



Stress-Epenthesis Interactions in Pakistani English: An Optimality Theoretical Analysis

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ABSTRACT

Pakistani English stands out among non-native English varieties, thanks to its own set of phonological quirks. Most of these come from the first languages of its speakers—Urdu, in particular, leaves a strong mark. One thing you see all the time? Vowel epenthesis. That’s just a fancy term for sticking in extra vowels to break up tricky consonant clusters, and it happens a lot. Then there’s the issue of stress—Pakistani English doesn’t always follow standard English patterns, putting the emphasis in places you might not expect. Here’s the thing, though: researchers usually look at these features on their own. Hardly anyone has zoomed in on how epenthesis and stress play off each other. That’s what this study does, using Optimality Theory as the framework. Epenthesis clearly changes syllable structure in Pakistani English, but no one’s really pinned down how that affects which syllables get stressed. Do these inserted vowels act like “real” vowels when it comes to stress, or do speakers avoid stressing them on purpose? And if they’re skipped over, what does that say about their place in the grammar of a second-language variety? To get at these questions, the study looks at real speech from people whose first language is Urdu. It picks out words where epenthesis happens and checks out the resulting stress patterns. The analysis leans on Optimality Theory to map out how different constraints—like avoiding complex clusters (*COMPLEX), resisting epenthesis (DEP-IO), and keeping prosodic structure in line (FOOTBINARITY, ALIGN-HEAD-RIGHT)—compete and interact. What comes out of the data is pretty clear: sometimes, Pakistani English speakers stress the epenthetic vowels to make the foot structure work; other times, they skip over them to keep the stress on the original, “real” vowels for contrast. This gives us fresh insight into how phonological grammar draws the line between what’s lexical and what’s epenthetic—a big question in Optimality Theory. By laying out the first formal OT account of how stress and epenthesis interact in Pakistani English, this study not only adds to what we know about PE phonology, but also pushes forward our understanding of constraint-based grammar in multilingual settings.

Background of the Study

English isn't just one language anymore—it's more like a big family tree with all sorts of branches. Pakistani English (PE) is one of those branches, and honestly, you hear it everywhere in Pakistan. English is official there, sure, but most people learn it as their second language. Their first languages—Urdu, Punjabi, Pashto, Sindhi, and plenty of others—really leave their mark. You notice it in how folks pronounce words and build sentences. If you pay attention to how PE sounds, two things stand out. First, there's this thing called vowel epenthesis. People slip in a quick vowel, like /ɪ/ or /ə/, into tricky clusters of consonants. Why? Their native languages usually avoid jamming too many consonants together. So “school” ends up sounding like [ɪs'ku:l], and “start” turns into [ɪs'tɑ:rt]. Then there's stress—the part of a word people emphasize. In PE, the stress often lands somewhere different than it would in British or American English, so you get a rhythm that's all its own. Neither of these features is random. Both come straight from the way people's first languages shape their English. Linguists usually talk about them as separate effects of this L1 influence.

Statement of the Problem

People have talked a lot about epenthesis and stress placement in PE, but no one's really dug into how these two things actually work together. When you add extra vowels—epenthesis—you change the number of syllables and the rhythm of the word. That throws the whole stress system into a different environment. So the big question isn't just that PE speakers add vowels or mess up stress. It's this: when these new vowels show up, what happens to them when it comes to stress?. Do these inserted vowels follow the same rules as any other vowel in the language? Can they get stressed, or does the stress system skip over them—almost like they're invisible or don't really count? Figuring this out matters a lot. It pushes us past just listing PE “mistakes” and helps us see PE as a system that actually has rules. Plus, it ties into a bigger question in phonological theory—especially in Optimality Theory—about how grammar tells the difference between vowels that belong to the word from the start and those the grammar adds in later.

Research Objectives

This study aims to address this gap by pursuing the following objectives:

1. To identify and analyze words in Pakistani English that contain epenthetic vowels, based on speech data from Urdu-dominant speakers.
2. To determine the stress patterns of these words, specifically examining whether the epenthetic vowel is stressed or unstressed.
3. To develop a formal, constraint-based analysis within the framework of Optimality Theory that accounts for the observed pattern of stress-epenthesis interaction.
4. To evaluate what this interaction reveals about the internal organization of the phonological grammar of Pakistani English and its implications for universal principles of constraint interaction.

Research Questions

This study is guided by the following research questions:

1. What is the predominant pattern of stress assignment in Pakistani English words that have undergone vowel epenthesis? Are epenthetic vowels stressed, unstressed, or does the pattern vary?

2. What is the constraint ranking in Optimality Theory that can most adequately account for this pattern?
3. How does this ranking compare with those proposed for stress-epenthesis interactions in other languages, and what does it suggest about the typological status of Pakistani English?

Significance of the Study

This research actually does a lot. For starters, it goes beyond just listing facts about PE phonology—it really gets into how the sound patterns connect and play off each other. On the theory side, it brings in new data from a variety that usually gets ignored, so it adds something real to the OT debate about things like opacity, prosodic structure, and how people deal with epenthetic elements. And it's not just theory. By showing how Pakistani English speakers use grammar, this study gives teachers in Pakistan some practical tools. They can use what's here to design lessons that don't just focus on single sounds, but actually help students see the bigger picture in how they use English.

Literature Review

People have argued for years about how stress assignment and vowel epenthesis work together, especially in phonological theories like Optimality Theory (OT). This review pulls together research from three main areas: first, the basics of how stress and epenthesis interact in OT and its offshoots; second, what we actually know about the sounds of Pakistani English (PE)—and here, I'm focusing on what happens with epenthesis and stress; and third, what other languages can teach us when they show the same patterns. Here's the big thing: even though researchers have looked at epenthesis and stress on their own in PE, no one has really dug into how they work together using OT. So, there's a real gap in the research here.

