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Optimality and correspondence theories in phonological shifts: a case study on Arabic guttural consonants in English loanwords

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The standardization of loanwords presents challenges for borrowers due to phonological adaptations, particularly with guttural speech sounds. This case study examined native English speakers' articulation of Arabic loanwords containing guttural consonants, applying optimality theory and correspondence theory to investigate phonetic and phonological constraints. The analysis revealed that participants experienced difficulty adhering to constraints in their articulation, resulting in the omission, repair, or replacement of guttural phones in Arabic loanwords. Contrary to initial assumptions, the study found that deletion and replacement mechanisms were not exclusively position-dependent but rather determined by specific guttural sounds. For example, replacement occurred with sounds such as /χ/, /q/, and /gʼ/, while deletion was applied to sounds like /ʕ/, /ʔ/, and /ħ/. The repair strategy, however, was observed to be position-dependent, occurring only with words containing a medial guttural. These findings contribute to the understanding of phonological adaptations in loanwords and the interrelationships among significant linguistic groups, highlighting the complex nature of guttural consonant articulation in cross-linguistic contexts.

KEYWORDS

constraints, correspondence theory, guttural sounds, loanwords, optimality theory, phonetics

1 Introduction

Loanwords are borrowed through language contact and incorporated into another source language (Hoffer, 2005). To satisfy the borrowing requirement and lexical understanding, there must be no morphemic substitution, and pronunciation must resemble the source language (Schmidt and Jien-shou, 2020). English has been enriched by this practice (Quirk et al., 1968; Darwish, 2015), which is commonly seen in the field of linguistics among major cultures (Hamdi, 2017). Some examples of English words borrowed from other cultures are "ease," and "café," borrowed from the French; "area" borrowed from Latin; "kindergarten" from German; and "algebra" and "alcohol" from Arabic. However, linguistic and phonetic limitations have caused the adoption and assimilation of some loanwords to change drastically (Calabrese, 2009; Darwish, 2015), whose origin is almost unrecognizable. Monolinguals may not be cognizant of the origins of these integrated words (Romaine, 1989). For instance, the English word "coffee" is Arabic in origin and emanates from Yemen; however, it vastly differs from the original word, *qahwah*. Similarly, the word "lute" emanated from the Arabic *al-ud* (the oud) but experienced language interference via the French term "lut." In recent years, globalization has undoubtedly

expanded the scope of borrowing practices, bringing diverse linguistic elements into closer contact. This global exchange highlights the need for focused studies on specific phonetic features, such as guttural sounds in Arabic loanwords, to understand their adaptation and assimilation into English (Durkin, 2014; Darwish, 2015). This study adopted a synchronic approach by identifying loanwords through non-native sound segments and morphological structures. The grammatical, phonological, and morphological systems of Arabic, including the Hebrew, differ significantly from those of English. This study targets the guttural sounds of loanwords of Arabic origin in English. Arabic guttural sounds are more diverse than those in English. For instance, Arabic guttural sounds are *k, χ, ɣ, q, ħ, ʕ, ʔ* and are transformed into English respectively as *k, kh, g, gh, q* and *h*. Current research in the area continues to challenge and expand assumptions of European-based linguistics (Smeaton, 1973; Hafez, 1996; Palfreyman and al Khalil, 2003; Alahmari, 2022).

Hafez (1996) maintains there are degrees of standardization of loanwords, one of which could be resistance to integration because they do not conflict with the patterns of the recipient language. Standardizing the articulation of loanwords from Arabic to English is more difficult with regard to phonological adaptation. For instance, "Khalifah" is a loanword that is pronounced /χa.liː.fah/ by the Arabic native speaker but the English speaker pronounces it as [ka.liː.fa]. A significant mismatch exists in the articulation of loanwords with guttural sounds because of significant mismatches in the articulation of the two languages. The challenge of integrating Arabic loanwords into English is partly due to Arabic's unique guttural sounds, which are absent in English. These sounds are broadly categorized based on their phonetic placement in words, which influences how they are adapted in English according to their placement, that is, guttural-initial (/χ/ ≈ خخ - "Khadem" - /χadɪm/ - Servant; see Table 1 for an additional list of Arabic examples), guttural-medial (/ħ/ ≈ حح – "Saara" - / saħraʔ/ - Desert; see Table 2 for additional exemplars), and guttural-final (/ ʕ/≈ عع – "burqa"- /burqʕ/ - Veil; see Table 3 for additional exemplars).

This study investigates the constraints and use of Arabic loanwords with guttural speech sounds, and suggests ways to overcome difficulties in their use among English speakers. According to Sylak-Glassman (2014, p. 1), Semitic languages involve "various phonological processes and distributional constraints [that] require reference to the post-velar consonants as a phonologically active class." Loanwords undergo processes of "sound alteration, addition, omission, and shifting" (Hafez, 1996, p. 384). Without these constraints, it is difficult to understand how and why such changes occur.

