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| RESEARCH ARTICLE

Strategies Adopted by Libyan Students in the Production of English Onset clusters: An Acoustic Study

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| ABSTRACT

This acoustic study investigates how Libyan second-semester university students at the Department of English, University of Tripoli, produce English word-initial three-consonant clusters. The study seeks to explore vowel epenthesis as one of the strategies adopted by those students to facilitate the production of these consonant clusters which do not exist in their mother tongue. The study also aims to investigate the site where the epenthetic vowel is inserted and its acoustic characteristics, such as duration and quality. Twenty Libyan second-semester students were recorded while reading nine sentences with the clusters /spl/, /spr/, /spj/, /str/, /skj/, /skr/, /skl/, /skw/ and /stj/ in word-initial position. Results of the acoustic analysis showed significant variability in participants' performance, with vowel epenthesis as the most preferred strategy to simplify the production of problematic clusters. In addition, the findings revealed that Tripolitanian Libyan Arabic shows features of both VC and CV dialects. As for the duration and quality of the epenthetic vowel, the results showed that epenthetic vowels are shorter than neighbouring vowels, and their quality is that of the short high-front unrounded vowel [ɪ]. These results highlight the importance of recognising phonological differences between first and second language and they could improve our understanding of phonological adaptation in second languages and the role it plays in improving learners' proficiency level and communication skills.

| KEYWORDS

Simplification Strategies, Consonant Clusters, Epenthetic vowels, EFL Libyan learners

| ARTICLE INFORMATION

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1 Introduction And Background:

The most important goal that learners of English as a second language (ESL) aspire to achieve is to speak English like native speakers. Several challenges arise in achieving this high level. For Libyan EFL learners, the phonotactic differences between Arabic and English affect their pronunciation, particularly when they produce words with three-consonant clusters in the word-initial position.

To overcome these variations in syllable structure between their mother tongue and English, Arabic-speaking English Language (ESL) learners adopt certain simplification strategies to facilitate the production of such problematic clusters and make them fit in their phonological competence. These strategies include vowel epenthesis and cluster reduction. Existing studies primarily focus on how Saudi, Jordanian, and Egyptian ESL learners approach English consonant clusters. The results from the current study are expected to provide insights into how Tripolitanian Libyan Arabic (TLA) speakers produce English three-consonant clusters in onset.

Existing studies primarily focus on how Saudi, Jordanian, and Egyptian ESL learners approach English consonant clusters. The results from the current study are expected to provide insights into how Tripolitanian Libyan Arabic (TLA) speakers produce English three-consonant clusters in onset.This study examines the strategies employed by Libyan EFL university students to adapt to word-initial three-consonant. The study aims to answer these questions: What are the most common strategies adopted by Libyan second-semester ESL students at the Department of English - University of Tripoli- when producing English syllable-initial

three-consonant clusters? Second, if vowel epenthesis is applied, where is this epenthetic vowel inserted? Finally, what are the acoustic features, in terms of duration and quality, of this epenthetic vowel?

2 Literature Review:

2.1 Phonotactic constraints in Arabic and English:

According to Trask (1996: 277-278), the word phonotactics is "the set of constraints on the possible sequences of consonant and vowel phonemes within a word, a morpheme or a syllable". In this sense, Arabic and English have different lists of consonants and vowels, the rules which control what consonants and how many can combine to form syllable onsets and codas. When speakers of Arabic try to learn English, the phonotactics of English will pose a difficulty when they divert from those of their mother tongue. For example, the maximum number of consonants in syllable-onset position in English is three. If three consonants occur, they should be in the form of /s/+ one of the voiceless plosives /p t k/ + /l/, /r/, /w/ or /j/". According to Al-Ani (1970), the syllabic template CV is the minimum necessary construction of the Arabic syllable, and the highest component is CVCC. In this respect, Tripolitanian Libyan Arabic (TLA) is more flexible with consonant clusters as it allows up to two consonants in the onset and coda positions of the syllable. In short, while English syllable constraints allow for three-consonant clusters in the syllable onset position, Arabic syllable constraints do not allow any consonant clusters in the onset position, and TLA only allows clusters with a maximum of two consonants in syllable-onset position.

