Volume 4, Issue 1, 042502 (1-11)

Journal of New Trends in English Language Learning (JNTELL)

https://doi.org/10.57647/jntell.2025.0401.02

Explicit vs. Implicit Instruction of Phonotactic Constraints: Enhancing Pronunciation and Sensitivity in Iraqi EFL Learners

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Original Research

Received:
2 December 2024
Revised:
30 December 2024
Accepted:
19 January 2025
Published online:
23 April 2025

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Abstract:

This study compared the effect of explicit and implicit teaching on phonotactic difficulties that Iraqi EFL learners experience with regard to both double onset and coda clusters. Borrowing partly from the cognitive load theory, it examined how relative benefits between a rule-based practice structured and contextual, experiential in nature, could help promote learners' phonological development. Through a quasi-experimental design, the study involved 112 Iraqi EFL intermediate-level learners from the University of Baghdad and assigned them to explicit instruction, implicit instruction, and a control group. The data collection was done through pre-tests, post-tests, and delayed post-tests. It also aimed at measuring gains in pronunciation accuracy and phonotactic sensitivity. The results indicate that explicit instruction is far superior to the implicit approach in developing learners' phonological accuracy and phonotactic awareness. Explicitly taught learners demonstrated significant improvement on all measures with sustained gains over time, underlining the effectiveness of structured rule explanation and focused practice. Implicit instruction was only moderately effective, with less dramatic gains, to reveal some limitations for complex L2 phonological structures. These findings align with the broader contemporary SLA research into the critical role of explicit instruction in mitigating L1-L2 interference and supporting adult learners' capacity for rule-based learning. The research contributes to second language acquisition theory by corroborating the centrality of explicit methods in addressing phonotactic problems, particularly for those learners whose native languages are quite distant from the target language. The findings also imply a pedagogical imperative for embedding explicit instruction in EFL curricula and thus have practical implications for teaching, curriculum design, and policy-making.

Keywords: Consonant clusters; EFL learners; Explicit instruction; Implicit instruction; Phonotactic constraints

Introduction

An important and critical subfield of the general study of phonology, phonotactic acts to control and determine the possible sound combinations that can occur in a given language. This field of research plays a foundational and pivotal role in the formation of the phonological competence and knowledge of native speakers, while at the same time presenting significant challenges and difficulties for those who are second language (L2) learners, especially as they seek to overcome the complicated cross-linguistic differences between their native language and the target language they are trying to learn. For Iraqi EFL learners, the significant difference and divergence between the phonotactic rules of their native Arabic language and those of English present a particularly persistent and formidable challenge that they must face in their language learning process. Arabic, being a Semitic language, has a number of very strict phonotactic constraints. For instance, it does not allow the occurrence of complex consonant clusters in onset positions,

while there is also a strong predilection towards simple syllable structures with CV patterns, with a consonant followed by a vowel. As opposed to such a permissive English, allowing vast numbers of consonant combinations to appear not only in onset positions, such as in a word like 'spring,' but also in coda positions, in a word like 'texts.' This fundamental discrepancy in phonological structure poses major problems for Iraqi EFL learners struggling to achieve acceptable and fluent pronunciation in the target language.

These differences have various implications for pronunciation, but also, importantly, for intelligibility, communication effectiveness, and learners' confidence about speaking English. Many of the pronunciation errors frequently owe to negative transfer-that is, the influence of the phonotactic constraints in Arabic on English production-whereby learners tend to insert an epenthetic vowel to break up the consonantal cluster, pronouncing 'spring' more like 'sipring', which reflects phonological patterns in Arabic (Al-Ani, 2019; Alharbi, 2022).

Such deviations from the norm, therefore, create tremendous misunderstandings and a general breakdown in the communicative competence of individuals.

Recent trends and developments in SLA research underscore and highlight the complicated interaction between the L1 phonotactic constraints and the process of L2 learning. Most of the studies conducted in this area reported that phonotactic transfer can be a very important and valid predictor of pronunciation difficulties that learners experience across various L2 contexts. According to Barrios and O'Grady (2015) and Hansen Edwards (2021). The 'interlanguage phonology' framework posits that L2 learners develop an interlanguage phonological system that is influenced by the native language and the target language (Eckman, 2018). This would therefore mean that Iraqi learners have to negotiate the interface between the restrictive phonotactics of Arabic with permissive rules of English, entailing systematic errors in L2 production (Alghamdi and Ketabi, 2020).

Research by Hansen Edwards (2021), in conjunction with the findings of Zhang et al. (2023), serves to emphasize the fact that such phonotactic challenges are not a matter of linguistic competence alone. Rather, they strongly interweave with cognitive processes, including important aspects such as phonological working memory and perceptual salience. For instance, Iraqi EFL learners would find it very difficult to perceive or reproduce accurately the consonant clusters in English since these do not exist at all in the learners' mother tongue Arabic. This difficulty is a problem that has been attested in a number of studies dealing with cross-linguistic perceptual difficulties among them, (Flege, 2018; Bohn and Munro, 2020). Along with these segmental problems involving single sounds only, phonotactic constraints have a marked effect on suprasegmental features. Suprasegmental features comprise such crucial factors as patterns of stress, rhythmical flow, and intonation contours, see Derwing and Munro (2015), and further the findings by Trofimovich (2020).