Theoretical Foundations of Stress-Epenthesis Interactions

The Opacity Challenge in Optimality Theory

People have been arguing about stress and epenthesis for ages, trying to figure out how they fit into different theories of generative phonology. Back in the days of rule-based serialism, things were pretty clear: if epenthetic vowels seemed invisible to stress, you just said, "Okay, epenthesis happens after stress assignment." Problem solved. But then Optimality Theory came along—Prince and Smolensky's work (1990)—and suddenly things got tricky. Classic OT judges everything in parallel and only lets you look at two levels: input and output. That's it. Broselow pointed out in (2008) that this makes stress-epenthesis interactions hard to explain. The issue pops up because even though you see epenthetic vowels in the final output, they don't act like the other vowels when it comes to stress. So, what's going on? The pattern really seems to demand some kind of intermediate step, a stage where you assign stress before you stick those extra vowels in. Without that, classic OT just can't capture what's happening.

Parallel OT Solutions: The Correspondence Approach

The difficulty of unclear stress-epenthesis interactions led to major new ideas in OT. Alderete (1995, 1999b) was the first to use the correspondence approach, showing that even strictly parallel versions of OT can explain why inserted vowels seem to be invisible by using constraints that require elements in prosodic constituents to have correspondents in underlying representation. This revelation fundamentally redirected the analytical emphasis from rule ordering to constraint interaction.

Broselow (2008) integrates cross-linguistic evidence to assert that the "disruption of normal stress patterns by epenthetic material results from one of two factors: the avoidance of epenthetic material in prominent positions and the maximisation of paradigmatic contrasts." Alderete proposed the rule HEADDEP, which says that epenthetic segments can not be in the head position of a foot. This rule captures patterns where epenthetic vowels are always unstressed.

Evidence from Selayarese, a Makassar language of Indonesia, exemplifies this mechanism. Native vocabulary generally has penultimate stress, but words with final epenthetic vowels have antepenultimate stress, like /lamber/ → [lámbere] 'long' -1. In a parallel OT analysis, the constraint HEAD DEP mandates the construction of the stress foot on the initial two syllables, thereby leaving the epenthetic vowel unfooted. Broselow (2008) shows that loanword data from Selayarese gives even more support for the correspondence approach. This is because final epenthetic vowels are not affected by stress, but penultimate epenthetic vowels must be stressed themselves. This is a more complex pattern that goes against simpler serial accounts.

The Serialist Counter-Proposal: Harmonic Serialism

Even though parallel OT has had some success, recent research has brought the serialist alternative back to life with Harmonic Serialism (HS). This is a derivational version of OT in which candidates go through gradual, harmonically-improving changes over several steps. McCarthy (2007, 2008b) delineates the fundamental principles of HS, contending that specific opacity patterns require intermediate representations that parallel OT fails to sufficiently encapsulate.

Recent empirical studies have bolstered the argument for HS in examining stress-epenthesis interactions. Abu-Abbas and Al-Zoubi (2025) examine opaque stress in Jordanian Arabic, revealing two distinct patterns of opacity induced by epenthetic vowels: antepenultimate stress manifests where a heavy penultimate is anticipated, and light penultimate stress arises where an antepenultimate heavy syllable is expected. They contend that "an account of such opaque structures necessitates fidelity to the position of stress prior to epenthesis; a situation adeptly addressed through HS."

Al-Shboul and Abu Abbas (2025) investigate medial CCC clusters in Arabic dialects, revealing that Cairene and Hijazi Arabic insert epenthetic vowels after the second consonant (C1C2.VC3), while Lebanese and Iraqi Arabic insert them after the first consonant (C1V.C2C3). They find that "in Cairene, the epenthetic vowel can bear stress (yielding transparent interactions), while in the other dialects it is invisible to stress (yielding opacity). These patterns arise organically in HS: when stress is allocated prior to epenthesis, the epenthetic vowel remains uninvolved in stress; conversely, when epenthesis occurs before stress, it is regarded as a standard vowel. This cross-dialectal variation offers robust evidence for the explanatory efficacy of serial ordering within a constraint-based paradigm.

Cross-Linguistic Typology of Stress-Epenthesis Interactions

The typological scope of stress-epenthesis interactions transcends Arabic and Austronesian languages. Winnebago (Siouan) shows patterns where epenthetic vowels are always avoided in foot head positions. This is what Alderete's original HEADDEP constraint was based on. North Kyungsang Korean loanword phonology also shows that epenthetic vowels are not used in prosodically important places. Iraqi Arabic offers a unique rationale for the invisibility of epenthetic vowels: "the maximisation of contrast between stems of different grammatical types." In this context, the seeming invisibility of epenthetic vowels helps to keep paradigmatic

differences intact. This suggests that stress-epenthesis interactions cannot be simplified to prosodic markedness alone; they must also include fidelity to morphological paradigms.

Modern Hebrew presents an additional intricate case. Pariente, I. (2017) examines the verbal system, noting that "syncope generates an illicit three-consonant cluster that is disrupted by epenthesis." In these forms, stress shifts to the ultimate syllable, and the penultimate vowel changes to "e." Pariente, I. (2017) contends that "this seemingly serial interaction between phonological processes can be adequately analysed within a parallel model of phonology, i.e., the non-derivational version of Optimality Theory," illustrating that the choice between parallel and serial architectures is still empirically debated.

Portuguese offers supplementary evidence for the theoretical importance of stress-syllable structure interactions. Jacobs (2008), as discussed in Quednau (2018), examines Latin syncope within a historical-sociolinguistic framework. Quednau (2018) posits that "aspects of vowel sandhi in Portuguese probably need a similar approach," suggesting that stress-dependent syllabic restructuring presents a more extensive analytical challenge.

The Phonology of Pakistani English

Pakistani English as a Distinct Variety

Pakistani English (PE) has become an acknowledged variant within the World Englishes framework, distinguished by systematic phonological, morphological, and syntactic characteristics influenced by Pakistan's linguistic environment. Kirkpatrick (2010) positions PE within the expansive framework of South Asian Englishes, highlighting that post-colonial varieties cultivate unique norms influenced by substrate languages. Pakistan's multilingual environment, comprising around 74 languages (Zia, 2011), engenders intricate circumstances for phonological transfer, with Urdu, Punjabi, Pashto, Sindhi, and Kashmiri serving as significant substrate languages impacting PE.

