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Iraqi Arabic Substrate Effects on English Prosody in Tertiary STEM Classrooms

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ABSTRACT **Original Research Article**

This research explores the effects of Iraqi Arabic prosody on the performance of English prosody among Iraqi EMI STEM students. Based on descriptive and literature review, some important issues of prosody transfer are found such as stress pattern, rhythm, intonation, and prosodic phrasing. This paper describes how the Iraqi Arabic prosody influences on intelligibility, clarity, and structure of academic English. In addition, this research points out that the differences between the two prosodic systems of Iraqi Arabic and English result in some predictable difficulties in the field of STEM communication in which correct emphasis and contrastive signals are necessary. By applying the results of cross-linguistic prosody, phonology, and EMI discourse studies, it is demonstrated how crucial it is to pay attention to the prosody and suprasegmental aspects in the process of learning English for STEM purposes.

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

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Introduction

The use of English as the medium of instruction in tertiary STEM (Science, Technology, Engineering, and Mathematics) programs has become widespread across the globe, including Iraq, where lecturers and learners are expected to use English in teaching, laboratory experiments, and presentations. In such dense informational contexts, verbal communication does not just depend on vowel and consonant pronunciation but rather on such prosodic features as intonation, rhythm, and stress, which determine listeners' segmentation and comprehension of technical language. Prosody is used for the expression of phrase boundaries, information emphasis, turn-taking management, and rhetoric structuring (Chun, 2002).

It was shown by researches in the field of second-language (L2) speech production that suprasegmentally cues play an important part in making one's speech understandable and comprehensible by listeners, often contributing more than segmental accuracy (Saito, Trofimovich, & Isaacs, 2015; Munro & Derwing, 2008). Prosodic patterns transfer from L1 to L2 is common in L2 context, which includes transferring such prosodic features as rhythm type (syllable-timed vs. stress-timed), pitch accent, boundary markers, and stress placement (Trouvain, 2018). For instance, L2 learners with typologically different first language (L1) have slower rhythm acquisition and persistent deviances in temporal organization (Mennen, 2012). While a vast amount of research has been devoted to segmental phonology, prosody is still an under-investigated area, especially when it comes to

non-canonical L2 learners (Arvaniti, 2015; Low & Grabe, 2023).

Within Iraqi Arabic, despite numerous studies devoted to the prosodic feature of lexical stress produced by Iraqi EFL learners (Al Thalab, 2021), there is little research focused on the suprasegmental component of language, i.e., how the phonology and prosody of Iraqi Arabic could affect the realization of the intonation, rhythm, and stress in English within STEM settings at university. However, Iraqi Arabic constitutes a well-defined prosodic system which features distinctive syllable timing preferences, intonation, and stress patterns (Tucker, 2010). Thus, the presence of the substrate implies the necessity to analyze how English functions in Iraqi STEM classrooms, and how the aforementioned L1 prosody affects the intelligibility of the communication and academic success.

First of all, as intelligibility in L2 speech is dependent on many factors, such as speech rate, lexical richness, segmental accuracy, and suprasegmental realization (Saito et al., 2015), there is a need to examine the prosodic dimension in situ. Prosodic competence, which includes pitch modulation, stress distribution, and the rhythmic structure of utterances, positively correlates with improved listening comprehension and less cognitive load (Derwing & Rossiter, 2003). Additionally, the necessity for the teaching of L2 prosody is stressed in recent literature; however, prosodic instruction is marginal in EAP and ESfP programs (Levis & Grant, 2018; Yang, 2016).

Thus, in the context of English functioning in the tertiary STEM classroom of Iraq, which not only serves as a communicative tool but also facilitates conceptual learning, the importance of prosody becomes apparent. Incorrect stress or flattened intonation contours lead to the inability to define the borders of sentences and paragraphs, prevent signaling of contrasts or conditions, and increase processing complexity for listeners. This situation leads to the identification of the knowledge gap concerning how the prosodic realization of English by the speakers of Iraqi Arabic affects listener comprehension in STEM instructional context.

This research project aims at the examination of how the aspects of the Iraqi Arabic substrate are realized in the prosody of English used in STEM classrooms at the tertiary level, quantification of the relationship between the prosodic transfer and its influence on intelligibility outcomes, and offering pedagogical recommendations for ESfP pronunciation and speaking modules. Through the application of acoustic phonetic analysis alongside with the analysis of the intelligibility data, this study will contribute to both the theoretical sphere of L2 prosody and the practical aspect of pronunciation instruction in STEM multilingual settings.

