مجلة جامعة بني وليد للعلوم الإنسانية والتطبيقية
Bani Waleed University Journal of Humanities and Applied Sciences
تصدر عن– جامعة بني وليد – ليبيا
Website: https://jhas-bwu.com/index.php/bwjhas/index

المجلد الحادي عشر – العدد الخامس – 2026 الصفحات (259- 278) ISSN 3005-3900

Acquiring English Coda Consonant Clusters by Libyan EFL Learners in the English Department at Sirte University

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اكتساب عناقيد الصوامت النهائية الإنجليزية لدي المتعلمين الليبيين للغة الإنجليزية كلغة أجنبية في قسم اللغة الإنجليزية بجامعة سرت

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Received: 05-06-2026	Accepted: 13-07-2026	Published: 22-07-2026

الملخص:
تبحث هذه الدراسة في نطق عناقيد الصوامت النهائية للكلمات في اللغة الإنجليزية لدي خمسة عشر متعلماً عربياً ليبياً والذين اختيروا من ثلاثة مستويات من الكفاءة (الفصل الدراسي الأول، والخامس، والثامن). واستنادا إلى نظرية الحد الأدنى لمسافة الرنين ونظرية العلامية النمطية، فحصت الدراسة آثار تعقيد العنقود، واستراتيجيات التبسيط، وتسلسل الرنين (السونية)، والتطور التدريجي على الصوتيات البينية لدي المتعلمين. وقد جُمعت بيانات الدراسة من خلال مهمة قراءة قائمة كلمات مضبوطة تحتوي على عناقيد نهائية مكونة من صامتين وثلاثة صوامت وأربعة صوامت، وتم توظيف التصميم الكمي لتحليل أداء المشاركين لقياس الدقة وأنواع الأخطاء. واظهرت النتائج ان المشاركين اتبعوا تسلسل هرمي واضح للصعوبة استناداً إلى تعقيد العنقود. وقد لوحظ ان العناقيد الثنائية الصامتة قد نطقت بأعلى درجة من الدقة، تليها العناقيد الثلاثية الصامتة، في حين شكلت العناقيد الرباعية الصامتة أكبر تحدي لدي جميع مستويات الكفاءة. واظهرت النتائج أيضا ان استراتيجيات التبسيط المنتظمة كانت إدخال الحروف المتحركة يتبعها تقليص العنقود، مما يظهر تأثيراً قوياً للغة اللأم لدي المشاركين. وعلاوة على ذلك فقد اثرت أنماط الرنين علي نطق عناقيد الصوامت النهائية، حيث نطقت العناقيد ذات الرنين الهابط بدقة أعلي مقارنة بالعناقيد ذات الرنين الصاعد والرنين المختلط. وعلى الرغم من حقيقة ان دقة النطق تحسنت مع زيادة الكفاءة، ظلت العناقيد شديدة العلامية والمعقدة صعبة في الاكتساب، حتى لدي المتعلمين المتقدمين. ويُستدل من هذه النتائج أن تأثير اللغة الأم، والقيود الصوتية العالمية، والعوامل التطورية يؤثر على المتعلمين الليبيين في اكتسابهم عناقيد الصوامت النهائية في اللغة الإنجليزية.

الكلمات الدالة: عناقيد الصوامت النهائية الإنجليزية، تأثير اللغة الأم، المتعلمون الليبيون العرب للغة الإنجليزية كلغة أجنبية، نظرية الحد الأدنى لمسافة الرنين، نظرية العلامية النمطية .

Abstract
The study explores the production of English coda consonant clusters by fifteen Libyan Arabic learners who were chosen from three proficiency levels (first, fifth, and eighth semesters). From the perspective of the Minimal Sonority Distance (MSD) theory and the Typological Markedness (TM) theory, the study investigated

the impact of complex clusters, simplification strategies, sonority patterns, and language development on learners' interlanguage phonology. A controlled word-list reading task was utilized to collect the study's data, which included two-, three-, and four-consonant clusters in the word-final position. The quantitative design was employed to analyze the participants' pronunciation in order to measure accuracy and error types. The findings showed that the participants followed a clear hierarchy based on the complexity of cluster. It was noticed that two-consonant clusters(CC) were articulated accurately, followed by three-consonant clusters (CCC), whereas four-consonant clusters(CCCC) were challenge for all proficiency levels. The results also revealed that the regular simplification strategies were vowel epenthesis followed by cluster reduction, showing a strong effect of the participants' first language. Furthermore, sonority sequencing also affected pronunciation coda consonant clusters, as falling-sonority clusters were pronounced more accurately than rising-and mixed-sonority clusters. Despite the fact that the pronunciation accuracy improved as learners became more proficient, more marked and complex clusters stayed difficult to acquire, even for proficient learners. These findings conclude that first language impact, universal phonological constraints, and progressive aspects influence on Libyan learners in their acquisition of English word-final consonant clusters.

Keywords: : English word-final consonant clusters, first language impact, Libyan Arabic EFL learners, Minimal Sonority Distance theory, Typological Markedness theory.

1. Introduction

Pronunciation plays a vital role in real-life communication as it reflects the speakers' identities and the communities they belong to (Loi, 2017). Pronunciation can be studied through two main aspects. The first is the segmental aspect, which includes vowels (monophthongs, diphthongs, and triphthongs) and consonants. The second is the supra-segmental aspect, which includes syllables, stress, and intonation. Within syllable structure, one of the most challenging aspects is the occurrence of consonant clusters. Consonant clusters refer to sequences of two or more consonants occurring within a single syllable (Roach, 2009). Learners of English as a Foreign Language (EFL) often face difficulties in acquiring these structures, especially when their first language (L1) does not contain similar clusters. As a result, English consonant clusters have long been viewed as a complex phonological issue and have received considerable attention in linguistic research.

This study focuses on the challenges associated with acquiring supra- segmental structure, particularly syllable structure. More specifically, it investigates how Libyan EFL learners produce consonant clusters in word-final (coda) position.

1.1 Statement of the Problem

Difficulties in English pronunciation among Arab EFL learners often arise from the influence of the mother tongue and the differences between the Arabic and English sound systems (Al-Saidat, 2010; Hassan, 2014; Hago & Khan 2015; Othman & Abubaker, 2021; Ashwehdy, 2023; Na'ama, 2011). In other words, Arabic and English differ in semantics, grammar, morphology, phonetics, phonology, and syntax (Ashour, 2017). These differences are partly due to the fact that "Arabic language is Semitic, while English language is believed to descend from the language of nomads roaming the plains of Eastern Europe and western Asia" (Al-Samawi, 2014, p. 264).

In Libyan classrooms, pronunciation–especially consonants clusters–receives less attention than grammar and vocabulary. As a result, many university students graduate with noticeable pronunciation difficulties, particularly in producing consonant clusters correctly.

In fact, consonant clusters within syllables pose a challenge for most of Libyan Arabic (LA) learners as they are considered a complex phonological feature. For example, LA only permits two-consonant clusters (CC) in final position. Therefore, Libyan learners often struggle to produce English consonant clusters containing three or four consonants (CCC or CCCC). Similar to other Arab EFL learners who speak different Arabic dialects, such as Egyptian, Iraqi, Saudi, and Jordanian, Libyan learners are expected to use strategies such as insertion, deletion, and substitution to simplify consonant clusters, especially in word-final clusters (Shitaw, 2025; Al-Yami & Alathwary, 2021; Elsaghayer, 2014; Al-Saidat, 2010; Al-Shuaibi, 2006). Therefore, this study seeks to investigate how Libyan learners acquire and produce English consonant clusters in coda position and to identify the patterns and strategies behind their pronunciation errors.

1.2 Research Questions

This study seeks to answer the following questions:

1. How does consonant cluster complexity (CC, CCC, and CCCC) affect LA learners' production of English coda clusters?
2. What repair strategies do LA learners employ to simplify the production of highly marked coda clusters?
3. How do sonority patterns (rising, falling, and mixed sonority clusters) influence LA learners' production of coda clusters?
4. What developmental patterns characterize LA learners' acquisition of English coda clusters across proficiency levels?

1.3 Objectives of the Study

This study aims to examine how LA learners acquire English consonant clusters in word-final position, identifying the errors patterns and repair strategies they use, and explore the sonority on their production and the influence of proficiency level. Through this investigation, the study aims to provide a clearer understanding of the pronunciation difficulties faced by Libyan learners and the phonological challenges related to this syllable structure.

1.4 Significance of the Study

Based on the researcher's teaching experience, only a few studies have examined in detail how Libyan learners acquire English consonant clusters. Therefore, the findings of this study are expected to benefit textbook designers, teachers, and students. Firstly, the outcomes may contribute to improving curricula at both school and university level. Secondly, the findings may help teachers in developing effective teaching techniques to assist students in overcoming difficulties with consonant clusters and implementing these strategies in the classroom. Finally, the study may help learners identify the most difficult aspects of consonant cluster acquisition.

2. Literature Review

2.1 Syllable Structure in English Language

According to Blevins (1995), languages differ in both the number and the types of vowels and consonants that can occupy a syllabic position. Selkirk (1982, 1984) explained that these elements are organized according to the Sonority Sequencing Generalization (SSG). In this principle, the most sonorous sounds, which are vowels, are adjacent to the centre of the syllable, while less sonorous sounds, such as consonants, are assigned to the syllable margins.