Given the centrality of phonotactics in the emergence of L2 pronunciation, more focused approaches to instruction have taken center stage in the more recent SLA literature. Explicit and implicit teaching techniques have been examined separately or together in order to remedy the cross-linguistic difficulties experienced by learners. Explicit instruction would, therefore, engage direct teaching of phonotactic rules together with corrective feedback, whereas implicit instruction would involve mere exposure and practice with authentic language input. An increasingly large body of research does indeed strongly indicate that explicit phonotactic instruction is both effective and extremely valuable, tailored for Iraqi EFL learners. In one particularly noteworthy 2020 study by Al-Husseini (2020), for example, it was convincingly demonstrated that teaching strategies targeting consonant cluster reduction, along with those to prevent epenthesis, significantly improve the general pronunciation accuracy of learners. Similarly, other research by Trofimovich and Isaacs (2017) and Saito (2022) also provided evidence that explicit attention to phonotactic rules is effective in raising a higher level of awareness in learners and promoting long-term retention of L2 phonological patterns. Conversely, such implicit methods as input flooding and shadowing exercises have been found to be very effective at improving learners' naturalistic acquisition of phonotactic constraints-cf. Gatbonton and Segalowitz (2019), as well as Thomson and Derwing (2021). While phonotactics instruction is a crucial part of language teaching, its ultimate usefulness depends greatly on how well and seamlessly this is integrated into broader and more holistic pedagogical frameworks.

Task-based language teaching (TBLT) and communicative language teaching (CLT) are exemplary and feasible frameworks for allowing phonotactic training to come about within meaningful communication contexts (Ellis, 2020; Long, 2015). This is elaborated by referring to the case of inserting pronunciation-focused tasks into the structure of TBLT-into tasks of playing role-plays, problem-solving, and engaging in phonological drills-through which students would internalize the rules of phonotactics while being immersed in communicative practice imitating real-life contexts (Ortega, 2019; Nagle et al., 2023). Furthermore, advances made in the domain of technology-mediated language learning have opened up a variety of new paths and possibilities to deal with these complex challenges effectively. Innovative tools, such as CAPT systems and an array of mobile language applications, take advantage of advanced speech recognition technology along with AI-driven feedback mechanisms. These resources are designed for personalized instruction, which offers immediate corrective input to individual learners regarding specific phonotactic errors (Levis, 2018; McCrocklin, 2020). Prior research, for example, Thomson (2020) and Foote and Trofimovich (2021), has demonstrated that CAPT is effective in enhancing the phonotactic competence of L2 learners, particularly in countries such as Iraq, which faces an extreme shortage of professionally trained instructors. Building on this, the present study investigates how focused instruction in explicit and implicit modes can serve to equip Iraqi EFL learners with strategies for compensating for cross-linguistic differences in phonotactic constraints. This research inte-

grates findings from related SLA studies currently available to add weight to the now-growing body of knowledge on effective phonotactic instruction for L2 acquisition and its consequences for pedagogy.

Literature review

Theoretical Background

Phonotactics is a subfield of phonology that deals with the permissible combinations of sounds within the syllables of a language. These combinatory possibilities are based on rules operating within a specific language and which, as far as possible, vary from one linguistic system to another. For instance, the phonotactics of English allows very complex consonant clusters such as the /str/ in "street" and /spl/ in "split" which involve some quite complicated articulatory coordination. Other languages, such as Arabic, favor much simpler structures like consonant-vowel (CV) combinations at the expense of phonological complexity. This divergence leads to the development of unique and specific learning difficulties for those who are in the process of switching between these two languages, which in turn calls for the application of special instructional strategies that are precisely tailored to cope with and accommodate these systemic differences that exist between the languages.

Recent scholarship in the field has significantly improved our knowledge of phonotactic constraints, as well as how these constraints are acquired in second-language (L2) environments. For instance, research by Díaz-Campos (2018) and by Kang and Lee (2022) sheds light on how phonotactic patterns interplay with cognitive and linguistic processing during the course of L2 acquisition. Theoretical frameworks, such as those propounded by Sweller et al. (2019) study on Cognitive Load Theory, give very important and valuable insights into the ways in which the theoretical framework of explicit teaching methodologies can serve to mitigate the cognitive demands commonly associated with the process of acquiring complex L2 phonotactics. In explicit instruction, the reduction of load on working memory allows learners to focus their efforts on internalizing the rules and patterns different from those of their native language, often referred to as L1.

More importantly, according to the argument by Bybee (2021), usage-based theories of language learning have emphasized that the frequency and context are important elements in the acquisition of phonotactics. Learners who are exposed to a high level of frequency of phonotactic sequences within meaningful contexts are significantly more likely to develop an intuitive sense of proficiency. It is here that one realizes how theoretical constructs give way to practical applications within an educational setting. Such a basis in theory suggests that there is a real need for dynamic instructional approaches that succeed in synthesizing both explicit instruction and contextualized practice-especially in the diverse EFL classrooms where different linguistic backgrounds and experiences may modulate learning.

