

Article

Arabic-Spanish Language Contact in Puerto Rico: A Case of Glottal Stop Epenthesis

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Received: 15 June 2019; Accepted: 13 November 2019; Published: 18 November 2019



Abstract: The current study examines the realization of adjacent vowels across word boundaries in Arabic-Spanish bilinguals and Spanish monolinguals in Puerto Rico, focusing specifically on the rate of glottal stop epenthesis in this context (e.g., *hombre africano* to [ʾom.bre.ʔa.fri.ʾka.no]). It was hypothesized that Arabic-Spanish bilinguals would show a higher rate of glottal stop epenthesis than Spanish monolinguals because of transfer from Arabic. In addition, we investigated the possible effects of stress, vowel height, language dominance and bilingual type on the rate of glottal stop epenthesis. Results from a reading task with 8 participants showed no significant difference in glottalization between bilinguals and monolinguals. For monolinguals, glottalization was significantly more likely when the first vowel was low or stressed; significant interactions between vowel height and stress were found for the bilingual group. Language dominance was a significant factor, with Arabic-dominant bilinguals glottalizing more than the Spanish-dominant bilinguals. In addition, early sequential bilinguals favored glottalization slightly more than simultaneous bilinguals, without reaching significance. Our data suggests some effects of syllable structure transfer from Arabic, particularly in Arabic-dominant participants. To our knowledge, our study is the first exploration of Arabic and Spanish in contact in Puerto Rico, and the first to acoustically examine the speech of Arabic-Spanish bilinguals.

Keywords: glottal stop epenthesis; Arabic-Spanish language contact; transfer; resyllabification; Puerto Rican Spanish; socio-phonetics

1. Introduction

Despite the existence of Arab populations in Cuba ([Fiddian-Qasmiyeh 2016](#)), Puerto Rico ([Alvarado-Leon 2015](#)), and the Dominican Republic, no studies to date have examined Arabic-Spanish language contact in the Caribbean. The current study is a first exploration of the outcomes of Arabic-Spanish language contact in Puerto Rico from a socio-phonetic perspective and is part of a larger ongoing study of Arabic-Spanish bilinguals in Puerto Rico. According to [Alvarado-Leon \(2015\)](#), Puerto Rico contains the largest number of Muslims in the Caribbean, many of whom are of Arab descent. The first wave of immigration to the island that had lasting effects occurred in the early 1940s when approximately 2000 immigrants arrived ([Chitwood 2017](#)). Around 80% of them were of Palestinian descent, as they were fleeing persecution and a poor social, economic, and political situation in Israel. Currently, around 5000 Arabs are estimated to reside in Puerto Rico ([Chitwood 2017](#)), with the majority speaking the Levantine variety of Arabic.

The contact situation between Arabic and Spanish in Puerto Rico provides an interesting opportunity to investigate various aspects of language contact as these languages differ considerably. In this study, we focus on phonetic differences pertaining to the realization of adjacent vowels across word boundaries. Spanish and Arabic have different phonotactic constraints on syllable structure

and they each utilize different strategies for resyllabification. These differences may result in transfer from L1 Arabic to L2 Spanish in Arabic-Spanish bilinguals, leading to the current investigation. The present study aims to investigate whether Arabic-Spanish bilinguals syllabify vowel sequences across word boundaries differently than Spanish monolinguals due to an influence from Arabic. Considering the findings of previous research (e.g., Biondi Assali 1989b; Broselow 1984; Fowler et al. 2008; Kehoe and Havy 2019; Van Coetsem 1988; Winford 2003), we examine if bilingual type (simultaneous vs. early sequential) and language dominance have an effect on phonetic transfer. We also investigate if height of the two vowels and stress of the second vowel affect how these participants realize vowel sequences (Barbería 2012; Hualde 2014; Hualde and Prieto 2002). This is the first study to examine resyllabification strategies acoustically as a result of transfer in Arabic-Spanish bilinguals, and the first study to explore these languages in contact in the Caribbean in general. Previous research on Arabic-Spanish bilinguals focused primarily on Spain and Morocco (Sayahi 2005, 2007, 2011a, 2011b), yet there have been no acoustic examinations of the speech of these populations.

The structure of the paper is as follows. Section 1.1 focuses on the different syllabification strategies utilized in Spanish and Arabic; Section 1.2 briefly discusses phonetic transfer, and Section 1.3 provides an overview of phonetic transfer in Arabic-Spanish language contact studies and our research questions. Section 2 presents the methodology of the study, and Section 3 the results. Lastly, Section 4 provides a discussion and some conclusions.

1.1. Syllabification in Spanish and Arabic

1.1.1. Spanish

Spanish is a language with a moderately complex syllable structure (Maddieson 2013). It shows a preference for open syllables, but permits syllables of up to two coda consonants: *árbol* ‘tree’ [‘ar.βol], *constante* ‘constant’ [kons.‘tan.te] (Colina 2009, 2012; Harris 1983; Hualde 2014). Across words, a coda consonant in word-final position syllabifies as the onset of a following word beginning with a vowel, as in *casas azules* ‘blue houses’ [‘ka.sa.sa.‘su.les] (Colina 2012; Harris 1983). In various dialects of Spanish, resyllabification of a word-final consonant goes hand in hand with aspiration (for word-final /s/), nasal velarization (for word-final /n/), or, more rarely, glottalization (for word-final /s/). Word-final consonants can also be deleted (Hualde 2014). Table 1 provides examples of these processes; word-final elision and aspiration are highly common in Puerto Rican Spanish (Lipski 2008), the variety that is studied here.

Table 1. Phonological processes of word final consonants.

Aspiration	Velarization	Glottalization	Elision
los enemigos	pantalón azul	tres años	las amigas
/los ene‘migos/	/panta‘lon asul/	/‘tres ‘aɲos/	/las a‘migas/
[lo.he.ne.‘mi.ɣos]	[pan.ta.‘lo.ŋa.‘sul]	[‘tre.‘ʔa.ɲos]	[la.a.‘mi.ɣas]

Crucial to the current study is the syllabification of adjacent vowels across words, as in *cuatro amigos* ‘four friends’. In this context, vowels can be realized in separate syllables, i.e., in hiatus (1a). However, Spanish has an aversion for hiatus and most speakers prefer to resolve them through diphthongization (i.e., both vowels are realized in one syllable) or elision of one of the vowels, with or without concomitant vowel lengthening (1b–d) (Barbería 2012; Chappell 2015a; Hualde 2005, 2014; Hualde and Prieto 2002; Souza 2010, among others). In some Spanish varieties, including Bolivian Spanish, glottal stop epenthesis is also attested in this context (1e) (Gonzalez and Christine 2017; Lipski 1994).

