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Iraqi Arabic Substrate Effects on English Prosody in Tertiary STEM Classrooms

Murtadha Hamid Hamzah*
Department of English Language and Literature, College of Arts Humanities, AL Mustaqbal University, Babylon, Hillah, 51001, Iraq

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ABSTRACT **Original Research Article**

This study investigates the potential impact of Iraqi Arabic prosodic features on the production of English prosody by tertiary STEM students in English-medium instructional settings. Through a descriptive and literature-based conceptual analysis, the study identifies key areas of prosodic transfer, including stress placement, rhythmic timing, pitch range, and prosodic phrasing. It explains how these features may affect intelligibility, clarity, and discourse organization in academic English. The study highlights that differences between the prosodic systems of Iraqi Arabic and English can lead to predictable challenges in STEM communication, where precise emphasis, contrastive signaling, and structured explanation are essential. By synthesizing findings from cross-linguistic prosody research, second-language phonology, and EMI discourse studies, the study underscores the importance of integrating prosodic awareness and suprasegmental instruction into English for STEM Purposes. The conclusions offer theoretical insights and pedagogical recommendations aimed at improving communicative effectiveness in Iraqi EMI environments.

Keywords: Iraqi Arabic Prosody, English Prosody, Suprasegmental Transfer, STEM Communication.

**Corresponding author: Murtadha Hamid Hamzah*
Department of English Language and Literature, College of Arts Humanities, AL Mustaqbal University, Babylon, Hillah, 51001, Iraq

Introduction

English-medium instruction has become increasingly prevalent in tertiary STEM (Science, Technology, Engineering, Mathematics) programs worldwide, including in Iraqi universities, where lecturers and students are often required to use English for lectures, laboratory instructions, and presentations. In such high density informational contexts, effective verbal communication involves more than accurate vowel and consonant articulation; it depends critically on prosodic features such as intonation, rhythm, and stress, which shape listeners' ability to parse, segment, and interpret technical discourse. Prosody plays a central role in signaling phrase boundaries, emphasizing key information, managing turn-taking, and clarifying rhetorical structure (Chun, 2002).

Research on second-language (L2) speech production has consistently demonstrated that suprasegmental cues contribute significantly to listener intelligibility and comprehensibility, often exerting a greater influence than segmental accuracy alone (Saito, Trofimovich, & Isaacs, 2015; Munro & Derwing, 2008). In L2 contexts, learners frequently transfer prosodic patterns from their first language (L1) into their English production. Such transfer may involve rhythmic timing (e.g., syllable-timed vs. stress-timed organization), pitch-accent patterns, boundary-marking strategies, and stress distribution (Trouvain, 2018). Learners whose L1 is typologically distinct from English typically show slower development of L2 rhythmic control and persistent deviations in temporal organization (Mennen,

2012). Despite these findings, the majority of L2 pronunciation research continues to focus on segmental phonology, leaving prosody comparatively underinvestigated, particularly in non-European learner contexts (Arvaniti, 2015; Low & Grabe, 2023).

In the case of Iraqi Arabic, although previous studies have addressed lexical stress production among Iraqi EFL learners (Al Thalab, 2021), the suprasegmental dimension namely how Iraqi Arabic prosody may influence English intonation, rhythm, and stress in university STEM settings remains largely unexplored. Iraqi Arabic constitutes a rich prosodic system characterized by distinctive syllable-timing tendencies, intonational contours, and stress strategies (Tucker, 2010). The presence of this prosodic substrate raises important questions regarding how English is produced and interpreted in Iraqi STEM classrooms, where L1 prosodic patterns may shape intelligibility, participation, and academic effectiveness.

Given that intelligibility in L2 speech is influenced not only by segmental accuracy but also by speech rate, lexical richness, and suprasegmental quality (Saito et al., 2015), examining prosody in context becomes essential. Prosodic competence—manifested in appropriate pitch movement, stress placement, and rhythmic organization has been shown to correlate with improved listener comprehension and reduced cognitive processing effort (Derwing & Rossiter, 2003). Nevertheless, explicit instruction in prosody remains marginal in English for Academic Purposes (EAP) and English for STEM Purposes (ESfP) curricula, despite strong pedagogical arguments for its inclusion (Levis & Grant, 2018; Yang, 2016).

In Iraqi tertiary STEM classrooms, where English functions as both a medium of communication and a vehicle for complex conceptual explanation, the role of prosody may be particularly salient. Misaligned stress patterns or flattened intonation contours can obscure sentence boundaries, weaken contrastive signaling, and increase processing demands on listeners. These challenges point to a clear knowledge gap: the prosodic realization of English by Iraqi Arabic speakers in STEM instructional environments, and its implications for intelligibility and academic discourse, remains under-researched.