The notions of differences between the first and second languages can be explained in the light of The Markedness Differential Hypothesis (MDH) as proposed by Eckman (1977). In its simplest forms, MDH claims that when learning a second language, features that will cause more difficulty in acquisition are those marked. In this respect, syllable-initial three-consonant clusters are marked in English and may be challenging for Arabic-speaking ESL learners to master.

2.2 Consonant Cluster Repair Strategies in Arabic Dialects:

Many researchers have investigated syllabification patterns and consonant cluster difficulties. Kiparsky (2003) investigated vowel epenthesis and classified Arabic dialects into three classes according to their syllabification pattern or the position in which they insert the epenthetic vowel in problematic clusters. These are namely VC-, C-, and CV- dialects. Kiparsky states that speakers of the three dialect types would break down a sequence of three consonants differently. In VC- dialects, a CCC cluster would be altered to CvCC with an epenthetic vowel inserted before the C2 of the cluster. While in C- dialects, this cluster is reserved as it contains no epenthetic vowel. In CV dialects, the same consonant cluster would be modified to CCvC with the epenthetic vowel inserted after the C2 in the cluster. Watson (2007) argues that Kiparsky's model is debatable and that not all dialects fit into the dialect types he classified. Watson supports her claim by arguing that TLA and San'ani dialects are of neither of the three types classified by Kiparsky but rather an intermediate type between C and VC dialects.

Previous research has identified two primary repair strategies for handling consonant clusters: vowel epenthesis and cluster reduction (Alotaibi, 2021; Al-Saidat, 2010). Different studies report variability in the repair strategy and the site where the epenthetic vowel is inserted. They attribute this variation to whether the dialect is CV or VC. (Salem, 2014).

2.3 Repair Strategies adopted by Arabic-speaking ESL Learners:

Several studies have explored how Arabic-speaking ESL learners produce English consonant clusters, particularly those which do not have an equivalent in their mother tongue. Broselow (1984, 1988) pointed out that Arabic-speaking ESL learners insert an epenthetic vowel to break up English consonant clusters that are not permitted in their native language. Similarly, Al-Saidat (2010) found that Jordanian university students struggle with complex consonant clusters. To solve this problem, they often use an epenthetic vowel to facilitate pronunciation. Notably, the placement of this vowel varies as a function of cluster complexity and position within the syllable. Participants typically inserted the high-front short vowel /ɪ/ after the first consonant in three-consonant clusters in the onset position.

Almalki (2014) provides further evidence to support these findings. He analysed speech samples from 46 participants and observed that vowel epenthesis was consistently employed to simplify clusters, with longer epenthetic vowels occurring in more marked clusters. Similarly, Hago and Khan (2015) found that Saudi secondary school students also faced difficulties with consonant clusters and used vowel epenthesis as a repair strategy. Finally, Bouchhioua (2019) conducted an acoustic and auditory study on the production of English consonant clusters produced by Tunisian students. Her results revealed that vowel epenthesis was the dominant strategy to overcome the challenges of producing English onset and coda clusters.

Research on Libyan Arabic has yielded similar results. Elsaghayer (2014) applied Eckman's MDH to examine Libyan students' production of syllable onset clusters. Elsaghayer (2014) found that Libyan students inserted a vowel before the /s/ in three-consonant clusters to facilitate their production. This finding further supports that Arabic-speaking ESL learners use vowel epenthesis as the main repair strategy to approach English three-consonant clusters.

In addition to vowel epenthesis, some studies have identified cluster reduction as an alternative repair strategy. For example, Alenazi (2016) examined the pronunciation of final two-consonant clusters by Saudi learners' and found that some

participants simplified them by deleting the second consonant as in "tamf"/tæmf/, which was realised as "tam"/tæm/. Similarly, Al-Yami and Alathwary (2021) analysed pronunciation errors made by Saudi EFL learners and attributed these errors to differences between Arabic and English phonological systems. Their findings also highlighted variations in cluster simplification strategies among students.