In the Spanish of Arabic-Spanish bilinguals in Argentina, speakers tend to reduce diphthongs containing /ie/ to /e/: *siempre* [‘sem.bre] ‘always’, and epenthesize the glottal stop [ʔ] before vowel initial words, such as [tu.a.βlas] *tú hablas* ‘you speak’ to [tu.‘ʔa.βlas] (Biondi Assali 1989b). Glottal

stop epenthesis has been reported in Puerto Rican Spanish as well, but only as a variant of /s/ in word-final, intervocalic position, as in *las alas* [la.ʔa.las] ‘the wings’ (Tellado-González 2007; Valentín-Márquez 2006). It has been suggested that one way in which this variant became a part of Puerto Rican Spanish is through contact with English (Valentín-Márquez 2006), later spreading to monolingual Puerto Ricans via contact with English-Spanish bilinguals. Although the glottal stop has only been reported as a variant of /s/ in Puerto Rican Spanish, it is possible that it serves as a hiatus resolution strategy as well. The deletion of syllable-final /s/ in intervocalic position leaves two adjacent vowels, as shown in the example of *las alas* ‘the wings’ given above. The resyllabification strategies mentioned previously, i.e., /s/ retention, aspiration, and elision, can lead to lexical ambiguity; however, this is not the case with glottal epenthesis (Valentín-Márquez 2006) (2).

1. Syllabification of adjacent vowels across words: ‘cuatro amigos’ /kwa.tro.a.mi.ʔos/

(a) Hiatus	[ˈkwa.tro.a.ˈmi.ʔos]	
(b) Diphthongization	[ˈkwa.tɾwa.ˈmi.ʔos]	
(c) Vowel elision	[ˈkwa.tɾa.ˈmi.ʔos],	[ˈkwa.tro.ˈmi.ʔos]
(d) Vowel elision with lengthening	[ˈkwa.tɾaː.ˈmi.ʔos],	[ˈkwa.troː.ˈmi.ʔos]
(e) Glottal stop epenthesis	[ˈkwa.tro.ʔa.ˈmi.ʔos]	

2.

(a) Retention [la.ˈsal.ta(s)] [la.ʔal.ta(s)] (b) Aspiration [la.ˈha.la(s)] [la.ʔa.la(s)] (c) Elision [la. mi.ˈʔa] [la. ʔa.mi.ˈʔa(s)]	<i>la saltas (la cuerda)</i> ‘you jump over it’ (the rope) <i>las altas (las mujeres)</i> <i>la jalas (la puerta)</i> ‘you pull it (the door)’ <i>las alas</i> ‘the wings’ <i>la amiga</i> ‘the (female friend)’ <i>las amigas</i> ‘the (female) friends’	<i>las altas (las mujeres)</i> ‘the tall ones (women)’ <i>las alas</i> ‘the wings’ <i>las amigas</i> ‘the (female) friends’
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As shown in the examples in (2), when there is glottal epenthesis, it can only be interpreted as the onset of the second vowel, possibly aiding to reduce ambiguity.

1.1.2. Arabic

The majority of Arabic speakers in Puerto Rico are from the Levant and speak a Levantine variety of Arabic. All our bilingual participants had a Levantine origin as well (see Section 2.1). Levantine Arabic permits relatively simple syllable structures such as (CV), (CVC), (CVV), and (CVVC), with (CV) and (CVC) being the most common (Hamdi et al. 2005). Complex onsets are accepted, but these usually occur in loanwords (AlAmro 2015). In contrast, other varieties of Arabic, such as Moroccan and Egyptian Arabic permit more complex syllable structures ((Hamdi et al. 2005; Maddieson 2013) and references therein). During syllabification across words, a consonant coda followed by a word beginning with a vowel is resyllabified as the onset of the following syllable (3), as in Spanish (Broselow 1984; Cardinaletti and Repetti 2009).

3. *Shaf alshems*
 ['ʃaf.təl.ʃɛms]
 Shaf-t al shems
 To see-2SG.PAST the sun
 'you saw the sun'

Unlike Spanish, however, Arabic does not allow onsetless syllables within or across words (Abu-Salim 1982; Biondi Assali 1989b; Broselow 1984, 2017). Glottal stop epenthesis occurs in contexts where a syllable would start with a vowel (Biondi Assali 1989b; Broselow 1984). The example in (4) shows glottal stop epenthesis in word-initial position and across words.

4. *almediina aljamila*
 al medin-a al jamil-a
 the city-FEM the pretty-FEM
 [ʔal.me.ˈdiː.na.ʔal.ja.ˈmiː.la]
 'the pretty city'

In sum, both Arabic and Spanish prefer to avoid onsetless vowels across word boundaries. However, while Arabic uses glottal stop epenthesis as the primary strategy, Spanish tends to employ other strategies, including diphthongization and vowel elision.

1.1.3. Phonetic Factors Affecting Vowel Realizations across Words

Two variables known to impact specific realizations of vowel sequences across word boundaries in Spanish are vowel height and stress (Barbería 2012; Chappell 2015a; Hualde 2014; Michnowicz and Kagan 2016; Trawick and Michnowicz 2019). Specifically, vowel sequences formed of at least one high vowel tend to diphthongize, as do unstressed vowels in contact (5) (Hualde and Prieto 2002).

5. *amigo inteligente* /aˈmigo.inteliˈxente/ [a.ˈmi.ʔoin.te.li.ˈxen.te]
 'intelligent friend'

On the other hand, a low-mid or mid-low vowel sequence has a higher likelihood of being realized in hiatus (6a), as do sequences of two adjacent stressed vowels (6b) (Barbería 2012).

6. a. *come aquí* /ˈkome aˈki/ ['ko.me.a.ˈki]
 'eat here'
 b. *comí algo* /koˈmiˈalgo/ [ko.ˈmi.ˈal.ʔo]
 'I ate something'

Gonzalez and Christine (2017) report that in Spanish, glottal stop epenthesis across word boundaries occurs more frequently when one of the vowels is stressed. This was also found by Chappell (2015b), Michnowicz and Kagan (2016), and Trawick and Michnowicz (2019), among others. Other languages where stress is conducive to glottal stop epenthesis include English (Dilley et al. 1996; Garellek 2014), German, and Silacayoapan Mixteco, among others (González). Relevant to the present study, in Puerto Rican Spanish stress is conducive to glottal stop epenthesis as a variant of /s/ as well (Mohamed and Muntendam; Tellado-González 2007; Valentín-Márquez 2006). Additionally, although typologically there is a tendency for low vowels to be glottalized (Brunner and Žygis 2011), Chappell (2013) and Michnowicz and Kagan (2016) found glottalization in Nicaraguan and Yucatan Spanish to be more common before a mid-rounded vowel /o/, while McKinnon (2018) reports glottalization in Guatemalan Spanish to be favored before /a/ and /o/.