This study addresses this gap by offering a conceptual and theory-driven analysis of how Iraqi Arabic prosodic features may shape the production of English prosody in tertiary STEM contexts. Rather than relying on empirical data, the study synthesizes findings from second-language phonology, cross-linguistic prosody research, and English-medium instruction literature to explain predictable patterns of suprasegmental transfer and their potential effects on intelligibility and discourse organization. The study's contribution lies in integrating prosodic theory with the communicative demands of STEM education, providing a unified framework that links L1 prosodic substrate, English academic prosody, and pedagogical practice in Iraqi EMI environments.

Novelty and Theoretical Contribution of the Study

This study offers a novel theoretical contribution by **integrating three domains that are rarely examined together:** Iraqi Arabic prosody, suprasegmental transfer in second-language speech, and the communicative demands of English-medium STEM instruction. While previous research has addressed prosody in Arabic–English contexts or pronunciation challenges in EMI settings separately, the present study is the first to propose a **unified conceptual framework** that explains how L1 prosodic substrate systematically shapes English academic discourse in STEM classrooms. The study advances current knowledge by linking prosodic theory to discipline-specific communication needs, thereby extending L2 prosody research into applied academic and STEM-oriented contexts. This integration provides both theoretical insight and pedagogical direction for English for STEM Purposes (ESfP) curriculum design in Iraqi and comparable multilingual educational environments.

Problem Statement

Although English is widely used as the medium of instruction in Iraqi tertiary STEM programs, limited attention has been given to how Iraqi Arabic influences English speech at the prosodic level. Most existing studies focus on grammar and individual sounds, overlooking suprasegmental features such as intonation, rhythm, and stress that are crucial for clarity and listener comprehension.

Iraqi learners often transfer elements of their native prosody into English, resulting in atypical stress placement, restricted pitch range, and altered rhythm. These features can reduce intelligibility and disrupt communication in STEM classrooms, where precise and clear explanations of complex ideas are essential.

The core problem is the lack of empirical understanding of how Iraqi Arabic prosody affects English speech in real academic contexts. Without this knowledge, pronunciation teaching remains limited to segmental accuracy, neglecting the broader rhythmic and intonational patterns that are essential for effective communication. This study addresses this gap by examining the influence of Iraqi Arabic prosody on English speech and by proposing strategies to improve spoken clarity in English medium STEM education.

Research Objectives

This study aims to theoretically examine how the prosodic characteristics of Iraqi Arabic may influence English speech in tertiary STEM contexts within English-medium instructional settings. Specifically, it seeks to:

1. Identify, based on existing linguistic and phonological literature, the dominant prosodic features (intonation, stress, and rhythm) associated with Iraqi Arabic that are likely to surface in English speech.

2. Explain how these features may reflect systematic suprasegmental transfer from Iraqi Arabic to English.
3. Theoretically analyze how such transferred prosodic features may affect intelligibility and clarity in English academic communication.
4. Propose pedagogical recommendations for improving prosodic competence in English for STEM Purposes (ESfP) based on the synthesized findings.

Scope and Generalizability of the Study

The scope of this study is intentionally limited to the theoretical examination of prosodic transfer from Iraqi Arabic to English within tertiary STEM contexts in Iraqi universities. The focus on Iraqi Arabic reflects the need to address an under-researched dialect whose prosodic system differs substantially from that of English and other widely studied Arabic varieties. The study does not aim to generalize its findings to all Arabic-speaking learners or to all English-medium instructional settings. Instead, it provides a context-specific conceptual framework that may offer analytical insights applicable to comparable EMI environments where English is used for technical and scientific communication. Future empirical research is required to test the applicability of this framework across different Arabic dialects, educational levels, and disciplinary contexts.

Significance of the Study

This study holds both theoretical and practical importance. Theoretically, it contributes to a deeper understanding of cross-linguistic influence at the suprasegmental level by theoretically examining how Iraqi Arabic prosody may shape English intonation, rhythm, and stress in academic communication. The study expands the limited body of research on Arabic–English prosodic transfer by providing a conceptual synthesis from a linguistic context that remains underrepresented in second-language phonology and English as a Lingua Franca (ELF) studies.

Practically, the study offers valuable insights for improving oral communication in English-medium STEM education. By clarifying how prosodic transfer may affect intelligibility and clarity, the analysis informs the design of pronunciation and speaking modules that move beyond segmental accuracy to include rhythm, stress, and intonation awareness. This can enhance students' ability to present, discuss, and explain technical concepts more clearly and confidently.

For educators and curriculum developers, the study provides theory-informed pedagogical recommendations for integrating prosody-focused activities into English for STEM Purposes courses. In the long term, it supports the development of more effective English-medium instruction across Iraqi universities and comparable multilingual academic settings, promoting clearer communication and improved learning outcomes.