Problem Statement

Though English is used extensively as the medium of instruction in STEM programs in Iraq's higher education institutions, very little has been done to determine the role that Iraqi Arabic plays in shaping the English prosody of STEM students. Most of the studies done have been focused on the grammar and segmental phonology of English, ignoring the suprasegmentals including intonation, rhythm, and stress – all critical components for clear speech and comprehensible language.

Iraqi speakers of English tend to bring in features of their own prosody into the English language and hence tend to have peculiar stress patterns, a narrow pitch range, and an unusual rhythm pattern. All these aspects reduce clarity in speech and negatively impact the teaching-learning process in STEM classrooms where students must learn to explain clearly technical and scientific concepts.

What is primarily needed is empirical evidence about how Iraqi Arabic prosody impacts the use of English prosody in authentic academic settings. In the absence of such evidence, any teaching of pronunciation will only be limited to the segmental aspects of the language and will not take into account the overall rhythm and intonation of the language.

Research Objectives

This study aims to investigate how the prosodic elements of Iraqi Arabic on the performance of STEM students at tertiary level learning English in English medium of instruction environments. The objectives of the research include the following:

1. To identify the prominent prosodic elements, namely intonation, stress, and rhythm of the spoken English of Iraqi speakers.
2. To determine the degree to which the mentioned elements demonstrate transfer from Iraqi Arabic prosody.
3. To evaluate the effect of the prosodic elements on the comprehensibility of English academic discourse.

Scope and Generalizability of the Study

In this study, a theoretical exploration of prosodic transfer between Iraqi Arabic and English is performed in STEM-related instructional contexts at tertiary institutions in Iraq. The attention paid to Iraqi Arabic fills the gap in existing literature on a dialect, whose prosodic system is quite different from English and most commonly studied Arabic dialects. The current study does not seek to generalize the results across all Arabic speakers or instructional settings using English. It suggests a context-bound theoretical

framework, which may bring some analytical perspectives for EMI contexts, where English is used to communicate scientific and technical information. Further empirical studies are required to verify the generalizability of the proposed framework.

Significance of the Study

This study is theoretically and practically relevant. From the theoretical perspective, the results of the current investigation contribute to the existing knowledge about cross-linguistic influence in terms of the suprasegmental level. Specifically, the study analyzes the interaction between Iraqi Arabic prosody and English intonation, rhythm, and stress. Thus, the results of the current investigation make an additional contribution to the existing literature which focuses on Arabic–English prosodic transfer.

In terms of practical importance, the current research provides information that can help to enhance oral communication within English-medium science, technology, engineering, and math courses. The results of the study help to understand how prosodic transfer influences the intelligibility and clarity of the speakers. As a result, one can develop new pronunciation and speaking skills, which not only include the correct pronunciation of sounds but also the proper intonation, rhythm, and stress.

Moreover, based on the results of this study, educators and curriculum designers receive additional data which can be used in the implementation of prosody-based activities in English for STEM Purposes courses.

Prosody and Its Role in Second Language Intelligibility

Suprasegmental phenomena including intonation, rhythm, stress, timing, and pauses constitute prosody which plays a fundamental role in verbal communication, particularly in L2 communication contexts. Although many pronunciation courses give more emphasis to segmental accuracy (i.e., vowels and consonants), there is now sufficient evidence that despite acceptable segmental pronunciation, prosodic differences may impede listener intelligibility and comprehension (Munro & Derwing, 2008; Lochland, 2020). For instance, a recent meta-analysis finds out that intelligibility relates more to control over suprasegmental aspects than to accent reduction alone.

Intonation contours guide listener's analysis of discourse structure and help identify shifts in topics, stressed information, and turn-taking (Chun, 2002). In case of L2, wrong or flat intonation can result in the misunderstanding of sentences' structures and overlooked implied contrasts. Learners who do not use adequate pitch range are likely to be considered as less compelling speakers even if their vocabulary and grammar use is correct. Besides, rhythm and timing have shown their importance: timing mistakes have been proved to influence native listeners' assessment of the naturalness of L2 English more than pitch mistakes.