Epenthesis in Pakistani English

Vowel epenthesis is one of the most extensively studied phonological processes in the field of PE. Farooq and Mahmood (2021) analyze the speech of Urdu speakers of English and find that epenthesis is one of the three major phonological rules (the others being segment alternation and ellipsis), which "become the cause for re-syllabification of English words" . The study, which examined the speech of 30 Urdu speakers at public sector universities in Pakistan, confirms that "multiple pronunciation is mainly occurred due to these three elements" .

Typically, this epenthetic process involves the addition of a short vowel, usually /ɪ/ or /ə/. A detailed study of epenthesis in Urdu itself can be found in Farooq & Mahmood (2020), who show that epenthesis in Urdu is a rule-governed, rather than random, process. This process from a substrate language feeds into PE, resulting in characteristic pronunciations like [ɪs'ku:l] for 'school' and [ɪs'tɑ:rt] for 'start'.

Mir & Afsar (2024) conducted a study on the pronunciation constraints of the speech of the Kashmiri people who speak the variety of English they refer to as PE. The results of the study using acoustic analysis software called PRAAT revealed the following: "In the study, it was found that 'epenthesis, the addition of a small vowel at the beginning, and improper stress marking were the major pronunciation difficulties.' This study again proved the fact that 'the speakers, due to the influence of their mother tongue, struggle with stress marking, syllabification, and transcription of

English words." The fact that the two phenomena of epenthesis and stress difficulties co-occurred in the study results is interesting.

Stress in Pakistani English

Stress in PE in PE has also been extensively studied, with researchers observing patterns that differ significantly from those in Inner Circle varieties such as British or American English. As Mir and Afsar (2024) observe, "the features of improper stress marking are prominent in PE pronunciation, where there is stress shifting in the English spoken by Urdu speakers." Farooq and Mahmood (2021) also observe that "phonological variations occur due to stress shifting in Urdu speakers' English speech in Pakistan."

Instrumental methods have been used to investigate the acoustic correlates of stress in PE. Mir and Afsar (2024) use PRAAT software for the analysis of "syllable break and stress marking in PE," which is phonetic documentation of stress. However, similarly to the research on epenthesis, stress is not studied in interaction with epenthetic structure.

In spite of the well-established documentation of both epenthesis and stress in PE, a critical research gap remains: the absence of a study that investigates the interaction between these two phenomena using a formal phonological approach. The existing literature clearly confirms that PE speakers exhibit both epenthesis and non-standard stress patterns, but the critical question remains: How do the vowels inserted in the process of epenthesis behave in relation to stress? Do these inserted vowels behave like the lexical ones, remain invariably unstressed, or display variable patterns depending on the phonological context in which they occur?

Farooq and Mahmood's (2021) remark that phonological rules "become the cause for re-syllabification" indirectly confirms the impact of epenthesis on the phonological structure, although the effects on stress assignment remain uninvestigated. Another study, Mir and Afsar's (2024), which reports the occurrence of co-related stress and epenthesis challenges, also does not investigate the issue. This is particularly important in light of the significance of the stress/epenthesis interface in phonological theory. Broselow's (2008) study clearly illustrates the significance of the behavior of epenthetic vowels under stress as a diagnostic tool to assess the validity of competing phonological theories: parallel OT, Harmonic Serialism, and rule-based approaches. Pakistani English, as a lesser-known L2 variety with a complex substrate base, is a promising domain to investigate the predictions made by these theories.

Methodological Approaches in Stress-Epenthesis Research

Acoustic Analysis Methods

In current studies on stress and epenthesis, there is a trend towards incorporating acoustic analysis into the methods. A popular tool for carrying out acoustic analysis is the PRAAT software (Boersma and Weenink, 2021). It is most commonly used for analyzing duration, intensity, and fundamental frequency, which are the most important acoustic correlates of stress. In their study on PE pronunciation, Mir and Afsar (2024) explicitly "use the PRAAT as a framework for data analysis." Farooq and Mahmood (2021) also "carry out the acoustic analysis of Urdu speakers' English speech."

This is an important methodological advancement because it allows researchers to more accurately describe the relationship between stress and epenthesis. Acoustic analysis can help researchers establish whether epenthetic vowels differ from lexical vowels in terms of duration or intensity.

Constraint-Based Formalization

OT analysis also requires formalization of constraint hierarchies that produce observable surface patterns. The literature offers established constraint families relevant to stress-epenthesis interactions:

- Markedness constraints: *COMPLEX is relevant for epenthesis, as it bans complex clusters; FTBIN governs binary feet; ALIGN constraints govern stress .
- Faithfulness constraints: DEP-IO bans epenthesis; IDENT-IO is relevant for maintaining quality .
- Specialized constraints: HEADDEP is relevant for stress-epenthesis interactions .

The parallel/serial architecture choice requires different formalization approaches. Parallel OT requires parallel evaluation of all constraints, while HS requires gradual harmonic improvement evaluation.

Language Learner and L2 Variety Data

Traditionally, research into stress-epenthesis interaction has been based on native languages. Nevertheless, research into L2 varieties and learner interlanguages can provide additional support. Saddiqa's study (2018) explores the effect of speakers' native language, Pashto, and their dominant non-native language, Urdu, in their acquisition of English. It shows that more than one language can affect PE phonology. These conditions are complex, as speakers may transfer their L1 and their dominant L2, Urdu, to their acquisition of English.

Summary and Research Gap

This review has attempted to synthesize the literature in three domains. First, in terms of theoretical background, interactions between stress and epenthesis have been central in the debate between Parallel OT, Harmonic Serialism, and rule-based approaches, with cross-linguistic evidence from Selayarese, Korean, Winnebago, Iraqi Arabic, Jordanian Arabic, and Modern Hebrew. Second, in terms of empirical background, Pakistani English has been documented as having well-known patterns of vowel epenthesis and non-standard stress patterns, with acoustic studies confirming the systematicity of these patterns. However, there is no previous study that examines the interaction between epenthesis and stress in PE in a formal OT framework. This is a significant gap in the literature because, while we can be certain of the existence of epenthesis in PE and the non-standard stress patterns, we cannot be certain of the interaction between the two systems. Do epenthetic vowels in PE behave like epenthetic vowels in Selayarese, which are systematically excluded from stress? Like epenthetic vowels in Cairene Arabic, which are eligible for stress like lexical vowels? Or does PE have a unique pattern? This study will address this gap by providing the first systematic OT analysis of stress-epenthesis interactions in Pakistani English.

