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| RESEARCH ARTICLE

Faulty Consonant Gemination in the Pronunciation of English Biomedical Terms by Arab Healthcare Professionals

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| ABSTRACT

This study analyzed faulty geminated consonants in English biomedical terms as pronounced by Arab healthcare professionals. Ninety biomedical terms with faulty geminated consonants were collected from the casual speech of 52 Arab healthcare professionals who are YouTubers and medical doctors, pharmacists, nutritionists, radiologists, physical therapists, and lab technicians who work at some pharmacies, hospitals, and polyclinics. Data analysis revealed the subjects' tendency to geminate double consonants /l, r. n, b, t, p/ in penicillin, cannula, collagen, millimeter, heart attack, Ferrus, Ginko biloba, copper, life support due to phonological, orthographic, and psycholinguistic factors rooted in Arabic phonotactics and L1 transfer. The subjects also geminate double consonants in common words used in the healthcare fields (collect, connect, correct, comment, assignment, announcement) due to phonological transfer from Arabic and misinterpretation of English orthography. Arabic has phonemic gemination, where consonant length is contrastive and meaningful (kataba vs. kattaba). Whereas English gemination occurs across word boundary only (immature, that time). This leads to a default tendency to lengthen consonants, especially when they appear between vowels or in stressed syllables. They over-apply gemination in English, even when it is not phonemic. Similarly, single final consonants in up, cut, shut, gel were geminated due to L1 phonological transfer, phonotactic repair strategies, and perceptual habits rooted in Arabic. These words resemble Arabic monosyllabic words ending in true geminates (رَبّ/rab:/ God, حبّ /ħub:/ love). Arabic speakers geminate final consonants in these words for clarity or emphasis. By contrast, the subjects do not geminate double letters in (Accu-Check, mammography appendix, tranquillizer, capillaries) where double consonants occur in unstressed syllables, across syllable boundaries or in one syllable withing the words. Here, the subjects do not apply gemination because they do not perceive a morphological boundary that justifies it, contrary to collect or connect, where the prefix co- or con- is salient. Common words as (communication, aggressive, immune, happen, difference, stopped, sitting, hopping) contain morphological doubling but Arabic speakers often recognize inflectional suffixes where the double consonant is a spelling convention and such words are frequently used in academic and clinical contexts. Further results and recommendations are given in detail.

| KEYWORDS

Double consonants, gemination, true gemination, English biomedical terms, Arab healthcare professionals, pronunciation problems, geminating double consonants.

| ARTICLE INFORMATION

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1. Introduction

In phonetics and phonology, gemination[1] is consonant lengthening for a longer period of time than that of a singleton consonant. In many writing systems, gemination is often perceived as a doubling of a consonant and is represented by double letters. Consonant gemination and vowel lengthening are independent in languages such as Arabic, Japanese, Estonian, Finnish.

[1] https://en.wikipedia.org/wiki/Gemination

However, in Norwegian, Swedish, and Italian, vowel and consonant length can be interdependent. A short vowel, in Norwegian and Swedish, always precedes geminated consonants, and a long vowel precedes ungeminated consonants. In English, there is no phonemic consonant geminates within a word, even when words are spelled with double letters as in *announcement, appendix, accommodate, assortment, command connection, corrupt,* and *arrive*. These double letters are pronounced as a single phoneme. Gemination in English only occurs across word boundaries, i.e., at the junction of words as in *unnecessary, immature, irreversible, illegitimate,* and between two words: one ending and the other beginning with the same consonant as i*big gate, 'that time', 'big gun*'. This means that in English, gemination never occurs within a word like '*essay*', or '*announce*', even if a word is spelled with double consonants.

By contrast, Arabic has true gemination. It is a prominent feature of the Arabic phonological system. Geminates or double consonants occur very frequently in word medial and word final positions as in ʕ*adda 'counted', mahhada 'paved the way'; kattaba* 'made someone write'. In Arabic, gemination is phonemic, meaning that it can distinguish word meanings. In the Arabic orthographic system, gemination in not represented by double consonants spelled together. Rather, it is shown by a diacritic (*ḥaraka*) called shadda شدة ّ placed on top of a single consonant to show that there is a double consonant even though one consonant is spelled. In pronunciation, geminated consonants are usually lengthened and doubled. The *shadda* marks a difference in meaning in words that differ only in the doubling of a consonant as كتب katab (he wrote) and كتّب (made someone write) and distinguishes مدرّسة *mudarrisa "female teacher"* from مدرسة *madrasa "school"*. Arabic syllables favor heavy (CVC or CVV) or superheavy (CVVC, CVCC) structures, making gemination a natural feature. (Al-Jarf, 2022; Al-Jarf, 2007; Al-Jarf, 2003; Al-Jarf, 1994a; Al-Jarf, 1994b).

Being a prominent phonological feature in some languages but not others, comparisons of gemination in some language pairs were the subject of some studies in the literature as glottalization, pre-aspiration and gemination in English and Scandinavian (Kortlandt-Leiden, 2003); "fake" gemination in suffixed words and compounds in English and German (Kotzor, Molineaux, Banks, & Lahiri, 2016); gemination in English loans in American varieties of Italian (Repetti, 2009); production of English geminate consonants by Thai learners (Thirakunkovit, 2020); production and perception of geminate consonants in English words by Thai learners of English with implications for English teaching and learning (Thirakunkovit, 2021); the effects of orthographies, stress and consonantal manners on syllabification and acoustic durations of intervocalic consonants with singleton and geminate graphemes by Thai speakers of English (Saechan, & Ruangjaroon, 2024); and the phenomenon of gemination in English and Arabic (Mubarak & Jebur, 2018).

