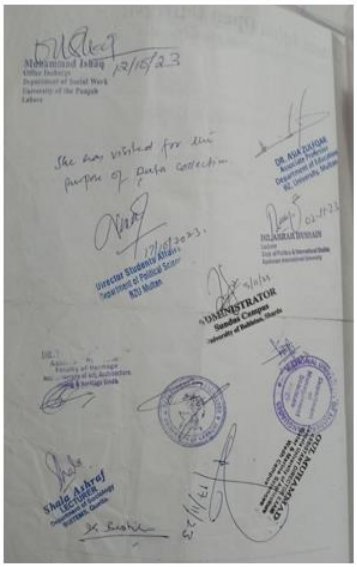
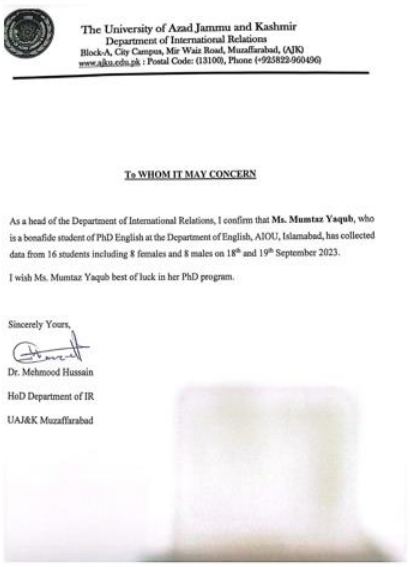
Appendix 2: Showing Stamps/Letter/E-mails of the Universities from where the Data was Collected





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To WHOM IT MAY CONCERN

As a head of the Department of International Relations, I confirm that **Ms. Mumtaz Yaqub**, who is a bonafide student of PhD English at the Department of English, AIOU, Islamabad, has collected data from 16 students including 8 females and 8 males on 18th and 19th September 2023.

I wish Ms. Mumtaz Yaqub best of luck in her PhD program.

Sincerely Yours,

Dr. Mehmood Hussain
HoD Department of IR
UAJ&K Muzaffarabad