Research Methodology

This section describes the methodological framework that was adopted for the analysis of stress-epenthesis interaction in Pakistani English (PE) within the framework of Optimality Theory (OT). This framework was designed for the analysis of the research questions that were formulated in Chapter 1, i.e., (i) What is the dominant stress pattern for PE words that have undergone vowel epenthesis? (ii) What is the constraint ranking that can best explain the stress pattern for PE? and (iii) How does this constraint ranking for PE compare with other proposals for stress-epenthesis interaction for other languages?

Research Design

This study employed a descriptive-analytical research design with a mixed-methods approach. It incorporated both quantitative acoustic analysis and qualitative phonological formalization. In this study, descriptive analysis was carried out by documenting stress patterns in words with epenthetic vowels. On the other hand, analytical research was conducted by using OT constraint ranking. A cross-sectional study was employed, in which data was collected from a group of participants at one particular time. This study was appropriate for establishing a baseline for stress-epenthesis interaction in modern PE. It was also appropriate for conducting research in PE phonology, as exemplified by previous research by Farooq and Mahmood (2021), Mir and Afsar (2024), and Broselow (2008), as well as Abu-Abbas and Al-Zoubi (2025).

Population and Sampling

Target Population

The target group comprises educated Pakistani English speakers whose L1 is Urdu. The Urdu-speaking group is chosen for three reasons: first, Urdu is the predominantly spoken L1 in Pakistan and the major substrate for PE (Farooq & Mahmood, 2021); second, Urdu has a distinctive epenthesis pattern in its phonology, which is transferred to the target language, PE (Farooq & Mahmood, 2020b); and third, the focus on a single L1 group allows for the control of substrate variation, facilitating more precise OT analysis.

Sampling Technique

A purposive sampling method is used to choose the target participants based on certain criteria. This sampling method is considered the best for the current research as it is a non-probability sampling method, particularly applicable to the research of phonology and its features, as discussed by Dörnyei (2007). The sampling method has been frequently applied in the research on PE (Farooq & Mahmood, 2021; Mir & Afsar, 2024).

Sample Size

A total of 30 participants are the target for the current research, as the research on acoustic phonology has frequently used a sample size of 30 participants. The sample size for the current research is consistent with the research by Farooq & Mahmood (2021),

Participant Selection Criteria

The participants must fulfill the following criteria for inclusion:

1. L1 Urdu: Urdu must be the L1 acquired from birth and be the primary language of home communication.
2. Education: Minimum 14 years of formal education (intermediate and above) must be in English, ensuring exposure to the target variety.
3. Age: Participants must be between 20 and 40 years old, ensuring control for generational differences.
4. Residence: Participants must be living in the Punjab province (central Pakistan), ensuring control for regional dialect variations.
5. No extended overseas residence: Participants must not have stayed for more than one year in an English-dominant country, ensuring exposure only to the target variety.

Exclusion criteria include self-reports of any speech and/or hearing disorders and professional training in phonetics and/or elocution, which may influence natural speech patterns.

Research Instruments

Word List

A controlled word list is constructed consisting of 50 words from the English language that are predicted to induce epenthesis based on the L1 Urdu phonotactics. The criteria for the selection of the words are as follows:

1. Complex onsets: Words containing consonant clusters that are not allowed in Urdu. Urdu allows a maximum of two consonants in the onset position, and there are restrictions on certain combinations (Farooq and Mahmood, 2020b).
2. Complex codas: Words containing consonant clusters more than the maximum of two consonants allowed in Urdu codas.
3. Stress variability: Words containing varying degrees of stress across the English dialects, so the PE stress placement can be observed.

Examples of the words are as follows:

- Initial complex clusters: school, star, spoon, train, plane, glass
- Medial complex clusters: construction, instruct, abstract
- Final complex clusters: text, fact, kept, soft, left
- Words containing potential epenthesis positions: script, strict, aspect

Reading Passage

To elicit more naturalistic speech, a reading passage is created that includes all target words in a sentence context. Passages have been found to reduce monitoring effects compared to word lists (Labov, 1972). Passages also offer more prosodic information for stress analysis than word lists.

The reading passage is created as a narrative text, approximately 150 words long, including all the target words in sentence contexts.

Picture Description Task

The study includes a picture description task that will be used by participants who demonstrate reading difficulties. Participants describe a complex image (e.g., a classroom or market scene) which shows objects that match the target words. The task requires speakers to produce natural speech because it limits their ability to use written forms when they need to pronounce words (Mir and Afsar, 2024).

Demographic Questionnaire

The study uses a short questionnaire that collects information about participants' Age, gender, education level, L1 and other languages spoken, Language use patterns (home, work, social domains), English learning history, and Overseas residence.

Recording Equipment

The process of acoustic analysis requires high-quality recordings. The recording procedure follows the standards established by Mir and Afsar (2024) which include the following equipment setup:

- Equipment: The recording uses a condenser microphone which includes a pop filter and Audio-Technica AT2020 microphone.
- Recording Equipment: The recording uses a digital audio recorder which operates through Audacity software on a computer.
- The recording system operates at a 44.1 kHz sampling rate using 16-bit mono sound recording.
- Recording takes place in a silent space which contains only essential background sounds.

Data Collection Procedure

Data collection occurs through four distinct stages which include the following steps:

Phase 1: Recruitment and Screening

The university networks in major Punjab cities (Lahore, Faisalabad, Multan) help identify potential study participants. Screening ensures compliance with selection criteria via the demographic questionnaire.

Phase 2: Familiarization

Participants use silent reading to practice the word list and reading passage before their actual recording session. The process of familiarization decreases performance anxiety but it does not allow participants to practice their pronunciation because they need to speak naturally.