In the same vein, Ladefoged (2006) stated that sonority increases as sounds approach the syllable peak and decreases toward the syllable margins (cited in Daana & Khrais, 2018). The sonority hierarchy is generally arranged as follows: vowels > glides > liquids > nasals > obstruents (stops and fricatives) (Clements, 1990). Highly sonorous sounds usually form the nucleus, whereas less sonorous sounds function as onset or coda elements.

Table 2.1: Sonority Hierarchy (adapted from Clements, 1990; Selkirk 1984)

Major Class	**Sonority Index**
Vowels	4
Glides	3
Liquids	2
Nasals	1
Obstruents	0

On the other hand, Kaye et al. (1990) described syllable structure in terms of constituent structure, which includes the CV patterns found across languages. In this model, the nucleus and the coda together form the rhyme, while the onset is treated as a separate constituent adjoined to the rhyme to complete the syllable. The coda position is licensed through a relationship with the onset of the following syllable. (see Figure 2.1)

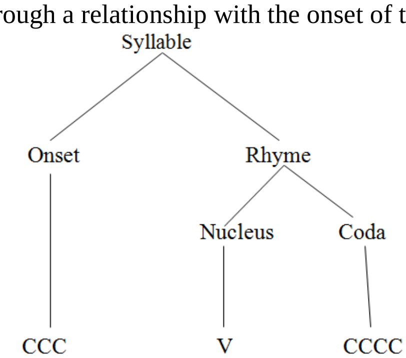

Figure 2.1: The Syllable Structure in English (adapted from Blevins, 1995)

In English language, the vowel occupies nucleus position and it is considered an essential part of every syllable. A syllable containing only one sound must consist of a vowel, such as *oh* /əʊ/ and *eh* /eɪ/. When a syllable contains more than one sound, one of them must be a vowel while the others are consonants as in *saw* /sɔ:/, *age* /eɪʤ/, and *tooth* /tʊ:θ/. Consonants are optional elements that may occupy onset and coda positions (Roach, 2009).

- Some syllables contain no onset but include a coda, such as *ought* /ɔ:t/, *ease* /ɪ:z/.
- Other syllables contain an onset but no coda, such as *key* /ki:/, *more* /mɔ:/.
- Many syllables contain both an onset and a coda, such as *ran* /ræn/, *fill* /fɪl/.

Table 2.2 identifies the maximum syllable patterns that occur in English.

Table 2.2: Syllable Patterns in English Language (adapted from Roach, 2009)

English Patterns	Example	IPA
V	*I*	/aɪ/
VC	*all*	/ɔ:l/
CV	*no*	/nəu/
CVC	*map*	/mæp/
CCV	*play*	/pleɪ/
CCCV	*spray*	/spreɪ/
CCVC	*phrase*	/freɪz/
CCCVC	*street*	/stri:t/
CCCVCC	*strange*	/streɪnʤ/
CCCVCCC	*strengths*	/streŋθs/
VCCC	*pre-empts (second syllable)*	/-empts/
CVCCCC	*texts*	/teksts/
CCVCCCC	*twelfths*	/twelfθs/

Note: IPA (International Phonetic Alphabet) is a standardized set of symbols used to represent the sounds of spoken language, with each symbol corresponding to one specific sound, independent of spelling.

2.2 Consonant Clusters in English Language

Alsilevani (2024) explained that the consonant clusters are formed when onset and coda constituents branch, and languages differ in the complexity of these syllable margins. As shown in Table 2.2, sequences of two or more consonants occurring either at the beginning or at the end of a syllable are called consonant clusters (Balasubaramian, 1981; Celce-Murcia et al. 1996; Roach, 2009). In English, the onset may contain up to three consonants (CCC), while the coda position may include up to four consonants (CCCC). The following sections provide further details regarding clusters in onset and coda positions.

2.2.1 Consonant Clusters in Onset Position

Before discussing clusters in the onset position, it is important to note that some syllables may begin without an onset consonant. This is known as a zero onset, as in *am* /æm/. When a syllable begins with one consonant, it is referred to as an initial consonant, and almost all consonants can occur in this position except /ŋ/ and /ʒ/.

Consonant clusters in onset position occur when consonants appear before the vowel within a syllable. English contains two main types of two-consonant onset clusters (CC) (Roach, 2009).

The first type consists of /s/ followed by another consonant, as in *stick* /stɪk/, *sway* /sweɪ/ and *snail* /sneɪl/, as well as some loanwords such as *sphinx* /sfɪŋks/ and *svelte*/svɛlt/. In these clusters, /s/ is called the pre-initial consonant, while the following consonant (/t/, /w/, /n/, /f/, /v/) is called the initial consonant.

The second type begins with one of approximately fifteen consonants followed by a liquid or glide (/l/, /r/, /w/, /j/), as in *gray* /greɪ/, *blue* /blu:/, *quick* /kwɪk/, and *few*/fju:/. In this type, the first consonant is called the initial consonant and the second is called the post-initial consonant.

Based on these two types of double onset clusters, a relationship can also be observed with three-consonant onset clusters (CCC). In triple onset clusters, the first consonant is always /s/ and is known as the pre-initial. It is followed by one of voiceless plosives /p, t, k/, which function as the initial consonant, and finally by /l/, /r/, /w/, or /j/ which are referred to as post-initial consonants, as in *split* /splɪt/, *stream* /stri:m/, and *square* /skweə/.

2.2.2 Consonant Clusters in Coda position

Unlike onset clusters, consonant sequences in coda position are more complex because English codas may contain up to four consonants (ibid). This complexity mainly results from the addition of inflectional morphemes such as -s and –ed at the end of words. The morpheme –s is added to nouns to form plurals and to verbs to form third-person singular forms. It is pronounced as voiceless /s/ after voiceless sounds, as in *cats* /kæts/ and *writes* /raɪts/, but as voiced /z/after voiced sounds, as in *dogs* /dɒgz/ and *runs* /rʌnz/.

In the same vein, the morpheme –ed is pronounced as /d/ after voiced sounds except /d/, as in *dragged*/drægd/, and as /t/ after voiceless sounds except /t/, as in *talked* /tɔ:kt/.

Despite the complexity of coda clusters, some syllable may contain no coda consonant, which is referred to as a zero coda, as in *go* /gəʊ/. A syllable ending with one consonant contain a final consonant, and almost all consonants may occur in final position except /h/, /w/, and /j/, as in *sit* /sɪt/.

Similar to onset clusters, there are two types of double coda clusters (CC). In the first type, a final consonant is preceded by a pre-final consonant, which may only be /m/, /n/, /ŋ/, /l/ or /s/, as in *dump* /dʌmp/, *bent* /bent/, *bank* /bæŋk/, *belt* /belt/, and *ask* /a:sk/.
In the second type, the final consonant is followed by a post-final consonant, which may only be /s/, /z/, /t/, /d/ or /θ/, as in bets /bets/, *beds* /bedz/, *backed* /bækt/, *bagged* /bægd/, and *eighth* /eɪtθ/.
Triple codas (CCC) also occur in two forms. In the first type, the consonants are distributed as pre-final+ final+ post-final, as in *helped* /helpt/, *banks* /bæŋks/, *bonds* /bɒndz/, and *twelfth* /twelfθ/. In the second type, there is more than one post-final consonant, producing the pattern final+ post final 1+ post final 2, as in *fifths* /fɪ:fθs/, *next* /nekst/, and *lapsed* /læpst/. Finally, four-consonant codas (CCCC) follow the pattern pre-final+ final+ post-final 1+ post-final 2, as in *twelfths* /twelfθs/ and *prompts* /prɒmpts/.

2.3 Syllable Structure in Libyan Arabic

The SSG is also applicable to Modern Standard Arabic (MSA). In MSA, vowels, whether short or long, always occupy the nucleus position of the syllable, whereas consonants, including /j/ and /w/, occur in marginal positions (Kiparsky, 2003; McCarthy, 1994; AL- Ani, 1970).
Similarly, syllable in LA consists of three main components: onset, nucleus, and coda. The nucleus must contain a vowel, either short or long. Abumdas (1985) stated that “in case the long vowel is presented, the adjacent coda must be a single consonant, or if it is a cluster, it must be identical as in *haarr* ‘hot’ ” (p.86).
In LA, the onset may consist of a single consonant, a two-consonant cluster (CC), or may be absent completely, which is known as a zero onset, as in *aswad* ‘black’. Consonant clusters in onset position generally occur at the beginning of words and only rarely in medial position.
The coda, like the onset, may contain a single consonant, a consonant cluster, or no consonant at all (zero coda), as illustrated in Table 2.3 below.
Concerning syllable patterns, LA shares five syllable structures with MSA: CV, CVV, CVC, CVVC, and CVCC (Watson, 2002). In addition, LA permits four extra patterns: CCV, CCVVC, CCVCC, and CCVC. These patterns are also found in other Arabic dialects, such as Egyptian Arabic (EA) (Omar, 2017) and Tunisian Arabic (TA) (Mahfoudhi, 2005). Abumdas (1985) further noted that “LA has got other ones, but all of them began with vowels” (p.89).
Table 2.3 presents examples of these syllable patterns in LA.