2 Literature review

This study focused on guttural consonants, which are speech sounds that begin in the throat, such as *k* and *g*. According to McCarthy (1994), the articulation of guttural sounds are called "throat consonants," which are produced primarily at the laryngeal—back of the throat; pharyngeal—the middle of the throat; and uvular—part of the throat nearest to the mouth. Sylak-Glassman (2014) notes these post-velar or guttural consonants comprise a universal guttural natural class, which he situates within

a phonologically active class, and is prevalent in Arabic. The Arabic sound system includes more consonant sounds and fewer vowel sounds than English sounds (Palfreyman and al Khalil, 2003). However, Arabic further distinguishes between the "emphatic" consonants that are pronounced with a tense and retracted tongue, moving any vowels adjacent to them backward in the mouth, with Arabic consonants known as the "gutturals" (Palfreyman and al Khalil, 2003). Articulation is determined by pharyngeal consonant phones, such as /ʔ/ and /ħ/ (Hess, 1990). The speech organs that produce these guttural sounds are shown in Figure 1. In addition, Hess (1990) highlighted the emphatic sounds of Semitic languages and their secondary pharyngeal constrictions. Generally, gutturals and emphatic constrictions occur in the laryngeal and pharyngeal regions of the vocal tract. This association suggests a connection between post-velar sounds and other types of sounds (Miller, 2007; Moisik et al., 2021).

Arabic comprises a rich consonantal system, which is far more difficult than its vowel system (Alahmari, 2022). Compared to English, Arabic has a maximum of two successive consonant systems (Hafez, 1996). Several studies have investigated the integration of English loanwords from different forms or dialects of Arabic (e.g., Hafez, 1996; Zibin, 2019; Alahmari, 2022). The guttural use of Arabic is often incongruent with other language systems. Alqarni (2021) found the inventories of Amharic and Argobba included the laryngeal [h], the uvular [q], and other glottalized ejectives. This contrasts with studies such as the Francophone systematic deletion of gutturals in Arabic loanwords because of the non-availability of the pharyngeal node. Paradis and LaCharité (2001) explained the reason for the systematic deletion of gutturals ħ, ʕ, h, and ʔ in French is because there is nothing close enough to the required adaptation. They maintain that gutturals are deleted when the foreign segment is unrealizable in L1. However, in an examination of the Central Kurdish (CK) adaptation of Arabic loan consonants, Hamid (2021) found a connection between faithful borrowing of guttural consonants and the frequency, orthographic input, and sensitivity of faithful pronunciation. Kurdish and Arabic represent two distinct language families, although they both have extensive contact through religion, politics, and education. Hamid highlighted that CK adapted emphatic sound by removing emphatic features. For political reasons, native Kurds ignored guttural phonemes in their writing by replacing them with non-guttural ones, for example, "penus" for "qa.lam." Furthermore, the Arabic and Uzbek languages experienced mutual lexical and phonetic influences (Yulduz, 2022). Currently, loanwords borrowing in languages such as Uzbek also lack emphatic consonants in addition to gutturals in their language, and these omissions have resulted in phonetic changes (Yulduz, 2022). Calabrese (2009) noted that non-native learners may encounter sounds that are excluded from the inventory of their language. Therefore, she claims that preservation of the phonological and morphological shape of the foreign word is unnecessary. However, in some instances of loanword adaptation and transfer, the language is unwritten, as in the case of the colloquial Arabic of Palestine (Butros, 1963). Omission is another process of loanword integration that Smeaton (1973) confirms is the result of syllabic omission to either facilitate pronunciation or trim consonants and syllables.

TABLE 1 Guttural-initial Arabic nouns.

Example	Target guttural	Loanword	Transcription	Meaning
1.	/χ/ ≈ خ ﺥ	khadem	/**χ**adɪm/	"Servant"
2.	/χ/ ≈ خ ﺥ	khair	/**χ**eɪr/	"Good"
3.	/χ/ ≈ خ ﺥ	khamsin	/**χ**amsi:n/	The number 50
4.	/q/ ≈ ق ﻕ	carat	/**q**i:rat'/	"Mass, a small unit of weight that measures gold purity"
5.	/ħ/ ≈ ح ﺡ	huqqah	/**h**o:kaʔ/ /**ħ**uqah/	*Shisha*, a water pipe *Huqqah* is used in the standard Arabic means vase or vessel
6.	/ʕ/ ≈ ع ﻉ	oud	/**ʕ**u:d/	"Lute," a musical string instrument used in the Middle East

TABLE 2 Guttural-medial Arabic nouns.

Example	Target guttural	Loanword	Transcription	Meaning
1.	/ħ/ ≈ ح ﺡ	Sahara	/sa**ħ**raʔ/	The name of an African desert
2.	/ħ/ ≈ ح ﺡ	tahini	/t'a**ħ**i:nħ/	"Crush," Arabic appetizer
3.	/ħ/ ≈ ح ﺡ	sahib	/sˤa:**ħ**ɪb/	"Friend"
4.	/ʕ/ ≈ ع ﻉ	ma'amoul	/ma**ʕ**mo:l/	Small shortbread pastries filled with dates, pistachios, or walnuts. Popular in Levantine cuisine and the Gulf countries
5.	/ʕ/ ≈ ع ﻉ	za'atar	/za**ʕ**tar/	Generic name for a family of related Middle Eastern herbs/thyme
6.	/ʕ/ ≈ ع ﻉ	rubaiyyat	/ruba**ʕ**i:jat/	"Quatrain"
7.	/ʕ/ ≈ ع ﻉ	Musta'rib	/musta**ʕ**rɛb/	Would be Arab
8.	/ɣ/ or /gʲ/ ≈ غ ﻍ	maghreb	/ma**gʲ**reb/	"Sunset"
9.	/ʔ/ ≈ ء	Qur'an	/qur**ʔ**an/	The holy book of Islam
10.	/q/ ≈ ق ﻕ	maqam	/ma**q**am/	System of melodic modes used in traditional Arabic music
11.	/q/ ≈ ق ﻕ	raqas sharqi	/ra**q**s ʃarqɪ/	"Oriental dancing," the classical Egyptian style of belly dance that developed during the first half of the 20th century
12.	/q/ ≈ ق ﻕ	burqa	/bur**q**ʕ/	"Veil"
13.	/q/ ≈ ق ﻕ	alkali or alqaly	/ɪl**q**alɪ/	A basic ionic salt of an alkali metal or alkaline earth metal chemical element