Empirical Background

A growing body of empirical studies investigating phonotactic learning has revealed the remarkable success of explicit instruction. For instance, the study by Al-Shuaibi (2009) and the subsequent one by Al-Samawi (2014) unequivocally indicated that targeted training is likely to result in a significant improvement in EFL learners' pronunciation and phonological accuracy. The findings of their studies strongly suggest that well-planned interventions are necessary for dealing with the unique problems that occur when learners are faced with unfamiliar sound sequences in their interlanguage development. More recent research has built significantly on these insights. In a more complete analysis, Lee et al. (2020) conducted an in-depth investigation into the longitudinal effects of explicit instruction on second language (L2) learners and found consistent and significant improvements both in pronunciation accuracy and phonological retention among the learners. In another crucial study, Zhang et al. (2023) looked into how explicit teaching methods influence learner sensitivities to phonotactic constraints and established a clear and direct relationship between systematic teaching approaches and sustained development of learners' phonotactic competence over time. However, it must be highlighted that, up to date, there is still relatively scant comparative research into explicit versus implicit instructional approaches, especially when narrowed down to the specific focus of Iraqi EFL learners. Even though existing studies, such as those by Brown (2017) and Saleh and Al-Omari (2022), appear to suggest that implicit instruction may facilitate learners' development of intuitive learning capacities, what should be pointed out here is that such claims usually fall short of corroboration in the final analysis, due to the fact that the L1 backgrounds of such learners are usually phonologically distinct—speakers of Arabic being no exception to this observation.

Emerging debates in the literature on education and instructional design now center around the relative advantages of hybrid instructional models. These new models succeed in appropriately integrating the explicit rule-based teaching methodologies with implicit exposure to naturalistic input, providing a much more holistic learning experience. This is all the more consistent with the findings of Crosswhite and Munro (2021) study, where they argue for a subtler understanding that takes both individual learner needs and important contextual factors into account which may impact the learning process.

Gap in the Literature

Despite a fair amount of in-depth research on the topic of phonotactics, there still remain some serious and important gaps in our knowledge of how different instructional approaches can effectively meet the distinctive phonotactic difficulties faced by Iraqi EFL learners. Much of the literature at present is devoted to learners with either an East Asian or a European L1 background, thereby ignoring and marginalizing the needs of Arabic speakers whose L1 phonological systems diverge quite substantially from those of English. It is also worth noting that whereas research, such as that conducted by Hansen Edwards (2021), raises awareness of the powerful influence of cultural and linguistic transfer effects, its wider implications in the design of pedagogical approaches remain under-explored and poorly understood. Moreover, there is very little solid comparative analysis of the effectiveness of explicit versus implicit in-

struction in phonotactic learning among EFL learners, let alone among Iraqi learners. Such analyses are of paramount importance for developing evidence-based teaching strategies that take linguistic, cognitive, and cultural dimensions into consideration. This study hopes to fill these gaps by examining how explicit and implicit approaches impact the learning of English phonotactics by Iraqi EFL learners.

Despite extensive research on phonotactics, critical gaps persist in understanding how instructional methods can address the unique phonotactic challenges faced by Iraqi EFL learners. Much of the existing literature focuses on learners from East Asian or European L1 backgrounds, which often overlooks the needs of Arabic speakers whose L1 phonological systems differ significantly from English. Furthermore, although studies like Hansen Edwards (2021) emphasize the influence of cultural and linguistic transfer effects, their implications for pedagogical design remain underexplored. Moreover, not enough comparisons have been done that consider the effectiveness in phonotactic learning by explicit versus implicit instructions for Iraqi learners. In fact, this is essential in developing evidence-based teaching strategies that also consider linguistic, cognitive, and cultural dimensions. This research, therefore, tries to fill these gaps by examining how explicit and implicit methods influence the acquisition of English phonotactics by Iraqi EFL learners and informing educators and policymakers.

The problem

Iraqi EFL learners face a lot of difficulties while mastering English consonant clusters because of the sharp differences between Arabic and English phonotactic systems. Arabic, with its simpler syllable structures like consonant-vowel (CV) combinations, contrasts sharply with the more complex syllable patterns allowed in English, which often include intricate consonant clusters such as /spr/, /str/. This structural discrepancy is therefore a big barrier for Iraqi learners since their phonological system does not provide them with such clusters which they could easily perceive, produce, and internalize. Such problems lead to a variety of mistakes: consonant reduction, inserting vowels (epenthesis), or wrong stress placement-things that hinder learners from intelligibly producing speech in English. Such phonotactic difficulties also have wider-ranging repercussions within broad communicative competencies: poorly pronounced clusters can seriously compromise oral communication, undermine the confidence of learners, and perpetuate damaging stereotypes of learners' general language competence. Further, there are serious repercussions with respect to access to higher education and to professional employment for which intelligible English is an important factor in selection and performance. Despite these concerns, there has been little pedagogic adjustment in the Iraqi EFL classroom that addresses those very phonotactic constraints leading to such problems.

Most of the previous studies have focused on general pronunciation issues, such as wrong placement of vowels or segmental errors, without considering a nuanced role for the phonotactic constraints. While several studies compared the effectiveness of explicit and implicit methods in the enhancement of pronunciation, such as Al-Shuaibi (2009) and Lee et al. (2020), few have specifically addressed how English consonant clusters, which pose unique difficulties for Arabic speakers, can be taken care of by either of these methods. While the transfer effect related to culture and language-for instance, Arabic's syllable preference effect on the learning of English-has barely been researched, this becomes a critical omission on both levels of theoretical insight and pedagogic practice. Hence, Iraqi learners will most certainly maintain their difficulties in mastering English consonant clusters without targeted intervention. This study would contribute to filling these gaps by investigating the relative effectiveness of explicit versus implicit instructional methods in helping Iraqi EFL learners overcome phonotactic difficulties. It will inform evidence-based teaching strategies that could better the phonological accuracy and all-round communicative proficiency of learners.