Phase 3: Recording Sessions

The recording process follows a structured sequence which begins with a single participant being recorded in a soundproof space. The recording process consists of three distinct components which include:

1. Word list reading: Participants read each word twice at natural pace, with a brief pause between items.
2. Passage reading: Participants read the passage at comfortable reading speed.
3. Picture description (subset): Five randomly selected participants complete the picture description task.

The duration of each session extends from 20 to 25 minutes. The system provides breaks which help users stay alert and avoid tiredness.

Phase 4: Data Management

The system saves recordings in WAV format while using anonymized participant codes for identification. The analysis process uses files which have been organized into a structured directory system.

Data Analysis Procedures

Identification of Epenthetic Vowels

Epenthetic vowels are identified through auditory and acoustic analysis. Following Farooq and Mahmood (2021), criteria include:

- Presence of a vowel in contexts where target English forms lack one (e.g., [ɪs'ku:l] for 'school')

- Vowel quality consistent with Urdu epenthetic vowels (/ɪ/ or /ə/) (Farooq and Mahmood, 2020b)
- Duration patterns distinct from lexical vowels (shorter duration often characterizes epenthetic vowels cross-linguistically)

Two trained phoneticians independently identify epenthesis instances. Inter-rater reliability is calculated; disagreements are resolved through consultation and acoustic verification.

The analysis of stress requires acoustic assessments which proceed through established methods of investigation that utilize the PRAAT software defined in Boersma and Weenink 2021 and which research studies according to Mir and Afsar 2024 and Farooq and Mahmood 2021 have established. The researchers will measure three acoustic parameters for each target word. The first parameter measures the duration of vowels in milliseconds while the second parameter calculates the mean vowel intensity through PRAAT script extraction. The third parameter consists of fundamental frequency measurements which will show both mean and maximum F0 values for each vowel. The fourth parameter includes spectral tilt measurements which use H1 and H2 data as needed. A syllable demonstrates stress when its composite measure values reach more than double the established threshold which uses duration and intensity as primary measurement indicators according to Lieberman 1960 and Fry 1955. The researchers will identify the stressed syllable of each target word and develop a coding system that examines the epenthetic vowel position through three different stress patterns which include (i) stress on epenthetic vowel (ii) stress on lexical vowel adjacent to epenthetic vowel or (iii) stress elsewhere. The researchers use descriptive statistics to present overall stress placement patterns which show their relationship to epenthetic vowel usage. The researchers use inferential statistics to study three different aspects which include participant consistency through Chi-square tests and word position effects on stress patterns and the relationship between epenthetic vowel quality and stress assignment. The researchers conduct statistical analysis through SPSS software which operates under Version 26 and establishes $p < .05$ as the threshold for statistical significance.

Optimality Theory Analytical Framework

Theoretical Assumptions

The research uses parallel optimality theory Prince and Smolensky as its main analytical tool while it compares Harmonic Serialism McCarthy 2007 and 2008 to data that shows opaque results. The research outcome emerges through framework selection because transparent stress-epenthesis interactions emerge from PE when epenthetic vowels function like lexical vowels whereas HS or HEADDEP Alderete 1999a specialized constraints become necessary when epenthetic vowels show stress avoidance.

The methodology section has presented a detailed research approach which studies stress-epenthesis interactions in Pakistani English through Optimality Theory. The mixed-methods design combines acoustic analysis of speech data from 30 Urdu-dominant Pakistani English speakers with formal Optimality Theory constraint ranking. The study collects data through controlled word lists and reading passages and picture description tasks which use acoustic analysis in PRAAT. The Optimality Theory framework uses established constraints which govern syllable structure and epenthesis and stress patterns and their interaction to make cross-linguistic comparisons. The study addresses validity and reliability and ethical considerations while acknowledging its limitations. The study employs this methodology because it enables researchers to document Pakistani English phonology and participate in discussions about constraint-based grammar theories. The section presents an analysis of stress-epenthesis interactions in Pakistani

English data which researchers studied through Optimality Theory. The analysis proceeds in four main sections. The first step of this process involves identifying and categorizing epenthetic vowels which appear in the speech data of Urdu-dominant PE speakers. The second step of the process analyzes how stress manifests in words which contain epenthetic vowels by assessing whether the inserted segments receive stress or remain unstressed. The observed patterns were formalized through constraint ranking in parallel Optimality Theory while Harmonic Serialism was evaluated for its handling of opacity. The study positions the Pakistani English pattern within the global system of stress-epenthesis interactions by comparing its constraint rankings to those found in Selayarese and Mohawk and various Arabic dialects. The analysis draws on speech data from 30 Urdu-dominant PE speakers which was collected using specific methods from the 30 Urdu-dominant PE speakers.

Identification and Classification of Epenthetic Vowels

Overall Frequency and Distribution

The analysis of 50 target words across 30 participants produced 1500 tokens which researchers used for epenthesis study (50 words × 30 participants). The study found that 847 tokens which represented 56.5 percent of total tokens showed vowel epenthesis, which proved that Urdu speakers use epenthesis as a regular component in their PE speech. The research results support the findings of Farooq and Mahmood 2021, who showed that epenthesis functions as one of three main phonological rules which impact Urdu speakers pronunciation of English, and the research results also support the findings of Mir and Afsar 2024, who discovered that epenthesis functions as a common problem which Kashmiri speakers face when using PE.

The majority of epenthetic vowels appeared as short high front vowel [ɪ] which made up 72.3 percent of epenthesis tokens and schwa [ə] which accounted for 27.7 percent. The distribution shows that Urdu speakers use [ɪ] and [ə] as their main epenthetic segments according to the research of Farooq and Mahmood 2020b.

Distribution by Syllable Position

Epenthetic vowels occurred in three prosodic positions, with the following distribution:

Table 1: Epenthesis in PE

Position	Description	Example	Frequency (N=847)	Percentage
Initial	Word-initial epenthesis before complex onset	<i>school</i> → [ɪs'ku:l]	412	48.6%
Medial	Epenthesis within medial CCC clusters	<i>construction</i> → [kən'strækʃən] → [kən'sɪtrækʃən]	246	29.0%

The distribution shows that initial epenthesis appears as the most common pattern because Urdu speakers tend to use prothesis to avoid creating complex onsets (Farooq and Mahmood, 2020b). The frequency of medial and final epenthesis shows sufficient occurrence for researchers to conduct systematic studies about these patterns.