2.1 Phonetics and phonology

The human vocal organs produce diverse sounds during oral communication. Phonetics studies how humans produce and perceive sounds (O'Grady and Katamba, 1997), while phonology examines the significant speech sounds of a particular language. All the languages have a phonemic inventory with distinctive speech sounds. However, the phonetics and phonology of first- and second-language speakers are not identical (Cohen, 2009). Indeed, speech sounds have a duality that allows neither phonetics nor phonology to operate in isolation (Moisik et al., 2021). Moisik et al. (2021) propose a notion of phonological potentials and a framework based on the phonological potential models that emphasize the physical mechanisms of speech as the foundation for discreteness. This study is instructive for proposing a model that exhibits patterns of alignment with the interaction of tone, phonetics, and vowel qualities. Based on the spoken varieties of Arabic (UAE, Syria, Turkey, Yemen, etc.), the number of consonants ranges from 25 to 30 (Alahmari, 2022). Classical Arabic has ~28 consonantal phonemes in nine places of articulation and 38 phonemes (Watson, 2007). In comparison, the English language writing system has 26 letters, which generally correspond individually or in combination with the 44 significant sounds or phonemes in the spoken language (Palfreyman and al Khalil, 2003).

2.2 Guttural speech sounds

Arabic has a larger phonemic inventory of guttural consonants and uses more guttural speech than does English (see Tables 4, 5). Points of guttural articulation are minor for English speakers, but can be heard in Scottish Gaelic, for example, the sound of /x/ ("loch"). The phonetic patterning of uvulars and glottals with pharyngeal, facilitated by articulation, provides a path for phonological association to occur (Sylak-Glassman, 2014). In the dialect of Central Kurdish (CK), Arabic alphabet loans with gutturals are left unadapted and are considered sounds within the consonant inventory of the CK. See for example, "qu.wa" and "raħ.ma" as words with gutturals with unmodified status to show faithful borrowing—"qu.wat" and "raħ.mat" (Hamid, 2021). Similarly, in Uzbek, the guttural ء and ح, and the yawning sound ع is omitted and not pronounced.

TABLE 3 Guttural-final Arabic nouns.

Example	Target guttural	Loanword	Transcription	Meaning
1.	/ħ/ ≈ ح	*matrah or tarah*	/matˤraħ/ or /tˤaraħ/	"Mattress"
2.	/ ʕ/≈ ع	*burqa*	/burqʕ/	"Veil"
3.	/h/≈ ه	*surah*	/suːrah/	A chapter in the Qur'an
4.	/q/≈ ق	*souk*	/suːq/	"Marketplace"
5.	/q/≈ ق	*sumac*	/summaːq/	A spice
6.	/q/≈ ق	*shorooq*	/ʃruːq/	"Sunrise"

FIGURE 1
Organs of speech. Source: https://dylansung.tripod.com/sapienti/phon/ipasymb.htm.
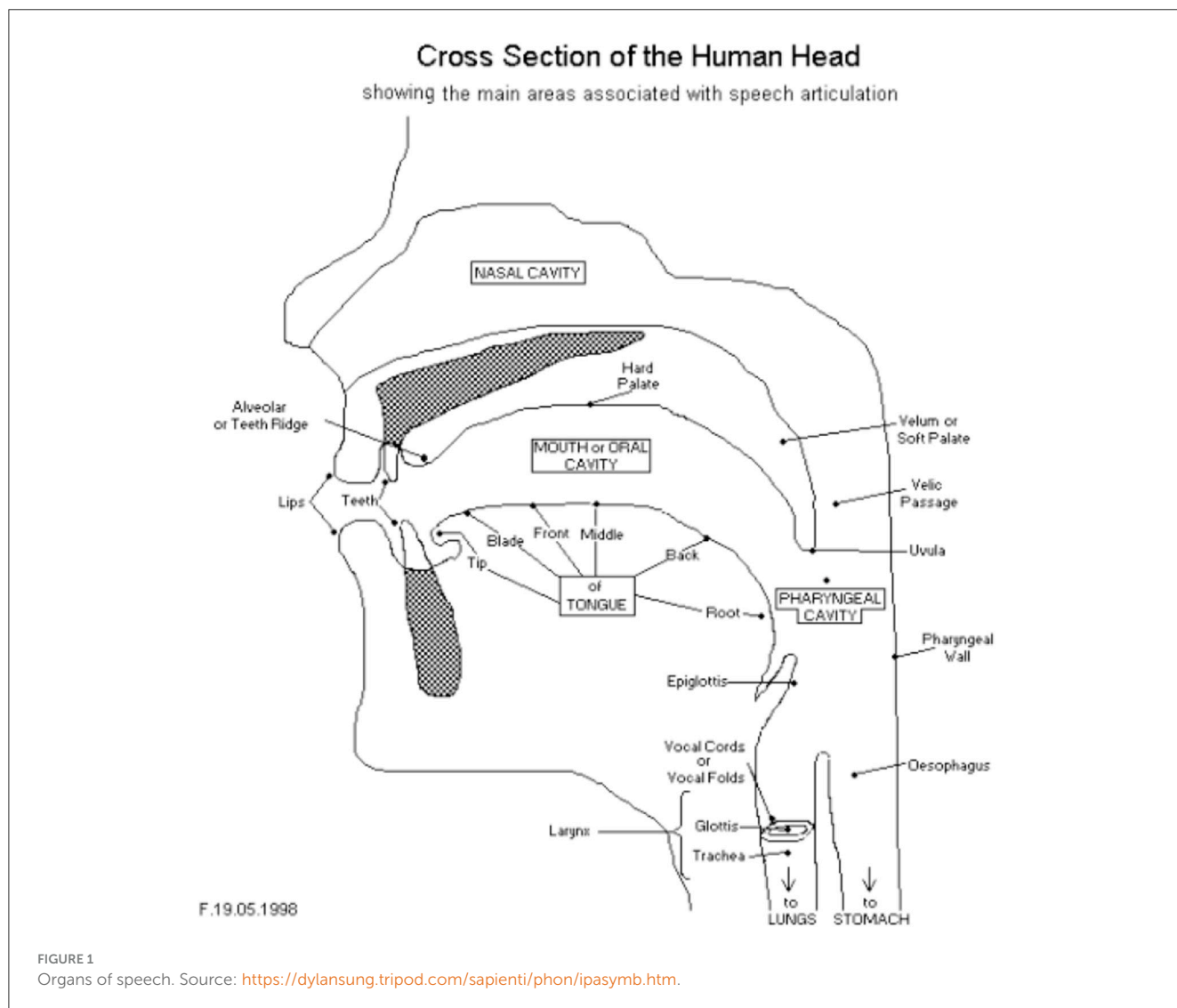
2.3 Standardization in pronunciation