Prosody and Its Role in Second Language Intelligibility

Prosody that is, suprasegmental features such as intonation, rhythm, stress, timing, and pausing plays a critical role in spoken communication, particularly in second-language (L2) contexts. Although many pronunciation teaching programs focus primarily on segmental accuracy (vowels and consonants), growing evidence indicates that even when learners produce acceptable segmental forms, mismatches in prosody can still impair listener intelligibility and comprehensibility (Munro & Derwing, 2008; Lochland, 2020). Recent synthesis studies have shown that intelligibility is more strongly associated with suprasegmental control than with accent reduction alone.

Intonation contours guide listeners' processing of discourse structure by signaling topic shifts, emphasis, and turn-taking cues (Chun, 2002). In L2 speech, misplaced or flattened intonation patterns may lead listeners to misinterpret sentence structure or overlook implied contrasts. Learners who fail to exploit pitch range effectively may also be perceived as less engaging or authoritative, even when their lexical and grammatical choices are accurate. Research further indicates that rhythm and timing play a crucial role in speech perception, with timing deviations often exerting a greater impact on perceived naturalness than pitch deviations alone.

Prosody also interacts closely with segmental production. When rhythmic structure is disrupted, speakers may overarticulate individual segments to compensate, resulting in speech that sounds unnatural or effortful. This interaction suggests that instruction focusing exclusively on segments is unlikely to be sufficient for achieving intelligible and fluent L2 speech. Importantly, intelligibility is multidimensional: it refers to how easily a listener can recognize what is said; comprehensibility concerns how easily meaning is understood; and accentedness reflects a listener's perception of how native-like the speech sounds (Munro & Derwing, 2008). Research consistently emphasizes that a foreign accent does not necessarily imply unintelligibility; rather, alignment with L2 suprasegmental patterns often plays a more decisive role.

In practical terms, within English-medium instruction (EMI) in STEM disciplines, prosodic clarity is essential for the effective delivery of complex information. Without clear prosodic cues, listeners may struggle to follow argumentation, sequential explanations, or contrastive points that are frequent in STEM lectures and presentations. Understanding the role of prosody in L2 intelligibility therefore provides a necessary foundation for examining how specific learner groups, such as Iraqi Arabic L1 speakers, may transfer their L1 prosodic tendencies into English academic speech.

Cross Linguistic Transfer of Prosody: Theoretical Frameworks and Empirical Evidence

Cross-linguistic influence (CLI) in prosody refers to the systematic carryover of L1 intonation, rhythm, and stress patterns into L2 speech. Although classic L2 speech theories were initially formulated to explain segmental acquisition, their predictions extend to the **suprasegmental domain** when phonological categories and implementation rules are comparable across languages. The Perceptual Assimilation Model (PAM/PAM-L2) predicts that learners assimilate unfamiliar L2 contrasts to the closest L1 categories, shaping how **intonational movements and prominence patterns** are perceived and produced (Best, 1995; see also applications to tone and intonation perception). The Revised Speech Learning Model (SLMr) further proposes that phonetic systems reorganize across the lifespan based on perceived dissimilarity between L1 and L2 and the quality of input; consequently, learners must acquire language-specific implementation rules such as pitch-accent alignment and boundary-tone realization in addition to segmental inventories (Flege & Bohn, 2021).

A second line of research has quantified rhythmic transfer using interval-based metrics. Pairwise Variability Indices (rPVI, nPVI) and related measures (%V, ΔV/ΔC, VarcoV) capture temporal variability associated with so-called **stress-timed** and **syllable-timed** rhythmic profiles and have been widely used in L1–L2 comparisons and developmental studies. However, rhythm metrics are sensitive to speech rate, syllable structure, and elicitation methods; therefore, their interpretation must be theory-driven and carefully contextualized (Arvaniti, 2012). Recent research further indicates that intonation, rhythm, and speech rate contribute differentially to perceived accentedness and comprehensibility, highlighting that **suprasegmental transfer** affects listener outcomes beyond segmental accuracy.

Intonational transfer has been documented across diverse L2 populations. Learners may retain L1-like pitch ranges, nuclear accent timing, or boundary tone choices, with the degree of transfer influenced by task demands and access to contextual meaning (e.g., interrogative rises, focus marking). For Iraqi Arabic specifically, phonological descriptions indicate quantity-sensitive trochaic stress and characteristic intonational contours, which form a plausible substrate for L2 English prosody (e.g., final-syllable prominence tendencies and narrower pitch excursions). When these L1-conditioned prosodic templates are mapped onto English where lexical stress is contrastive and pitch movement encodes information structure misalignment may emerge in the form of flattened contours, atypical stress placement, or altered rhythmic timing, with potential consequences for intelligibility in high-density STEM discourse.