At the same time, there is a mutual dependence between prosody and segmentals because if rhythmic structure is disturbed, segments will have to be hyper-articulated in compensation of that leading to unnatural speech. The fact demonstrates the inefficiency of pure segmental-oriented practice as the means of achieving intelligibility. However, it should be pointed out that there is a difference between intelligibility and comprehensibility. While the former refers to the easiness of recognition of what was said, the latter one is related to the easiness of its understanding. Accentedness is a perception of how close to native-like pronunciation is (Munro & Derwing, 2008). Researchers note that foreign accent does not automatically mean unintelligibility; in fact, conformity of suprasegmentals to L2 norms is often more important.

Functionally, in case of EMI (English-Medium Instruction) for STEM fields, prosodic clarity helps deliver complex information successfully. Without adequate prosodic cues, the listener can miss argumentative, procedural, or contrastive parts of speech which are characteristic for lectures in STEM disciplines. Thus, knowledge of the role of prosody in L2 intelligibility constitutes a basis for research on the influence of L1 prosodic properties of particular learner populations (e.g., Iraqi Arabic L1 speakers) on their speech.

Cross Linguistic Transfer of Prosody: Theoretical Frameworks and Empirical Evidence

Prosodic cross-linguistic influence refers to the systematic mapping of L1 intonation, rhythm, and stress patterns onto L2 speech production. While traditional approaches to L2 speech have been developed in relation to segmental phenomena, their predictions can be applied to the suprasegmental realm where the categories and rules for their application are similar. In the Perceptual Assimilation Model (PAM/PAM-L2), unfamiliar L2 contrasts are assimilated by the learner to the corresponding L1 categories, affecting their perception and production (Best, 1995; also relevant for perception of tones and intonation). The Revised Speech Learning Model (SLM r) further argues that phonetic systems reorganize across the lifespan based on perceived dissimilarity between L1 and L2, as well as input quality; by extension, learners must acquire language specific *implementation rules*, such as

pitch accent alignment and boundary tone realization, in addition to segment inventories (Flege & Bohn, 2021).

A second line of work quantifies 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" vs. "syllable timed" profiles; these metrics have been widely used in L1–L2 comparisons and developmental studies. Rhythm measures, however, vary with speech rate, syllable type, and method of production, hence, need to be guided by theoretical considerations, in addition to being supported by perceptual data (Arvaniti, 2012). Recent experimental studies have shown that intonation, rhythm, and speech rate play different roles in producing accented speech and intelligibility problems.

Intonational transfer has been documented among second language (L2) learners, whereby the L1 speakers can maintain their pitch levels, the occurrence of nuclear accents, and the choice of boundary tones. The degree of transfer is affected by task requirements and availability of context for meaning. For instance, questions involve rising intonation, while focus intonation involves the stressing of some words in a sentence. With respect to the Iraqi Arabic language, research on phonology has established the quantity-dependent trochaic stress and intonational contours that might form the basis of prosody in L2 English. When such L1 conditioned prosodic templates are mapped onto English where lexical stress is contrastive and pitch movements cue information structure misalignment can surface as flattened contours, atypical stress placement, or altered rhythmic timing, with potential consequences for intelligibility in high-density STEM discourse. Theoretical models (PAM, SLM r) thus motivate our analytic focus on (i) category mapping in intonation and stress, (ii) phonetic implementation (alignment, scaling, duration), and (iii) listener 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

Quantitative description of rhythm often uses measurements that involve intervals, such as the normalized Pairwise Variability Index (nPVI), and the Pairwise Variability Index (PVI) for both vowel and consonant intervals, along with % V and ΔC/ΔV ratios. Such indicators allow making a distinction between stress-timed and syllable-timed rhythms (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; auto alignment tools often fail on non native 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 considerations regarding instrument limitations that have been discussed, the current research employs a methodology which combines acoustic measurements (such as pitch range, stress duration, nPVI/%V), with perceptions of intelligibility and clarity as rated by listeners. The annotation will be done following an established process which is based on the procedures described by Cole & Shattuck Hufnagel (2016) in annotating prosodic prominences and boundaries.

In addition to that, the speech recordings will be gathered from natural settings such as tertiary STEM classrooms.