2.4 The Site of Vowel Epenthesis:

There are many factors that can influence the place where the epenthetic voqwel is inserted. For example, Dialectal variation has been identified as a factor in determining the site of vowel epenthesis. Alezetes (2007) states that while syllables in Cairene Arabic are mapped from left to right, in Iraqi Arabic, syllables are mapped from right to left. These differences lead to differences in the site of epenthesis. In agreement with these findings, Gouskova and Hall (2009) and Hall (2013) observed that Levantine Arabic speakers tend to insert a vowel within the cluster. For speakers of Egyptian Arabic, Salem (2014) found that the epenthetic vowel is inserted within the cluster, too. However, Galal (2004), using an Optimality Theory framework, found that Cairene Arabic speakers employ either pre-cluster or within-cluster epenthesis when adapting loanwords. Gulf Arabic speakers tend to insert the epenthetic vowel before the cluster (Al-Abdullah and Almutairi, 2024; Al-Deaibes and Rosen, 2016). These results are further confirmed for Najdi Arabic (Al-Abdullah; 2004) and Kuwaiti Arabic (Al-Deaibes and Rosen 2016), where the speakers of these Arabic varieties tended to insert vowels before English consonant clusters predominantly.

In addition to the influence of dialectal variation on the site of epenthesis, vowel epenthesis is influenced by the sonority of the consonants composing the cluster. While in two-consonant clusters of s + stop, an epenthetic vowel is inserted before the clusters (Al-Deaibes and Rosen 2016, Mousa, 2020), in clusters of a stop + liquid, it is more likely to insert the epenthetic vowel between them (Al-Deaibes and Rosen 2016). In a recent study, Chen et al. (2024) examined the role of the Sonority Sequencing Principle in the production of initial consonant clusters by Chinese students. Their hypothesis is that larger sonority gaps between the consonants forming the cluster, which make the cluster marked, result in vowel epenthesis. Their results confirm their hypothesis that the more marked a cluster is, the more likely it is to have an epenthetic vowel.

Finally, the learners' proficiency levels have also been shown to influence epenthesis patterns. Salem (2014) noticed that speakers of Levantine Arabic insert an epenthetic vowel after the second consonant in English consonant clusters; a tendency was not observed in the speech of more proficient English speakers. This pattern was also observed among Saudi learners (Alotaibi, 2021), confirming the role of language proficiency in cluster production.

Research highlights that Arabic-speaking ESL learners employ various strategies, primarily vowel epenthesis and cluster reduction, to handle English consonant clusters. These strategies are influenced by phonotactic constraints, dialectal background,

2.5 Acoustic Features of Epenthetic Vowels:

One of the main characteristics of epenthetic vowels is its duration. Broselow and Finer (1991) stated that the duration of epenthetic vowels is different from that of lexical vowels. In general, the duration of epenthetic vowels ranges between 40-70 ms, which is shorter than lexical vowels. It has also been stated that epenthetic vowels are shorter than English vowels and their duration is influenced by speech rate Weinberger (1994).

The acoustic properties of Epenthetic vowels have been the subject of several acoustic studies. It was found that the dialect in question and the sonority of the consonants that make up the cluster determine the site and quality of the epenthetic vowel (e.g Gouskova and Hall, 2009, Hall 2013). While Gulf Arabic speakers insert a shwa-like vowel (Al-Deaibes and Rosen 2016), greater variability has been noticed amongst speakers of Egyptian and Levantine Arabic (Gouskova and Hall 2009).