Taken together, these theoretical models (PAM, SLMr) motivate the present study's analytic focus on:

- category mapping in intonation and stress,
- phonetic implementation (alignment, scaling, and duration), and
- listener-oriented perceptual outcomes.

Instrumentation for L2 Prosody Research: Metrics, Annotation, and Acoustic Measures

Investigating prosody in second language (L2) speech requires rigorous instrumentation both in terms of acoustic measurement and in terms of perceptual annotation. Accurate and reliable tools are crucial for capturing intonation, stress, rhythm, and timing in L2 contexts. This section reviews three interrelated components: (i) acoustic metrics for rhythm, stress, and intonation; (ii) annotation and transcription methods for prosodic features; and (iii) the challenges unique to L2 speech research.

Metrics for Rhythm, Stress & Intonation

Quantifying rhythm often involves interval based measures, such as the normalized Pairwise Variability Index (nPVI) or raw Pairwise Variability Index (rPVI), for vocalic and consonantal intervals, as well as the percentage of vocalic time (% V) and ΔC/ΔV ratios. These metrics help distinguish stress timed from syllable timed rhythm patterns (Grabe & Low, 2002). However, in L2 speech, these metrics may be influenced by factors such as speech rate, syllable structure, and segmental complexity (Algethami, 2024). Intonation and stress are commonly traced via pitch range, pitch level, duration of stressed vs unstressed syllables, and their alignment with syntactic or informational structure (Liu, 2021). For instance, studies with Mandarin English learners found differences in pitch range, maximum pitch level, and duration when signaling contrastive information (Liu, 2021).

Annotation & Transcription of Prosodic Features

Reliable annotation is a core concern given the variability of prosody within and across speakers. Traditional expert transcription is labour intensive and subject to inter transcriber discrepancies. As an alternative, Cole and Shattuck Hufnagel (2016) proposed methods such as Rapid Prosody Transcription (RPT) and cue specification, which enable non expert annotators to label prominence and boundaries and derive continuous prosody scores. The study emphasizes that variability in acoustic cues should not be treated as noise, but as a meaningful signal in prosodic research.

Challenges in L2 Prosody Research

Researching L2 prosody introduces specific methodological challenges: the acoustic cues for prosodic features may differ from L1 norms; autoalignment tools often fail on nonnative speech; segmental deviations may contaminate prosodic measures; and high intra speaker variability complicates statistical modelling (Mairano et al., 2023). Additionally,

when learners produce technically dense speech (e.g., STEM lectures), the added cognitive load and domain specific vocabulary can influence prosodic patterns and complicate the isolation of L1 transfer effects.

Implications for the Current Study

Given the methodological and instrumentation considerations discussed above, the present study does not employ empirical data collection or acoustic measurement. Instead, it adopts a conceptual and theory-driven analytical perspective, drawing on established findings from phonetic, phonological, and EMI research to explain how prosodic features of Iraqi Arabic may influence English prosody in tertiary STEM contexts. The analysis relies on previously documented acoustic and perceptual evidence reported in the literature, rather than on newly collected speech samples. By synthesizing these sources, the study aims to provide a coherent theoretical account of suprasegmental transfer and its implications for intelligibility and academic discourse in English-medium STEM instruction.

Prosody in English Medium STEM Instruction: Contextual Demands and Learner Output

In English medium instruction (EMI) environments within STEM disciplines, spoken communication carries a heavier functional load compared to general academic settings. Lecturers and students in fields such as engineering, computer science, and applied sciences must deliver highly technical information with precision, conceptual sequencing, and logical coherence. Prosody plays a crucial role in this process: intonation guides the signaling of topic shifts, stress highlights critical terminology, and rhythm ensures the segmentation of dense informational units. When these suprasegmental cues are misaligned, comprehension breakdown becomes more likely, particularly for listeners working in a second language environment (LaCroix, 2019).

Recent EMI literature highlights that linguistic challenges persist even for content specialists with strong disciplinary knowledge. In a comprehensive review of EMI teacher development, researchers noted that many instructors still struggle with oral communication demands, including issues related to prosody, clarity, and discourse organisation (Wang, Yuan, & De Costa, 2025). Such challenges inevitably influence classroom interaction, modelling, and students' own spoken output. In parallel, research on L2 prosody confirms that deviations in timing, stress, and pitch range significantly increase the cognitive load on listeners, reducing accuracy in processing syntactic relations and discourse markers (Henry, 2017).

Within STEM lectures, the importance of prosody is magnified. Technical explanations often rely on contrasts (e.g., cause vs. effect, input vs. output, dependent vs. independent variable), and these contrasts are typically cued through pitch accenting and prosodic phrasing. When learners transfer L1 prosodic patterns such as a narrow pitch range or syllable timed rhythm into English, their speech may lack the prominence cues necessary to signal these relationships clearly. This is particularly relevant for Iraqi Arabic speakers, whose prosodic system differs substantially from English in its rhythmic organization and stress placement tendencies.