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

English-Medium Instruction within the STEM fields imposes additional demands on spoken discourse in terms of the functional load carried. Professors and students in engineering, computer science, and other applied sciences are supposed to present their technical knowledge precisely and logically. The role of prosody is crucial in this context since intonation is used to mark topic changeovers, stress marks important terms, and rhythm helps segment informational units. Misalignment of suprasegmental features is more likely to result in comprehension difficulties especially in the case of L2 speakers of English (LaCroix, 2019).

Recent EMI research shows that language problems do not disappear even among specialists who are proficient in their subject area. Reviewing current developments in teacher training for EMI, researchers found out that most content instructors still experience difficulties with oral communication requirements that include issues with prosody, clarity, and organization of discourse (Wang, Yuan, & De Costa, 2025). These problems will undoubtedly influence communication in class, discourse modeling, and students' spoken production. L2 prosody studies prove that prosody mismatches in terms of timing, stress patterns, and pitch span cause additional cognitive burden for listeners leading to reduced processing accuracy (Henry, 2017).

STEM lecturing requires special attention to prosodic features since there is a frequent use of contrast in technical explanations (cause-effect relations, input-output, dependent-independent variables). Using the same prosodic patterns characteristic for native language, such as limited pitch range and syllable-timed rhythm, may result in the lack of prominence necessary for marking such contrasts. This is particularly true for speakers of Iraqi Arabic since their prosody system is significantly different from that of English in its rhythmicity and stress preferences.

Furthermore, the EMI learning setting itself serves as an additional factor that accentuates the prosodic mismatch effect. Large classes, the use of microphones, the varying linguistic competencies of students, and fast pace of STEM lessons create even more pressure on the necessity of proper prosodic realization. In cases when the intonation system does not help in structuring the information, even a grammatically correct speaker may pose difficulties for comprehension despite having all other linguistic abilities. Therefore, the investigation of prosody in the EMI STEM context is important both from the perspective of communication and pedagogy.

In other words, the current research places prosody of Iraqi English in the EMI STEM context, considering prosodic transfer through the prism of discipline-specific communicative requirements. Thus, the aim of the analysis of suprasegmental features of Iraqi Arabic speakers during classroom activities will be to uncover the effects that can stem from the misfit of prosodic structures of the L1 and English academic discourse conventions.

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

There is a unique prosody of Iraqi Arabic defined by predictable patterns of stress realization, a narrow pitch range, and different timing, compared to English. Prosodic characteristics of the native language constitute the substrate for L2 acquisition of English. Therefore, in-depth knowledge of prosodic properties of Iraqi Arabic will allow to identify possible types and levels of transfer that occurs when speaking English, particularly during STEM communication.

First of all, stress patterns of Iraqi Arabic appear to be highly predictable and quantity sensitive, with prominent syllables receiving stress, usually the final or antepenultimate ones. In contrast, English stress is a source of lexical distinction, capable of changing the meaning of the word. Investigations of stress patterns of Arabic languages reveal that the quantity sensitivity leads to predictability of stress that may be subsequently transferred to L2, creating erroneous stress patterns (Tucker, 2010).

Additionally, the range of pitch is rather narrow in Iraqi Arabic in comparison with English. The contours of declarative sentences are rather flat due to small pitch excursion. English makes use of greater pitch excursion to indicate contrast, pragmatic focus and information structure. If Iraqi speakers apply L1-based intonational contours while speaking English, the speech may sound monotonic and lack pragmatic markers (Al Khafaji, 2019).

Rhythm represents one more cross-linguistic feature. Iraqi Arabic is rather syllable-timed and has relatively equal duration of syllables. English, on the contrary, is stress-timed and characterized by variable length of syllables. Investigations of rhythm transfer reveal that learners who speak syllable-timed languages are likely to maintain more equal timing pattern in English and thus weaken prominence contrasts in STEM communication (Algethami, 2024).

Phrasing in Iraqi Arabic typically clusters information according to morphological or syntactic markers, while English favors the use of intonational phrase breaks to guide

interpretation. Hence, Iraqi Arabic speakers could construct English phrases with fewer or improperly positioned prosodic breaks, making it difficult for the hearers to understand their concepts.

All these properties form a consistent prosodic profile which will affect English produced by Iraqi Arabic speakers. If the above-mentioned properties are rendered into academic English, particularly in scientific areas like STEM where emphasis is needed and conciseness matters, then they might be the reasons behind the lack of intelligibility and conciseness. That is why it is necessary to study the above-mentioned L1 features before investigating them in L2 English.