3 Methodology:

3.1 Participants:

The study recruited twenty Libyan female ESL students from the Department of English, University of Tripoli. They were selected from second-semester students to ensure a relatively uniform proficiency level, as they have not studied any phonetics and phonology courses. All participants are native speakers of TLA and were born and raised in Tripoli, the capital of Libya,

3.2 Data collection:

All participants were informed that their identities would be kept anonymous. The participants were then recorded while reading nice sentences containing the target words: "Spring"/spr/, "split"/spl/, "spume"/spj/"street"/str/, "stupid"/stj/, "Scream"/skr/, "sclera"/skl/, "skew"/skj/ and "squash"/skw/. These words were embedded in the carries sentence: "Don't same_____ again". These words were chosen based on their phonological structure and frequency. Apart from "spume" and "sclera", the words are the most common words with syllable-initial three-consonant clusters in onset position.The recording session was conducted in a controlled environment to ensure consistency in data collection, minimise background noise, and monitor variation in speech rate.

3.3 Data Analysis:

This study adopts an acoustic analysis framework to record and analyse the data. The speech software Praat was used to record and analyse the data. First, spectrograms and waveforms were visually inspected to assess each student's recording. Then, for each token the epenthetic vowel was identified. The sudden increase and decrease of amplitude were taken as the boundaries of the epenthetic vowel. Finally, the frequency values of the first and the second formants (F1 and F2) were obtained using Praat scripts.

4 Results:

4.1 Simplification strategies:

Table 1 summarises the results of the acoustic analysis and the simplification strategies adopted in each word. The total number of productions is 180. Of those, 116 (64.4%) were accurate productions, i.e., the consonant clusters were produced correctly without any epenthesis or deletion. The remaining productions that were not pronounced correctly were 64 instances (35.6%).

		IPA transcription	correct productions	Incorrect productions	Phonological Error
1-	Spring	/sprɪŋ/	12	8	Epenthesis (4 instances of vC1and 4 instances of C1v)
2-	Split	/splɪt/	13	7	Epenthesis (4 instances of vC1 and 2 instances of both vC1 + C2v and 1 instance C1C2v)
3-	Spume	/spju:m/	13	7	Epenthesis (2instances of vC1, 1 instance vC1 + 1 instance of deletion, 2 instances of C1v, one instance of C1C2v and deletion)
4-	Street	/stri:t/	17	3	Epenthesis (3 instances of vC1)
5-	Stupid	/stju:pɪd/	15	5	Epenthesis (5 instances of vC1)
6-	Screen	/skri:n/	11	9	Epenthesis (7 instances of vC1 and 2 instances of C1v)
7-	Sclera	/sklɛərə/	13	7	Epenthesis (5 instances of vC1 and 2 instances of C1v)
8-	Skew	/skju:/	10	10	Epenthesis (8 instances of vC1 and 2 instances of C1v)
9-	squash	/skwɒʃ/	12	8	Epenthesis (7 instances of vC1 and 1 instances of C1v)

Table 1. The instances of correct and incorrect productions for each word and the strategies adopted when the production is incorrect.

The following is an analysis of the data word by word:

1- Spring: There were 12 correct productions of the word "Spring" and 8 incorrect productions. Of those, there were 4 instances of inserting an epenthetic vowel inserted before the consonant cluster produced by 3, 4, 6 and 7 (/əsprɪŋ/). In the remaining instances of incorrect productions, Participants 1, 2. 5 and 11 inserted an epenthetic vowel after the first consonant (/səprɪŋ/). While some participants adopted a CV insertion, i.e., inserting the vowel after the first consonant in 13 instances, others adopted a VC insertion, i.e., inserting an epenthetic vowel before the first consonant in 61 instances.