Moreover, the EMI environment itself amplifies the consequences of prosodic mismatch. Large classrooms, microphone use, mixed proficiency audiences, and rapid pacing in STEM lectures place additional demands on prosodic clarity. If a speaker's intonation does not support information structuring, listeners may struggle to follow complex explanations, regardless of the speaker's grammatical or lexical accuracy. For this reason, examining prosody in EMI STEM settings is essential for understanding both communication effectiveness and the pedagogical interventions needed to support learners.

This study, therefore, situates Iraqi English prosody within the broader EMI STEM context, emphasizing how prosodic transfer intersects with disciplinary communication demands. By theoretically examining suprasegmental patterns associated with Iraqi Arabic and synthesizing evidence from existing phonological and EMI research, the study explains how misalignment between L1 prosodic structures and English academic discourse conventions may affect intelligibility, listener comprehension, and overall communicative effectiveness.

Prosodic Features of Iraqi Arabic and Their Potential Influence on L2 English

Iraqi Arabic possesses a distinct prosodic system characterized by predictable stress patterns, relatively narrow pitch variation, and rhythmic timing that differs from English. These native language features form the prosodic substrate through which Iraqi speakers acquire and produce English. Understanding these characteristics is vital for analyzing the nature and magnitude of prosodic transfer in L2 settings, particularly in English medium STEM communication.

Stress in Iraqi Arabic tends to follow quantity sensitive patterns: heavy syllables attract stress, often resulting in prominence placed on final or penultimate syllables. This contrasts with English, where stress placement is lexically contrastive and can change word meaning. Research on Arabic stress systems reveals that quantity sensitivity leads to consistent stress assignment that may later be transferred into English, potentially causing misplaced or overly regular stress patterns (Tucker, 2010).

Additionally, the pitch range of Iraqi Arabic is typically narrower than that of English. Iraqi Arabic declarative contours exhibit limited pitch excursion, resulting in a flatter overall intonation. English, however, uses wider pitch movements to mark information structure, contrast, and emphasis. When Iraqi speakers rely on L1 intonational templates, their English speech may sound monotonic or lacking in pragmatic signaling (Al Khafaji, 2019).

Rhythm constitutes another area of notable cross linguistic difference. Iraqi Arabic exhibits more syllable timed characteristics, with relatively even syllable durations, whereas English is stress timed, characterized by substantial variability in syllable length. Studies on rhythm transfer show that learners from syllable timed L1 backgrounds often retain more regular timing patterns in English, which may reduce the prominence contrasts needed for highlighting key information in STEM explanations (Algethami, 2024).

Finally, prosodic phrasing in Iraqi Arabic often groups information in ways that align with morphological or syntactic boundaries, whereas English relies more heavily on intonational phrase breaks to guide discourse interpretation. As a result, Iraqi Arabic speakers may produce English utterances with fewer or misplaced prosodic boundaries, which can affect listeners' ability to follow complex ideas or logical progression.

Together, these features form a coherent prosodic profile that can shape the English output of Iraqi speakers. When transferred into academic English, particularly in STEM contexts where clarity and emphasis are crucial, these L1 patterns may lead to reduced intelligibility, diminished contractiveness, and increased listener effort. Understanding these L1 characteristics is therefore essential before investigating how they manifest in L2 English and how they can be addressed pedagogically.

Empirical Studies on Arabic–English Prosodic Transfer

Research on prosodic transfer from Arabic to English has expanded in recent years, although studies focusing specifically on Iraqi Arabic remain limited. Existing work across various Arabic dialects provides valuable insights into how L1 prosodic structures may influence L2 English production, particularly in the domains of intonation, rhythm, stress, and prosodic phrasing. Collectively, these studies highlight the systematic nature of suprasegmental transfer and its documented impact on listener perception and intelligibility in academic contexts.

Studies investigating Gulf and Levantine Arabic speakers have shown that learners frequently maintain L1likeintonational patterns when speaking English, often producing narrower pitch ranges and flatter contours than native English speakers. These reduced pitch excursions can limit the expression of contrast, emphasis, and discourse segmentation in English (Almbark, 2014). Similar findings were reported for Jordanian Arabic speakers, whose English productions demonstrated constrained pitch modulations and an increased reliance on syllable based timing, resulting in reduced prominence marking and greater listener processing effort (Jasim, 2020).

Research on North African Arabic varieties also provides evidence of rhythmic transfer. Tunisian Arabic speakers, for example, were found to transfer syllable timed rhythmic patterns into English, resulting in more uniform syllable durations and less pronounced stress contrasts (Ghoul, 2019). Such rhythmic uniformity can diminish the prosodic cues necessary for highlighting key information in complex academic discourse.