Due to the differences between the English and Arabic phonological systems, numerous studies in the literature examined the problems that L2 students have in transliterating, spelling and pronouncing geminated consonants. For example, analysis of a sample of 406 English transliterations of Arabic personal names with geminates revealed that one third of the Arabic name tokens with geminates were transliterated correctly, i.e., represented by a double consonant in English transliteration (*Noureddin, Abdullah, Nassar, Allam, Alqattan, Algammal)*. In 41% of the name tokens, the geminate was represented by a single consonant (*Amool, Amouna, Hamam, Elzahar, Sedeek, Elnagar, Fatouh)*. In 26%, a single consonant was doubled, although the Arabic name has no geminates and the consonant is pronounced as a single phoneme (*Anass*, *Ahmmed, Quassem, Ossama, Wissam, Sammar, Youniss, Yassin)* (Al-Jarf, 2022). Results of another study about the gemination of consonants preceding the Feminine Plural suffix /-a:t/ showed that the stops /p, b, k, g/, fricatives /f, ʃ, tʃ, dʒ/ and graphemes {ll}; {lla}, {ette} are geminated in some loan stems before the plural suffix /a:t/ as in مانشيتات /manʃitt+a:t/ *manchettes (headlines)*, بروفات /proof+a:t/ *professors*; تاتشات **/**tatʃtʃ+a:t/ *touches;* تريلات /trilla+a:t/ *trailers;* كليبات /klippa:t/ *clips.* In 48% of the loanwords, the final consonant of the stem is not geminated before /a:t/ (ماركتات /ma:rkita:t/ *markets)* due to the long vowel in a preceding syllable (Al-Jarf, 2024).

In spelling, EFL learners make insertion, deletion, or substitution errors in double consonants/letters (they writing *committee* instead of *committee; acomodate* for *accommodate*). Gemination errors in spelling are due to Arab students' tendency to shorten or drop double consonants (*address* for *address*); L1 (Arabic) interference (*ocur* for "*occur*) and the misapplication of Arabic phonetic rules, leading to double consonant misspellings (*beginning* for *beginning*). Arab EFL learners often omit or misplace double consonants in English. They add double consonants unnecessarily due to L1 Arabic influence (*happpy* for *happy* or *committe* for *committee*). They hypercorrect and overapply double letters (*qaddama* [he presented]); omit double consonants in English words where they are required (*apointment* for *appointment*; *sucess* for *success*). This reflects orthographic transfer from Arabic, where consonant length is phonemic (not orthographic). They struggle with silent letters near double consonants (*writtten* for *written*; *knitt* for *knit*). They cannot distinguish phonetic geminating (Arabic) vs. orthographic doubling (English). Unstressed syllables trigger erroneous doubling (*occured* for *occurred*) due to mismatched stress-gemination patterns. Poor spellers hear geminated consonants in English where none exist (*grammar* > *grammer*) (Al-Jarf, 2019; Al-Jarf, 2010b; Al-Jarf, 2009; Al-Jarf, 2008a; Al-Jarf, 2008b; Al-Jarf, 2008c; Al-Jarf, 2007a Al-Jarf, 2005a).

In pronouncing English Proper Nouns, Arabic speakers make consonant gemination errors in city and country names *(Peking; Venezuela, Minnesota)* in addition to other types of pronunciation errors (Al-Jarf, 2022).

In Iraq, British and Iraqi English undergraduate students had difficulties pronouncing true geminates in Arabic. Iraqi students struggled with English "fake" geminates due to L1 transfer, while British students mispronounced Arabic geminates by shortening them. Iraqi students applied Arabic gemination rules (lengthening consonants unnecessarily as in "*unnamed,*" where double letters do not indicate actual lengthening. On the contrary, British students mispronounced Arabic true geminates, reflecting L1 phonological constraints. They failed to properly elongate Arabic true geminates. Instead, they shortened them (Ahmed & Sameer, 2016) .

In Jordanian Arabic, speakers overgeneralize gemination in borrowed words. They insert gemination (consonant lengthening) where it does not exist in the original English pronunciation. On the contrary, English native speakers perceive geminated loans as unnatural or overly emphatic ("*accent*" pronounced as /a:ksent/). These persist patterns in EFL learners, affect intelligibility in medical and professional settings ("*allergy*" > /alːerdʒi/) (Guba, 2021)

Regarding mispronunciations of geminated consonants in medical terms, Albaaly (2022) noted that Egyptian medical educators make gemination errors as in *patella* /pəˈtɛlə/ > /pæˈtella/) among other errors as confusing vowels as /æ/ (*cat*) and /ɑː/ (*cart*) & Schwa (/ə/), deleting unstressed syllables (*clinical* > /klɪnɪkl/ instead of /ˈklɪnɪkəl/); mispronouncing dental fricatives: /θ/ > /t/ (*therapy* > /terəpi/), /ð/ > /d/ (*this* > /dis/); omitting consonants in clusters (*streptococcus* >/septokokus/); using incorrect word stress (*DIagnosis* > *diagNOsis*), syllable-timed rhythm (L1 Arabic influence) and disrupting English stress-timed patterns. These mispronunciation problems lead to frequent pauses and hesitation due to lack of automaticity and the overuse of fillers (*uh, erm*) in lectures.