Table 2.3: Syllable Patterns in LA

Patterns Start with Vowel(s)	**LA Words**	**Gloss**
V	*oskot*	keep silent
VV	*yalab*	play
VC	*ahmer*	red
VVC	*yad*	hand
Common Patterns (found in MSA)	**Examples**	**Gloss**
CV	*mazraa*	farm
CVV	*laa*	no
CVC	*nar*	fire
CVVC	*maat*	died
CVCC	*bent*	girl
Patterns Start with Consonant Clusters	**Examples**	**Gloss**
CCV	*hla*	welcome
CCVC	*wrag*	papers
CCVVC	*ktaab*	book
CCVCC	*hlemt*	I dream

As shown above, LA allows different types of syllables patterns. These include:

- Light or open syllable, such as V, VV, CV, and CVV.
- Closed or heavy syllables, including VC, VVC, CVC, CCV, and CCVC.
- Super-heavy syllable, such as CCVVC and CCVCC.

The final pattern, CCVCC is considered one of the most difficult syllable structures (cf. Salem, 2014). This demonstrates that sequences of two consonants may occur both in onset and coda positions in LA. These consonant clusters differ from those found in MSA, and this difference may influence the acquisition of English consonant clusters by LA learners.

2.3.1 Two-Consonant Clusters in Libyan Arabic

As discussed earlier, LA permits two-consonant clusters (CC),which may occur in initial, medial, and final positions within words or across morpheme boundaries as a result of historical development (Versteegh, 1997). This differs from MSA, which allows consonant clusters only in final position and does not permit them initially (Fantazi, 2003).Table 2.4 below presents examples of two-consonant clusters in different positions in LA.

Table 2.4: LA Two-Consonant Clusters (CC) in Three Positions

Initial Position	IPA	Gloss	Medial Position	IPA	Gloss	Final Position	IPA	Gloss
kdaab	/kda:b/	lying	*silmate*	/sılmat/	she is saved	*leabt*	/leʕbt/	I played
kleet	/kli:t/	I ate	*ygra*	/jgra:/	he reads	*ketabk*	/ketæbk/	your book
wrag	/wræg/	papers	*shirkah*	/sirkaħ/	partnership	*resamt*	/resamt/	I drew
frash	/fraʃ/	mattress	*mazraa*	/mazraʕ/	farm	*shams*	/ʃams/	sun

Similar to MSA, the consonant clusters found in LA generally follow the Sonority Sequencing Principle (SSP) proposed by Clements (1990). Therefore, it is predicted that LA learners will find clusters that follow the SSP easier to produce. In addition, two-consonant clusters (CC) are not expected to create major difficulties for Libyan learners because such structures are already familiar in their native language. This may indicate that learners are successfully acquiring the target language norms.

On the other hand, consonant sequences that violate the SSP are expected to be more difficult for LA learners. Furthermore, three-consonant (CCC) and four-consonant (CCCC) clusters are believed to create significant difficulties for LA learners for two main reasons. First, these clusters types do not exist in the syllable structure of LA. Second, they are considered universally and typologically marked structures (Eckman, 2008; Eckman & Iverson, 1993). As result, second and foreign language learners of English usually experience greater difficulty with syllables containing longer onset or coda clusters (Carlisle, 2001).

2.4 Theoretical Frameworks

The acquisition of consonant clusters has mainly been studied through two theoretical frameworks: Minimal Sonority Distance (MSD), proposed by Broselow and Finer (1991), and Typological Markedness (TM), developed by Eckman and Iverson (1993, 1994). These frameworks offer complementary explanations for the difficulties learners face in acquiring English consonant clusters and will be applied in analyzing the findings of this study.

2.4.1 Minimal Sonority Distance (MSD)

According to Broselow and Finer (1991), the syllable is organized in a sonority hierarchy which starts with "most sonorous elements (vowel) which is considered the centre of the syllable and the rest segments are arranged towards the margins of the syllable" (p.37). They argue that foreign learners need to recognize the required sonority distance between consonants in a cluster in order to acquire English consonant clusters successfully. The number of steps between consonants on the sonority hierarchy measures this distance. Therefore, some consonant clusters are easier to learn than others.

The MSD parameters are based on the sonority scale, as shown in Table 2.5 below.

Table 2.5: The MSD Parameters Settings

Class of Sound	Value	Defining Language
Stops	1	L1 language that requires a sonority distance of 1(allows the most clusters)
Fricatives	2	L2 clusters must differ by 2 in sonority
Nasals	3	L3 allow Cy and Cl/r clusters
Liquids	4	L4 allows only Cy clusters
Glides	5	L5 allows no clusters

The MSD theory assumed that languages requiring a greater sonority difference between adjacent consonants permit fewer consonant clusters. In contrast, languages allowing smaller sonority differences permit more cluster types. For example, a language with a minimal sonority difference of 5 allows only single consonants because no two consonants on the sonority scale differ by 5. A language with a minimal sonority difference of 4 allows only stop-glide clusters because these are the only consonants separated by a value of 4 on the sonority scale. A value of 3 allows stop-liquid and fricative-glide clusters.

This means that learners whose L1 does not contain complex consonant clusters are expected to acquire English clusters with larger sonority distances more easily than those with smaller distances. Thus, clusters with a value of 5 (single consonant in coda position) and 4 (C+ y/w) are generally easier than clusters with a value 3 (C+ l/r) and 2 (C+ n/m).

For example, in onset position, the sonority distance between the stop /p/ and the glide/j/ is large, as in *play* /pleɪ/. Such cluster is considered less marked and easier to pronounce. On the other hand, the distance between the fricative /s/ and the stop /p/ is small, as in *spend* /spend/, making the cluster more marked and difficult to produce. Therefore, the MSD framework predicts that clusters with greater sonority distance are acquired earlier and produced with fewer errors, while clusters with smaller sonority distance are more difficult for learners.

2.4.2 Typological Markedness (TM)

Typological Markedness (TM) is a linguistics concept distinguishes between unmarked and marked language structures based on their distribution across the world's languages. According to this perspective, unmarked structures are those that occur more frequently across languages, are structurally simple, and are acquired more easily by language learners. In contrast, marked structures are less common cross languages, involve structural complexity, and are generally more difficult to acquire (Eckman & Iverson ,1993, 1994).

Building on the earlier Markedness Differential Hypothesis (MDH) (Eckman, 1977), Eckman and Iverson (1993, 1994) argued that TM is a key factor in predicting the relative difficulty of second language (L2) acquisition. Their central claim is that the more typologically marked a linguistic structure is, the greater the difficulty learners will experience in acquiring it. Thus, learning difficulty is determined not only by whether a structure differs from learners' L1, but also by its degree of markedness. Features that are both absent from the learner's L1 and typologically marked are expected to present the greatest learning challenge.

Within phonology, TM has been widely applied to the acquisition of consonant clusters. Eckman and Iverson (1993, 1994) propose that the markedness of consonant clusters is determined by their complexity and cross-linguistic frequency. Clusters consisting of few consonants and exhibiting simple sonority patterns are considered less marked because they are found in a large number of languages. On the other hand, clusters with great number of consonants or more complex phonotactic structures are regarded as more marked because they occur in few languages.

This principle applies to both onset and coda consonant clusters. For example, two-consonant clusters in onset position such as /pl/, /pr/, or /tr/ are considered less marked than more complex three-consonant clusters such as /spl/, /spr/, and /str/. The presence of a three-consonant onset cluster in a language implies that the language also permits simple two-consonant clusters, whereas the reverse is not necessarily true. Thus, markedness is defined as " a phenomenon A in some languages is more marked than B if the presence of A in a language implies the presence of B but not vice versa''(Archibald 1998, p.55) .

In the same vein, in coda position, clusters become more marked as their complexity increases. Thus, single final consonants are less marked than two-consonant codas, while three- and four- consonant codas (e.g., the final clusters in *texts* /teksts/ or *strengths* /streŋθs/) are among the most typologically marked syllable structures. These highly complex codas occur in relatively few languages and therefore predicted to pose greater difficulty for L2 learners.

As a result, learners are expected to produce simple onset and coda clusters more accurately than complex clusters and to simplify more marked clusters through processes such as consonant deletion, epenthesis, or cluster reduction.

2.5 Review of the Related Studies

Several studies have explored how Arab learners of English acquire English consonant clusters. The findings generally indicate that Arab learners struggle with English consonant clusters due to the simpler syllable structure of Arabic compared to English. As a result, learners tend to rely on repair strategies such as vowel insertion, consonant deletion, and substitution to reduce the complexity of difficult clusters. The following section reviews the studies most relevant to the present investigation.

Fantazi (2003), who examined 28 LA speakers studying English in the United Kingdom, conducted one of relevant study in Libyan context. The participants were distributed into three main groups according to their level of English: low, moderate, and high level. The study examined the perception and production of English syllable structure and stress by designing three test sections. One of these sections contained picture-based tasks that aim to elicit the production of English CC and CCC consonant clusters in both onset and coda positions. The findings indicated that the majority of participants pronounced CC more accurately than CCC clusters. Vowel insertion was the most repair strategy that employed to reduce the clusters' difficulties. Furthermore, the study found that participants who had greater exposure to English achieved better than those with moderate or low exposure. The study suggested that increased language input assists the acquisition of English syllable structure by English learners.