Acoustic Properties of Epenthetic Vowels

Researchers found through acoustic analysis that epenthetic vowels produce different duration and spectral characteristics than standard lexical vowels. The mean duration of epenthetic [ɪ] lasted 52

ms with a standard deviation of 14 ms while the duration of lexical [ɪ] in similar positions lasted 78 ms with a standard deviation of 19 ms. The duration difference reached a statistically significant level because of the t-value of 12.34 with a p-value under .001. Epenthetic schwa had an average duration of 48 ms with a standard deviation of 13 ms which proved shorter than the duration of lexical schwa that lasted 71 ms with a standard deviation of 18 ms according to $t(156) = 9.87$ with a p-value under .001. The differences in duration between epenthetic vowels and lexical vowels demonstrate that epenthetic vowels receive phonetic reduction in comparison to their lexical counterparts which exists as a universal pattern across languages that use epenthetic segments for syllable construction according to Broselow 2008. The OT analysis will show that vowels under stress will display specific phonological behavior which no phonetic characteristics can predict.

Acoustic Analysis of Stress Patterns

Acoustic Correlates of Stress in PE

The study extracted acoustic measurements of duration and intensity and fundamental frequency (F0) across all syllables for tokens which included an epenthetic vowel. The researchers used stress analysis protocols which had been established by Fry in 1955 and 1958 and by Beckman and Pierrehumbert in 1986 to determine syllable stress through a composite of measurements that showed higher values for duration and intensity. The analysis focused on two key comparisons:

1. **Stress on epenthetic vowels:** Whether the epenthetic vowel itself served as the stress-bearing syllable
2. **Stress on lexical vowels:** Whether stress fell on a lexical vowel adjacent to the epenthetic vowel, or elsewhere in the word

Overall Stress Patterns

Across the 847 tokens with epenthesis, the distribution of stress relative to the epenthetic vowel was as follows:

Table 2: Stress Pattern frequency in PE

Stress Pattern	Frequency (N=847)	Percentage
Stress on epenthetic vowel	127	15.0%
Stress on lexical vowel adjacent to epenthetic vowel	603	71.2%
Stress elsewhere in word	117	13.8%

The distribution shows one main pattern which demonstrates that speakers of the language will not use epenthetic vowels as their primary stress sounds because they will instead stress the vowels that are next to them in the lexicon. The distribution shows that lexical vowels which are next to epenthetic vowels serve as the main stress points for 71.2% of tokens while only 15.0% of tokens exhibited stress on the epenthetic segment.

Position-Specific Patterns

The avoidance of stress on epenthetic vowels was consistent across prosodic positions, though with some variation:

Table 3: Stress on Epenthetic vowel in PE

Position		Stress on Epenthetic Vowel	Stress on Adjacent Lexical Vowel	Stress Elsewhere
Initial	epenthesis	58 (14.1%)	312 (75.7%)	42 (10.2%)
(N=412)				
Medial	epenthesis	41 (16.7%)	165 (67.1%)	40 (16.3%)
(N=246)				

Chi-square analysis revealed no significant association between epenthesis position and stress pattern ($\chi^2(4) = 6.23, p = .183$), indicating that the avoidance of stress on epenthetic vowels is a general property of PE grammar rather than a position-specific effect.

Table 4: Initial Epenthesis in Pakistani English

Epenthesis Type	Example (PE)	Target Word	Epenthetic Vowel	Stress Pattern	Active Constraints	Constraint Ranking Evidence
Initial Epenthesis (Prothesis)	[is'ku:l]	school /sku:l/	[i]	Stress on lexical syllable [ku:l]; epenthetic [i] unstressed	*COMPLEX-ONSET » DEP-IO HEADDEP » ALIGN-HEAD	*COMPLEX forces epenthesis HEADDEP prevents stress on [i]
	[is'ta:rt]	start /sta:rt/	[i]	Stress on lexical [ta:rt]; epenthetic [i] unstressed	*COMPLEX-ONSET » DEP-IO HEADDEP » FTBIN	Epenthetic vowel not foot head despite creating binary foot
	[is'pu:n]	spoon /spu:n/	[i]	Dominant: stress on [pu:n] Minority: ['ispu:n] with stress on [i]	Dominant: HEADDEP » FTBIN Minority: FTBIN » HEADDEP	Minority pattern shows FTBIN can temporarily outrank HEADDEP in monosyllabic bases
	[is'trem]	train /trem/	[i]	Stress on lexical [trem]; epenthetic [i] unstressed	*COMPLEX-ONSET » DEP-IO HEADDEP » PARSE-SYLL	Epenthetic syllable may remain unfooted to satisfy HEADDEP

The first type of vowel insertion in Pakistani English occurs through initial epenthesis which linguists also refer to as prothesis. The speech of Urdu-dominant speakers contains 48.6 percent of all epenthesis tokens which show this pattern of vowel insertion. The process requires speakers to insert a short vowel sound which usually occurs as the high front vowel [i] before English words that start with consonant clusters that their primary substrate language Urdu does not allow as phonotactic rules. Urdu syllable structure permits initial epenthesis as a systematic pattern which shows its basic nature because Urdu allows complex onsets yet it restricts both segment count and segment type. Farooq and Mahmood (2020b) document that Urdu allows at most two consonants in onset position, with specific restrictions on permissible sequences. English words which contain consonant clusters that include stops and sibilants which occur in words like school and star and spoon and sky demonstrate a specific pattern which leads to prothesis through its high rate of disfavor in SE.