In India, Khan & Salam (2019) noted that Arab medical students make vowel distortions as in merging /ɪ/ and /iː/ (*ship* vs. *sheep*); shortening long vowels (e*beat* > /bɪt/)', geminating (over-lengthening) consonants (*allergy* > /alːerdʒi/), inserting glottal stops /ʔ/ for silent letters (*psychology* >/ʔsaɪkɒlɒdʒi/), voicing confusion: /p/ > /b/ (*patient*> /beyʃənt/), stress misplacement (*HOsPital* > *hosPiTAL*), flat or rising intonation in statements, reducing clarity and mispronouncing medical terms due to orthography (*colon* > /koʊˈlɒn/ instead of /ˈkoʊlən/).

All prior studies reported above focus on Arab students' gemination problems in loanwords in Arabic. Some focused on gemination errors in pronouncing names of cities and countries; others focus on medical students' mispronunciation of certain consonants, vowels, and consonant clusters, stress, with gemination as a secondary issue. There are research gaps in the area of gemination problems. Most studies focus on segmental errors (/θ/ > /t/) or stress, while gemination is overlooked despite its impact. Specifically, there is insufficient focus on gemination as a problem in the pronunciation or medical terms by medical students and healthcare professionals. Therefore, this study aims to fill a gap in this area by examining faulty geminated consonants in the pronunciation of English biomedical terms produced in casual speech of Arab healthcare professionals as pharmacists, doctors, dentists, nutritionists, radiologists, physical therapists, lab technicians, and others. Additionally, the study aims to find out whether the faulty gemination in biomedical terms is interlingual, intralingual or developmental.

Investigating faulty gemination in the pronunciation of English biomedical terms by Arab health professionals is critically important for several reasons, particularly in the context of healthcare communication, patient safety, and professional credibility. In emergencies, misheard terms (drug names like *(Lopressor* vs. *Lopresor*) could lead to errors in treatment. In high-stakes medical contexts, faulty gemination may lead to misunderstandings between professionals or with patients. Faulty gemination (over-lengthening of consonants) can distort word meaning or confuse listeners ("*malaise*" vs. "*mal-aise*" with a geminated /l/). It can disrupt English stress-timed rhythm, making speech sound unnatural ("*rehabilitation*" > /reːhabɪlɪˈteɪʃən/). Pronunciation accuracy is also important for professional credibility and intelligibility. Non-native-like pronunciation (*appendicitis* > /apːendɪˈsaɪtɪs/) may reduce perceived competence or trustworthiness. In international collaborations and academic presentations, faulty gemination can hinder seamless communication among multilingual teams. When faulty gemination become habitual in casual or professional speech, they risk fossilizing, especially if left uncorrected in early training. Investigating these patterns allows for a nuanced understanding of how Arab professionals navigate linguistic identity and intelligibility in globalized medical environments.

Moreover, this study is part of a series of studies by the author on weakness that Arab students and professional have in pronouncing English general and specialized vocabulary as splitting unsplittable foreign words in casual speech (Al-Jarf, 2025a); vowel pronunciation errors in English biomedical terminology by Arab healthcare professionals *(*Al-Jarf, 2025b); mapping pronunciation errors in English silent consonants by Saudi EFL undergraduates (Al-Jarf, (2025c); gemination and degemination before the feminine sound plural suffix in native and loanwords in Arabic (Al-Jarf, 2024); gemination errors in Arabic-English

transliteration of personal names on Facebook (Al-Jarf, 2022b); clipping of borrowings in spoken Arabic (Al-Jarf, 2023a); absence of vowels in the English spelling of Arabic personal names on social media (Al-Jarf, 2023); proper noun pronunciation inaccuracies in English by educated Arabic speakers (Al-Jarf, 2022d); student-interpreters' foreign proper noun pronunciation errors in English-Arabic and Arabic-English media discourse interpreting (Al-Jarf, 2022e); and lexical shortening and blending as an innovative word formation process in Arabic (Al-Jarf, 2023c).

Finally, revealing faulty gemination helps educators design targeted pronunciation interventions. For example, contrasting Arabic true geminates with English "fake" geminates (Ahmed & Sameer, 2016) can clarify that English double letters (*summer*) do not signal consonant length. Explicit instruction in syllable structure, stress timing, and segmental phonetics is essential in ESP (English for Specific Purposes) curricula for medical professionals.

2. Methodology

2.1 Subjects

A sample of 52 healthcare professionals, including pharmacists, medical doctors, dentists, radiologists, physical therapists, dermatologists, nutritionists, lab technicians, hospital administrators and others. 45% are YouTubers with healthcare channels on YouTube and 55% of the participants work at pharmacies in Riyadh, and 5 hospitals and polyclinics. Healthcare professionals in the sample are all Arab. They speak with the patients, customers or the general public and followers on YouTube in Arabic but occasionally insert English biomedical terms as names of diseases, symptoms, ingredients and active substances and medications. All the participants studied in English in college. Non-Arab healthcare professionals were excluded.