Phonology provides insights into the use of loanwords with distinctive phonemes in English. Pronunciation is an infinite variable because speech sounds are uniquely individual. Standardizing the pronunciation of loanwords is difficult when considering speech sounds in a global language. In an attempt to understand standardization in language, the pronunciation of a word may vary according to dialect and idiolect, and each speaker may differ in sound even while pronouncing the same word (Calabrese, 2009). Although orthography attempts to address this issue, it may be more apt when dealing with phonetics and morphology. Therefore, Ferguson (1997) characterizes standardization as an increase in the communication network through a language or language variety acquired and welcomed throughout the speech community. In an earlier version of this

TABLE 4 Arabic guttural phonemic inventory.

Manner of articulation	Glottal state	Place of articulation			
		Velar	Uvular	Pharyngeal	Glottal
Plosive	Voiceless	[K] ك	[q] ق		[ʔ] ء
Fricative	Voiceless	[χ] خ		[ħ] ح	[h] هـ
	Voiced	[g'/ ɣ] غ		[ʕ]ع	

TABLE 5 English guttural phonemic inventory.

Manner of articulation	Glottal state	Place of articulation			
		Velar	Uvular	Pharyngeal	Glottal
Plosive	Voiceless	[K]			
	Voiced	[g]			
Fricative	Voiceless				[h]
	Voiced				

definition, he termed it a "supradialectal norm" (Ferguson, 1966, p. 31).

2.4 Orthography

Orthography is the set of rules and regulations that enables the writing of spoken language, such as hyphenation, capitalization, emphasis, punctuation, and other symbol systems. Orthography standardizes language by reducing dialect and idiolect variations in speech sounds (Stoehr and Martin, 2021) and is "correlated with the choice of consonantal length" (Hamann and Colombo, 2017, p. 688) in writing. The importance of orthography in the loan adaptation process is correlated with second-language perceptions in writing (Hamann and Colombo, 2017; Hamdi, 2017). Despite this salience, Hamdi (2017) contends that orthography is often disregarded and marginalized in the literature, while Paradis and LaCharité (2001) contend that its minimal role is justified, as it cannot be controlled in adaptation. Multiplicity in orthographic forms is often shaped by L2 speakers' awareness and frequency. However, the influence of modern technology adds another dimension to this argument. Social media has demonstrated systematic innovation in written and spoken language, which affects emphasis and formality. Indeed, the expressiveness of the language, which is equally highly context-dependent, is also more conversational than written (Bevacqua and Scheffler, 2020, p. 4). Hamann and Colombo (2017) found no cases of the deletion of perceptual borrowings in their study of English intervocalic consonants after short vowels in Italian. Indeed, they noted a larger influence of auditory information on the borrowing of vowels, whereas the borrowing of consonants seemed to be more influenced by writing. The authors ascribed this pattern to the weaker perception of consonantal cues. Phonological and orthographic investigations can be useful for ascertaining the constraints and differences in English speakers' use of Arabic loanwords. In addition, while Smith (2009) noted that loanword adaptation provides little evidence of grammar in individual languages, it contributes to a comprehensive understanding of universal grammar and phonological theory.