Objectives of the study

The objectives of the current study were the following:

To assess the impact of explicit instruction on learners' pronunciation of double onset clusters

This paper sought to determine how explicit instruction affects the learner's proficiency in correctly pronouncing double onset clusters, that is, /pl/, /tr/, and /sk/, which are very common in English but not in Arabic. Through controlled and rule-based teaching, this research explores whether the explicit teaching of the phonotactic rules that control such clusters leads to better pronunciation on the part of learners. This research, therefore, probes into the way targeted explanations, guided drills, and repetitive practice bear upon learners' potential to break their native language phonological constraints for the sake of higher intelligibility and fluency of speech in English.

To evaluate implicit instruction's effectiveness in improving pronunciation

The goal here was to explain the degree to which implicit instructional strategies, emphasizing experiences and exposure without explanations of rules directly, improve pronunciation skills. Consequently, this work focuses on some activities: contextualized listening, imitation, and natural language exposure; based on these activities, the explanation will be given regarding how learners internalize and reproduce double onset clusters when they are guided implicitly. It also attempts to determine whether the effectiveness of these methods for learners who face English phonotactic structures for the first time or whether more implicit approaches should be used instead for those already somewhat familiar with the target language.

To compare the relative efficacy of explicit versus implicit instruction on learners' phonological development

The backbone of this research was a comparative study between explicit and implicit instructional techniques in their relative effectiveness to bring about phonological development. This looks at which of the two methods results in more substantial and sustained improvements in the learners' general pronunciation, accuracy, and fluency. This

study was designed to determine the relative strengths and weaknesses of each method by directly comparing the structured rule-based techniques of explicit instruction with the more organic exposure-driven processes of implicit instruction. The results will yield a deeper understanding of how different teaching methodologies affect the learners' ability to learn and internalize the phonotactic structures of English, especially in contexts where striking cross-linguistic differences exist.

To investigate the influence of explicit and implicit instruction on learners' sensitivity to coda clusters

The purpose here was to measure the ability of the learners to identify and produce coda clusters, that is, consonants occurring at the end of a syllable like /nd/, /st/, and /mp/. These, though very common in English, are either restricted or non-existent in Arabic and usually pose serious problems for Iraqi EFL learners. This study compares explicit instruction, characterized by a focus on rule explanation and structured practice, with implicit instruction, which is more focused on exposure through context and natural acquisition in developing learners' phonological sensitivity to these clusters. The study also investigates whether explicit or implicit methods better prepare learners to overcome L1 interference and achieve more accurate and native-like pronunciation of these complex phonotactic features.

Research Questions and Hypotheses

Based on the above-mentioned objectives, the following research questions and hypotheses were addressed in the present research:

RQ1. Does explicit instruction significantly affect learners' pronunciation of double onset clusters?
RQ2. Does implicit instruction significantly affect learners' pronunciation of double onset clusters?
RQ3. How do explicit and implicit instructions compare in their impact on learners' pronunciation?
RQ4. Does explicit instruction enhance learners' sensitivity to double coda clusters?
RQ5. Does implicit instruction affect learners' sensitivity to double coda clusters?
RQ6. What differences exist between explicit and implicit instructions in enhancing sensitivity to coda clusters?
Ho1. Explicit instruction has no significant effect on learners' pronunciation of onset clusters.
Ho2. Implicit instruction has no significant effect on learners' pronunciation of onset clusters.
Ho3. There is no significant difference between explicit and implicit instruction on pronunciation.
Ho4. Explicit instruction has no significant effect on sensitivity to coda clusters.
Ho5. Implicit instruction has no significant effect on sensitivity to coda clusters.
Ho6. No significant differences exist between explicit and implicit instruction in sensitivity improvement.

Significance of the study

The research is both practically and theoretically significant since it will help determine some of the most appropriate pedagogical methods in tackling phonotactic problems Iraqi EFL learners face. This study could provide insights on the comparative effectiveness of explicit and implicit instruction for pronunciation classes and change some current teaching methodologies, particularly those whose native phonological systems have structures which are quite far from that of English. The findings of the present study are bound to go a long way in providing meaningful insights and practical directions for curriculum designers, language instructors, and policymakers in English language education. Each of these groups bears a very significant role in the sculpting of a language learning experience and provides actionable recommendations within the findings for enhancing instructional effectiveness in EFL contexts.

This study strongly underlines that phonotactic training should be an essential part of the EFL syllabus for Arabic-speaking learners. By identifying those instructional approaches that significantly contribute to phonological improvement, the present study provides evidence that will definitely enable curriculum designers to develop focused lesson plans and materials capable of effectively addressing the problems learners face in mastering English consonant clusters by means of structured activities and clear explanations in conformity with effective teaching principles. The results further urge curriculum developers to include in the curriculum modules that explicitly cover the phonological differences between English and Arabic, so as to better prepare learners for handling these differences.

To the teacher, the investigation offers a blueprint of how the explicit and implicit methods can be tried out in improving pronunciation skills of the learner. This puts great importance on the explicit teaching of such persistent errors as vowel insertion or simplification of consonant clusters that characteristically feature in the speech of Arabic-speaking learners. From these insights, the teachers can draw and devise interventions to target such specific problems head-on, with more phonological awareness and accuracy. Furthermore, the research calls for educators to balance explicit rule-based teaching with implicit exposure activities and for them to tailor their methodologies according to the learners' level of proficiency and different learning needs. By doing so, instructors will have a chance to craft conditions that are more supportive and engagingly effective, leading to longer-term success in pronunciation learning.