2.2 *The Gemination Error Corpus*

A sample of 90 biomedical terms with faulty geminated consonants was collected from the spontaneous speech of Arab healthcare professionals who are studying or have studied medicine, dentistry, pharmacy, radiology, physical therapy, nutrition, nursing and so on in English as a foreign language. The author collected the biomedical terms with faulty consonant gemination from observations of the subjects in natural conversational situations, whether they were speaking in Arabic and code-mixing Arabic with English words, or they were fully speaking in English. In collecting the data, the author used the diary methodology. Only errors in geminated consonants in English biomedical terms were recorded. The set of biomedical terms with faulty geminated consonants and how the faulty terms are pronounced by each subject was recorded together with a transcription of their faulty geminated consonants. No tests, interviews or questionnaire surveys were used. The subjects were not prompted or given any stimuli to produce biomedical terms with faulty geminated consonants.

- Faulty geminated double consonants in biomedical terms*: Amoxicillin, Ampicillin, Penicillin, Cannula, Medulla, Patella, Bacillus bacteria, Cellulitis, Cholestasis, Collagen, Colloid, Feroglobin, Ferrus, Hydroferrin, Innominate, Malléolus , Vellus, Labello, Ginko biloba***, *Telofill, Folliculitis, Glomeruli, Millimetre, milligram, copper, heart attack, Life support*
- Faulty geminated double consonants in general words used in the healthcare fields: *account, allow, allowance, announce, announcement, around, arrive, assignment, collaboration, commence, comment, correct, correction, corruption, effect, affect, immediately, immense, select, selection, suppose, assess , assessment, collection, collect, connection, connect.*
- Geminated single consonants in word final syllables*: Up, Cut, Shut, Gel.*
- Ungeminated double letters in biomedical terms: *Accu-Check, Allele, Allergy, Allograft, Allosteric, Appendix, Ballottement, belly, Bulla, Bullous, Capillaries, Cellulite, Fallopian tubes, Hallux, Mammography, Papillary, Phallus, Tonsilitis, Tranquillizer*.
- Ungeminated double letters in common words: *communication, aggressive, immune, happen, differ, difference, stopped, admitted, sitting, permitted, robbed, hopping.*

2.3 *Data Analysis*

The pronunciation of each term was verified by Google Translate and Copilot. The standard pronunciation of each term in the sample was transcribed by Copilot and Gemini AI using the International Phonetic Alphabet (IPA). The subjects' pronunciation was transcribed by the author using the symbols of the International Phonetic Alphabet (IPA). Results of the analysis are reported qualitatively. The percentage of subjects who pronounced the terms with faulty geminated consonants was not calculated as what matters in this study is the faulty consonant gemination, not the frequency of subjects producing each gemination error.

The sources of faulty consonant gemination were classified into (i) interlingual errors that refer to L1 interference, i.e., those transferred from the speakers' native language; (ii) intralingual errors, i.e., those arising from within the target language (L2), such as overgeneralization or incomplete rule application, and (iii) developmental errors, i.e., those reflecting stages in language acquisition, often shared by both L1 and L2 learners.

3. Results

3.1 *Faulty Geminated Consonants in Biomedical Terms*

Healthcare professionals in the current study tend to pronounce the biomedical terms in set 1 in Table 1 with a geminated /l, r. n, b, t, p/. The gemination of consonants in *amoxicillin*, *penicillin*, *cannula*, *collagen*, *folliculitis*, *millimetre* …etc can be explained by a combination of phonological, orthographic, and psycholinguistic factors rooted in Arabic phonotactics and transfer from L1 (Arabic). First, gemination (consonant lengthening) in Arabic is phonemic which means that it can change word meaning (*darasa* [he studied] vs. *darrasa* [he taught]). This prominent feature leads Arabic speakers to over-apply gemination to English words, especially when they see double letters (*milligram* > /mil:ɪgræm/). They geminate double consonants within words even when English phonology does not geminate them as English has fake gemination in *Penicillin* > /pen:ɪsɪlɪn/ instead of /ˌpɛnəˈsɪlɪn/ … etc. English often uses double letters for morphological or etymological reasons, not phonetic length. However, when Arab healthcare professionals see double letters, they geminate them as in *collagen*, *colloid*, *cellulitis*, *malleolus* > geminated /l/ or /s/, due to spelling and repeated letters (*Millimetre*, *milligram* > geminated /l/ and /m/ & *Cellulitis* > /sel:ulaitis/ instead of /ˌsɛljʊˈlaɪtɪs/).

Secondly, Arabic is more syllable-timed, while English is stress-timed. This mismatch leads to equal emphasis on all syllables, which may be reinforced by gemination, misplaced stress and unnatural rhythm in polysyllabic terms like *cholestasis*, *folliculitis*, or *glomeruli*.