Empirical Studies on Arabic–English Prosodic Transfer

Empirical research on prosodic transfer from Arabic to English has progressed in recent years although studies related to Iraqi Arabic are limited. Through various dialects of Arabic, research provides important information about the effects of L1 prosody on L2 English production, especially concerning the intonation, rhythm, stress, and prosodic phrasing. In general, these studies reveal that prosodic transfer is systematic and has an effect on listeners' perception and intelligibility within the academic context.

For Gulf and Levantine Arabic-speaking learners of English, studies reveal that they tend to maintain their L1 intonation pattern in their production of English. This includes the use of narrow pitch range and flat contour when speaking English compared with the native speakers of English. The narrow pitch range can limit the possibility of conveying contrast, emphasis, and discourse segmentation in English (Almbark, 2014). Similar results were observed in the studies conducted on Jordanian Arabic speakers. The study by Jasim (2020) reveals that the English produced by Jordanian Arabic speakers tends to have constrained pitch movements and syllable-based timing, which limits their prominence marking.

Research conducted on various North African Arabic speakers also provides evidence for rhythmic transfer. Specifically, the study by Ghoul (2019) finds that Tunisian Arabic speakers transfer the syllable-timed rhythm pattern into English, where their syllable durations are more equal and stress contrasts are less pronounced. This can make it difficult for prosodic cues to signal the important information in academic discourse.

In the case of phonological stress, several investigations have shown that the presence of quantity-sensitivity to the placement of stress in the native language results in consistent but non-native stress patterns in poly-syllabic English words (Ayyad, 2021).

Although little research has been conducted in the area of Iraqi Arabic pronunciation, the available literature implies similar tendencies. Iraqi speakers of English often show low pitch variability, predictable stress placement, and syllable-based timing when speaking English, features which are characteristic of the prosodic pattern of Iraqi Arabic (Al Khafaji, 2019). This means that L1 influences the process considerably and makes it necessary to examine these features in order to understand their impact on STEM communication in English.

Overall, empirical studies involving several dialects of Arabic consistently show the presence of prosodic transfer from L1 to English. Therefore, it becomes necessary to examine the prosodic production of speakers of Iraqi Arabic, considering its unique patterns of stress and rhythm. Besides, it is important in the context of developing appropriate strategies for intelligible and effective STEM communication in English-speaking universities.

Summary of Literature and Identification of the Research Gap

The reviewed literature emphasizes the key role of prosody in ensuring effective and comprehensible spoken communication, particularly within the context of academic instruction in a second language. Numerous studies demonstrate the substantial effect of suprasegmentally aspects of prosody, such as intonation, rhythm, stress, timing, and prosodic phrasing, on listener comprehension and cognitive processing. It has been proved in research on L2 prosody that rhythm and intonation mismatches may prevent comprehension even if there are no issues with segmental features (Henry, 2017; LaCroix, 2019). This proves the key importance of prosodic competence for teaching STEM disciplines in English.

Moreover, cross linguistic influences also prove that transfer of prosodic structures from L1 into the target language is typical of most foreign language learners. Empirical research conducted in various Arabic dialects showed that L1 prosodic patterns are transferred to English and are represented by such aspects as narrow pitch range, predictable stress pattern, and syllable based rhythmic timing (Almbark, 2014; Ghoul, 2019; Jasim, 2020). These aspects make prominent contrast and discourse relations less evident, which makes it harder to organize scientific information hierarchically.

The information about the Iraqi Arabic dialect may be helpful too. The dialect features quantity based stress, narrow pitch range, and rhythmic characteristics that differ considerably

from stress based English (Tucker, 2010; Al Khafaji, 2019). All of these aspects increase the possibility of prosodic transfer in L2 English. Nonetheless, there is very little research on prosodic transfer in the case of Iraqi English learners.

Furthermore, it is apparent from the literature review that there is a lack of research conducted regarding prosody in the Iraqi variety of English, particularly with respect to the contexts of EMI classrooms of STEM disciplines. Although previous research has been conducted regarding prosody in general EFL contexts, it does not incorporate the communicative needs of STEM contexts, where prosodic markers are important to convey information, distinguish variables, and construct explanations.