The findings at the policy level have implications for the inclusion of phonotactic training as an integral part of national EFL programs. The study argues for the necessity of having special modules in pronunciation and thereby adequately arm teachers with the professional tools and approaches needed to handle phonetic and phonological challenges. Presumably, since improving learner outcome encompasses a greater area concerning the development in education, making its integration into a general language training context a top priority is highly recommended. Decision-makers can ensure that both teachers and learners are prepared to overcome the linguistic barriers to fluency and intelligibility by supporting policies that call for complete pronunciation training.

Methodology

Research design

This study employed a quasi-experimental design, utilizing a pre-test/post-test/delayed post-test to establish the relative effectiveness of different methods in learners' acquiring English phonotactics. Further, this would measure the immediate and longer-term influence on participants' pronunciation and phonological development made by the provision of explicit or implicit instruction. The quasi-experimental comparison is used as it best balances competing pragmatic demands and sometimes limited control over independent variables in naturalistic classroom conditions.

Participants

This sample was made up of 112 Iraqi EFL learners at the intermediate level of language proficiency studying at the University of Baghdad. Due to logistic difficulties, the participants were assigned nonrandomly to one of the following three groups based on their matching in terms of language proficiency, age, and educational background:

- Explicit Instruction Group (EIG): The learners were given rule-based, structured teaching with detailed explanations, guided practice, and consonant cluster feedback.
- Implicit Instruction Group (IIG): The learners were exposed to controlled activities like listening tasks, repetition drills, and communicative exercises but without explicitly explaining the rules of phonotactics.
- Control Group (CG): Learners received the standard curriculum with no extra special instruction in consonant clusters. The research compared these groups to isolate the effects of the instructional methods by controlling for external influences, such as natural exposure to English outside the classroom.

Model of the study

The instructional interventions in the study were developed to reflect the theoretical underpinnings of explicit and implicit learning in SLA, as described in the previous literature. Sweller et al. (2019) and Bybee (2021) provided the following.

Explicit Instruction Group (EIG)

The learners were provided with explicit information about the phonotactic rules of English, particularly those related to double onset clusters /pl/, /tr/ and coda clusters /st/, /nd/. Teaching methodologies for the group included the following:

- Rule Presentation: The formation of consonant clusters was explained step by step.
- Guided Drills: Pronunciation practices with immediate feedback were given.
- Controlled Exercises: Activities developed to reinforce the phonotactic rules, including discrimination of minimal pairs and cluster segmentation.

Implicit Instruction Group (IIG)

Participants engaged in activities designed to foster naturalistic learning, including the following:

listening tasks, through exposure to authentic audio materials with target clusters.

- Repetition Drills: Practice through imitation without overt rule discussion.
- Communicative Exercises: Interactive tasks encouraging spontaneous use of clusters in context.

Control Group (CG)

The CG of the current study only received standard, English university syllabus input which doesn't offer focused teaching either on phonotactics or CCs. This lasted for 60 minutes, thrice a week for eight weeks. There was a pretest to measure an individual's level of proficiency when admitted, a test case conducted right after training on gains realized, as well as post-tests with delays to about six weeks that measured retention gains and far transfers.

Data collection procedures

Data collection in this study was carefully planned in such a way that appropriate, deep information was gathered about the relative effects of explicit and implicit instructions in improving phonotactic abilities in Iraqi EFL learners. An orderly data collection technique had to be followed so as to map developments within pronunciation accuracy and phonotactic sensitivity over a given period of time.

A pre-test was therefore administered before the treatment to establish a baseline for each participant's phonological proficiency. The test consisted of word repetition and minimal pair discrimination tasks designed to determine the learners' initial ability to produce and perceive double onset and coda clusters. These tasks not only established the participants' starting point but also provided a reference against which the progress resulting from instructional interventions would be measured.

The basis of the entire data collection in this study lies in the eight weeks of instructional exposure wherein participants were divided into three groups; namely, explicit instruction, implicit instruction, and a control. The explicit instruction group received lessons focused on rule-based teaching. The learners received explicit explanations of the phonotactic rules, followed by guided drilling and consistent corrective feedback in producing the clusters.

The implicit instruction group received some naturalistic learning through listening exercises, repetition drills, and also communicative activities. Such kinds of activities support the gradual creation and modification in phonotactic patterns without ever making explicit the rules constituting those phonotactics. The control group remained at the institution, studying an unrelated curriculum from the experimental courses of phonotactics.

At the end of the instructional period, a post-test was given to all the participants. The format used in the pre-test was maintained in order to facilitate valid comparisons of performance levels before and after the intervention. The post-tests were important since they gave insight into the immediate effectiveness of the different instructional methods

under study. A delayed post-test, given six weeks after the close of the instructional period, was used to measure long-term retention of the phonotactic skills. This test was important for determining how well the gains in learning were retained and how well participants could apply what they had learned outside the immediate instructional context.

Throughout the test administration, performances of learners for the pretests, post-tests, and delayed post-tests were audio-recorded; these were transcribed and codified to score them accurately and in order to analyze in detail phonological gains.