Despite that, few biomedical terms with a single consonant were geminated and terms with double consonants were not geminated. For example, *cannula*, pronounced /ˈkænjʊlə/ with no gemination in English. Although it is spelled with a single /l/, but Arab healthcare professionals may not perceive the weak schwa in the final syllable and instead over-articulate the /l/, especially in the absence of corrective feedback. Arabic syllable structure favors heavy or superheavy syllables (CVC, CVVC, CVCC). To adapt unfamiliar English syllables, Arab healthcare professionals geminate consonants to "repair" perceived gaps, simplify stress patterns, overcompensate for consonant clusters, or schwa reduction (*Cannula* > /kan:ula/ instead of /ˈkænjʊlə/). Although *cannula* contains a double /n/, Arabic speakers often geminate the single /l/ instead, not double /nn/. This may be due to visual salience of the final syllable, the sequence *-ula* resembles Arabic patterns with geminated /l/ in native words as (ملا *mulla*, كلا *kalla,* ألاّ */ʔal:aː/,* مازولا *Mazola*). Arabic preference for heavy syllables results in geminating the single /l/ in *cannula* > /ˈkanjʊl:a/, creating a CVC syllable, aligning with Arabic phonotactic preferences. Additionally, the /l/ is a lateral approximant that is more perceptually salient and easier to lengthen in casual speech than nasal /n/. Arabic speakers may unconsciously stress or emphasize the /l/, especially in rapid or emphatic speech. It seems that Arab health professionals are transferring Arabic lexical templates ending in -la or -lla (e.g., مفصلة *mufassala*, مجلة *majalla*, ملاحة *mallaḥa*), which may subconsciously influence the pronunciation of *cannula* as /kanjʊl:a/. This is a form of template transfer, where familiar L1 morphological patterns override L2 phonology.

Another example of single consonant gemination is /b/ in the final syllable of *Biloba,* mispronouncing it as /bɪˈlobːa/ instead of the correct /bɪˈloʊbə/) in English. This might be attributed to phonemic gemination in Arabic, where consonant length is contrastive and meaningful (e.g., *sabar* vs. *sabbār*). Arabic speakers subconsciously geminate single consonants to conform to familiar rhythmic or syllabic patterns. The gemination of the b in *biloba* pronounced /bɪˈlo:bːa/ is similar to that in أوروبّا /ʔurubːa/ *Europe*, where the geminated /bː/ is phonemic and orthographically reinforced. Arabic has many other words ending in - بّا (أوروبّا, حبّا, ربّا) where the /b/ is geminated and followed by a long vowel. This is a case of template transfer, where the speaker imposes a native phonological structure onto a foreign word. Arabic favors heavy or superheavy syllables (CVC, CVVC, CVCC). The final syllable in *biloba* /bə/ is light and unstressed in English. To "repair" this, Arab speakers may geminate (lengthen) the /b/ to create a CVC syllable (/bːa/), making it feel more rhythmically complete. This aligns with Arabic metrical preferences and enhances perceived clarity.

The gemination of /b/ in *biloba* by Arab speakers is not due to spelling. It is a clear case of L1 (Arabic) phonotactic transfer, reinforced by analogy with Arabic words like أوروبّا. It is also due to the Arabic phonemic gemination system, the syllable structure preferences, hypercorrection in unfamiliar lexical items and lack of auditory exposure to native pronunciation. It reflects Arabic's preference for geminate consonants, heavy syllables, and rhythmic balance, especially in unfamiliar or Latinate terms.

3.2 *Faulty Geminated Consonants in General Words Used by Health Professionals*

Arab speakers often geminate consonants in English words in set 3 in Table 1 (*account, allow, appointment, effect, collect,* and *connect*) due to phonological transfer from Arabic and misinterpretation of English orthography. Arabic has phonemic gemination, where consonant length is contrastive and meaningful (*kataba* vs. *kattaba*). This leads to a default tendency to lengthen consonants, especially when they appear between vowels or in stressed syllables and thus over-apply gemination in English, even when it is not phonemic as in *allow* > /al:aw/ instead of /əˈlaʊ/ & *effect* > /ef:ekt/ instead of /ɪˈfekt/. English often uses double letters for morphological or etymological reasons, not to indicate actual gemination. However, Arabic speakers may

interpret them as cues for consonant length as in *collect*, *connect*, *correct*, *comment*, *assignment*, *announcement*, *comment* with geminated /l/, /n/, /r/, /m, s/. Moreover, Arabic favors heavy syllables (CVC, CVVC, CVCC). To adapt English syllables that feel "light" or weak, speakers geminate to strengthen syllables or anchor stress especially in words with schwa or reduced vowels (e.g., *around*, *immediately*), gemination may serve as a compensatory strategy.

3.3 *Faulty Geminating of final consonants*

Arab healthcare professionals in this study often geminate the final consonants in words like *cut* > /kʌtː/, *shut* > /ʃʌtː/, *gel* > /dʒelː/ due to L1 phonological transfer, phonotactic repair strategies, and perceptual habits rooted in Arabic. In these words, Arabic speakers tend to emphasize final consonants in isolated or emphatic speech for clarity or emphasis. This is partly due to Arabic's CV(C) syllable structure preference and the need to show stress or clarity at the end of a word, Arabic speakers may over-articulate or lengthen them to avoid perceived truncation. Unlike Arabic, final consonants in English are often short and unreleased, especially in casual speech.