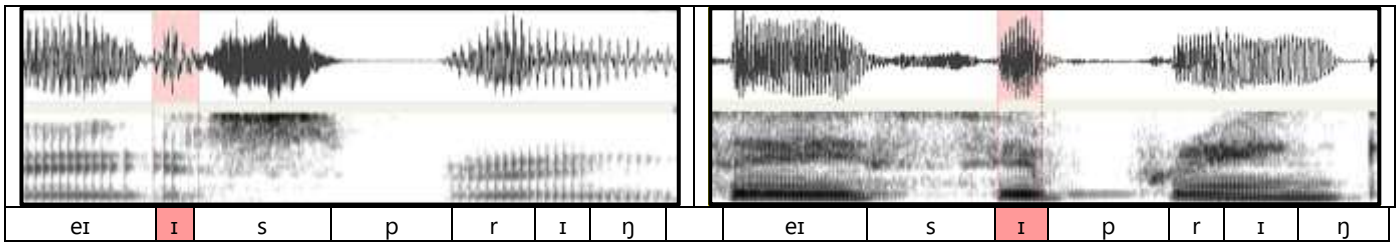

Figure 1. Spectrogram and waveform of the word 'spring' produced with an epenthetic vowel inserted before the first consonant (left) and after the first consonant (right).

2- split: In the word "split, there were 12 instances of correct production. During the production of the 8 remaining tokens, the participants inserted an epenthetic vowel before the cluster in 5 instances, /əsplɪt/, and before and after the first consonant in 3 instances, /əspɪlt/, produced by participants 3, 5 and 7.

3- spume: This word is the most interesting as students applied various simplification strategies. The participants inserted an epenthetic vowel before the cluster in 2 instances, /əspju:m/, one instance of inserting an epenthetic vowel before the first

consonant while at the same time deleting the third consonant, /əspu:m/, 2 instances of inserting an epenthetic vowel after the first consonant, /səpju:m/. Finally, there were two instances of deleting the third consonant /j/ and producing the word "spume" as /spu:m/.

4 - street: 17 participants correctly produced the word "street." Only three instances of inserting an epenthetic vowel occurred before the first consonant, /əstri:t/.

5- stupid: 15 participants correctly produced the word "stupid." Only three instances of inserting an epenthetic vowel before the first consonant, /əstjpɪd/, occurred.

6- scream: There were 11 correct productions of the word "Spring" and 9 incorrect productions. There were 7 instances of inserting an epenthetic vowel before the consonant cluster, /əskri:m/, and 2 instances after the first consonant, /səkri:m/.

7- sclera: There were 13 correct productions of the word "Spring" and 7 incorrect productions. There were 5 instances of inserting an epenthetic vowel inserted before the consonant cluster, /əskleɪrə/, and 2 instances after the first consonant, /səkleɪrə/.

8- skew: There were 10 correct productions of the word "Spring" and 10 incorrect productions. There were 8 instances of inserting an epenthetic vowel before the consonant cluster, /əskju:/, and 2 instances after the first consonant, /səkju:/.

9- squash: There were 12 correct productions of the word "Spring" and 8 incorrect productions. There were 7 instances of inserting an epenthetic vowel before the consonant cluster, /ɪskwɒʃ/, and after the first consonant in one instance, /sɪkwɒʃ/.

4.2 Acoustic analysis of epenthetic vowels:

4.2.1 Duration:

The average duration of all epenthetic vowels is 45 ms. As Figure (2) shows, the duration of the epenthetic vowel ranges between 37ms in 'sclera' and 52ms in 'screen. Results of the statistical tests shows no significant differences between these durations.