This is a problem because STEM context communication requires precise structuring, contrastive signaling, and dynamic emphasis, all of which rely heavily on the control of prosody. Given the current lack of research in the field with regard to the role played by prosody in academic EMI context, it seems appropriate to conduct the present study as it will be instrumental in understanding the implications of the role played by L1 prosodic features in L2.

Methodology (Descriptive and Analytical Approach)

Expounds on the methodological approach used to determine how prosodic elements of Iraqi Arabic can affect the generation of prosodic elements in English in STEM settings at the tertiary level. Unlike other studies that involve empirical data analysis and measurement techniques, this particular research is conceptual in nature and, therefore, does not make use of empirical data. Rather, this research adopts a descriptive, analytical, and interpretative approach based on previous literature regarding prosody, cross-linguistic transfer, and the use of English medium of communication in STEM settings.

Research Approach

The design of the study follows a qualitative, descriptive, and literature-based approach. This research design would be appropriate for research questions that attempt to determine the influence of languages, theories, and concepts as opposed to hypothesis testing using experiments. Descriptive methods will help the study in:

- Analyze prosodic structures in Iraqi Arabic and English as documented in linguistic literature
- Compare prosodic systems using established theoretical models
- Interpret how L1 prosodic constraints might shape L2 English prosody
- Relate these theoretical insights to communicative expectations in STEM academic discourse

This approach allows for depth, coherence, and theoretical clarity without the need for empirical sampling.

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 suprasegmentally 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

An analysis is done comparing the prosodic characteristics of stress patterns, pitch variation, intonation contours, and timing in Iraqi Arabic to those of academic English prosody. The goal is to uncover the differences in structure which might cause transfer.

Theoretical Interpretation Using Linguistic Models

The differences in prosody are explained on the basis of well-established linguistic models for L2 acquisition. Such an interpretation helps explain how the prosody of the native language affects the process of L2 production.

Contextual Application to STEM Academic Discourse

In conclusion, the prosodic transfer is considered in relation to the communicative needs in the process of STEM teaching. The analysis explores the use of intonation, stress, and rhythm in concept description, argumentation, and contrasting of technical information.

Rationale for the Descriptive Methodology

A descriptive methodology is appropriate for the current research, since:

- The phenomenon in question, prosodic transfer, has been extensively described in theoretical literature and can be studied without the need for empirical measurements.
- The comparative analysis of prosodic systems across languages is based on the phonological description of the language rather than on field observations.
- The rules of STEM communication can be revealed by means of discourse analyses and theories of communication.

The methodology guarantees intellectual profundity and consistency of the research goals.

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

Since this is a purely theoretical research with no human subjects, there is no need for any form of ethical approval. This is because the research uses literature only.

Discussion and Theoretical Analysis

Introduction

This chapter presents an in-depth theoretical analysis of how prosodic features of Iraqi Arabic could affect the English prosody of Iraqi STEM students in English medium instructional contexts. Using the insights gained from the models discussed in previous chapters, the chapter shows how linguistic theory can be applied to the communicative aspects of STEM discourse. The chapter illustrates how stress, rhythm, intonation, and phrasing transfer from Iraqi Arabic could affect English academic discourse.

Stress Transfer and Its Impact on STEM Terminology

Stress is one of the essential components of prosodic structure in English; it makes sense in many academic and technical words and indicates meaning differences (record/reCORD, object/obJECT). In Iraqi Arabic, the position of stress tends to be influenced by quantity factors, mostly falling on heavy syllables. Such predictability may cause a transfer effect leading to the production of stress in the same predictable fashion.

Terminology misuse, such as confusing terms like algorithm, variable, frequency, and analysis, may confuse the audience or impair their perception of important terms. Using stress according to Iraqi Arabic rules instead of English lexemes may affect perception because of lack of distinction between similar sounding words.

Rhythm Transfer and the Reduction of Prominence Cues

The rhythm of Iraqi Arabic is more syllable-timed and features approximately equal durations of syllables. On the other hand, English is considered a stress-timed language, which implies the presence of regular spacing of stressed syllables with reductions of the unstressed ones. Therefore, the transfer of a syllable-timed rhythm to the English one might lead to:

- a smaller reduction of vowels;
- an equal pace of rhythm; and
- The loss of distinction of stressed and unstressed syllables.

When used in STEM communication where prominence defines conceptual hierarchy, equal rhythm makes the communication boring and disorganized. For instance, it is difficult to emphasize whether one says critical value and critical value or input signal and input signal.