3 Theoretical framework and hypotheses

3.1 Optimality theory

Prince and Smolensky introduced the optimal theory (OT), a novel approach to language (McCarthy, 2007). The subsequent development of OT by linguists (McCarthy, 2002; Kager, 2004) has resulted in a changed understanding of phonology and the history of generative grammar by establishing a dichotomy between the operational and constraint components of grammar (McCarthy, 2007). OT grammar consists of a generator (GEN) and an evaluator (EVAL). The GEN component generates possible output forms that deviate from the input in different ways. The EVAL component compares and evaluates all possible output forms with a series of ranked constraints (Cohen, 2009). In OT, each language has its own constraint ranking (McCarthy, 2007), although Kager (2004) claims that they differ in their ranking. OT recognizes two constraint rankings: faithfulness and markedness (Zibin, 2019). Markedness constraints are concerned with the formation of the output; that is, complex consonant clusters are bad, whereas faithfulness constraints require stability in that the grammatical output resembles its input (Prince and Smolensky, 2008). Because markedness constraints favor certain linguistic structures, they often compete with faithfulness constraints. The objective of faithfulness constraints is to resist modifications to the input structures, which is referred to as constraint conflict. For an OT system, if there are two freely ranked constraints or unranked constraints, then each individual ranking might produce a different output, which might invariably result in variation in a language.

3.2 Correspondence theory

McCarthy and Prince (1995) were instrumental in formalizing source-similarity effects in loanword adaptation using correspondence theory (CT). Other linguists classify it as a "subtheory of faithfulness constraints, allowing a limited set of structural changes, such as deletions, insertions, fusions, and featural changes" (Kager, 2004, p. 53). According to Smith (2009), loanword adaptation cannot be attributed to speech perception alone because borrowing word constraints are involved in loanword adaptation. The use of CT to model source similarity constraints means that such constraints are not required.

3.3 Hypotheses

This study examines how native English speakers articulate guttural Arabic speech sounds by applying the constraint ranking optimality theory (Kager, 2004) and source-similarity correspondence theory (McCarthy and Prince, 1995) to capture this articulation. The following three hypotheses are proposed:

H0: Native English speakers articulate loanwords with distinct guttural sounds exactly as native Arabic speakers do.
H1: Native English speakers change the articulation of Arabic loanwords with distinctive guttural sounds.
H2: Orthography significantly influences the articulation of Arabic loanwords by native English speakers.

4 Methods

4.1 Sampling and procedure

OT and CT were used to model source-similarity constraints to explain the Arabic guttural deletions of words adapted to English. The compilation of the sample list of Arabic loanwords considered the constraints and differences that might have occurred during the transfer and involved phonology and orthography. Participants included two monolingual native English speakers and a researcher whose vernacular language was Arabic. The participants were college students aged between 20 and 22 years who consented to act as volunteers. Participants had no Arabic knowledge or exposure of any kind. The sessions occurred in a quiet, private, and comfortable environment. First, a list of modern Arabic loanwords was typed in English and presented to participants. Subsequently, the researcher pronounced the words in Standard Arabic and asked the participants to repeat them three times. In this way, the participants implemented their visual-auditory senses through reading and listening. This procedure took approximately 5–6 min per participant and was recorded with consent.

5 Results

The phonological OT analysis rejected the null hypothesis. The two English speakers struggled with pronunciation, although they had orthographies of each word placed before them as a guide. An influential version of OT that incorporated CT explicitly invoked correspondence between the elements in the input and output strings. Here, an influential version of OT that incorporated CT (McCarthy and Prince, 1995) and explicitly invoked correspondence between the elements in the input and output strings was applied. The two English speakers amended the articulation of Arabic loanwords with distinctive guttural sounds, thereby supporting H1 and H2.

5.1 Constraints within optimality theory

With constraints acting as filters, the basic architecture and tenets of classical OT suggested there should be no particular underlying phoneme or structure inventory to protect (van Oostendorp, 2011). In the CT analysis data, participants used three mechanisms to articulate the peculiar guttural speech sound.

- **Replacement**: In the loanword, *Khaliji* /χali:ʒɪ/, the native English speakers replaced the guttural sound /χ/ with another guttural sound /k/ and pronounced it as /kali:ʒɪ/.
- **Repairing**: In the loanword, *magreb* /magʔ.reb/, the native English speakers repaired through resyllabification and pronounced the word as /ma. greb/.
- **Deletion**: In the loanword, *Surah* /su:rah/, the native English speakers deleted the consonant phone /**h**/ in the last syllable and pronounced it as /su:ra/.

5.1.1 Constraints
The following constraint ranking was derived from the application of OT:

*PHARY—"No pharyngeal segment is allowed in the output"
NoCoda—"Syllables do not have coda consonants"
MAX-IO—"Every input segment has an output correspondent"
MAX-OO—"Every output segment has an output correspondent" (no deletion)
DEP-OO—"Every output segment has an output correspondent" (no epenthesis)
*UVU—"No uvular segment is allowed in the output"
Velar-OO [±Voi]—"Every velar output must have a velar output correspondent that agrees in voicing"
IDENT (syllabic)—"Output syllabic structure should have a correspondent syllabic structure in the input"
[*RTR]—"Assign one violation mark for every segment that is [+RTR]"
"*"—unattested
"!"—not correct at all
"**"—no. of violations (Example: two times for two "**")
☞—output that wins

5.1.2 Guttural-initial nouns
In this section, two Arabic to English loanwords with initial gutturals were presented and discussed. Table 6 presents the tableau for the loanword *Khalifah* with the following ranking of constraints:

TABLE 6 Tableau for *Khalifah*/ χa.liː.fah/.