In Arabic, neither vowel height nor stress affect glottal stop epenthesis; onsets are obligatory (AlAmro 2015; Watson 2007) and therefore, glottal stop epenthesis must occur to supply the onset.

Based on these differences across Spanish and Arabic, for our study it was expected that Arabic-Spanish bilinguals would have higher rates of glottal stop epenthesis than Spanish monolinguals.

1.2. Theoretical Background on Phonetic Transfer

In addition to differing phonotactic constraints across languages, social factors can also affect the outcomes of language contact, specifically transfer, which is broadly defined as the incorporation of features from one language (LA) into another language (LB). For the present study, we utilize Grosjean (2011, p. 14) definition of transfer which posits that the term transfer is used for “the static interferences that reflect permanent traces of one language (LA) on the other (LB)” which “are linked to the person’s competence”. Thus, an occasional misuse of a preposition, the accidental mispronunciation of a word, or the overreliance on the L1 or the dominant language during the process of acquisition would not be considered transfer, but rather, interference. Conversely, once a language has already been acquired or a high level of proficiency has been attained, a foreign accent (i.e., the use of phonotactic constraints of LA during LB production) would be considered transfer under his definition. This definition is most useful to the present study, because the bilingual participants investigated are highly proficient in both languages.

According to Winford (2003), phonetic and phonological transfer is usually rare, and generally only occurs when there is a large amount of lexical borrowing, or when there are gaps in the phonemic inventory of one language which can be filled by the other language. In addition, as bilingualism and language contact increase, so do the phonetic and phonological features that are transferrable. Specifically, while light or moderate language contact is usually limited to phonetic transfer through loanwords, intense language contact permits transfer of more complex phonological features such as prosody and syllable structure (Thomason and Kaufman 1988; Thomason 2001; Winford 2003).

Several social factors can play a role in phonetic transfer, such as language dominance, type of bilingual, proficiency, and identity, among others ((Amengual 2019; Thomason and Kaufman 1988; Thomason 2001; Van Coetsem 1988; Winford 2003), among others). In this paper, we solely examine language dominance and type of bilingual (simultaneous vs. early sequential). Van Coetsem (1988) posits that language dominance can play an important role in transfer, specifically a type of transfer he refers to as source language (SL) agentivity. SL agentivity refers to transfer that occurs when the SL speaker is the agent of transfer (Van Coetsem 1988). In this case, the SL speaker is dominant in the SL and imposes the pronunciation of the SL on the recipient language (RL). If the SL is the speaker’s dominant language, it is more probable that features from the SL will be transferred into the RL. This often occurs for instance when Arabic (source language) speakers of Spanish (recipient language) pronounce words in Spanish containing /p/, with a /b/, as the voiceless bilabial stop does not exist in most dialects of Arabic.

The effect of language dominance in phonetic transfer has been attested in several studies, including Broselow (1984), Simonet (2011, 2014) and Amengual and Chamorro (2015). Broselow (1984) shows the role of dominance in a study on the effects of L1 constraints on L2 production and perception of syllabification in Arabic-English bilinguals. Participants in her study relied on phonotactic constraints from their dominant language when syllabifying across words in English. These findings led her to propose the Syllable Structure Transfer Hypothesis, which states that if the second language contains syllable structures not permitted in the first language, speakers will continue to utilize the syllable structure of the first language when producing the second language.

Simonet (2011, 2014) also shows an effect of language dominance in his study of Spanish-dominant and Catalan-dominant Catalan-Spanish bilinguals. Through the examination of Spanish /o/ and Catalan /o/ and /ɔ/, he shows that Spanish-dominant bilinguals created a new ‘merged’ category for Catalan /o/ and /ɔ/, while Catalan-dominant bilinguals maintained the distinction between the two vowels. In other words, instead of creating an entirely new category for Catalan /ɔ/, Spanish-dominant bilinguals combined elements from their dominant language and their second language to facilitate production.

Amengual and Chamorro (2015) also examine language dominance, focusing on the production of Galician mid-vowels in Spanish-Galician bilinguals. Their results showed that Galician-dominant bilinguals maintained a distinction between Galician /e/ and /ɛ/, and /o/ and /ɔ/. Conversely, Spanish-dominant bilinguals produced a merged category for /e/ and /ɛ/, but maintained a clearer distinction between /o/ and /ɔ/. Essentially, the work of Amengual and Amengual and Chamorro (2015) and Simonet (2011, 2014) suggests that there is an underlying continuum of language dominance. Catalan-dominant and Galician-dominant bilinguals do not entirely behave like monolingual speakers of either Spanish nor Catalan/Galician.

When examining the differences between types of bilinguals, a distinction can be made between simultaneous bilinguals (those who learned two languages at the same time) and sequential bilinguals (those who learned one language followed by another). Kehoe and Havy (2019) show that language dominance has less of an effect on phonetic transfer in early sequential and simultaneous bilinguals than in late sequential bilinguals. While some studies have suggested that early sequential and simultaneous bilinguals do not differ drastically from monolinguals of both languages (Guion 2003; Mack 1989), Fowler et al. (2008) suggests that there are differences in production between these groups. In their study, simultaneous English-French bilinguals and early sequential English-French and French-English bilinguals were compared to their monolingual counterparts in VOT production of voiceless plosives /p t k/. The results showed that early sequential bilinguals behaved similarly to the monolinguals of their L1, i.e., early sequential bilinguals with L1 English closely resembled English monolinguals. Simultaneous bilinguals, however, tended to have VOTs that fell more in the middle, i.e., their VOTs were not as long as those of English monolinguals or English-French bilinguals, but not as short as those of French monolinguals or French-English bilinguals.

In Mora and Nadeu's (2012) study on early sequential Catalan-Spanish bilinguals' production of /e/ and /ɛ/, however, early sequential bilinguals were different from monolinguals. That is, early exposure to Catalan did not facilitate the maintenance of the distinction once the speakers began receiving exposure to Spanish. Extensive language use of Spanish caused the participants to shift from maintaining the distinction to production that was more similar to the L2 Spanish, since /ɛ/ does not exist in Spanish.