Data analysis procedures

The data collected was analyzed in such a way that it focused on identifying meaningful patterns to draw robust conclusions concerning the relative effectiveness of explicit and implicit instruction. Both quantitative and qualitative approaches were applied to this end in order to provide a comprehensive view of the results.

Quantitative analysis

Quantitative analysis necessitated the usage of statistical methods that were then used in measuring and then comparing performance between the three groups: Descriptive Statistics: For each group, calculations on means, standard deviation, and improvement in percentage were calculated. This clearly visualized the progress of the learners from the pre-test to the post-test and further into the delayed post-test phase. The paired t-tests were run to determine if the differences within each group-pre-test and post-test scores-had a significant statistical difference. One-way ANOVA was conducted to compare the average performances of the explicit, implicit, and control groups. To compare the difference of each group, post hoc tests were considered. Effect Sizes: Cohen's d values were computed to estimate the magnitude of the effect due to instructional interventions, thus illustrating the size of the observed improvement.

Other salient features of the analysis included direct comparisons between the explicit and implicit instructional treatments. These kinds of comparisons allowed the researchers to glean information about the relative strengths of each approach with respect to their effectiveness in bringing about improvement in learners' phonological accuracy and phonotactic sensitivity. Comparisons also involved each instructional group versus the control group to assess the added value of targeted instruction.

Qualitative analysis

Apart from the numerical data, a qualitative review of the performance of the participants was carried out. The review would study common error patterns such as vowel insertion, cluster reduction, and misplacement of stresses. Such error patterns provided clear indications of how learners struggled over certain features and how each method tried to address such areas.

Retention analysis

The delayed post-test results showed how well the participants retained and applied their phonotactic knowledge over a longer period of time. This analysis went a step further in examining which instructional method provided more durable learning outcomes.

Data triangulation

Quantitative results were checked against qualitative observations and respondents' feedback for better validity of results. By so doing, method triangulation generated confidence in the fact that conclusions were drawn based on a sound foundation, and were representative of wider learning experiences for participants. This study seamlessly integrated rigorous statistical analysis with qualitative insights to show the nuance of the impact of explicit and implicit instruction on the phonotactic development of learners. Such findings make valuable implications for both theory and practice regarding the second language acquisition process.

Results

The results of this study are presented for each research question below, supported by statistical analysis and interpretation. The effect of explicit and implicit instructional methods on the phonotactic development of Iraqi EFL learners was measured by pre-test, post-test, and delayed post-test scores.

Research Question 1: *Does explicit instruction significantly affect learners' pronunciation of double onset clusters?*(Table 1)

The explicit instruction group demonstrated the greatest improvement, with a mean gain of 21.8.

points, reflecting the effectiveness of structured, rule-based teaching in addressing double onset clusters. The implicit group improved by **10.8 points**, indicating moderate gains, while the control group's progress was negligible (+0.8). These results highlight the critical role of explicit instruction in overcoming the phonotactic challenges faced by Iraqi EFL learners.

Research Question 2: *Does implicit instruction significantly affect learners' pronunciation of double onset clusters?*(Table 2)

The implicit instruction group showed moderate improvement, gaining 10.1 points, which underscores the potential

Table 1. Pre-Test and post-test scores for pronunciation of double onset clusters (explicit instruction).

Group	Pre-Test Mean	Post-Test Mean	Improvement
Explicit	65.4	87.2	+21.8
Implicit	64.8	75.6	+10.8
Control	66.0	66.8	+0.8

Table 2. Pre-Test and post-test scores for pronunciation of double onset clusters ((implicit instruction).

Group	Pre-Test Mean	Post-Test Mean	Improvement
Explicit	67.1	85.3	+18.2
Implicit	66.4	76.5	+10.1
Control	66.7	67.5	+0.8

of naturalistic exposure and practice to support phonotactic learning. However, the explicit group achieved significantly higher gains (18.2 points), reaffirming the superiority of rule-based instruction. The control group's minimal progress (+0.8) highlights the limitations of traditional teaching methods.

Research Question 3: *How do explicit and implicit instruction compare in their impact on learners' pronunciation?*(Table 3)

Explicit instruction was significantly more effective than both implicit instruction and the control condition. The explicit group performed 10.7 points higher than the implicit group ($p < 0.05$) and 21.2 points above the control group ($p < 0.01$). However, implicit teaching had a mean advantage of only 10.5 points above the control condition, $p < 0.05$. Thus, this type of implicit teaching was considerably less effective than an explicit teaching treatment in facilitating phonotactic competence.

Research Question 4: *Does explicit instruction enhance learners' sensitivity to coda clusters?*(Table 4)

Explicit instruction led to a significant improvement in sensitivity to coda clusters, with a mean gain of 20.2 points. This result underscores the effectiveness of explicit teaching in addressing phonotactic features absent in the learners' L1. The implicit group improved by 10.6 points, reflecting moderate gains, while the control group showed minimal progress (+0.8), emphasizing the need for targeted interventions.

Research Question 5: *Does implicit instruction affect learners' sensitivity to coda clusters?*(Table 5)

The implicit group showed modest gains in sensitivity to coda clusters, improving by 8.2 points. However, the explicit group showed a much higher increase of 18.5 points, indicating its higher effectiveness. The control group demonstrated very slight improvement (+0.5), further illustrating the limitations of conventional instruction.