Input: /χa.liː.fah/	NoCoda	*PHARY	MAX-IO
ga.liː.fah	*!		*
☞ [ka.liː.fa]			**
χa.liː.fah	*!	*	

TABLE 7 Tableau with different order for *Khalifah*/ χa.liː.fah/.

Input: /χa.liː.fah/	MAX-IO	*PHARY	NoCoda
ga.liː.fah	*!		*
ka.liː.fa	*!		
☞ χa.liː.fah		*	*

TABLE 8 Tableau for *Qur'an*/ qur.ʔan/.

Input: /qur.ʔan/	*UVU	Velar-OO [±Voi]	NoCoda	MAX-IO
Qur.ʔan	*!		*	
☞ [kuran]			*	*
Gur.an		*!	*	*

TABLE 9 Tableau for *Magreb*/ magʼ.reb/.

Input: /magʼ.reb/	NoCoda	Velar-OO [±Voi]	IDENT (syllabic)
mak.reb	**!	*	
☞ ma. greb	*		*
magʼ.reb	**!		

TABLE 10 Tableau with different orders for *Magreb*/ magʼ.reb/.

Input: /magʼ.reb/	IDENT (syllabic)	Velar-OO [±Voi]	NoCoda
mak.reb		*!	**
ma. Greb	*!		*
☞ magʼ.reb			**

TABLE 11 Tableau for *Musta'rib*/ mus.taʕ.rɛb/.

Input: /mus.taʕ.rɛb/	NoCoda	*PHARY	MAX-IO
mus.ta. rɛb	**!		*
mu.stah. rɛb	**!		*
☞ mu.sta. rɛb	*		**
mus.taʕ.rɛb	***!	*	
muar.ib	**!		****
mus.taħ.rɛb	***!	*	*

TABLE 12 Tableau for *Souk*/ suːq/.

Input: /suːq/	*UVU	Velar-OO[±Voi]	NoCoda	MAX-IO
suːq	*!		*	
☞ suːk			*	*
suːg		*!	*	*

TABLE 13 CT Tableau for *Mat'rah* /matʼ.raħ/.

Input: /matʼ.rah/	NoCoda	[*RTR]	*PHARY	MAX-IO
mat.raħ	**!		*	*
matʼ.ra	*!	*		*
matʼ.rak	**!	*		*
☞ ma.tra				**
mad.raħ	**!		*	*

NoCoda >> *PHARY >> MAX-IO. Reversing the first and third constraints (NoCoda >> *PHARY >> MAX-IO) gives the incorrect output presented in Table 7. Table 8 gives the tableau for *Qur'an*, the ranking for which is *UVU >> Velar-OO [±Voi] >> NoCoda >>MAX-IO.

Under the correct ranking, the markedness constraint NoCoda dominates *PHARY, and that in turn outranks MAX-IO: Markedness overpowers and dominates faithfulness. The differences between two language systems must be limited and specific for the right outcomes (Chomsky, 1972, 2007).

5.1.3 Guttural-medial nouns

Magreb and *Musta'rib* are two examples of Arabic loanwords with medial gutturals. In this study, the two native English-speaking participants used the articulation mechanism of repairing through resyllabification, in addition to the replacement mechanism (i.e., substituting /gʼ/ into /g/) to pronounce *magreb*. Table 9 presents the tableau for *magreb* in correct ranking order, and Table 10 shows the incorrect ranking output if faithfulness is placed as the highest constraint.

Table 11 presents the optimal output for a word in which markedness rules over faithfulness, *Musta'rib*. For /mus.taʕ.rɛb/, the medial guttural /ʕ/ is deleted in the outcome in the mechanism

of deletion, entirely bypassing a foreign segment. Also, the repair mechanism through re-syllabification is used. The correct ranking for *Musta'rib* is *UVU>> Velar-OO[±Voi] >> NoCoda >> MAX-IO.

5.1.4 Guttural-final nouns

The word souk means "mall or market" and is articulated in Arabic as /suːq/ with a final guttural (uvular)/q/. One of the English-speaking participants articulated /q/, which does not exist in the English phonemic inventory, as uvular as /k/, switching the unknown sound to a familiar one. This reflects the final mechanism of pronouncing loanwords with unfamiliar phonemes (replacement). Table 12 presents the tableau for souk with the ranking NoCoda >> [*RTR] >> *PHARY >> MAX-IO.

TABLE 14 CT Tableau for *Magreb*/ magˈ.reb/.

Input: /magˈ.reb/	MAX-OO	DEP-OO	NoCoda	MAX-IO
mak.reb	*!		**	*
☞ ma. greb			*	*
magˈ.reb	*!		**	

TABLE 15 CT Tableau for *Mustaʿrab*/ mus.taʕ.rɛb/.

Input: /mus.taʕ.rɛb/	MAX-OO	DEP-OO	NoCoda	MAX-IO
mu.ta. rɛb	*!		*	**
mu.stah. rɛb		*!	**	*
☞ mu.sta. rɛb			*	*

TABLE 16 Tableau for *Souk*/ su:q/.