Finally, Amengual (2019) investigated the production of [b, d, g] and [β, ð, ɣ] in Spanish in early sequential and simultaneous Spanish-English bilinguals and late sequential bilinguals. His findings show that while simultaneous and late sequential bilinguals patterned similarly, producing [β, ð, ɣ] with more constriction, early sequential bilinguals' production was more lenited. In other words, early sequential bilinguals' production was most similar to that of monolingual Spanish speakers. These findings suggest that there is variation amongst early bilinguals, which may lead to differences in transfer as well. Based on these findings, we expected to find differences in glottalization rates amongst the early sequential and simultaneous bilinguals, with early sequential bilinguals behaving more similarly to monolingual Arabic speakers than the simultaneous bilinguals due to age of acquisition of Spanish.

In sum, the research mentioned prior has shown that L1 phonotactic constraints, language dominance, and type of bilingual can affect phonetic outcomes of language contact, thus motivating the current study.

1.3. Phonetic Transfer in Arabic-Spanish Language Contact

To date only a handful of studies have investigated Arabic-Spanish contact and, to our knowledge, no acoustic studies have been conducted on the phonetic outcomes of this contact situation. Previous studies have primarily focused on language attitudes or served as an overview of linguistic characteristics of Arabic-Spanish contact in Morocco (Sayahi 2005, 2007, 2011a), Spain (Sayahi 2011a, 2011b), Western Sahara (Morganthaler García 2011) and Argentina (Biondi Assali 1989a, 1989b, 1991, 1992). Some examples of phonetic transfer in Arabic-Spanish bilinguals in Spain and Morocco include vowel raising (/ko'memos/ [ko.'mi.mus] 'we eat');

vowel lowering (/ko'mimos/ [ko.'me.mos] 'we ate'), and overgeneralization of penultimate stress: [a.'ra.βe] *árabe* 'Arab/Arabic'; [pe.li.'ku.la] *película* 'movie' (Sayahi 2005, 2011a, 2011b). Lastly, Morganthaler García (2011) reports that in Western Sahara, Arabic speakers maintain consonantal clusters such as /pt/ and /kt/ more frequently than Spanish monolinguals, who tend to lenite or delete the first consonant in these consonantal groups, as in the word /as'pekto/ 'aspect', pronounced [as.'pek.to] by bilinguals and [as.'pe.to] by monolinguals (García García de León 2015).

Biondi Assali (1989b) provides an overview of phonetic characteristics common in the Spanish of Arabic-Spanish bilinguals in Argentina. As mentioned in Section 1.1.1, in this variety, the speakers tend to reduce diphthongs, and epenthesize the glottal stop [ʔ] before vowel-initial words. In addition, elision of the first syllable of a word is observed, as in the phrase *al intendente* 'to the supervisor', pronounced [al.ten.'den.te] (Biondi Assali 1989b).

The current study contributes new information on Arabic-Spanish language contact by investigating possible phonetic transfer of the glottal stop from Arabic to Spanish in Puerto Rico. We also examine the possible effect of vowel height, stress, language dominance and bilingual type on this resyllabification strategy. The research questions are as follows:

1. How do Arabic-Spanish bilinguals compare to Spanish monolinguals regarding glottal stop epenthesis across words in Spanish?
2. Do vowel height and stress play a role in the realization of glottal stop epenthesis across word boundaries?
3. What is the effect of language dominance and bilingual type on the use of the glottal epenthesis strategy in Arabic-Spanish bilinguals in Puerto Rico?

For our first research question, we predicted that Arabic-Spanish bilinguals would have a higher likelihood of glottal stop epenthesis as a result of transfer from Arabic than Spanish monolinguals, based on the differences between Arabic and Spanish. For our second research question, we expected glottal stop epenthesis to be more frequent in the context of low vowels or low and mid-rounded vowels (Brunner and Żygis 2011; Mckinnon 2018; Chappell 2013; Michnowicz and Kagan 2016). Additionally, we expected glottal stop epenthesis to be preferred when the second vowel of the sequence is stressed (Chappell 2013, 2015a; Michnowicz and Kagan 2016; Trawick and Michnowicz 2019). Regarding our third question, based on previous research (Amengual and Chamorro 2015; Simonet 2011, 2014), we predicted that language dominance would play a role, with Arabic-dominant participants showing a preference for glottal stop epenthesis to a higher extent than Spanish-dominant participants. Last but not least, for bilingual type we expected early sequential bilinguals to glottalize more than simultaneous bilinguals, and for simultaneous bilinguals to have glottalization rates that fell in the middle of Spanish and Arabic monolinguals, in line with Amengual (2019) and Fowler et al. (2008).

2. Methodology

2.1. Participants

The present study was conducted throughout the island of Puerto Rico. Arabic-Spanish bilingual participants and monolingual Spanish participants were recruited from the municipalities of Trujillo Alto, Vega Baja, Vega Alta, Carolina, Bayamón, and San Juan, which are located in the northeastern area of Puerto Rico, and Ponce, which is located in the southwest. These areas have the highest concentration of Arabs in Puerto Rico. All subjects gave their informed consent for inclusion before they participated in the study. This was conducted in accordance with the Common Rule, and the protocol was approved by the Human Subjects Committee of Florida State University (2018.23606). Following the consent forms, the bilingual participants completed a modified version of the Bilingual Language Profile (BLP; (Birdsong et al. 2012)) in Spanish, which elicited information about education level, language dominance, language history, attitudes towards Arabic and Spanish, as well as attitudes towards Puerto Rico and their Arab country of origin. In addition, questions pertaining to the participants' identity, religion, family history, and basic information such as age and gender were included.

The participants for this study were divided in two groups: five Arabic-Spanish bilinguals (participants one–five) and three monolingual Spanish speakers (participants six–eight), for a total of 8 participants. Although the number of participants is limited, this is a first exploration of Arabic-Spanish bilinguals in Puerto Rico. The monolinguals were divided into two males and one female with an age range of 21 to 41 years, and a mean age of 28. All of the monolingual participants had at least a Bachelors' degree or were enrolled in the last year of a four-year university. The bilingual group contained three males and two females with an age range of 22 to 54 years, and a mean age of 31. When examining the educational background of the bilingual population, apart from one participant who was matriculated in her last year of the university, all had at least a Bachelor's degree, and one participant had a Master's degree.