In the domain of stress, several studies have confirmed that Arabic speakers tend to apply quantity sensitive stress placement from their L1 to English, leading to consistent but nonnative like stress patterns in polysyllabic English words (Ayyad, 2021). This type of transfer may impact lexical recognition and word level intelligibility, particularly in STEM terminology, where stress position can differentiate technical terms.

While research on Iraqi Arabic is more limited, existing studies indicate similar trends. Iraqi English learners often exhibit a restricted pitch range, predictable stress placement, and syllable oriented timing when speaking English, all of which closely align with the prosodic characteristics of Iraqi Arabic (AlKhafaji, 2019). These patterns suggest a strong L1 influence and support the need for a focused investigation into how these features impact English medium STEM communication.

Taken together, empirical studies across Arabic dialects reveal consistent evidence of L1 prosodic transfer to English. These findings underscore the importance of examining the prosodic output of Iraqi Arabic speakers specifically, given the unique stress and rhythmic properties of the dialect. Moreover, such research is crucial for developing pedagogical strategies that enhance intelligibility and communicative effectiveness in English medium university settings, particularly in technical disciplines where nuanced prosody is essential for clarity and precision.

Summary of Literature and Identification of the Research Gap

The reviewed literature highlights the central role of prosody in facilitating intelligible and effective spoken communication, particularly in second-language academic contexts. Studies consistently indicate that **suprasegmental features** such as intonation, rhythm, stress, timing, and prosodic phrasing contribute significantly to listener comprehension and overall cognitive processing load. Research in L2 prosody confirms that mismatches in rhythm and intonation can hinder understanding even when segmental accuracy is adequate (Henry, 2017; LaCroix, 2019). These findings underscore the fundamental importance of prosodic competence in English-medium STEM instruction.

The literature on cross-linguistic influence further demonstrates that learners commonly transfer prosodic structures from their first language to the target language. Research across Arabic dialects documents consistent patterns of L1 prosodic transfer into English, including restricted pitch range, predictable stress assignment, and

syllable-oriented rhythmic timing (Almbark, 2014; Ghoul, 2019; Jasim, 2020). Such patterns often reduce prominence contrasts and diminish the clarity of discourse relations, both of which are essential for the linear and hierarchical presentation of scientific information.

Research on Iraqi Arabic offers additional insights into the prosodic characteristics of the dialect, including quantity-sensitive stress placement, limited pitch modulation, and rhythmic tendencies that differ markedly from stress-timed English (Tucker, 2010; Al Khafaji, 2019). These features create a strong potential for prosodic transfer in L2 English. However, studies focusing specifically on suprasegmental transfer among Iraqi English learners remain scarce. Existing work has largely focused on segmental pronunciation or general communicative challenges, leaving the suprasegmental dimension relatively underexplored.

Moreover, the literature reveals a notable absence of research examining Iraqi English prosody within English-medium STEM classroom contexts. While prior studies have addressed prosody in general EFL settings, they do not fully capture the communicative demands of STEM discourse, which relies heavily on prosodic cues to structure explanations, highlight variables, and support the interpretation of technical information. To date, no study has provided a **theory-driven synthesis** that explains how Iraqi Arabic prosodic features may influence intelligibility and communicative effectiveness in STEM academic communication.

This gap is significant, as STEM discourse requires precise organization, contrastive signaling, and dynamic emphasis, all of which depend heavily on prosodic control. Without a clear conceptual understanding of how L1 prosodic features may shape English academic speech in STEM settings, pedagogical interventions remain limited in scope. The gap identified in the literature therefore positions the present study as timely and necessary, as it aims to **theoretically examine and synthesize** existing knowledge on Iraqi Arabic prosodic transfer and to articulate its implications for intelligibility and academic communication in tertiary STEM environments.

Methodology (Descriptive and Analytical Approach)

Presents the methodological approach adopted for examining how prosodic features of Iraqi Arabic may influence the production of English prosody in tertiary STEM contexts. As this study is conceptual rather than experimental, it does not rely on empirical data collection or acoustic measurements. Instead, it employs a descriptive, analytical, and interpretive methodology grounded in existing scholarly literature on prosody, cross linguistic transfer, and English medium STEM communication. The aim is to synthesize theoretical perspectives, compare established linguistic models, and construct a coherent analytical framework that explains potential patterns of prosodic transfer within the Iraqi context.