Input: /su:q/	MAX-OO	DEP-OO	NoCoda	MAX-IO
su:**q**	*!	*	*	
☞ su:**k**			*	*
su:**g**	*!	*	*	
su:	*!			*

5.2 Implementation of the correspondence theory

CT created multiple relationships among the proposed candidates, which were used in the OT approach. Given two strings S1 and S2, correspondence was reflected in the relationship R, shifting the elements of S1 to those of S2; the elements αεS1 and βεS2 correspond to αRβ. This comprehensive definition generated a full set of faithfulness constraints: IO:{MAX-IO, DEP-IO, IDENT[F]-IO, INTEGRITY-IO,...}; OO:{MAX-OO, DEP-OO, IDENT[F]-OO,...}BR:{MAX-BR, DEP-BR,...}. Differentiating faithfulness relationships, namely, input–output (IO), base–reduplicant (BR), and output–output (OO) relations, was the basic premise. The OO constraint was similar to an intermediate stage, in which the optimal candidate was checked against the intermediate-derived output. Outputs concerning other outputs enable an understanding of the constraints. Tables 13–16 reflect the CT analyses, which are useful for understanding the constraints more precisely than the regular OT approach.

With the loanword matˈrah (Table 13), the study participants resyllabified the word by deleting the coda; /ħ/ is not recognized because English prohibits pharyngeal sounds. Therefore, participants used deletions to resolve this discrepancy.

In Table 14, the CT tableau for *magreb*, the ranking is MAX-OO >> DEP-OO >> NoCoda >> MAX-IO. Table 15 presents *Mustaʿrab* (MAX-OO >> DEP-OO >> NoCoda >> MAX-IO), and Table 16 presents *souk* (MAX-OO >> DEP-OO >> NoCoda >> MAX-IO).

TABLE 17 English orthography of Arabic guttural phones.

Arabic sounds	/q/	/χ/	/ħ/	/h/	/ʔ/	/gˈ/ /ɣˈ/	/ʕ/
English orthography	q c k	kh	H	h	a	g gh	a o

MAX-OO "Every output segment has an output correspondent" (no deletion).

DEP-OO "Every output segment has an output correspondent" (no epenthesis).

NoCoda "Syllables do not have coda consonants."

MAX-IO "Every input segment has an output correspondent."

5.2.1 Implementation of orthography

English and Arabic differ in speech sounds, grammar, points of articulation, orthography, and alphabet, among other differences. For instance, /χ/ is an Arabic phone orthographically represented as /k/ by English speakers and pronounced "kh." In English, the orthographic combination "kh" is negligible and indicates that the word is a loanword and will be articulated differently. Although the participants were presented with English orthographies of the list of loanwords, they still encountered difficulties with pronunciation. This suggests that orthography also influences the articulation of loanwords. Hence, orthographic representation of loanwords provides the speaker with clues, but is misleading in the case of pronunciation. Table 17 shows the Arabic sounds with English orthography.

6 Discussion

Optimal transitions of loanwords into second languages require there to be few and specific differences between the two language systems, as in the case of Arabic states, for example, CK. Native English speakers adjusted the distinct guttural sounds in Arabic loanwords according to their speech backgrounds. Due to the lack of guttural phones in the English language phonemic inventory, the participants experienced difficulties articulating guttural consonants (Al Mahmoud, 2020; Yulduz, 2022). Appendix A presents the English orthography of the Arabic guttural phones. Using the regular OT approach, two native English speakers articulated Arabic loanwords based only on input. However, the CT was more precise because it allowed for the consideration of other outputs under the highlighted constraints. The difficulties of uttering loanwords with distinct sounds were confirmed, as English speakers attempted to account for these constraints using deletion, replacement, and repair. In addition, this study showed that orthography influences the understanding of distinct sounds from a different language, making it easier to understand and articulate Arabic loanwords. Orthography is another influential factor when considering a speaker's knowledge of a source language (Haugen, 1950; Lovins, 1973; Dohlus, 2005; Vendelin and Peperkamp, 2006). In addition, orthography affects pronunciation quality and supports the work of fellow linguists (Bassetti and Atkinson, 2015; Bassetti et al., 2018; Stoehr

and Martin, 2021). However, despite the confirmation of these revelations in the literature, there is still limited research on the influence of loanwords, especially Arabic guttural consonants loaned to English, which could be a methodological flaw. Orthographic effects are pervasive in adaptation; however, their subtle impacts can often be detected only by large-scale statistical studies or carefully targeted experimentation (Daland et al., 2015). However, the results showed possible orthographic influences.

This study demonstrated how English speakers can unconsciously adopt these three phonological mechanisms as they listen to and read loanwords that contain guttural sounds in the absence of corresponding sounds in their L1 speech inventories. Code-switching differs from loanwords and should be explored further as it illustrates how bilinguals and learners alternate between the two languages using single words or phrases. Mustafawi's (2002) examination of loanwords within an Arabic context found that loanwords operated according to the grammar of the recipient language and were better at borrowing than code-switching. While the application of L1 to L2 is normal, this does not mean that L2 is a loanword. Code-switching does not illustrate the adaptation of phonological and morphological features as in well-established borrowing. Pronunciation is essential for better word comprehension (Al Mahmoud, 2020; Yulduz, 2022). Written words contain spaces, punctuation, and different letter representations (Ahmed, 2019) that help readers better understand loanwords. However, for oral mastery, the quality of loanwords' pronunciations minimizes the confusion between the speaker and listener. Pronunciation quality improves the understanding of Arabic loanwords (As-Sammer, 2015; Yulduz, 2022), even when the task requires the phonology mechanisms of deletion, replacement, and repair (Hamdi, 2017). Poor-quality pronunciation of loanwords reduces the understanding of the particular loanword but also negatively influences the pronunciation of adjacent words that precede or follow it and facilitate misunderstanding. McCarthy (1994) did not consider the uvular stop /q/ as an Arabic guttural, despite its non-appearance in the English phonemic inventory. Furthermore, the research challenges Sylak-Glassman's (2014) contention that the uvular stop is grouped with the dorsal consonants (/k/ and /g/) and the pharyngealized consonant.