Elsaghayer (2014), who tested the pronunciation difficulties of LA learners of English at the language Centre of Misurata University, conducted another related study. The study investigated the effect of markedness in learners' articulation of English consonant clusters CC and CCC in onset and coda positions. Eckman's Markedness Differential Hypothesis (MDH) was the theoretical framework of this study. Data were collected through word lists containing target consonant clusters and unstructured interviews with 20 intermediate-level students. The results revealed that CCC onset clusters and CC/CCC coda clusters were the most challenging for learners, who simplified them mainly through the insertion of schwa /ə/ and short/ɪ/. The study concluded that the absence of complex consonant clusters in the learners' L1 was a key contributing to these pronunciation difficulties, and the findings supported the predictions of the MDH.

An important study by Alosaimi (2023) examined the effects of L1 transfer, cluster markedness, and input frequency on the acquisition of English consonant clusters by Hijazi Arabic speakers. The study comprised three experiments: production task, a lexical decision task, and an AX discrimination task. Thirty low-proficiency non-native English speakers participated in all tasks, while 30 native English speakers took part in the perception tasks as a control group. The study focused on English CCVC and CVCC words containing rising and falling sonority clusters. The results showed that learners frequently inserted vowels reflecting the phonological patterns of their first language. Less marked clusters were produced and perceived more accurately than more marked ones, and clusters appearing in high-frequency words were processed more successfully than those in low-frequency words. The study concluded that first language phonotactic knowledge, cluster markedness, and input frequency strongly influence learners' production and perception of English consonant clusters.

In another study, Al-Yami and Alathwary (2021) investigated the pronunciation difficulties of English consonant clusters among Saudi EFL learners. The participants were 134 female freshman students from the English Department at Najran University. Two instrument were used: a pronunciation test and a questionnaire. The framework of Optimality Theory (OT) was employed to interpret this study's findings. The findings showed that participants encountered difficulties producing English consonant clusters in both word-initial and word-final. However, the clusters CCCC in coda position were the most challenge for most learners. The repair strategies that learners utilized to simplify these clusters included vowel insertion, consonant deletion, and substitution. Questionnaire responses suggested that the difficulties were related to limited pronunciation knowledge, insufficient language instruction, and L1 influence. The OT analysis further revealed that onset cluster were mainly affected by first language constraints, whereas coda clusters were more influenced by universal markedness constraints.

A similar study was carried out by Na'ama (2011) on Yemeni university students. The sample consisted of 45 students from different proficiency levels in the English Department at Hodeidah University. Participants were required to read words containing two- and three- consonant initial clusters, as well as two-, three-, and four-consonant final clusters. The findings indicated that learners had difficulties with two- and three- consonant onset clusters. Final clusters consisting of three and four consonants were found to be the most difficult. However, learners did not experience major difficulties with two-consonant final clusters because such clusters also exist in Arabic. The most common repair strategy used by participant was short vowel insertion.

Likewise, Al-Shuaibi (2006) examined the production of English syllable-initial and syllable-final consonant clusters by Yemeni speakers of English at Universiti Sains Malaysia. The study involved 30 Yemeni postgraduate students and adopted Selinker's Interlangauge Theory as its theoretical framework. Data were gathered through passage-reading and word-reading tasks. The findings showed that learners had difficulties producing both initial and final consonant clusters, particularly three-consonant onset clusters and three- and four-consonant coda clusters. Learners demonstrated a strong tendency to insert vowels to simplify difficult clusters, while other repair strategies included deletion and substitution were not widely employed.

To conclude, Al-Saidat (2010) examined the acquisition of English onset and coda consonant cluster by Jordanian undergraduate students. The number of participants was 20 students from the fourth-year studying English Language and Literature at two public universities in Jordan. All participants spoke Amani Arabic dialect. The participants' pronunciation was recorded while reading a word- task. The results illustrated that Jordanian students faced difficulties in the production of both onset and coda consonant clusters. To simplify these clusters, vowel epenthesis was the most repair strategy used by the participants, while consonant deletion and substitution were not used regularly.

Overall. The studies mentioned above illustrate that Arab EFL learners encountered significant difficulties regarding the acquisition of English consonant clusters, particularly in coda position. These studies have investigated how cluster complexity (CC, CCC, or CCCC) influences the accuracy of Arab learners' pronunciation and the repair strategies they employ to simplify these clusters. It has been noticed that the most repair strategies followed are vowel insertion, consonant deletion, and consonant substitution. Although there are wide interest by research on the acquisition of English consonant clusters, only limited studies have focused specifically on LA learners and two main gaps have not addressed extensively by the previous studies. First, few studies have investigated how sonority patterns (rising, falling, and mixed sonority clusters) affect the pronunciation of English consonant cluster in word-final position. Second, little attention has been given to the impact of different proficiency levels among LA learners in acquiring these clusters. Observing these gaps highlights the significance of the current study.

3. Methodology

3.1 Research Design

Gay et al (2012) stated that quantitative design should be involved if a research aims to collect and analyze numerical data to describe, explain, predict, and control phenomena. The current study utilizes a quantitative experimental design in order to examine LA learners' ability in acquiring English coda consonant clusters. This design was selected because all participants completed the same word-reading task under controlled conditions and their performance was measured analytically.

3.2 Research Method

Dawson (2002) showed that the techniques and tools used to collect the data needed for a study are considered as research methods. In the current study, LA learners were recorded to elicit their articulation of English words containing consonant clusters in coda position. Consequently, the main method of data collection in this study was audio recordings, which have been commonly implemented in previous studies examining second and foreign language learners in acquiring English consonant clusters (e.g., Shitaw, 2025; Alsilevani, 2024; Alosaimi, 2023; Al-Yami & Alathwary, 2021).

3.3 Participants

Fifteen Libyan undergraduate students from the English Department at Sirte University were recruited to participant in this. Their age ranged between 19 and 23 years old and all reported normal vision and hearing. These participants were randomly selected from three semesters (first, fifth, and eighth semesters) and grouped to five students from each semester. These three levels of proficiency allowed the researcher to test the influence of English exposure in acquiring English consonant clusters, especially those occurring in the final position of English words.

3.4 Stimuli

The participants were given three lists of English monosyllabic and disyllabic words as a controlled word-list reading task (see Appendix B). These words were chosen to observe participants' pronunciation of consonant clusters in word-final position in accurate way.

For each list, six types of words were arranged in order to gain data that are more comprehensive. The first six words contained CC clusters (e.g., *wax* /wæks/). The second six words included CCC clusters (e.g., *elects* /ɪlekts/). The third six words consisted of CCCC clusters (e.g., *prompts* /prɒmpts/).These word lists were carefully designed by the researcher to include clusters with different levels of complexity.

Furthermore, these words were selected based on learners' familiarity, as Al-Shuaibi (2006, p.252) noted that unfamiliar words in the target language may negatively affect participants' pronunciation performance. Cambridge University Press dictionary was consulted as references for pronunciation (McIntosh, 2013).

The selected words represented different sonority patterns in English coda consonant clusters. Three main sonority patterns were included: rising, falling, and mixed sonority clusters. In rising-sonority clusters, the second consonant is more sonorous than the first consonant, as in /-ps/, /-ts/, and /-ks/. In falling-sonority clusters, the second consonant is less sonorous than the first consonant, as in /-ft/, /-mp/, and /-lt/. According to the SSP, sonority normally decrease toward the end of the syllable in coda position. Therefore, falling- sonority clusters are considered less marked because they conform to the expected sonority pattern, whereas rising-sonority clusters are more marked because they violate the SSP by showing increasing sonority values (cf. Alsilevani, 2024).

The word list also included mixed-sonority clusters, which contain both rising and falling sonority transitions within the same coda cluster. These occurred in words with CCC codas (e.g., /- ŋks/, /-kst/, and /-ndz/) and CCCC codas (e.g., /-mpts/, /-mpʃn/, /-ktfl/, and /-stfl/). These clusters are more complex than rising or falling clusters because they involve multiple sonority changes within a single coda. As a result, they were expected to present greater pronunciation difficulties for the LA learners.

3.5 Procedures of Data Collection

The recordings were conducted in a quiet room at the Language Centre of Sirte University to ensure clear audio quality. Before recording the participants, they were provided with enough time to revise the three lists of words in order to become familiar with the given words. For the clarity, the participants were informed to produce each target word for one time, carefully, and slowly. They were required to pause briefly after pronouncing each word to gain accurate data.

Each recording session lasted about three minutes as each participant was recorded individually. The participants' pronunciations were recorded through using the built-in microphone of an HP laptop and kept in WAV format using Audacity. This process allowed the research to listen to the audio recordings several times for the clarity of analysis and to identify the participants' production errors.

Before taking part in this study, all participants received a consent form explaining the objectives of the study. They were invited to read and sign the form before starting the recording session (see Appendix A).

3.6 Data Analysis

The IPA was utilized as a standardized set of symbols to transcribe the participants' productions (Roach, 2001) in order to compare with the target pronunciations. To ensure accurate identification of the learners' pronunciation, the recordings were played several times and this allowed the researcher to spend about ten minutes analyzing each participant's actual pronunciations by listening, pausing, and replaying the audio. The participants' pronunciation errors were categorized into three main types: vowel insertion, consonant deletion, and consonant substitution. Appendix C showed the actual performance of each participant in three semesters .

The descriptive statistics were performed to analyze the data quantitatively using Microsoft Excel (2013) to calculate rates and classify common errors patterns across the different types of English word-final consonant clusters.

4.Results

The current study's results show the quantitative analysis of Libyan leaners' pronunciation of English word-final consonant clusters. The analysis emphases four main parts: the accuracy of pronunciation across different cluster types, the learners' strategies to simplify the coda clusters, the influence of sonority patterns on the pronunciation of word-final clusters, and the effectiveness of the three proficiency levels on the learners' performance.