All the bilingual participants had heritage from the Levant area, meaning that they spoke similar dialects of Arabic. Specifically, two participants were from Palestine, one from Lebanon, one from Syria, and one from Jerusalem, but all participants were born in Puerto Rico. Three participants were early sequential bilinguals and began acquiring Arabic prior to Spanish. The two remaining participants were simultaneous bilinguals. Moreover, four participants were dominant in Spanish, and one was dominant in Arabic, based on their BLP scores. Table 2 summarizes the participants' social demographics, language history, and language-dominance scores based on the BLP (for the bilingual participants).

Table 2. Summary of the characteristics of the Arabic-Spanish bilingual participants (participants 1–5), and the Spanish monolingual participants (participants 6–8).

Participant	Age	Gender	AoA Arabic	AoA Spanish	Type of Bilingual or Monolingual	BLP Score	Language Dominance
1	32	M	0	0	Simultaneous	11	Spanish
2	54	M	0	0	Simultaneous	−9	Arabic
3	22	M	0	4	Early sequential	20	Spanish
4	26	F	0	4	Early sequential	69	Spanish
5	21	F	0	4	Early sequential	47	Spanish
6	21	M			monolingual		
7	41	F			monolingual		
8	21	M			monolingual		

Note: BLP scores range from −218 to 218, with negative values corresponding to Arabic-dominant and positive values to Spanish-dominant. Scores closer to 0 signify a more balanced bilingual.

In the questionnaire, bilingual participants were also asked to rate their speaking, listening, reading, and writing proficiency in Spanish and Arabic on a Likert scale from zero ('none') to six ('high'). Table 3 provides the averages of the proficiency ratings, with standard deviations presented in parenthesis.

Table 3. Average language proficiency ratings for Arabic and Spanish for the bilingual participants (0 = 'none'; 6 = 'high'). Standard deviations are presented in parentheses.

Skill	Spanish	Arabic
Speaking	5.8 (0.4)	5.4 (0.6)
Listening	6 (0)	5.8 (0.5)
Reading	6 (0)	3.4 (2.8)
Writing	5.6 (0.5)	3 (2.5)
Total	5.9	4.4

The bilinguals' proficiency in Spanish was overall higher than in Arabic. This coincides with the language dominance scores based on the BLP (Table 2). Listening and speaking skills were relatively high for both languages, whereas reading and writing scores in Arabic were relatively low. It is important to note that participants four and five reported their Arabic reading and writing score as

zero, which affected the average for the group. In addition, speaker two, a simultaneous bilingual, moved back to the Middle East around age 13, where he received several years of education in Arabic. He reported that he maintained skills in Spanish by communicating with his mother and other family in Puerto Rico by phone. In addition, this speaker reported higher proficiency skills in Arabic than in Spanish; specifically, this participant's speaking and writing proficiency were slightly higher in Arabic than in Spanish. The other four participants reported lower proficiency in Arabic than Spanish and did not have any official educational experience in Arabic.

2.2. Tasks

The main task in the present study was a reading task, which contained a total of 65 sentences; 50 sentences contained experimental items and 15 sentences were fillers. All the sentences were pseudo-randomized.

Experimental items consisted of noun phrases in the form noun+adjective or article+noun (7a, 7b). Article-noun sequences were included because it was difficult to get all of the vowel combinations with noun-adjective sequences. For uniformity, verb phrases were not included as they may behave differently than noun phrases. Table 4 provides examples of each of the possible vowel combinations. In order to investigate the effect of stress, half of the target items included unstressed vowels in contact (7a), and the other half consisted of an unstressed-stressed vowel sequence (7b).

Table 4. Examples of the different vowel combinations in the reading task.

Final Vowel of Word 1	First Vowel of Word 2				
	a	e	i	o	u
a	<i>hacha amarilla</i> 'yellow ax'	<i>ogra hermosa</i> 'beautiful ogar'	<i>herida infectada</i> 'infected wound'	<i>gata obesa</i> 'obese cat'	<i>campaña unida</i> 'united campaign'
e	<i>padre arrogante</i> 'arrogant dad'	<i>hombre elegante</i> 'elegant man'	<i>nene inteligente</i> 'intelligent boy'	<i>tigre horrendo</i> 'horrendous tiger'	<i>presidente universitario</i> 'university president'
i	<i>kiwi azul</i> 'blue kiwi'	<i>bikini elegido</i> 'selected bikini'	<i>chimichurri italiano</i> 'italian chimichurri'	<i>brócoli oriental</i> 'oriental broccoli'	<i>confeti universal</i> 'universal confetti'
o	<i>arco antiguo</i> 'old arc'	<i>hombro herido</i> 'wounded shoulder'	<i>hijo inútil</i> 'useless son'	<i>espejo ornamental</i> 'ornamental mirror'	<i>trabajo urgente</i> 'urgent job'
u	<i>espíritu amazónico</i> 'Amazonian spirit'	<i>tribu enorme</i> 'enormous tribe'	<i>tu intercambio</i> 'your exchange'	<i>tofu occidental</i> 'occidental tofu'	<i>su uniforme</i> 'his uniform'

7. a. bikini
/bi'kini ele'xido/
bikini
'chosen bikini'
- b. hijo
/'ixo
son only
'only son'
- elegido
chosen
único
'uniko/

Sentence frames were designed with experimental items in the middle of the sentence, preceded by two to three words and followed by two to four words as well (8a, 8b).

8. a. Tiene una herida infectada en el estómago.
He/she/you have a wound infected in the stomach.
'He/she/you has/have an infected wound in his/her/your stomach.'
- b. Se cayó una uva debajo del sofá.
Fell a grape underneath the couch.
'A grape fell underneath the couch.'

The sentences were checked by three native speakers from Puerto Rico to ensure that the lexical items used in the task were familiar to Puerto Ricans.

2.3. Procedure

The present study is part of a larger ongoing investigation of Arabic-Spanish bilinguals in Puerto Rico, and consisted of three parts: a modified version of the BLP, a sociolinguistic interview, and a reading task. In total, the sessions took approximately 1.5 h per participant. In this paper, however, we only report the findings from the reading task. Data were collected in the participants' home, the investigator's home, or in different mosques throughout the island. After recruitment, participants were asked to fill in the consent form and the BLP questionnaire, before completing the interview and the reading task. For the reading task, participants were shown a PowerPoint that contained the target sentences and fillers. Participants were told to read each of the sentences aloud as naturally as possible twice, back-to-back. The sessions were conducted entirely in Spanish.

The data were recorded using a DR-07MK II linear PCM digital recorder, at 44,100 Hz, 16 bit wav. Experimental items were transcribed and analyzed acoustically using Praat (Boersma and Weenink 2019), and the data were analyzed statistically using Rbrul (Boersma and Weenink 2019).