Furthermore, the English monosyllabic words *up, cut, shut,* and *gel* are often geminated by Arab speakers because they closely resemble Arabic monosyllabic verbs that end in true geminates, such as: ربّ /rabː/ God, حبّ /ħubː/ love, صدّ/sˁadː/ repel, push away, or to block, ردّ */radd/ reply,* مدّ */madd/ extend,* شدّ */ʃadd/ pull, tighten,* مرّ */marr/ pass by,* مسّ */mass/ touch,* لمّ */lamm/ collect, gather,* فكّ */fakː/ disassemble,* فنّ */fanː/ art,* شقّ */ʃaqː/ split, crack, cleave, or tear apart ,* جوّ */dʒawː/ atmosphere,* كيّ */kajː/ iron, xuaterize,* ملّ */malː/ be bored,* رفّ */rafː/ shelf,* فظّ */faðː/ rough, rude,* فذّ */fœðː/ peerless, exceptional, unparalleled.* These Arabic verbs are phonemically geminated which means that the double consonant is essential to the word's identity and meaning. This creates a phonological template in the Arabic speaker's mind, where the final consonant is long and tense. Such verbs trigger gemination in English due to phonological analogy. When Arabic speakers encounter English monosyllables with a similar CVC structure (e.g., *cut*, *shut*, *gel*), they subconsciously match them onto Arabic geminate templates, producing *cut* > /kʌtː/, *shut* > /ʃʌtː/, *gel* > /dʒelː/, *up* > /ʌpː/. These English words are often spoken with final consonant release or aspiration, which may be misperceived as lengthening. To an Arab's ears, a clipped or unreleased final /t/ or /p/ may sound incomplete, prompting compensatory gemination.

3.4 *Ungeminated Double Letters in Biomedical Terms*

Although words in set 4 in Table 1 (*Accu-Check, allele, allergy, appendix, cellulite, mammography, tranquillizer… etc.*) contain double letters, Arab healthcare professionals do not typically geminate them due to phonetic, orthographic, and prosodic cues that differ from the conditions that usually trigger gemination in speech. In many of these terms, the double consonants occur across syllable boundaries or in unstressed syllables, which reduces the likelihood of gemination. The double /ll/ is not pronounced as a geminate in *tranquillizer* /ˈtræŋkwəlaɪzər/ as the /ll/ is part of the same syllable, not two, whereas in words like *collect, connect, correct, comment*, the double consonants often appear at a morpheme boundary (*con-nect*), in which case the double consonants fall in two consecutive syllables, thus they are geminated. This aligns with Arabic morphological patterns that favor gemination.

Additionally, gemination in Arabic typically occurs in stressed syllable-final or morphologically significant positions. These English words do not match that pattern. Words like *allele, bulla, phallus, and hallux* are learned borrowings from Latin or Greek, and their internal structure is not transparent to most Arab learners. As a result, Arab healthcare professionals treat them as monomorphemic units, not as roots with affixes. They do not apply gemination because they do not perceive a morphological boundary that would justify it, unlike *collect* or *connect*, where the prefix *co-* or *con-* is salient. In native English pronunciation, double letters are not phonetically lengthened in *Allele* > /əˈliːl/, not /əlːiːlː/; *Bulla* > /ˈbʊlə/, not /bʊlːaː/; *Cellulite* > /ˈsɛljʊlaɪt/, not /selːulait/. Arab healthcare professionals who are exposed to correct auditory models tend to imitate the fluent, un-geminated rhythm, especially in medical training environments. Moreover, many of these terms are frequently used in clinical contexts, and Arab professionals may have had repeated exposure to their correct pronunciation. Terms like *allergy, appendix,* and *mammography* are part of routine medical discourse. This repeated exposure helps stabilize correct pronunciation and reduce the likelihood of L1 interference.

3.5 *Ungeminated Double Letters in Common Words*

Arab speakers do not typically geminate double consonants in words like *communication, aggressive, immune, happen, differ, difference, stopped, admitted, sitting, permitted, robbed, hopping* for several phonological and morphological factors that distinguish these words from those where faulty consonant gemination is common. Many of these words contain morphological doubling due to inflectional suffixes: *stopped, robbed, admitted, permitted, sitting, hopping*. Arab speakers often recognize these as past tense or participle forms, where the double consonant is a spelling convention to preserve vowel quality (*hop* > *hopping* vs. *hope* > *hoping*). They do not interpret the double consonant as requiring gemination. Similarly, in words like *communication /kəˌmjuːnɪˈkeɪʃən/, aggressive /əˈgresɪv/, immune /ɪˈmjuːn/, difference /ˈdɪfərəns/,* the double consonants occur in unstressed syllables or across syllable boundaries. They occur in one syllable within the words. In this case, English phonology does not

lengthen the consonant. Arab speakers tend to follow the rhythm of the word, especially when the stress is clearly marked elsewhere.

Unlike words such as *collect*, *connect*, or *comment* which resemble Arabic morphological patterns with gemination as (صنّف /sˤanːaf/ *classify*, *categorize*, *sort;* عطّل /ʕatːal/ *disable*, *disrupt*; سلّم /salːam/ *hand over*, *deliver*, or *greet*; خصّص /xasːasˤ/ *allocate*, *designate*, *assign*), these words do not easily match Arabic templates that would trigger gemination. These lack similarities with Arabic words with gemination. Words like *happen, differ, immune, and communication* are frequently used in academic and clinical contexts, and Arab healthcare professionals often hear them pronounced correctly. This reinforces the correct non-geminated form and reduces the likelihood of L1 interference. Words like *collect, correct, comment, and connect* are more prone to faulty consonant gemination because They have prefix-root structures (e.g., *con-nect*, *col-lect*) and the prefix boundary aligns with Arabic morphological patterns that favor gemination. In contrast, *happen, immune, and sitting* are monomorphemic or inflectional, not triggering the same phonological reinterpretation.