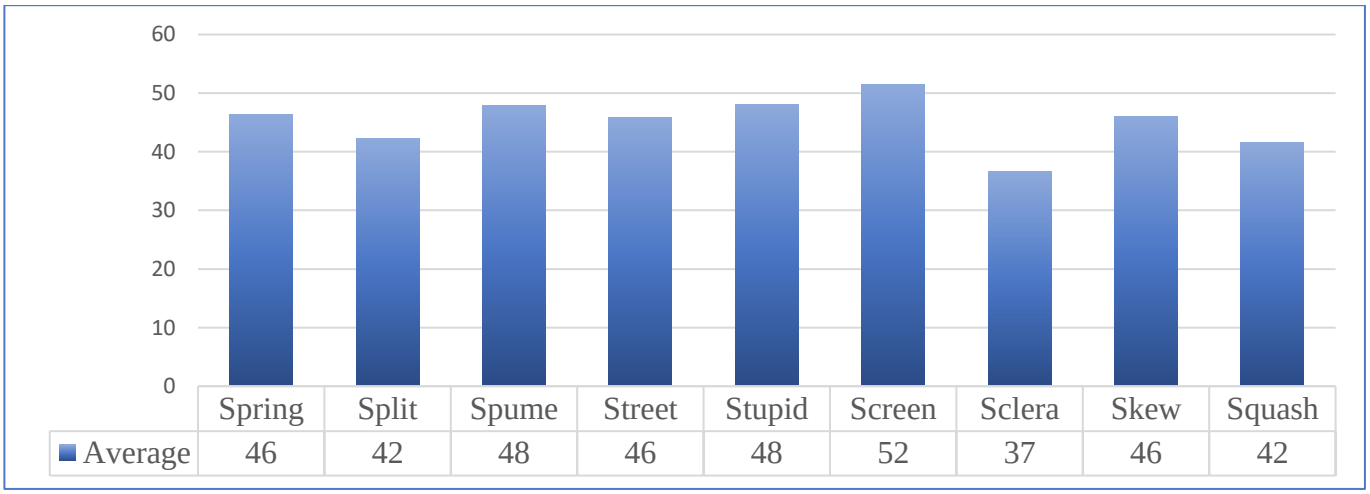

Figure 2. The duration of epenthetic vowels inserted in each word.

4.2.2 Acoustic features of epenthetic vowels:

The values of F1 and F2 of the epenthetic vowel were plotted and compared with British English vowels (as presented by Deterding,1997) to determine their vowel quality. As seen in Figure 3, the measurements of F1 and F2 indicate that the epenthetic vowel exhibits characteristics of high-front unrounded vowels, aligning with the acoustic properties of the vowel [ɪ], especially for the epenthetic vowel inserted after the first consonant. The epenthetic vowel which was inserted before the first consonant, shows more open quality.