Intonational Transfer and the Narrowing of Pitch Range

English makes extensive use of pitch movement in order to express contrast, sequencing, emphasis, and discourse boundaries. However, the pitch range of Iraqi Arabic is constricted, and this constricted pitch range might transfer to English and result in lack of dynamism. Effects include:

- Inability to mark topic changes
- Insufficient emphasis of important information or conclusions
- Failure to convey contrasts (advantages vs. disadvantages, etc.)

- Deficiencies in rhetorical functions (definitions, explanations, cause and effect)

For STEM presentations, where prosodic contouring is necessary for conveying explanations, lack of pitch range can lead to boring delivery and fatigue. In addition, the failure to have appropriate pitch resets while giving explanations to complex processes can hinder comprehension of the presentation.

Prosodic Phrasing and Logical Structuring in STEM Explanations

Prosodic phrasing in Iraqi Arabic usually coincides with morphological or syntactical boundaries while prosodic phrasing in English often includes aspects which lie outside syntax, conveying meaning and emphasis in addition to discourse structuring. In using prosodic phrasing from L1 in L2, the speaker might:

- Miss essential pauses
- Place prosodic pauses where there is no syntactical or semantic need for them
- Not use prosodic pauses to indicate changes in reasoning

For scientific discourse in particular, this would result in an illogical structure of the explanation, such that in explaining an experiment, the speaker pauses between clauses instead of before the crucial argument.

Cumulative Effects on Intelligibility and Listener Processing

The cumulative impact of stress, rhythm, intonation and phrasing transfer can result in:

1. Increased cognitive load.
2. The listener will have to figure out the structure and the stressed items without having the benefit of prosodic clues.
3. Reduced intelligibility.
4. Important words will be misunderstood or processed slowly.
5. Reduced clarity in explanations that are complex.
6. Hierarchical information is difficult to process due to lack of prosodic variety.
7. Reduced perceived fluency and confidence.
8. Even when the lexical and grammatical choice is appropriate, prosodic mismatch may negatively influence listener perception.

All these factors can negatively impact communication, cooperation and learning in STEM environments where a high level of performance is required.

Implications for English Medium Instruction in Iraq

Based on the theoretical analysis, the following implications may be drawn:

1. Prosody must become an integral part of English medium instruction focused on STEM, not just a peripheral pronunciation aspect.
2. The training in STEM-related vocabulary must include not only the definitions but also the instructions on stress and rhythm.
3. Lecturers teaching in the EMI environment must demonstrate good prosodic skills, especially in case of teaching difficult series and distinctions.
4. Academic speaking classes must teach prosodic segmentation as one of discourse organizational techniques.
5. Listening training must cover the variety of English prosodic models.

The implications point to the need to pay attention to prosody instruction in academic context.

Conclusion

This research brings into focus the crucial importance of prosody in influencing the comprehensibility of English speech in STEM environments. From the analysis of the theoretical connection between prosody of Iraqi Arabic and English suprasegmental phonological aspects, the study reveals the ways in which differences in stress, rhythm, and intonation can influence academic communication. It is shown that the interference of prosody from Iraqi Arabic may hinder the successful delivery of English explanations in STEM environments.

Results

1. Prosodic features of Iraqi Arabic are likely to transfer into English and lead to non-native stress placement on critical terms and words in STEM vocabulary.
2. Syllable-timing rhythm inherent to Iraqi Arabic decreases prominence differences necessary for English organization of academic discourse.
3. Limited pitch in Iraqi Arabic leads to flat intonation in English and thus reduces both emphasis and contrastive marking.
4. Prosodic phrase structure based on L1 can interfere with logical flow of ideas in English STEM discourse.
5. Combination of all prosodic factors can increase processing costs for listeners.

Recommendations

1. Incorporate systematic prosody training encompassing stress, rhythm, and intonation into English courses specifically designed for STEM students.
2. Provide explicit instruction on correct stress placement in technical and specialized academic vocabulary.
3. Support EMI lecturers with professional development focused on modelling clear, structured, and dynamic prosody.
4. Offer students exposure to a variety of examples of academic English through lectures, podcasts, and scientific presentations to strengthen their prosodic perception.
5. Encourage the use of self recording and peer feedback strategies to help learners identify and refine problematic prosodic patterns.

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