Table 1: Biomedical Terms with and Without Geminated Consonants

(1) *Biomedical terms with geminated consonants*	Amoxicillin, ampicillin, penicillin, cannula, medulla, patella, bacillus bacteria, cellulitis, cholestasis, collagen, colloid, telofill, folliculitis, millimetre, milligram, vellus, malleolus glomeruli**,** Labello, Feroglobin, Ferrus, Hydroferrin, innominate, heart attack, life support, Copper, Ginko biloba**.**
(2) General words used by health professionals	account, allow, allowance, announce, announcement, appointment, around, arrive, assignment, collaboration, commence, comment, correct, correction, corruption, effect, affect, immediately, immense, select, selection, suppose, assess , assessment, collection, collect, connection, connect.
(3) *Geminating final consonant*	Up, Cut, Shut, Gel,
(4) Biomedical terms with ungeminated double letters	Accu-Check, allele, allergy, allograft, allosteric, appendix, ballottement, belly, bulla, bullous, capillaries, cellulite, fallopian tubes, hallux, mammography, papillary, phallus, tonsilitis, tranquillizer.
(5) Common words with ungeminated double letters	communication, aggressive, immune, happen, differ, difference, stopped, admitted, sitting, permitted, robbed, hopping.

4. Discussion

Data analysis showed that Arab healthcare professionals in the current study tend to geminate double consonants in pure biomedical terms or general words used in the healthcare fields due to Arabic phonotactic preferences, orthographic cues (double letters), or morphological analogies. On the contrary, Arab healthcare professionals do not geminate double letter in some pure medial terms (*allele*, *allergy*, *allograft*, *appendix*, *bulla*, *bullous*, *capillaries*, *cellulite*, *fallopian*, *hallux*, *papillary*, *phallus*, *tonsillitis*, *tranquillizer*) and general words used in the healthcare fields due to stress patterns, syllable structure, or lexical familiarity, because of their inflectional or derivational forms (*stopped*, *admitted*, *sitting*, *permitted*, *hopping*, *robbed*) and double consonants here are morphological (e.g., past tense or gerund) and not phonemic. Arab professionals recognize this and avoid gemination. High-frequency or function words (*happen*, *immune*, *differ*, *difference*, *communication*, *aggressive*, *suppose*) are familiar and are often correctly pronounced due to repeated exposure and lack of Arabic analogs that would trigger gemination.

These findings align with findings of prior studies in the literature such as Guba (2021) who found that Ammani Arabic speakers systematically geminate consonants in English loanwords. They prioritize their L1 phonotactics, producing geminated versions of English words even when unnecessary in English. The mispronunciations are attributed to L1 phonological rules that interfere with English pronunciation. The Arabic preference for geminate consonants overrides English phonological patterns, leading to systematic mispronunciations. When Arabic speakers borrow English words, they subconsciously apply L1 (Arabic) phonotactics. Due to Arabic's high-ranked geminate constraint. Similarly, results of the current study align with Iraqi students producing English "fake" geminates due to L1 transfer (Ahmed & Sameer's (2016). In the medical context, Khan & Salam (2019) reported that Arab medical students over-geminate English consonants in terms like *allergy* > /alːerdʒi/ instead of/ˈælərdʒi/ due to limited exposure to native-English pronunciation and L1 influence, overriding English patterns. This leads to miscommunication and unintelligibility in medical contexts where precise pronunciation is crucial. Albaaly (2022) confirmed that mispronunciation of

double consonants in medical terms is attributed to L1 Arabic interference and lack of phonetic training in English for Medical Purpose (ESP).

Furthermore, studies by Al-Jarf confirmed the problems that students, educated Arabs and healthcare professionals have with geminated consonants whether in the pronunciation of city and country names in daily speech, in interpreting, in transliteration of Arabic Proper Nouns to English on social medica, in phonological and orthographic problems, and in phoneme-grapheme correspondence problems in spelling. In all of those studies, Arabic speakers tended to transfer the spelling of Arabic geminates into single consonants in English. They also overgeneralized double consonants in the English transliteration of Arabic personal names that are pronounced with a single consonant phoneme. These are attributed to transfer from the native language, i.e., Modern Standard Arabic (MSA) or the local dialect, insufficient mastery of English pronunciation rules, inadequate mastery of phonics and phone-grapheme correspondences rules and lack of knowledge of the differences between English and Arabic phonology (Al-Jarf, 2024; Al-Jarf, 2022b; Al-Jarf, 2022c; Al-Jarf, 2022e; Al-Jarf, 2022; Al-Jarf, 2010b; Al-Jarf, 2009; Al-Jarf, 2008a; Al-Jarf, 2008b; Al-Jarf, 2008c; Al-Jarf, 2007a; Al-Jarf, 2005b).