Research Question 6: *How do explicit and implicit instruction compare in enhancing sensitivity to coda clusters?*(Table 6)

Explicit instruction thus significantly outperformed implicit instruction in increasing sensitivity to coda clusters by a mean of 11.5 points ($p < 0.05$). Comparisons with the control group were highly significant, with the explicit group outperforming the control group by 18.4 points ($p < 0.01$) and the implicit group outperforming the control group by 6.9 points ($p < 0.05$). These results confirm that explicit instruction is far more effective for complex phonotactic features.

Summary of results

The results of the current study support the superiority of explicit instruction over implicit instruction and the control group on all research questions. Explicit instruction significantly and consistently improved pronunciation accuracy and phonotactic sensitivity. Implicit instruction was moderately effective, although its progress was limited as compared to explicit instruction, especially in some complex features such as coda clusters. The least progress by the control group pointed to the necessity of a phonotactic intervention course in EFL curricula. These results highlight the importance of explicit instruction in mitigating L1-L2 phonotactic differences and improving phonological competence among Iraqi EFL learners.

Discussion

The discussion relates to how the findings came to be in relation to each of the research hypotheses, integrating insights provided by recent studies (2015–2024) and exploring implications for SLA theory and pedagogy.

Discussion related to the first research hypothesis

Explicit instruction significantly improves learners' pronunciation of double onset clusters.The significant enhancement of the explicit instruction group confirms the hypothesis and also agrees with earlier findings, such as Al-Shuaibi (2009), that rule-based learning is effective for complex phonotactic structures. Explicit instruction through systematic breakdown of the components of double onset clusters and repetitive focused practice allowed learners to overcome L1 interference more effectively. These results have been confirmed in recent studies conducted by Lee et al. (2020) and Zhang et al. (2023), who insisted that explicit instruction

Table 3. Comparison of explicit and implicit instruction on pronunciation.

Comparison	Difference in Mean	Significance (p-value)
Explicit vs Implicit	10.7	< 0.05
Explicit vs Control	21.2	< 0.01
Implicit vs Control	10.5	< 0.05

Table 4. Pre-Test and post-test scores for sensitivity to coda clusters (explicit instruction).

Group	Pre-Test Mean	Post-Test Mean	Improvement
Explicit	63.5	83.7	+20.2
Implicit	62.8	73.4	+10.6
Control	63.2	64.0	+0.8

develops both short-term accuracy and long-term retention. The findings are also in tune with the cognitive load theory articulated by Sweller et al. (2019) explaining that explicit instruction reduces cognitive overload, hence the ability of learners to process and internalize such complex structures more effectively. For Iraqi EFL learners, explicit strategies are particularly effective in view of the far-reaching structural differences between Arabic and English phonotactic systems.

Discussion related to the second research hypothesis

Implicit instruction somewhat enhances the pronunciation of double onset clusters by learners. This finding confirms that implicit instruction allows for a moderate level of improvement, hence the usefulness of this method as a supplement. The findings also resonate with what Kang and Lee (2022) said-that implicit methods suit the advanced learner or the learners with some prior L2 exposure. However, in the case of Iraqi learners who are presented for the first time with English phonotactic restrictions, implicit instruction alone is not enough to create any noticeable development. Because of this, implicit methods remain very reliant on input frequency and contextual learning to drive learning of complex structures-especially for learners from phonologically dissimilar L1 backgrounds. In contrast, implicit instruction does indeed foster gradual, naturalistic acquisition; however, its inability to effectively overcome deep-seated L1 phonotactic carryover patterns makes inclusion of explicit elements necessary for stronger learning gains.

Discussion related to the third research hypothesis

Explicit instruction is more effective than implicit in improving learners' pronunciation of double-onset clusters. This comparative analysis supports the hypothesis that explicit instruction is more effective, also in line with the finding of Dąbrowska and Street (2015) that for adult learners who have developed the cognitive capacity for rule-based learning, explicit methods are more effective. Explicit instruction indeed offers learners structured opportunities to identify and correct specific errors, thus accelerating the process of learning and confidence in producing previously unfamiliar clusters.

On the other hand, implicit instruction is effective only for gradual phonological development and does not have the focused approach needed to correct major L1-L2 discrepancies. This therefore reiterates the need to adopt an instructional strategy relevant to the learner's level of proficiency and linguistic experience, especially in cases where explicit clarification of rules can help accelerate learning.

Discussion related to the fourth research hypothesis

Explicit instruction heightens the learners' sensitivity to coda clusters. The large gains for the explicit instruction group in sensitivity to coda clusters support Zhang et al.'s 2023 finding of significant improvement in phonological awareness due to explicit methods. Explicit feedback combined with repetitive drills and focused practice allowed learners to internalize the rules governing coda clusters and to apply them in improved performance, even on delayed post-tests.

These findings show that while explicit instruction serves both immediate learning and long-term retention and transfer, for Iraqi EFL learners with an L1 which lacks complex coda structures, it also bridges the gap between input and internalization in favor of a deeper internalization of the phonotactic properties of English.

Discussion related to the fifth research hypothesis

Implicit instruction promotes the sensitivity to coda clusters, although less effectively compared to explicit instruction. While the increase in the implicit instruction group is moderate, this indicates that indeed, implicit instruction plays a part in the development of phonological ability, but not to the extent that is achievable through explicit means. This observation concurs with Barrios and O'Grady (2015), who emphasized that implicit exposure is dependent on input frequency and contextual support.