2.4. Acoustic Analysis

Experimental items were examined for glottal stop epenthesis or glottalization in between the target adjacent vowels across words. Glottal stop epenthesis involves a period of silence between the two adjacent vowels followed by a burst (Figure 1) and/or an abrupt beginning of the second vowel (Figure 2). The square in the waveform in the figures indicates the period of silence and/or the abrupt beginning of the following vowel. Note also that a brief phase of aperiodicity occurs at the end of the first vowel in both Figures 1 and 2.

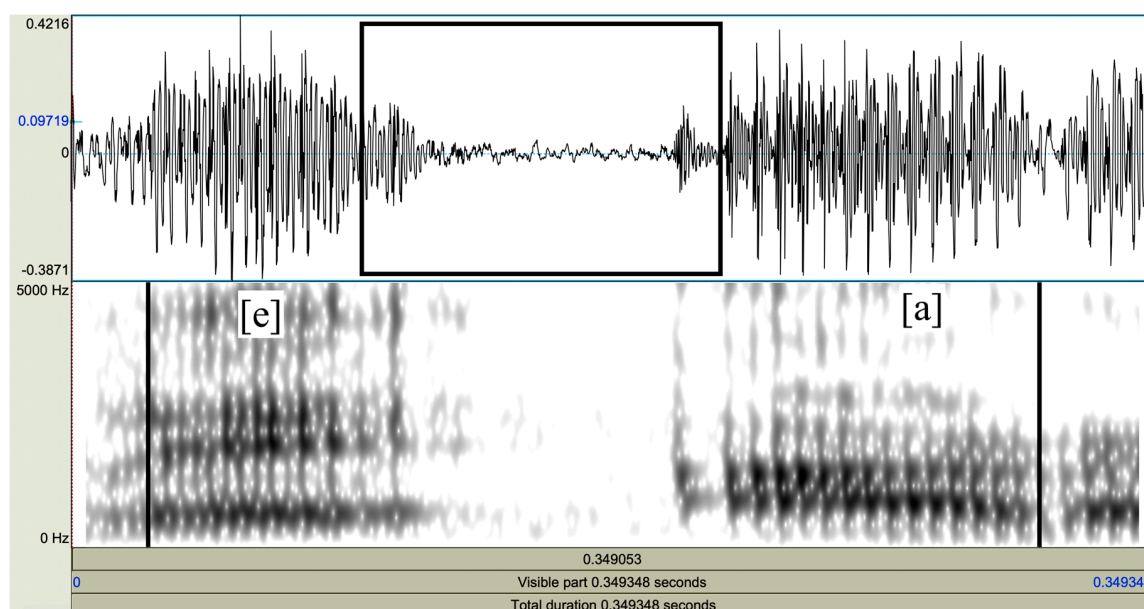


Figure 1. Epenthesis of glottal stop in the phrase *padre arrogante* ‘arrogant father’, uttered by Participant 3 (a 21-year old Spanish-dominant bilingual male).

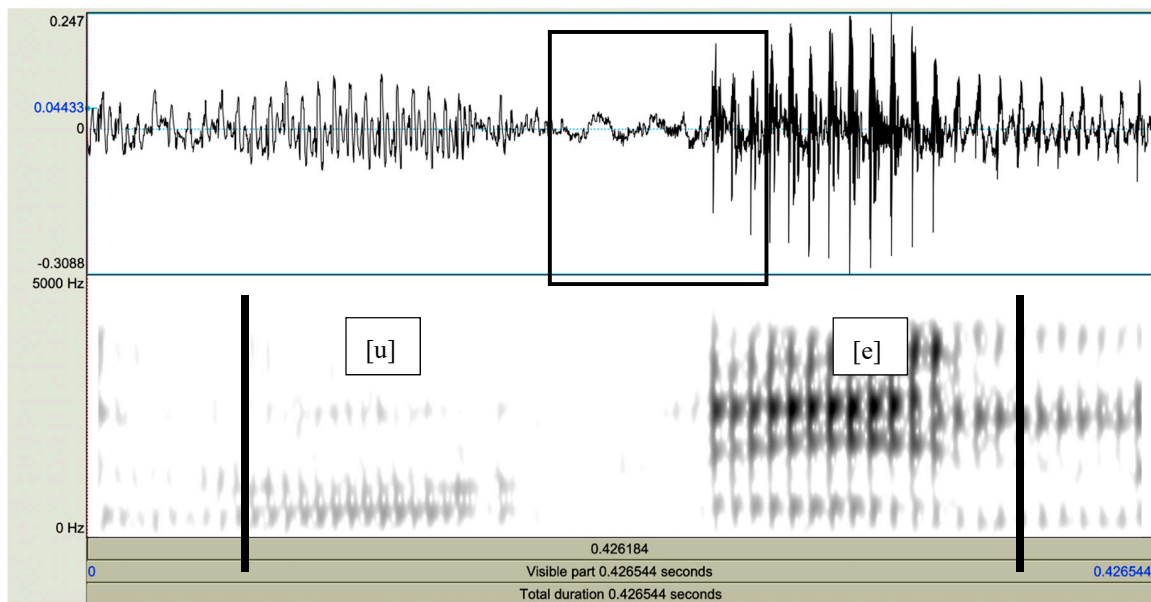


Figure 2. Epenthesis of glottal stop in the phrase *tribu enorme* ‘enormous tribe’, uttered by Participant 1 (a 32-year old Spanish-dominant bilingual male).

Glottal stop epenthesis can also be realized as vowel glottalization (aka creaky voice) (Ladefoged and Maddieson 1996, pp. 73–77, and references therein). Most commonly, glottalization is shown as discontinuous duration of consecutive pulses (aperiodicity), different amplitude or shape of consecutive pulses (diplophonia), and/or gradual widening of pulses with F0 lowering and amplitude damping (creak) (Dilley et al. 1996; Redi and Shattuck-Hufnagel 2001). Examples are provided in Figures 3 and 4. The square in the waveform clearly shows a greater distance between pulses across the word boundary.