Research Approach

The study adopts a qualitative, descriptive, and conceptual literature-based research design. This approach is appropriate for research questions that seek to explain linguistic influence, theoretical mechanisms, and conceptual relationships, rather than to test hypotheses through experimental or empirical procedures. The descriptive-analytical framework enables the study to:

- Analyze prosodic structures in Iraqi Arabic and English as documented in established phonetic and phonological literature.
- Compare prosodic systems using recognized theoretical models of cross-linguistic influence and second-language acquisition.
- Interpret how L1 prosodic constraints may shape L2 English prosody at the suprasegmental level.
- Relate these theoretical insights to the communicative demands of STEM academic discourse in English-medium instructional contexts.

This research approach ensures analytical depth, conceptual coherence, and theoretical clarity while explicitly excluding empirical data collection, acoustic measurement, or participant-based analysis.

Sources of Data

As a non empirical study, the primary data consist of scholarly literature, including:

1. Peer reviewed phonetic and phonological studies on Iraqi Arabic prosody
2. Research on L2 Prosodic Acquisition and Suprasegmental Transfer
3. Studies on English prosody in academic and STEM discourse
4. Theoretical models explaining cross linguistic influence, such as:
    - The Speech Learning Model (SLM)
    - The Perceptual Assimilation Model (PAM)
    - Prosodic Typology frameworks
    - Rhythm class theories

The chapter synthesizes these sources to build an integrated theoretical model of how Iraqi Arabic prosodic structures could influence English academic speech.

Method of Analysis

The analysis in this study proceeds through three descriptive steps:

Comparative Prosodic Analysis

The prosodic features of Iraqi Arabic stress patterns, pitch range, intonational contours, and rhythmic timing are examined in contrast with English academic prosody. This step identifies structural discrepancies between the two systems that may lead to transfer.

Theoretical Interpretation Using Linguistic Models

Prosodic differences are interpreted through the lens of influential models of L2 acquisition. This interpretive step clarifies the mechanisms through which L1 prosody shapes L2 production, including perceptual categorization, phonetic implementation, and transfer of timing patterns.

Contextual Application to STEM Academic Discourse

Finally, the analysis situates prosodic transfer within the communicative demands of STEM instruction. It examines how intonation, stress, and rhythm function in explaining concepts, structuring arguments, and highlighting technical contrasts, thereby relating linguistic theory to academic communication.

Rationale for the Descriptive Methodology

A descriptive methodology is suitable for the present study because:

- The phenomenon under investigation prosodic transfer is well documented in theoretical literature and can be analyzed without empirical measurement.
- Cross linguistic comparison of prosodic systems relies heavily on phonological descriptions rather than field data.
- STEM communication conventions can be understood through discourse analytic studies and academic frameworks for communication.
- The study seeks to provide conceptual clarity, pedagogical implications, and a structured understanding of prosodic influence rather than to evaluate real time performance.

This methodological approach ensures intellectual depth, analytical precision, and coherence with the research aims.

Reliability and Validity in a Conceptual Study

Although the study does not involve empirical data collection, reliability and validity are maintained through:

- **Use of established phonological descriptions** drawn from reputable scholarly sources
- **Triangulation of theoretical perspectives** across phonetics, SLA, and discourse analysis
- **Consistency of interpretation** based on cross referenced findings in prior studies
- **Clear conceptual definitions** and boundaries for prosody, academic discourse, and transfer

This strengthens the credibility and scholarly value of the analysis.

Ethical Considerations

As a purely conceptual study with no human participants, no ethical approval is required. The analysis relies entirely on published literature, which does not involve personal or sensitive data.

Discussion and Theoretical Analysis

Introduction

This chapter provides an in-depth theoretical analysis of how prosodic features of Iraqi Arabic may shape the English prosody produced by Iraqi STEM students in English-medium instructional environments. Drawing on the comparative insights and models outlined in previous sections, the discussion synthesizes linguistic theory with the communicative demands of STEM discourse. The analysis demonstrates how stress, rhythm, intonation, and prosodic phrasing transferred from Iraqi Arabic can influence the clarity, coherence, and intelligibility of English academic speech.

Stress Transfer and Its Impact on STEM Terminology

Stress is a central component of English prosody, particularly in academic and technical vocabulary where stress placement differentiates meaning (e.g., *record* vs. *reCORD*, *object* vs. *obJECT*). In Iraqi Arabic, stress placement is largely quantity-sensitive, typically targeting final or penultimate heavy syllables. When this predictable pattern is transferred to English, Iraqi learners may apply stress in a uniform or L1-consistent manner.

In STEM contexts, inaccurate stress placement in terms such as *algorithm*, *variable*, *frequency*, or *analysis* may reduce intelligibility and hinder listeners' recognition of key concepts. When stress follows Iraqi Arabic patterns rather than English lexical conventions, prominence contrasts may be weakened, disrupting comprehension during lectures, presentations, and procedural explanations where precision is essential.