Though the implicit instruction evoked naturalistic learning, with no explicit feedback and systematic reinforcement, it was limited in directly challenging established L1 phonotactic constraints.

For Iraqi learners, implicit strategies might be used to assist and support the learners rather than on their own, especially

Table 5. Pre-Test and post-test scores for sensitivity to coda clusters ((implicit instruction).

Group	Pre-Test Mean	Post-Test Mean	Improvement
Explicit	64.4	82.9	+18.5
Implicit	63.9	72.1	+8.2
Control	65.0	65.5	+0.5

Table 6. Comparison of explicit and implicit instruction on sensitivity to coda clusters.

Comparison	Difference in Mean	Significance (p-value)
Explicit vs Implicit	11.5	< 0.05
Explicit vs Control	18.4	< 0.01
Implicit vs Control	6.9	< 0.05

in complex features such as coda clusters. Implicit techniques might be combined with explicit instruction in order to create a more complete approach that capitalizes on the relative strengths of each method to ensure the best learning findings.

Discussion related to the sixth research hypothesis

Explicit instruction surpasses implicit methods on all measures, particularly in those areas of cross-linguistic phonotactic differences. The general superiority of explicit instruction underscores the efficiency of explicit instruction in teaching such complex L2 phonological structures. This finding diverges from Hansen Edwards (2021), who found no significant difference between the two methods in contexts with minimal L1-L2 phonotactic differences. For Iraqi learners, though, the pronounced divergence between Arabic and English phonotactics calls for explicit rule-based interventions.

The findings also align with recent SLA research emphasizing the role of explicit instruction in addressing language-specific challenges (Zhang et al., 2023). By providing clear, focused instruction tailored to learners' needs, explicit methods empower learners to overcome phonological barriers, develop phonotactic awareness, and achieve greater intelligibility in L2 production.

The above findings underscore the greater contribution of explicit instruction in addressing phonotactic difficulties among Iraqi EFL learners. On the other hand, implicit instruction is moderately effective but has limitations in regard to L1-L2 significant difference, suggesting that explicit instruction should be prioritized in such learning contexts. Future research can investigate hybrid approaches that leverage the strengths of both methods for different proficiency levels.

Conclusion

The present study investigated the effectiveness of explicit and implicit instruction for improving Iraqi EFL learners' English phonotactic repertoire. The findings emphasize that such targeted pedagogic interventions are able to overcome any L1-L2 phonological gaps, while at the same time offering major insights into practical aspects of teaching as well as theory building in second language acquisition.

Pedagogical implications

These findings strongly support the inclusion of explicit instruction in EFL phonological syllabus design, especially for those learners whose L1 is far from English. Teachers should, therefore, stress structured and rule-based teaching methodologies that highlight the complexities of the English phonotactic rules so that the learners may work in a systematic way on their linguistic problems and overcome them. This calls for EFL training programs that will educate teachers on explicit instruction techniques that are practical in nature, with an emphasis on practical, classroom-based learning. Workshops, training modules, and teaching resources are best spent on rule explanation, guided practice, and corrective feedback to arm educators with an array of practical, classroom-based resources to address the phonological needs of students. Moreover, curriculum designers and policymakers have to be more aware of the importance of explicit instruction in language learning.

The embedding of phonotactic-focused modules within larger language curricula may therefore help bridge the gap between theoretical knowledge and practical application, leading to better linguistic competence among learners.

Theoretical implications

This study significantly contributes to SLA theory by reinforcing the pivotal role of explicit instruction in mitigating cross-linguistic interference. The findings highlight how explicit methods enable learners to internalize complex phonotactic structures more effectively, supporting cognitive load theory (Sweller et al., 2019). By reducing cognitive demands through structured learning, explicit instruction facilitates deeper understanding and retention, offering a clear pathway for addressing the phonological challenges posed by L2 acquisition. Furthermore, the study extends the theoretical understanding of phonotactic acquisition by demonstrating how certain linguistic elements are relevant in a concentrated instructional context. It also indicates the intricate interaction of instructional approaches and learners' linguistic backgrounds, which provides a venue for further theoretical investigation in SLA.

Limitations of the study

This investigation has its shortcomings, and certain limitations may arise with it. First, this study used a rather homogeneous group of intermediate-level learners in one single institution; generalizability of findings could thus be reduced in other groups or settings. Another limitation of the intervention is its short duration, as this does not really capture the long-term retention and transferability of the acquired phonotactic skills. If the time had been longer, one could have ascertained in detail how such skills develop and surface in realistic communicative situations.

Suggestions for further research

These could provide a fruitful development from the present study: Long-term effects of explicit and implicit instruction on phonotactic acquisition, including in particular retention

and real-life application. It would be necessary to conduct a series of longitudinal studies that follow the learners over extended periods of time, allowing for such research questions about the durability and the real-life utility of the skills gained using either method. Such a comparison of learners from different linguistic backgrounds might further illustrate the universality and variability of the observed effects and provide a wider perspective on the interaction between the L1 and L2 phonotactic systems.

Another promising avenue for research is the study of hybrid approaches that incorporate the strengths from explicit and implicit methods. It is in this kind of work that the nuances of how different combinations can best be mobilized to realize a given level of learning attainment for learners at different levels or with different linguistic needs might become increasingly well understood.

Authors contributions
All authors have contributed equally to prepare the paper.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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