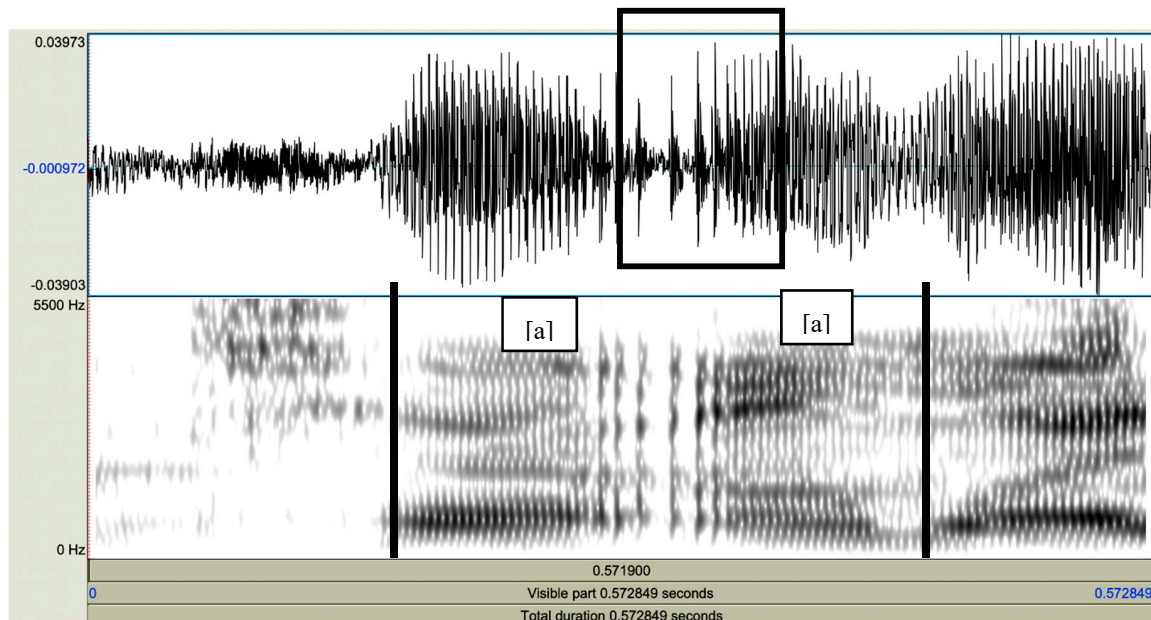


Figure 3. Glottalization or creaky voice produced in the phrase *hacha amarilla* ‘yellow ax’, uttered by Participant 1 (a 32-year old Spanish-dominant bilingual male).

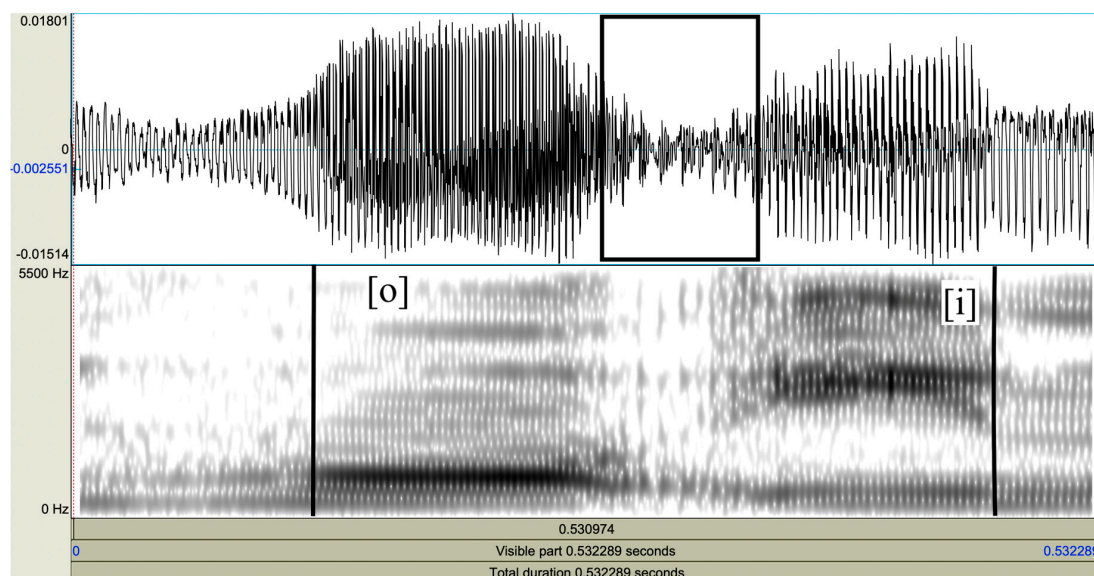


Figure 4. Glottalization or creaky voice produced in the phrase *hijo inútil* ‘useless child’, uttered by Participant 7 (a 41-year old Spanish monolingual female).¹

3. Results

The data were analyzed using mixed-effects modeling in Rbrul (Johnson 2019). The results are based on a total of 761 tokens, as 39 out of 800 tokens (4.9% of the data) had to be discarded due to background noise or participants placing stress in a different location. The experimental item *rugbi élite* was removed from the data because all participants placed stress on the penultimate syllable of *élite* as opposed to the antepenultimate.

Several models were run to analyze the data: one model for the monolinguals, one model including both the monolinguals and the bilinguals, and three models for the bilinguals (one for the linguistic variables, one for the extralinguistic variables, and one with both the linguistic and extralinguistic variables). The monolingual and bilingual participants were run in separate models first to examine the role of the different factor groups in each group of participants. In the bilinguals, linguistic and extra linguistic variables were originally separated, following Kennedy Terry (2017), and then run together to examine the data for interactions.

Figure 5 shows the glottalization rates of the Spanish monolinguals and the Arabic-Spanish bilinguals. The Spanish monolinguals produced 283 tokens, 92 of which were glottalized (33%). In comparison, 164 of the 478 tokens (34%) produced by the bilingual participants were glottalized. A regression was run to compare the two participant groups, and included rate of glottalization as the dependent variable, ‘Speaker’ and ‘Phrase’ as random factors, and Group (‘bilingual’ vs. ‘monolingual’) as the independent variable. The results showed no significant difference in glottalization rate between bilinguals and monolinguals ($p = 0.93$).

The model for the Spanish monolinguals included ‘Phrase’ as a random effect², and Height of the first vowel (‘low’, ‘mid’, ‘high’), Height of the second vowel (‘low’, ‘mid’, ‘high’), and Stress of the second vowel (‘stressed’, ‘unstressed’) as the independent variables. The dependent variable for all models was the presence or absence of glottalization. The results show that the variable height of the second vowel had a significant effect ($p = 0.03$) on glottalization rates in Spanish monolinguals.

¹ Figures 3 and 4 show examples of creaky voice produced by a bilingual and a monolingual participant, respectively. We found no differences in the way glottalization was produced in monolinguals compared to bilinguals.