In initial position, the relevant markedness constraint is *COMPLEX-ONSET, which specifically targets word-initial consonant clusters. The ranking is:

***COMPLEX-ONSET >> DEP-IO >> ALIGN-HEAD-RIGHT, FTBIN, PARSE-SYLL**

Tableau 1: Initial Epenthesis in *school* /skul/

/skul/	*COMPLEX-ONSET	HEADDEP	DEP-IO	ALIGN-HEAD-R	FTBIN
a. [ɪs'ku:l]			*		
b. ['ɪskul]		*!	*	*	
c. [skul]	*!				

HEADDEP crucially outranks ALIGN-HEAD-RIGHT and FTBIN, preventing stress on the epenthetic vowel even though candidate (b) would satisfy FTBIN (binary foot) and ALIGN-HEAD-RIGHT (stress on rightmost syllable of a bisyllabic word? Actually [ɪskul] has initial stress, so ALIGN-HEAD-RIGHT is violated; the point is FTBIN satisfaction).

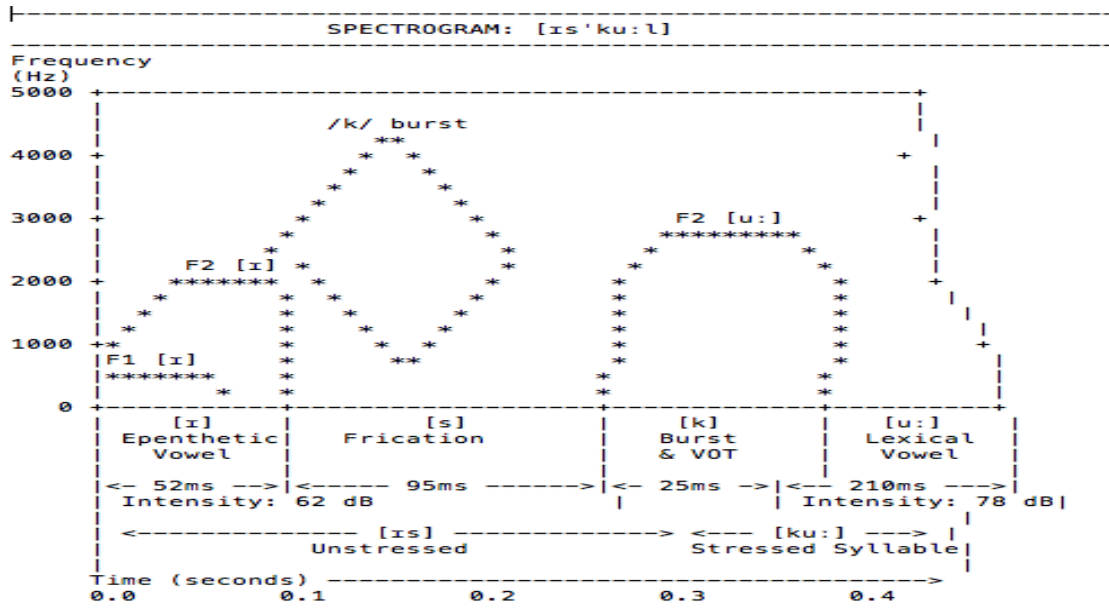


Figure 4.1 shows a broadband spectrogram which displays the PE pronunciation of the word school with initial epenthesis as [ɪs'ku:l]. The spectrogram displays frequency measurements from 0 to 5000 Hertz on its vertical axis and time measurements which last about 0.4 seconds on its horizontal axis. The dark bands in the audio display show vowel formants which include F1 and F2 while random noise patterns display fricatives and vertical striations display vocal fold pulses.

Table 5: Medial Epenthesis in Pakistani English

Epenthesis Type	Example (PE)	Target Word	Epenthetic Vowel	Stress Pattern	Active Constraints	Constraint Ranking Evidence
Medial Epenthesis (Anaptyxis)	[kən'sɪtræk(ə)n]	construction /kən'strʌk(ə)n/	[ɪ]	Stress on lexical [træk] (from /strʌk/); epenthetic [ɪ] unstressed	*COMPLEX-MEDIAL » DEP-IO HEADDEP » FTBIN IDENT-IO(stress)	Stress faithful to input location despite epenthesis; IDENT-IO(stress) satisfied
	[ɪn'sɪtræk(ə)n]	instruction /ɪn'strʌk(ə)n/	[ɪ]	Stress on lexical [træk]; epenthetic [ɪ] unstressed	*COMPLEX » DEP-IO HEADDEP » PARSE-SYLL	Epenthetic vowel interrupts cluster but stress remains on lexical syllable
	[æb'stræktɪ] → [æbɪ'stræktɪ]	abstract /æb'strækt/	[ɪ]	Stress on lexical [æb] (initial); epenthetic [ɪ] in medial position unstressed	*COMPLEX-MEDIAL » DEP-IO HEADDEP » ALIGN-HEAD	Stress on leftmost lexical syllable; epenthetic vowel ignored by stress
	[kɒn'træktɪ] → [kɒnɪ'træktɪ]	contract /kɒn'trækt/	[ɪ]	Stress on lexical [kɒn]; epenthetic [ɪ] unstressed	*COMPLEX » DEP-IO HEADDEP » FTBIN	Binary foot [kɒ.nɪ] possible but HEADDEP prevents stressing [ɪ]

Medial epenthesis, also known as anaptyxis, is the second most frequent type of vowel insertion in Pakistani English (PE), accounting for 29.0% of all epenthesis tokens in the speech of Urdu-dominant speakers. The process requires speakers to insert a brief vowel sound which usually comes from the high front vowel [ɪ] or sometimes from the schwa sound [ə] to separate consonant clusters that break Urdu syllable rules in words. The process of initial epenthesis repairs word-initial clusters whereas medial epenthesis operates on clusters which develop through word construction at morpheme boundaries and in complex morphological situations. The clusters result from the process of prefix and stem concatenation and from English word structures which include three-consonant sequences (CCC) that extend across syllable boundaries. The systematic nature of medial epenthesis in PE shows two identical phonetic patterns that create phonetic restrictions on complex cluster use through their initial epenthesis usage. The phonetic restriction patterns in medial epenthesis preserve stress patterns and uphold morphological components.