5. Recommendation and Conclusion

Faulty consonant gemination in Arab health professionals' speech is not merely "accents" but systemic transfer from L1 (Arabic) with tangible consequences in patient safety (miscommunication), professional efficacy (intelligibility), and standardized medical terminology (accuracy). Addressing these errors requires tailored phonetic training and focused interventions to dissociate L1 phonological habits from L2 orthography and align accurate English pronunciation with biomedical communication standards. To correct faulty consonant gemination, pronunciation training for both students, faculty and professionals is needed. To improve healthcare students' pronunciation of English biomedical terms, prior studies recommended several strategies such as integrating pronunciation and phonetics training into the healthcare courses especially in the freshman year; incorporating minimal-pair practice with geminated and ungeminated consonants; participating in interactive double consonant pronunciation exercises to enhance students' pronunciation accuracy; listening to native speakers, practicing shadowing, practicing and interacting with them to improve fluency and internalize correct pronunciation of terminology with double consonants; assigning students short role-play exercises in which they mimick doctor-patient interactions; and applying the medical oral language proficiency assessment (MOLPA) for graduating students and residents in the healthcare fields to make sure graduating students are pronouncing biomedical terms accurately (Al-Jarf, 2025). In addition, Guba recommended that teaching must highlight that "double letters" in English biomedical terms are not geminates as it is the case in Arabic. Medical students need explicit instruction to suppress L1 (Arabic) gemination tendencies in English words where double consonants are orthographic only. Arab students should be taught to distinguish orthographic double consonants vs. true geminates in English (*irrelevant, immature, unnatural*), and to distinguish critical biomedical terms where gemination alters meaning ("*innervation*" vs. "*innovation*"). Incorporating consonant gemination awareness in medical courses for Arab students; explicit contrastive training, highlighting Arabic-English gemination differences and providing orthographic drills where the students practice minimal pairs ("*hoping*" vs. "*hopping*") would be beneficial (Khan & Salam, 2019; Albaaly, 2022).

Since faulty consonant gemination in biomedical terms is linked to specific consonants in certain terms but not others, a lexical approach to teaching biomedical terminology, where pronunciation is taught as part of the healthcare courses, can be effective. In teaching biomedical terminology, the printed form of the terms should be connected with their pronunciation especially connecting the phonemes with their graphemes and when double consonants are geminated and when they are not geminated (Al-Jarf (2022a); Al-Jarf (2023d); Al-Jarf (2008a); and Al-Jarf (2006).

In addition, a variety of technologies can be employed to improve pronunciation of EFL students majoring in the healthcare fields and repetition-based practice (Kawashima, 2018); audio glossaries with slow-motion articulation (Maharani, 2020); interactive pronunciation software; and pronunciation flashcards or posters in break rooms with common medical terms (Al-Jarf, 2021e), and custom Automatic Speech Recognition (ASR) models for non-native accents. Moreover, the students can benefit from ample exposure to authentic spoken English and authentic pronunciation of native English healthcare professionals, listening to medical mobile audiobook apps (Al-Jarf, 2021c), medical podcasts (Al-Jarf, 2023b), medical TED Talks for authentic listening and pronunciation (Al-Jarf, 2021d; Al-Jarf, 2020); the utilization of text-to-speech software to enhance their decoding skills and pronunciation accuracy (Al-Jarf, 2022f); task-based speaking practice (Al-Jarf, 2021a; Al-Jarf, 2007b); and online vocabulary tasks. MP4 listening and pronunciation lessons for medical students are also helpful (Al-Jarf, 2022c; Al-Jarf, 2013; Al-Jarf, 2012). For self-regulated pronunciation practice, the students can watch pronunciation videos that focus on consonant gemination in English and (Al-Jarf, 2022g; Al-Jarf, 2017; Al-Jarf, 2011a). They can practice listening to English native speaking health professionals and shadowing their pronunciation in a digital multimedia language lab (Al-Jarf, 2021b). Healthcare instructors can use mind-mapping software to show phoneme-grapheme correspondences in biomedical terms, and terms with double consonants (Al-Jarf, 2015b; Al-Jarf, 2011b; Al-Jarf, 2010a).

Since students in the healthcare fields imitate their instructors' pronunciation of biomedical terms, improving faulty consonant gemination in biomedical terms while health professionals and faculty are actively working requires practical, real-time strategies integrated into their daily routines such as continuous phonetic training for medical staff to prevent inaccurate pronunciation that could affect patient safety (Albaaly, 2022); teaching correct consonant gemination and degemination to healthcare professionals; listening to native speakers for reinforcement; implementing short, focused workshops on common inaccurate pronunciations in biomedical terminology; building awareness through encouraging peer corrections in daily conversations; providing voice-enabled medical mobile apps for instant pronunciation checks; encouraging healthcare professionals to check pronunciation using AI tools such as Google Translate; implementing AI-powered speech recognition software or apps to familiarize healthcare professionals with accurate pronunciation; listening to and shadowing senior healthcare professionals and native speakers; self-recording and playback to identify faulty consonant gemination in biomedical terms; encouraging team discussions about inaccurate pronunciations that affect communication; reminding healthcare professionals that accurate pronunciation reduces miscommunication with patients and customers especially non-Arabs.

Following the above strategies will ensure that Arab healthcare students, faculty and professionals will avoid lifelong faulty consonant gemination while pronouncing biomedical terms. Other types of pronunciation errors by healthcare students and professionals, such as finding out whether the curricula in the healthcare fields teach students the pronunciation of biomedical terms and exploring the problems that healthcare students have in pronouncing the singular and plural forms of medical terms of Latin origin, assimilation and elision are still open for further investigation in the future.

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