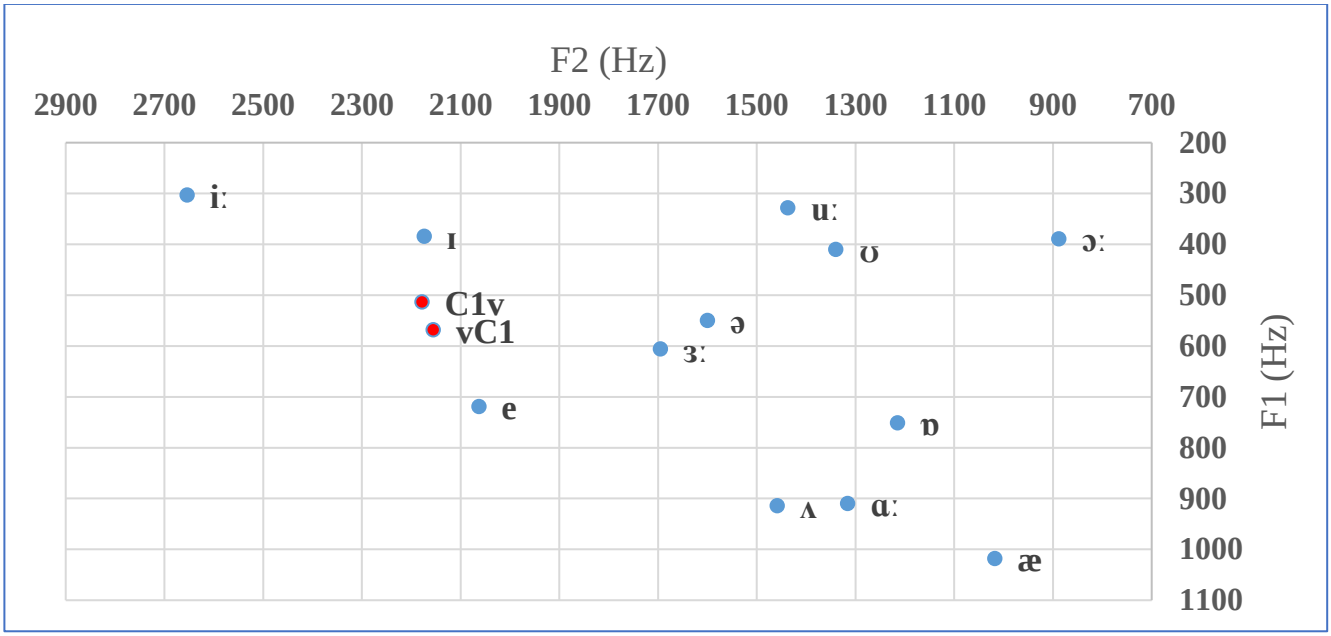

Figure 3: F1/F2 plot comparing British English Cardinal Vowels with epenthetic vowels. vC1 is for epenthetic vowels inserted before the first consonant and C1v is for epenthetic vowels inserted after the first consonant

5 Discussion:

This study investigated the production of syllable-initial three-consonant clusters by second-semester ESL students at the University of Tripoli – Libya. It aimed to investigate how Libyan ESL students will approach the production of complex consonant clusters, which do not exist in their mother tongue, and whether they will employ vowel epenthesis to facilitate the production of these clusters. The acoustic analysis showed clear evidence that Libyan university students have difficulty producing three-consonant clusters in syllable initial position and that vowel epenthesis is the most preferred strategy. These results align with previous studies on Saudi and Jordanian learners (Alotaibi, 2010; Al-Saidat, 2010; Almalki, 2014) and on Libyan Arabic (Elsaghayer, 2014;), that vowel epenthesis is the main repair strategy, particularly in clusters starting with /s/.

The findings support the Markedness Differential Hypothesis (Eckman, 1977), which states that marked structures in the second language pose greater difficulties for second-language learners. The tendency to insert an epenthetic vowel aligns with the principle that learners modify marked structures to fit in their native phonological system.

The site of the epenthetic vowel differs across Arabic dialects. This finding agrees with Kiparsky's (2003) classification of Arabic dialects into VC, C, and CV types. However, the variation in epenthesis site exhibited by TLA speakers aligns with Watson's (2002) observation that Libyan Arabic shares features of both VC and CV dialects.

Word frequency played a factor in determining which clusters were the most difficult to produce. The first could be an example of confusing "split" with "spelt," and the second could be due to the word being unfamiliar. Interestingly, words with lower frequency in the participants' exposure, such as 'spume' and 'sclera,' exhibited more variation in pronunciation strategies, indicating that word frequency may determine which repair strategy is used. The duration of the epenthetic vowel ranges between 37ms in 'sclera' and 52ms in 'screen. This confirms previous findings (Gouskova & Hall, 2009), that epenthetic vowels are significantly shorter than lexical vowels.

6 Conclusion:

Native speakers of Libyan Arabic face some difficulties in producing English word-initial three-consonant clusters. As a result, they tend to apply their native language phonotactics when speaking English, which can lead to mispronouncing certain clusters. According to the results, vowel epenthesis is the most preferred mechanism employed by Libyan ESL second-semester university students at the Department of English – the University of Tripoli to overcome the production of English complex clusters. The duration of the epenthetic vowel is shorter than the vowels in their vicinity. Measurements of F1 And F2 have shown that the quality of the epenthetic vowel is similar to the short high-front vowel /ɪ/. In addition, it seems that consonant deletion is not common among Libyan students.

The study included 20 participants, which restricts the generalizability of the results. A bigger sample size would provide a more comprehensive view of the challenges facing Libyan EFL learners. Additionally, the research focused exclusively on syllable-initial three-consonant clusters. Moreover, since all participants were from Tripoli, the findings may not apply to other Libya regions with different dialectal influences.

Future research could recruit participants, both males and females, at different proficiency levels to assess whether exposure would influence the choice of the repair strategy and to investigate whether gender would affect the phonological patterns in second-language acquisition. Future research can also investigate the production of three and four-consonant clusters in the coda position. Finally, investigating the impact of explicit phonetic training on reducing vowel epenthesis would be valuable in developing more effective ESL teaching strategies for Libyan-speaking ESL learners.

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