4.1 Accuracy of Pronunciation across Different Cluster Types

In this study, 270 pronunciation tokens were collected from 15 participants at three levels of proficiency (first, fifth, and eighth semesters). The participants pronounced three types of English word-final consonant clusters which were two consonants (CC), three consonants (CCC), and four consonant (CCCC) clusters.

Table 4.1: Accuracy Across Cluster Types

Cluster Type	Tokens N	Total Correct	Percentage (%)	Mean	SD
CC	90	81	90.0	4.50	0.81
CCC	90	37	41.1	2.06	0.96
CCCC	90	27	30.0	1.50	1.18

The descriptive statistics illustrated in Table 4.1 show a clear hierarchy of difficulty through three types of clusters. Furthermore, the results show that the length of cluster has a strong influence on LA learners' pronunciation accuracy.

The majority of the participants produced CC clusters with highest accuracy (90.0%). This clusters also had the highest mean score (M=4.50) while the standard deviation was relatively low (SD=0.81), illustrating the fact that the performance of most learners was accurate and consistent. In comparison, the learners' production of CCC clusters dropped to 41.1% with a lower mean score (M=2.06) and a higher standard deviation (SD=0.96), indicating increased challenges in learners' pronunciation of complex coda clusters. The accuracy of CCCC experienced the lowest percentage (30.0%) with the decrease of mean score (M=1.50), and the increase of standard deviation (SD=1.18). The increased variability indicated that four-consonant codas were not only difficult but also inconsistently produced across participants.

These results demonstrate that two-consonant clusters (CC) are not expected to create major difficulties for Libyan learners because such structures are already familiar in their native language. This may indicate that learners are successfully acquiring the target language norms as stated in 2.3.1 above. Taken together, the findings, which are illustrated in the above table and in the following pie chart, provide strong evidence that phonotactic complexity pays an important role in learners' ability to produce English coda clusters accurately.

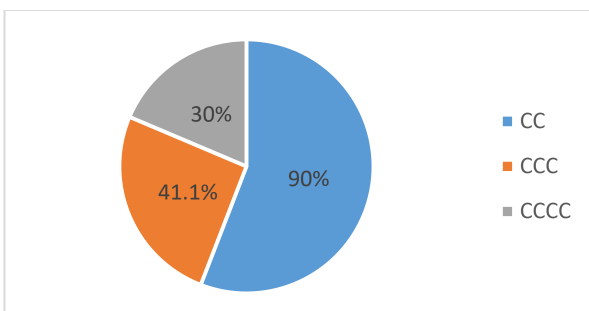

Figure 4.1: The Distribution of Accuracy across Cluster Types

4.2 The Simplification Strategies Used to Produce Coda Clusters

Learners employed a range of phonological strategies to produce coda clusters, as summarized in Table 4.2 below. Five major strategy types were identified: target-like production, vowel epenthesis, cluster reduction (deletion), substitution, and mixed strategies.

Table 4.2: Simplification Strategies across Semesters

Strategy	First Semester	Fifth Semester	Eighth Semester	Total N	Percentage (%)
Target-like production	32 (11.8%)	61 (22.5%)	89 (32.9%)	182	67.4
Vowel epenthesis	68 (25.1%)	41 (15.1%)	22 (8.1%)	131	48.5
Cluster reduction (deletion)	49 (18.1)	33 (12.2%)	19 (7.0 %)	101	37.4
Substitution	21 (7.7%)	14 (5.1%)	7 (2.5%)	42	15.5
Mixed strategies	30 (11.1%)	18 (6.6%)	9 (3.3%)	57	21.1

Note: percentages exceed 100% because some tokens show more than one strategy (e.g. epenthesis+ deletion), which is standard in phonological error analysis.

Across all semesters, vowel epenthesis emerged as the most frequently used repair strategy (48.5%). The high front vowel /ɪ/ and the schwa/ə/ were highly employed to separate difficult consonant sequences. For example, the cluster /-kts/ in *elects*/ɪlekts/ was produced as /-ktəs/ and the cluster /-ksθs/ in *sixths* /sɪksθs/ was produced as /-ksɪtɪs/. The five learners used this repair strategy frequently in the first semester (25.1%). While its used decreased gradually by fifth-semester learners (15.1%) and by eighth-semester learners (8.1%), suggesting that the pronunciation of the target form was mastered by learners as their proficiency increased.

The second most common simplification strategy was consonant deletion (37.4%). It was employed to reduce the pronunciation of CCC and CCCC clusters as both clusters are not found in LA. It was noticed that learners tended to delete one or more consonants while keeping the more sonorous or perceptible sounds. For example, the cluster /-ŋks/ in *banks* /bæŋks/ was pronounced as /-ŋk/ and the cluster /-mpts/ in *prompts* /prɒmpts/ was pronounced as /-mtɪs/. Although learners that are more proficient decreased the use of deletion, advanced learners in eight semester also employed this strategy for simplification (7.0%).

Substitution was less frequent but systematic (15.5%). It included voicing changes (e.g., /p/→ /b/ in *maps*), place-of-articulation substitutions (e.g., /θ/→/t/ in *sixths*), and incorrect realization of inflectional morphemes. It was noticed that several learners failed to distinguish between the plural allomorphs /s/ and /z/, producing *bonds* with /s/ instead of /z/. Similarly, the past tense suffix –ed was often produced as /d/ instead of the target /t/ following voiceless consonants such as -ed in *helped* /helpt/ was produced as /d/ instead of /t/.

Overall, the distribution of strategies across semesters reflects a clear developmental progression from reliance on repair strategies toward increased target-like production as seen in Figure 4.2.

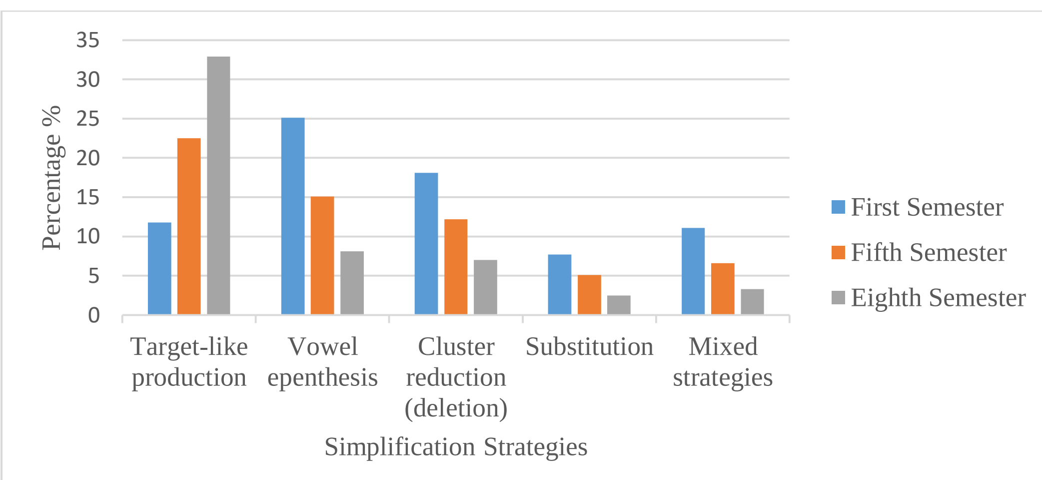

Figure 4.2: The Distribution of Strategies across Semesters

For the clarity of analysis, Table 4.3 below presents the percentage of the simplification strategies by cluster types independently.

Table 4.3: Simplification Strategies by Cluster Types

Simplification Strategy	CC (%)	CCC (%)	CCCC (%)
Target-like production	75.1	56.0	26.7
Vowel epenthesis	21.3	37.3	56.0
Cluster reduction (deletion)	12.9	28.9	39.1
Substitution	12.0	10.2	16.9
Mixed strategies	7.1	16.4	29.3

CC codas showed a high rate of target-like production (75.1%), confirming that two-consonant codas pose relatively little difficulty for LA learners. Repair strategies such as epenthesis and deletion were comparatively rare in this cluster type.

In contrast, CCC codas exhibited a sharp increase in vowel epenthesis (37.3%) and cluster reduction (28.9%), reflecting greater phonotactic complexity. Target-like production dropped to 56.0%, indicating that learners increasingly relied on repair strategies as cluster length increased.