7 Conclusion

Loanwords are inevitable and enrich the language of recipient borrowers. This study investigated the challenges English speakers encounter when articulating Arabic loanwords with guttural consonant sounds. The study involved a comparison of the outputs, which were the intermediate stages spent in deriving the correct candidate with the best pronunciation. A concise description was provided using the OT approach to demonstrate how English speakers learn the pronunciation of Arabic loanwords using the three phonological mechanisms of replacement, repair, and deletion. This study advances the understanding of communication between Arabic and English speakers and elucidates how and why constraints occur. These findings are instructive for teacher education, assessments, and pedagogy.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Siham Alhaider/IRB/King Khalid University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Appendix A

TABLE A1 List of modern loanwords of Arabic origin.

No.	Target guttural	Position in word	*Example*	Transcription	Meaning
1	/χ/ ≈ خ	Initial	Khalifah	/χali:fah/	The civil and religious leader of a Muslim state
2	/χ/ ≈ خ	Initial	Khadem	/χadɪm/	"Servant"
3	/χ/ ≈ خ	Initial	Khaliji	/χali:ʒɪ/	From the Gulf States
4	/χ/ ≈ خ	Medial	mulukhiyah	/muluχɪəh/	The leaves of the genus Corchorus, used as a vegetable in Middle Eastern and North African cuisine
5	/χ/ ≈ خ	Final	Sheikh	/ʃeɪχ /	A leader, elder, or noble, especially in the Arabian Peninsula, where Shaikh became a traditional title of a Bedouin tribal leader in recent centuries
6	/ħ/ ≈ ح	Initial	Huqqah	/ho:kaʔ/ /ħuqah/	Arabic spelling of "hookah," a water pipe (also shisha)
7	/ħ/ ≈ ح	Medial	Sahara	/saħraʔ/	The name of an African desert
8	/ħ/ ≈ ح	Medial	Tahini	/tˤaħi:nɪ/1	"Crush," an Arabic appetizer
9	/ħ/ ≈ ح	Medial	Sahib	/saħɪb/	"Friend"
10	/ħ/ ≈ ح	Final	matrah or tarah	/matˤraħ/ or /tˤaraħ/	"Mattress"
11	/ ʕ/ ≈ ع	Initial	Arafah	/ʕrafah/	The day falls on the 9th day of Dhul Hijja in the lunar Islamic Calendar
12	/ ʕ/ ≈ ع	Initial	Arabi	/ʕrabɪ/	Arabic (Adj/N)
13	/ ʕ/ ≈ ع	Initial	oud	/ʕu:d/	"Lute," a musical instrument equivalent to a guitar used in in the Middle East
14	/ ʕ/ ≈ ع	Medial	ma'amoul	/maʕmo:l/	Small shortbread pastries filled with dates, pistachios, or walnuts that are popular in Levantine cuisine and in the Gulf countries
15	/ ʕ/ ≈ ع	Medial	za'atar	/zaʕtar/	A generic name for a family of related Middle Eastern herbs/thyme
16	/ ʕ/ ≈ ع	Medial	rubaiyyat	/rubaʕi :jat/	"Quatrain"
17	/ ʕ/ ≈ ع	Medial	musta'rib	/ mustaʕrɛb/	Would be Arab
18	/ ʕ/ ≈ ع	Final	burqa	/burqʕ/	"Veil"
19	/ɣ/ or /g'/≈ غ	Initial	gharbala	/gˈarbala/	"Garble" or "sift," possibly from Latin
20	/ɣ/ or /g'/≈ غ	Initial	baba ghanoush	/baba gˈno:ʒ/	A Levantine dish of eggplant mashed and mixed with olive oil and various seasonings
21	/ɣ/ or /g'/≈ غ	Medial	maghreb	/magˈreb/	Sunset
22	/ʔ/ ≈ ء	Medial	Qur'an	/qurʔan/	The holy book of Islam
23	/h/ ≈ ه	Final	surah	/su:rah/	A chapter of the Qur'an
24	/q/≈ ق	Initial	carat	/qi:ratˤ/	A small unit of weight that measures gold purity
25	/q/≈ ق	Initial	qirtim	/qurtum/	The carthamin dye plant or its seeds
26	/q/≈ ق	Medial	maqam	/maqam/	System of melodic modes used in traditional Arabic music
27	/q/≈ ق	Medial	raqas sharqi	/raqs ʃarqɪ/	"Oriental dancing," the classical Egyptian style of belly dance that developed during the first half of the 20th century
28	/q/≈ ق	Medial	alkali or alqaly'	/ɪlqalɪ/	A basic ionic salt of an alkali metal or alkaline earth metal chemical element
29	/q/≈ ق	Final	souk	/su:q/	Marketplace
30	/q/≈ ق	Final	sumac	/summa:q/	A cherry red spice used extensively in cooking throughout the Middle East
31	/q/≈ ق	Final	shorooq	/ʃru:q/	Sunrise