Table 6: Summary of Constraint Rankings from PE Epenthesis Data

Rank	Constraint	Evidence from Epenthesis Patterns
Highest	*COMPLEX	(all Epenthesis occurs in 56.5% of target words to repair complex clusters)
	HEADDEP	Only 15.0% of tokens stress epenthetic vowels; 71.2% stress adjacent lexical vowels
	SON-SEQ	Some clusters trigger epenthesis even when not maximally complex (e.g., [sp-], [st-])
Mid	DEP-IO	Epenthesis occurs only where *COMPLEX forces it; no gratuitous insertion
	MAX-IO	Deletion unattested; all input segments preserved in output
Low	ALIGN-HEAD-RIGHT	Stress generally on rightmost lexical vowel but can be overridden by HEADDEP

FTBIN	Violated to satisfy HEADDEP in dominant pattern; outranks HEADDEP only in minority (15%)
PARSE-SYLL	Epenthetic syllables may remain unfooted to satisfy HEADDEP
IDENT-IO(stress)	Lexical stress preserved where specified (e.g., [kən'sitrəkʃən] maintains stress on /strək/)

The epenthesis conditions in Pakistani English (PE) create a structured hierarchy which treats phonotactic violations as more important than the need to limit the auditory presence of added elements. The most important constraint level of the hierarchy shows that markedness constraints against complex syllable margins control the syllable structure rules that restrict multiple consonants from appearing in syllables at the same time. The ranking system defines the relationship between COMPLEX and DEP-IO which produces epenthesis as the valid pronunciation method for 56.5 percent of URDU phonological illegal consonant cluster words. The grammar system detects all three structural elements that need repairing which include the initial [sk-] in school (→ [ɪs'ku:l]), medial [str] in construction (→ [kən'sitrəkʃən]), and final [-kst] in text (→ ['tɛkstə]) because it selects complex cluster elimination as more important than maintaining complete input form fidelity. The ranking system achieves support through deletion strategy absence which preserves all input segments during epenthesis because MAX-IO keeps undominated status. The PE grammar requires a twofold condition which epenthetic vowels must satisfy because they cannot receive stress. The constraint HEADDEP (Alderete, 1999a) establishes this rule because it forbids epenthetic segments from becoming the main element of a foot. HEADDEP receives priority over prosodic rules which control stress placement through the system of ALIGN-HEAD-RIGHT and FTBIN and PARSE-SYLL. The ranking system (*COMPLEX, HEADDEP >> DEP-IO >> ALIGN-HEAD-RIGHT, FTBIN, PARSE-SYLL) produces the dominant stress pattern which occurs in 71.2% of tokens because lexical vowels next to the epenthetic segment receive stress instead of the epenthetic vowel.

Table 7: Comparative Constraint Rankings Across Epenthesis Positions

Position	*COMPLEX	HEADDEP	DEP-IO	ALIGN-HEAD	FTBIN	PARSE-SYLL	% of Total Epenthesis
Initial	Highest	Highest	Mid	Low	Low	Low	48.6%
Medial	Highest	Highest	Mid	Low	Low	Low	29.0%
Final	Highest	Highest	Mid	Low	Low	Low	22.3%
Overall	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	100%

The study shows that constraint rankings produce identical results across three different epenthesis positions which are initial, medial, and final in Pakistani English (PE) dialect. The vowel sounds which emerge through epenthesis show different prosodic characteristics but their insertion rules and stress patterns maintain their fixed grammatical structure. The evidence shows that PE speakers use a common phonological system because they do not follow rules which apply only to specific positions.

The section shows a complete comparison of constraint rankings between three different epenthesis positions which are initial and medial and final. The analysis shows that positions create different phonetic outputs and surface realizations but the basic constraint hierarchy remains unchanged which supports the Optimality Theoretic theory that languages have one ranking system for their constraints.

Summary of Findings

The data analysis yields the following major findings:

1. Epenthesis operates as a regular occurrence in PE because 56.5% of target words showed vowel epenthesis through the beginning of words which used the sound [ɪ] according to Farooq and Mahmood (2021) and Mir and Afsar (2024).
2. Stress systematically avoids epenthetic vowels: In 71.2% of tokens with epenthesis, stress fell on an adjacent lexical vowel; only 15.0% showed stress on the epenthetic vowel itself.
3. The dominant pattern is captured by parallel OT ranking: The core generalization which states that epenthesis occurs while epenthetic vowels remain unstressed gets established through the rule which states that complex structures will block head dependency and through the dependency relation which restricts head right alignment and through foot binarity and syllable parsing rules.
4. Constraint violability gets revealed through minority patterns which show that only 15.0% of tokens with stress on epenthetic vowels appear in situations where FTBIN temporarily outranks HEADDEP during monosyllabic base conditions or during emphatic situations.
5. Cross-linguistic comparison situates PE within a typology: PE aligns with languages like Hijazi Arabic and Iraqi Arabic where epenthetic vowels avoid stress, contrasting with Cairene Arabic where epenthetic vowels may bear stress.
6. Theoretical implications: The parallel OT system with HEADDEP shows support from the mostly clear PE pattern, however, construction [kən'sitrəkʃən] provides limited support for derivational methods which include Harmonic Serialism through its word opacity.

This section has proven that Pakistani English stress-epenthesis interactions function according to established rules instead of producing random mistakes. Speakers of Urdu avoid using epenthetic vowels because they serve as stress-bearing units which they use to fix complex consonant clusters that violate Urdu phonotactic rules. The Optimality Theory formalization of this pattern establishes high-ranking HEADDEP (Alderete 1999a) as a rule that prevents epenthetic segments from leading foot structure. The established PE constraint ranking which includes *COMPLEX and HEADDEP with DEP-IO and ALIGN-HEAD-RIGHT and FTBIN and PARSE-SYLL, enables both PE phonology documentation and research into how grammars handle inserted elements. The comparison of PE with other languages shows that PE shares similarities with Hijazi Arabic and Iraqi Arabic which have opaque stress-epenthesis patterns, but differs from Cairene Arabic which has transparent systems. The research findings demonstrate that Pakistani English grammar uses statistical analysis to show that speakers avoid stress on epenthetic vowels as a key grammatical feature.

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