CCCC codas were the most problematic. Vowel epenthesis was highly employed in these types of clusters(56.0%), followed by consonant deletion (39.1%), and mixed strategies (29.3%). Target-like production was detected in only 26.7% of tokens, revealing a clear hierarchy of simplification: CC< CCC< CCCC. The results indicate that LA learners analytically regulate their repair strategies in reaction to increasing complexity of consonant clusters as it is stated in Figure 4.3

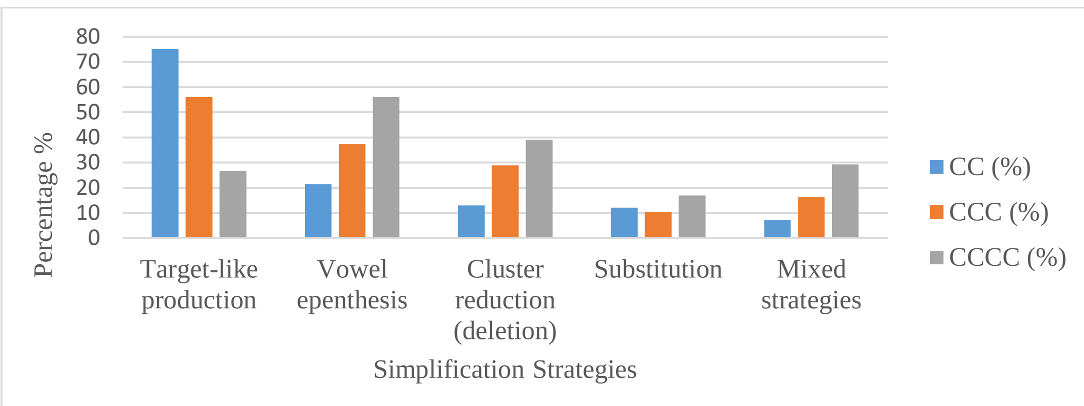

Figure 4.3: The Distribution of Strategies across Cluster Types

4.3 Learners' Pronunciation of Sonority Patterns in English Coda Consonant Clusters

The impact of sonority patterns on LA learners' accuracy in acquiring English coda consonant clusters are summarized in Table 4.4 below.

Table 4.4: Production Patterns by Sonority Type in English Coda Clusters

Sonority Pattern	Correct N	Incorrect N	Total Tokens	Accuracy (%)	Error Rate (%)	Percentage of Total Tokens (%)
Falling	73	32	105	69.5	30.5	38.9
Rising	27	33	60	45.0	55.0	22.2
Mixed	45	60	105	42.9	57.1	38.9
Total	145	125	270	53.7	46.3	100.0

The descriptive statistics illustrate that the clusters that contained both falling-sonority and mixed-sonority patterns accounted for 105 tokens (38.9%), while rising-sonority clusters represented 60 tokens (22.2%) of the total numbers. Learners produced falling-sonority clusters (e.g., /-nt/, /-lt/, and /-lpt/) with the highest level of accuracy as they produced 73 tokens (69.5%) and mispronounced 32 tokens (30.5%). In contrast, rising-sonority clusters (e.g., /-ps/, /-ks/, and /-kts/) showed a lower accuracy rate, with only 27 correct productions (45.0%) and 33 incorrect productions (55.0%). Mixed-sonority clusters (e.g., /-ŋks/, /-kst/, /-mpts/, /-mpʃn/, and /-ktfl/) were the most difficult, with 45 correct productions (42.9%) and 60 incorrect productions (57.1%). Overall, learners correctly produced 145 tokens (53.7%) and incorrectly produced 125 tokens (46.3%), suggesting that sonority pattern influenced production accuracy, with falling-sonority clusters being considerably easier than rising and mixed sonority clusters. Figure 4.4 below further confirms that sonority pattern strongly influences coda cluster production.

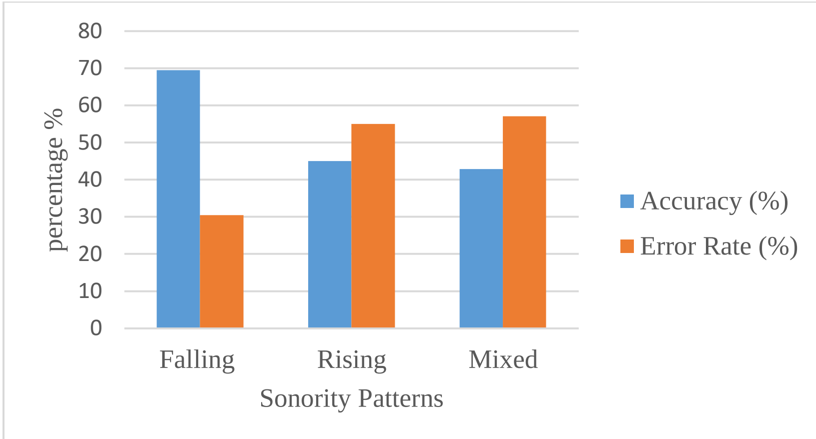

Figure 4.4: The Distribution of Accuracy and Error Production by Sonority Type in Coda Clusters

4.4 Developmental Patterns across Semesters

Finally, Table 4.5 summarizes overall accuracy by semester, regardless cluster type.

Table 4.5: Overall Accuracy by Semester

Semester	Tokens N	Percentage (%)	Mean Accuracy	SD
1st	90	41.1	2.06	1.42
5th	90	54.4	2.72	1.29
8th	90	65.6	3.28	1.11

First- semester learners exhibited the lowest mean accuracy (M= 2.06; 41.1%), accompanied by the highest variability (SD=1.42%), indicating unstable and inconsistent performance. Fifth- semester learners showed moderate improvement (M= 2.72; 54.4%), while eighth-semester learners achieved the highest mean accuracy (M= 3.28; 65.6%) and the lowest standard deviation (SD=1.11).

These results confirm a clear developmental trend: phonological competence in English coda cluster production improves with proficiency and exposure as illustrated in Figure 4.5 below. Although of general progress, four consonant clusters in coda position stay obstacles even for advanced learners, indicating the impacts of markedness.

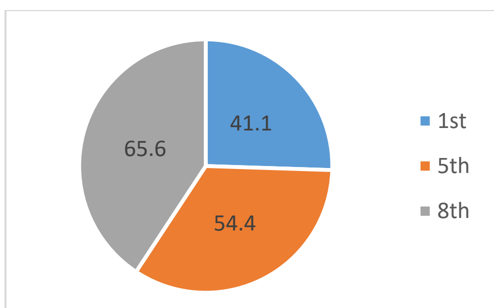

Figure 4.5: The Distribution of Overall Accuracy by Semester

5. Discussion

The current study investigated the acquisition of English word-final consonant clusters by LA learners at three levels of proficiency. It focused on four main aspects namely, cluster complexity, simplification strategies, sonority patterns, and learners' development over time. The findings are deliberated using the Minimal Sonority Distance (MSD) theory (Broselow & Finer, 1991) and the Typological Markedness (TM) theory (Eckman & Iverson, 1993). The study's findings are also compared with the findings of previous studies on Arabic context and associated with the study's four research questions (RQ1-RQ4).

5.1 Cluster Complexity and Accuracy

The effect of consonant cluster complexity on LA learners' production accuracy examines RQ1, which revealed a clear and regular hierarchy of difficulty: CC< CCC< CCCC. This hierarchy was consistent across all proficiency levels and strongly supported both the MSD and the TM frameworks.

From the MSD view, clusters with more sonority distance between adjacent consonants are easy to acquire, whereas clusters with minimal sonority distance are difficult to produce because they are more marked clusters. The high accuracy rates observed for CC clusters reflect the fact that two-consonant codas are already permitted in LA and generally conform to sonority sequencing constraints. As a result, these clusters required minimal phonological restructuring by learners (e.g., /-nt/ in *bent* /bent/, /-sk/ in *ask* /a:sk/, and /-lt/ in *belt* /belt/). From TM perspective, CC clusters was produced more easily because it is present in LA learners' L1 and typologically unmarked.

In contrast, CCC and CCCC clusters involve reduced sonority distance and increased structural complexity, and such sequences are not licensed within LA syllable structure (e.g., /-kts/ in *elects* /ılekts/ and /-lfθs/ in *twelfths* /twelfθs/). The sharp decline in accuracy of these clusters supports the MSD predictions that learners encounter significant difficulty with clusters requiring fine-grained sonority control in highly complex codas environments. Furthermore, the TM framework predicts that CCC and CCCC clusters are typologically marked, thus structures that are both universally marked and absent in the learners L1 are expected to pose greater acquisition challenges. These findings are closely aligned with those reported in previous studies on Arabic-speaking EFL learners, including Na'ama (2011), who found that three- and four-consonant final clusters were the most difficult for Yemeni learners and Al-Yami and Alathwary (2021), who similarly reported that four-consonant coda clusters were the most problematic for Saudi EFL learners. Generally, these findings stress that cluster complexity and markedness form hierarchies of difficulty for acquiring coda cluster across different Arabic-speaking learners.

5.2 Repair Strategies Employed by LA Learners

The investigation of LA learners' simplification strategies answers RQ 2, which examine how LA learners pronounce more marked English word-final consonant clusters. The findings illustrate that learners used systematic and regular strategies, rather than random errors, to avoid the violations of phonotactics and reduce the complexity of difficult consonant clusters.

The most common simplification strategy used across all proficiency levels was vowel epenthesis, providing a strong influence of LA learners' L1. Because LA does not permit complex coda consonant clusters, learners often inserted a short vowel, which were /ɪ/ or /ə/, to produce syllable patterns that are adequate in their native language, such as CV and CCV. Elsaghayer (2014) reported the same finding as it was observed that LA learners frequently employed /ɪ/ or /ə/ to simplify the complexity of coda clusters.

According to the MSD theory, the insertion of vowel leads to increase the sonority distance between neighbouring consonants, making the cluster easier to acquire. From the TM view, vowel insertion decreases markedness by eliminating a complex clusters into a less marked CV or CCV syllable. For example, the cluster /-kst/ in *suffixed* /sʌfıkst/ was often pronounced as /-ksıd/ or /ksıt/, showing that learners preferred to change the syllable pattern rather than produce the target cluster accurately. Similar findings have been reviewed in previous studies conducted on Arabic EFL learners (e.g., Fantazi, 2003; Al-Saidat, 2010; Al-Shuaibi, 2006; Na'ama, 2011; Alosaimi, 2023). The employment of vowel epenthesis declined as the level of learners became more proficient, suggesting that they increasingly became more capable to pronounce marked structure. However, its highly use in CCCC demonstrates that these clusters remained difficult even for proficient learners.