Rhythm Transfer and the Reduction of Prominence Cues

Iraqi Arabic rhythm tends toward a syllable-timed structure, characterized by relatively even syllable durations. English, by contrast, is stress-timed, with prominent syllables occurring at roughly regular intervals and unstressed syllables undergoing reduction. The transfer of syllable-timed rhythm into English may result in:

- Reduced vowel reduction
- More uniform timing
- Weakened contrast between stressed and unstressed syllables

In STEM discourse, where emphasis signals conceptual hierarchy, such rhythmic uniformity can make speech sound flat and poorly organized. As a result, contrasts essential for meaning (e.g., *critical value* vs. *critical value*, *input signal* vs. *input signal*) may be insufficiently highlighted, making complex explanations more difficult to follow for listeners processing dense technical information.

Intonational Transfer and the Narrowing of Pitch Range

English relies heavily on pitch movement to signal contrast, sequence, emphasis, and discourse boundaries. Iraqi Arabic, however, typically exhibits a narrower pitch range. When this characteristic transfers into English, speech may lack dynamic variation, resulting in:

- Reduced signaling of topic shifts
- Limited highlighting of key results or conclusions
- Weakened contrastive marking (e.g., advantages vs. disadvantages)
- Difficulty signaling rhetorical functions such as definition, explanation, or cause–effect relationships

In STEM presentations, where clarity depends on effective prosodic contouring, reduced pitch variation can lead to monotonous delivery and increased listener fatigue. For example, explaining multi-step processes without pitch resets may prevent listeners from identifying transitions and understanding argumentative structure.

Prosodic Phrasing and Logical Structuring in STEM Explanations

Iraqi Arabic prosodic phrasing tends to align closely with morphological or syntactic boundaries, whereas English frequently uses prosodic phrasing to encode discourse structure beyond syntax. When Iraqi speakers apply L1 phrasing strategies to English, they may:

- Omit necessary pauses
- Insert pauses at syntactically logical but pragmatically inappropriate points
- Fail to mark shifts in reasoning through prosodic breaks

In STEM discourse, such misalignment can weaken the logical coherence of explanations. For instance, pausing after every clause rather than before a key justification may make explanations appear fragmented or disjointed.

Cumulative Effects on Intelligibility and Listener Processing

The combined influence of stress, rhythm, intonation, and phrasing transfer may have cumulative effects on communication:

- Increased cognitive processing load for listeners
- Reduced intelligibility of key terminology
- Lower clarity in complex explanations
- Difficulty tracking hierarchical or sequential information
- Lower perceived fluency and speaker confidence

In high-stakes STEM environments such as presentations, laboratory briefings, and problem-solving discussions, these effects may hinder communication, collaboration, and academic performance.

Implications for EnglishMedium Instruction in Iraq

The theoretical analysis points to several pedagogical implications:

1. Prosody should be integrated into STEM-focused English instruction rather than treated as a peripheral pronunciation skill.
2. STEM terminology instruction should include explicit guidance on stress placement and rhythmic highlighting.
3. EMI lecturers should model clear and structured prosody, particularly when presenting complex sequences or contrasts.
4. Academic speaking courses should teach prosodic phrasing as a tool for discourse organization.
5. Listening instruction should expose students to varied academic prosodic patterns to strengthen perceptual mapping.

These implications emphasize the instructional importance of prosody for effective academic communication beyond general English proficiency.

Conclusion

This study has demonstrated the critical role of prosody in shaping the clarity and intelligibility of English academic speech in tertiary STEM contexts. Through a conceptual analysis of Iraqi Arabic prosody and its relationship to English suprasegmental features, the study explains how differences in stress, rhythm, intonation, and phrasing may influence academic communication. The findings highlight the need for greater attention to prosodic competence in English-medium instruction, particularly in STEM disciplines where communication precision is essential.

Results

The theoretical synthesis presented in this study highlights the following patterns of prosodic transfer from Iraqi Arabic to English in tertiary STEM contexts:

1. Stress patterns from Iraqi Arabic may transfer into English, leading to non-native stress placement in technical vocabulary.
2. Syllable-timed rhythm may reduce prominence contrasts necessary for structuring complex academic information.
3. Narrow pitch range may contribute to flattened intonation and weakened emphasis.
4. L1-based prosodic phrasing may disrupt the logical flow of STEM explanations.
5. The cumulative effect of suprasegmental transfer may increase listener processing effort and reduce overall intelligibility.

Recommendations

1. Incorporate systematic prosody training (stress, rhythm, and intonation) into English courses designed for STEM students.
2. Provide explicit instruction on stress placement in technical and specialized academic vocabulary.
3. Support EMI lecturers with professional development focused on modeling clear, structured prosody.
4. Expose students to a variety of academic English input through lectures, podcasts, and scientific presentations.
5. Encourage self-recording and guided peer feedback to help learners identify and refine problematic prosodic patterns.

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