The second most common simplification strategy was consonant deletion, particularly in CCC and CCCC clusters. This finding is aligned with that of Al-Yami and Alathwary (2021), who reported similar patterns among Saudi EFL learners.it was observed that learners usually deleted obstruents and kept sonorants. This pattern is consistent with the TM, which claims that obstruents are more marked than sonorants in coda position. For example, *banks* /bæŋks/ was usually produced as /bæŋk/ and *redemption* /rıdempʃn/ as /rıdemʃn/. These examples provide an evidence that learners were sensitive to markedness differences with word-final consonant clusters.

Substitution was the third repair strategy used, although it was employed less often than vowel insertion and consonant reduction, it highlighted the weakness in learners' phonological and morphological understanding. Most substitution errors involved English inflectional morphemes, such as the plural marker -s and the past tense marker -ed. For example, *bonds* /bɒndz/ was produced as /bɒnds/ and *helped* /helpt/ as /helpd/.These errors propose that inflectional endings increase the obstacles of acquiring word-final consonant clusters. Similar findings have been observed by Elsaghayer (2014), Al-Saidat (2010), Al-Shuaibi (2006), and Al-Yami and Alathwary (2021), who reported that the presence of inflectional morphemes in coda position cause additional level of challenges for Arabic-speaking learners.

5.3 The Influence of Sonority Patterns on the Pronunciation of Coda Consonant Clusters

The investigation of sonority patterns addresses RQ 3, which explores how sonority influence the production of English word-final consonant clusters by LA learners. The findings illustrated that falling-sonority clusters (such as /-nt/, /ft/, and /lt/) were performed with high accuracy by all proficiency levels. LA learners were able to master these clusters because they follow the SSP as sonority decreases toward the end of the syllable. This interprets why CC clusters such as in words *sift* /sıft/, *bent* /bent/, and *belt* /belt/ were produced correctly by all learners even those in the first semester. Furthermore, these clusters exist in LA, making them the least marked and the easiest to acquire according to the TM theory.

Although CCC clusters were considered as difficult clusters than CC clusters, the benefit of falling-sonority clusters showed higher accuracy. For example, LA learners pronounced the falling-sonority CCC clusters /-skt/ in *husked* /hʌskt/ and /-lpt/ in *helped* /helpt/ correctly than other CCC clusters. This suggests that sonority pattern affects the pronunciation of clusters regardless of the complexity of these clusters.

On the other hand, the production of rising-sonority clusters, such as /-ps/ and /-ks/, which do not follow the SPP because sonority increases toward the end of the syllable, observed to be more marked and more difficult than falling-sonority clusters. As a result, learners often employed repair strategies to avoid their difficulties. For example, the CC cluster in *maps* /mæps/ was regularly produced as /-pɪs/ by employing vowel epenthesis or as/-bs/ through voicing substitution, particularly by first- and fifth- semester learners.

The CCC rising-sonority clusters were further more difficult because LA learners had to deal with both obstacles, which were sonority violations and clusters complexity. For example the cluster in *elects* /ɪlekts/ was often produced as /-ktəs/ through vowel epenthesis or as /-kt/ by removing /s/ to avoid the difficulty of rising- sonority cluster /-kts/. These results are consistent with the previous work by Alosaimi (2023), who stated that Arabic EFL learners encountered more difficulty when they pronounced rising-sonority coda clusters than when they produced falling-sonority clusters. Together, these findings confirm the view that sonority patterns play a crucial role in acquiring English word-final consonant clusters by Arabic EFL learners.

Among the three sonority patterns, mixed-sonority clusters proved to be the most challenging. These clusters occurred mainly in complex CCC codas (e.g., /-kst/ in *suffixed* /sʌfɪkst/ and /-ndz/ in *bonds* /bɒndz/) and CCCC clusters (e.g., /-mpʃn/ in *redemption* /rɪdempʃn/ and /-ktfl/ in *respectful* /rɪspektfl/). Because these clusters involve multiple rises and falls in sonority within the same coda while also containing three and four consonants, learners frequently relied on repair strategies.

Overall, the findings demonstrate that both sonority pattern and phonological markedness influence the production of English coda clusters by LA learners. Falling-sonority clusters, which are less marked and compatible with LA phonotactics, were produced with the highest accuracy. In contrast, rising and mixed sonority clusters, which were more marked and less compatible with the learners’ L1, resulted is significant lower accuracy and more frequent use of repair strategies. Taken together, the findings support the predictions of the MSD approach, which proposes that clusters with less favorable sonority relationships are more difficult to produce and support the predictions of TM by showing that increased markedness is associated with pronunciation difficulty.

5.4 Developmental Patterns across Proficiency Levels

The findings related to proficiency development directly address RQ4, which explores how LA learners’ production of coda clusters changes over time. The results showed a clear developmental trend, whereby overall accuracy improved from the first to the eighth semester, and learners’ productions became more stable and less variable as their exposure to English grew. These developmental patterns are in line with the earlier findings of Fantazi (2003), who demonstrated that the level of target language input plays a significant role in shaping learners’ phonological competence, with greater exposure leading to more accurate production of English language.

However, despite overall improvement, the persistence of errors in CCCC clusters even among advanced learners suggests that proficiency alone is insufficient to overcome the effect of high markedness. While eight-semester learners showed greater stability and reduced reliance on epenthesis, CCCC clusters (e.g., /-lfθs/ in *twelfths* /twelfθs/ and/-mpts/ in *prompts* /prɒmpts/) continued to trigger vowel insertion and cluster reduction. According to the TM theory, structures that are both typologically marked and absent in the L1 are expected to show delayed or incomplete acquisition, a prediction that is fully supported by the present findings.

Overall, the findings demonstrated that cluster complexity, typological markedness, sonority sequencing, and developmental factors systematically shaped LA learners’ production of English coda clusters. Developmental improvement is evident, but highly marked structure, particularly rising and mixed sonority clusters remained resistant to full acquisition. The convergence of the present results with the MSD and the TM predictions, as well as with empirical studies, underscores the explanatory power of these frameworks in accounting for the phonological difficulties faced by LA learners.

6. Limitations of the Study

Despite the contributions of the present study, several limitations should be acknowledged. First, the study included a small number of participants and they were chosen from the same academic context. Although this allowed for controlled data collection and clarity of analysis, the findings can not be generalized to the broader group of Libyan EFL learners. Second, the study focused on production data through a word-list reading task. While controlled tasks are effective for eliciting specific phonological structures, they may not fully reflect learners’ spontaneous speech performance.

Finally, the analysis focused on production data only. Perception was not examined, although perceptual abilities are known to pay a crucial role in phonological acquisition. As a result, the absence of perceptual data makes it difficult to determine whether production errors come from articulatory difficulty, perceptual constraints, or both.

7. Conclusion and Recommendations

7.1 **Conclusion**

This study investigated the production of English coda clusters by LA across three proficiency levels, with particular attention to cluster complexity, simplification strategies, sonority sequencing, and developmental patterns. Drawing on the frameworks of the MSD and the TM, the findings demonstrated that learners' interlanguage phonology is systematically constrained by both universal phonological principles and L1 phonotactic limitations.

The results revealed a consistent hierarchy of difficulty based on cluster complexity, with two-consonant clusters(CC) being produced most accurately , followed by three-consonant clusters (CCC), while four-consonant coda clusters were the least accurately produced across all proficiency levels. Although overall accuracy improved with increased proficiency, the same hierarchy persisted, indicating that greater exposure enhance performance but do not fully eliminate the effect of phonotactic complexity.

In addition, learners employed systematic and rule-governed simplification strategies to repair marked coda structures. Vowel epenthesis was highly employed as a repair strategy, especially in CCC and CCCC. This shows a strong influence of learners' L1 as only CC in onset and coda positions are allowed in LA. The second simplification strategy was consonant deletion and employed mainly in complex clusters. Although substitution was not used widely, but it showed that LA learners had obstacles with English inflectional morphemes, especially -s and -ed in word-final position.

The investigation of sonority sequences also illustrated that LA learners pronounced falling-sonority coda clusters with higher accuracy than rising-sonority coda clusters. On the other hand, mixed-sonority coda clusters, exclusively with four consonant clusters (CCCC), stayed the most difficult patterns even for proficient learners. These findings emphasize that both the sequences of sonority and the complexity of clusters influence the pronunciation of English coda consonant clusters. The predictions of the TM and MSD support these finding as the former states that more marked structures which are not found in L1 are more difficult to master, while the latter explains that cluster with less positive sonority relationships are more possible to cause pronunciation obstacles.

Finally, the results showed clear development across the three proficiency levels. Learners became more accurate and consistent as their skill increased. However, highly marked four- consonant clusters remained the most challenging, even for the advanced learners.

7.2 Recommendations

Based on the findings of the current study, some recommendations can be suggested for pedagogical implications and future research.

From a perspective of teaching, the attention should be paid more for English word-final consonant clusters, specifically for CCC and CCCC clusters. English teachers should assist their students in understanding cluster complexity and the various sequences of sonority and illustrate why some clusters within syllable are more challenging than others and how they differ from clusters in LA. Additionally, teaching pronunciation should transfer beyond individual sounds and focus on syllable structure and English phonotactic rules. This can be achieved through involving these topics in EFL courses and providing activities such as phonetic transcription, minimal pair distinctions, and step-by-step exercises that show learners the gradual movement of consonant clusters from simple to more complex. Furthermore, teachers should provide clear instruction on English inflectional morphemes, particularly the production of the ending morphemes –s and –ed, because these endings are produced with various allomorphs, making learners fail to distinguish between them.

For Future research, it is advised that studies should recruit a large number of participants so that the findings can be implemented more confidently to a wide group of learners. Future research could also provide spontaneous speech to examine learners' pronunciation, sentence-reading task, or provide more comprehensive picture of coda cluster production through conversational exercises. Finally, future research could explore the perception-production relationship, investigating whether perceptual difficulty contributes to production errors.

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Appendix C: English Words Containing Consonant Coda Clusters and Their Modifications

Table C.1:The Total Production of Two Consonant Coda Clusters (CC) by Five Students in the First Semester

Words	IPA Transcription	CC	S1	S2	S3	S4	S5
1-wax	/wæks/	/-ks/	/-kɪs/	/-ks/	/-ks/	/-sk/	/-ks/
2-bent	/bent/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/
3-ask	/a:sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/
4-sift	/sɪft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/
5-maps	/mæps/	/-ps/	/-ps/	/-bs/	/-bs/	/-pɪs/	/-ps/
6-belt	/belt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/

Table C. 2: The Total Production of Three Consonant Coda Clusters (CCC) by Five Students in the First Semester

Words	IPA Transcription	CCC	S1	S2	S3	S4	S5
1-elects	/ɪlekts/	/-kts/	/-ktəs/	/-ktəs/	/-kt/	/-kt/	/-kts/
2-husked	/hʌskt/	/-skt/	/-skəd/	/-skəd/	/-sk/	/-skd/	/-skt/
3-banks	/bæŋks/	/- ŋks/	/-ŋkɪs/	/-ŋks/	/-ŋks/	/-ŋk/	/-ŋks/
4-suffixed	/sʌfɪkst/	/-kst/	/-ksɪd/	/-ksɪd/	/-ks/	/-ksɪd/	/-ksd/
5-helped	/helpt/	/-lpt/	/-lbəd/	/-lbəd/	/-lp/	/-lb/	/-lpt/
6-bonds	/ bɒndz/	/-ndz/	/-ndəs/	/-ndəs/	/-nd/	/-nds/	/-ndz/

Table C.3: The Total Production of Four Consonant Coda Clusters (CCCC) by Five Students in the First Semester

Words	IPA Transcription	CCCC	S1	S2	S3	S4	S5
1-sixths	/sɪksθs/	/-ksθs/	/-ksɪt/	/-ksɪt/	/-ks/	/-ksɪt/	/-ksθ/
2-twelfths	/twelfθs/	/-lfθs/	/-lfɪtɪs/	/-lfɪt/	/-lfɪs/	/-lfɪs/	/-lft/
3-prompts	/prɒmpts/	/-mpts/	/-mtɪs/	/-mst/	/-mtɪs/	/-mbt/	/-mpt/
4-redemption	/rɪdempʃn/	/-mpʃn/	/-	/-mʃn/	/-mbɪʃn/	/-mpʃn/	/-mpʃn/

			mbɪʃn/				
5-respectful	/rɪspektfl/	/-ktfl/	/-ktɪfl/	/-ktɪfl/	/-ktɪfl/	/-ktɪfl/	/-ktfl/
6-wistful	/wɪstfl/	/-stfl/	/-stɪfl/	/-stɪfl/	/-stɪfl/	/-stfl/	/-stfl/

Table C.4: The Total Production of Two Consonant Coda Clusters (CC) by Five Students in the Fifth Semester

Words	IPA Transcription	CC	S1	S2	S3	S4	S5
1-wax	/wæks/	/-ks/	/-kɪs/	/-ks/	/-ks/	/-ks/	/-ks/
2-bent	/bent/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/
3-ask	/a:sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/
4-sift	/sɪft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/
5-maps	/mæps/	/-ps/	/-ps/	/-bs/	/-ps/	/-ps/	/-bs/
6-belt	/belt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/

Table C. 5: The Total Production of Three Consonant Coda Clusters (CCC) by Five Students in the Fifth Semester

Words	IPA Transcription	CCC	S1	S2	S3	S4	S5
1-elects	/ɪlekts/	/-kts/	/-kts/	/-kt/	/-ktəs/	/-kt/	/-kts/
2-husked	/hʌskt/	/-skt/	/-skt/	/-skd/	/-sk/	/-skt/	/-skəd/
3-banks	/bæŋks/	/-ŋks/	/-ŋks/	/-ŋkɪs/	/-ŋks/	/-ŋks/	/-ŋks/
4-suffixed	/sʌfɪkst/	/-kst/	/-ksɪt/	/-ksd/	/-ks/	/-kst/	/-ksd/
5-helped	/helpt/	/-lpt/	/-lpt/	/-lbəd/	/-lp/	/-lpt/	/-lpəd/
6-bonds	/ bɒndz/	/-ndz/	/-ndz/	/-ndəs/	/-nd/	/-nd/	/-ndz/

Table C. 6: The Total Production of Four Consonant Coda Clusters (CCCC) by Five Students in the Fifth Semester

Words	IPA Transcription	CCCC	S1	S2	S3	S4	S5
1-sixths	/sɪksθs/	/-ksθs/	/-ksɪtɪs/	/-ksɪtɪs/	/-ksɪθɪs/	/-ksθ /	/-ksθ/
2-twelfths	/twelfθs/	/-lfθs/	/-lfɪtɪs/	/-lfɪtɪs/	/-lfɪs/	/-lfθ/	/-lfθ/
3-prompts	/prɒmpts/	/-mpts/	/-mbɪtɪs/	/-mbɪst/	/-mtɪs/	/-mbɪtɪs/	/-mbt/
4-redemption	/rɪdempʃn/	/-mpʃn/	/-mpʃn/	/-mbɪʃn/	/-mbʃn/	/-mpʃn/	/-mpʃn/
5-respectful	/rɪspektfl/	/-ktfl/	/-ktfl/	/-ktɪfl/	/-ktɪfl/	/-ktfl/	/-ktfl/
6-wistful	/wɪstfl/	/-stfl/	/-stfl/	/-stɪfl/	/-stɪfl/	/-stfl/	/-stfl/

Table C.7: The Total Production of Two Consonant Coda Clusters (CC) by Five Students in the Eighth Semester

Words	IPA Transcription	CC	S1	S2	S3	S4	S5
1-wax	/wæks/	/-ks/	/-ks/	/-ks/	/-ks/	/-ks/	/-ks/
2-bent	/bent/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/	/-nt/
3-ask	/a:sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/	/-sk/
4-sift	/sɪft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/	/-ft/
5-maps	/mæps/	/-ps/	/-bs/	/-ps/	/-ps/	/-ps/	/-ps/
6-belt	/belt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/	/-lt/

Table C.8: The Total Production of Three Consonant Coda Clusters (CCC) by Five Students in the Eighth Semester

Words	IPA Transcription	CCC	S1	S2	S3	S4	S5
1-elects	/ɪlekts/	/-kts/	/-ktəs/	/-ktəs/	/-kts/	/-kts/	/-kt/
2-husked	/hʌskt/	/-skt/	/-skəd/	/-skt/	/-skt/	/-skt/	/-sk/
3-banks	/bæŋks/	/-ŋks/	/-ŋks/	/-ŋks/	/-ŋks/	/-ŋks/	/-ŋk/
4-suffixed	/sʌfɪkst/	/-kst/	/-ksɪd/	/-ksd/	/-kst/	/-kst/	/-ksd/
5-helped	/helpt/	/-lpt/	/-lbəd/	/-lpt/	/-lpt/	/-lpt/	/-lp/
6-bonds	/ bɒndz/	/-ndz/	/-ndəs/	/-ndz/	/-ndz/	/-ndz/	/-nd/

Table C.9: The Total Production of Four Consonant Coda Clusters (CCCC) by Five Students in the Eighth Semester

Words	IPA Transcription	CCCC	S1	S2	S3	S4	S5
1-sixths	/sɪksθs/	/-ksθs/	/-ksɪθ /	/-ksɪtɪs/	/-ksɪθɪs/	/-ksθs /	/-ksθ/
2-twelfths	/twelfθs/	/-lfθs/	/-lfɪθ/	/-lfɪtɪs/	/-lfɪθɪs /	/-lfθs/	/-lfθ/
3-prompts	/prɒmpts/	/-mpts/	/-mbɪt/	/-mpɪst/	/-mpt/	/-mpts/	/-mbt/
4-redemption	/rɪdempʃn/	/-mpʃn/	/-mbʃn/	/-mpʃn/	/-mpʃn/	/-mpʃn/	/-mʃn/
5-respectful	/rɪspektfl/	/-ktfl/	/-ktɪfl/	/-ktfl/	/-ktfl/	/-ktfl/	/-ktɪfl/
6-wistful	/wɪstfl/	/-stfl/	/-stɪfl/	/-stfl/	/-stfl/	/-stfl/	/-stfl/