² Due to the limited number of speakers, Speaker could not be included as a random factor.

According to the factor weights, contexts where the second vowel was low favored glottalization (0.735), whereas mid and high vowels disfavored glottalization (see Table 5).

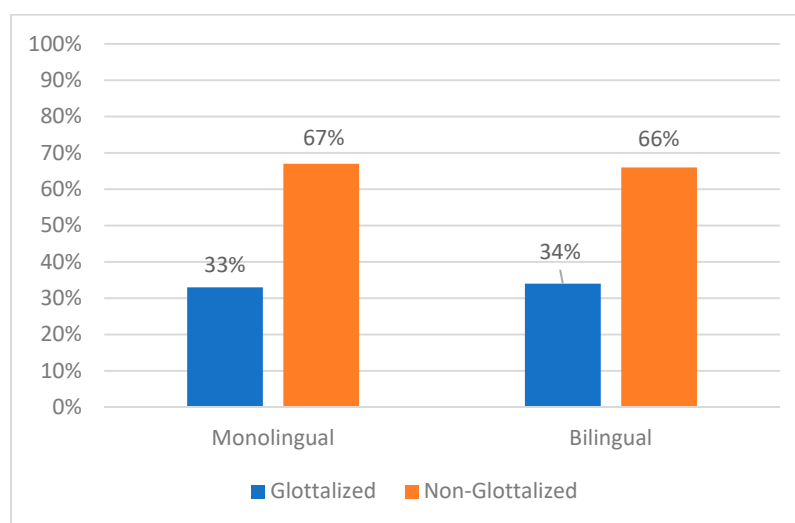


Figure 5. Percentage of glottalized vs. non-glottalized tokens in monolingual vs. bilingual participants.

Table 5. Results for the monolingual participants (V1 = first vowel; V2 = second vowel).

Factor Group	Log Odds	Tokens	Factor Weights	<i>p</i> -Value
Height of V1				0.09
Low	−0.118	53	0.471	
Mid	0.794	117	0.689	
High	−0.676	113	0.337	
range			35	
Height of V2				0.03
Low	0.156	55	0.735	
Mid	−0.132	110	0.470	
High	−1.024	118	0.288	
range			44	
Stress of V2				0.31
Unstressed	0.296	142	0.573	
Stressed	−0.296	141	0.427	
Range			15	

An examination of the data shows that in monolinguals, 41% of the tokens followed by an unstressed low vowel were glottalized, while 48% and 19% of the tokens followed by an unstressed mid or high vowel, respectively, were glottalized. Next, in contexts in which the following vowel was stressed, glottalization occurred in 57% of the tokens followed by a low vowel, 20% of the tokens followed by a mid vowel, and 27% of the tokens followed by a high vowel (see Figure 6).

There were no significant interactions. Table 5 summarizes the results for the monolingual participants, including the factor groups, log odds, number of tokens, factor weights and *p*-values.

Next, we ran a regression for the linguistic variables affecting glottalization in the bilingual group. The model included ‘Speaker’ and ‘Phrase’ as random effects, and Height of the first vowel, Height of the second vowel, and Stress of the second vowel as the independent variables. The dependent variable was again the rate of glottalization. The results are displayed in Table 6.

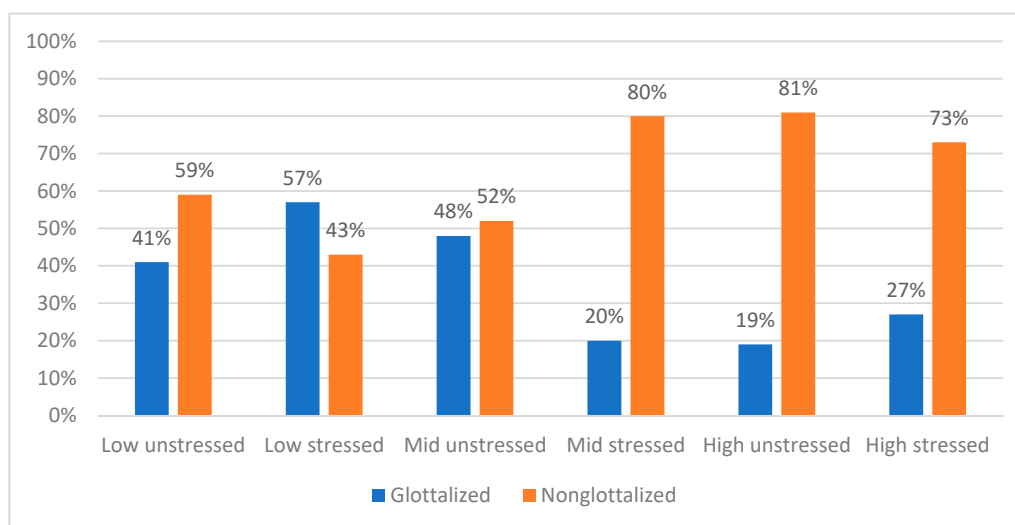


Figure 6. Glottalization rates for the monolingual Spanish participants according to height of the second vowel ('low', 'mid', 'high') and stress of the second vowel ('unstressed', 'stressed').

Table 6. Results for the linguistic variables for the bilingual participants (V1 = first vowel; V2 = second vowel).

Factor Group	Log Odds	Tokens	Factor Weights	p-Value
Height of V1				0.27
Low	−0.0348	95	0.491	
Mid	0.3370	196	0.583	
High	−0.3022	187	0.425	
Range			16	
Height of V2				0.11
Low	0.323	96	0.580	
Mid	0.219	189	0.555	
High	−0.542	193	0.368	
Range			21	
Stress of V2				0.21
Unstressed	0.23	244	0.557	
Stressed	−0.23	234	0.443	
Range			11	
Height of V2: Stress				0.02
Low unstressed	−0.697	48	0.332	
Mid unstressed	0.467	99	0.615	
High unstressed	0.230	97	0.557	
Low stressed	0.697	48	0.668	
Mid stressed	−0.467	90	0.385	
High stressed	−0.230	96	0.443	
Range			34	
Height of V1: Height of V2				0.05
Low-low	0.874	18	0.706	
Low-mid	−0.373	40	0.408	
Low-High	−0.501	37	0.377	
Mid-low	−1.137	40	0.243	
Mid-mid	0.462	77	0.613	
Mid-high	0.675	79	0.663	
High-low	0.263	38	0.565	
High-mid	−0.089	72	0.478	
High-high	−0.174	77	0.457	
Range			46	

The results show no significant main effects of height of the first vowel, height of the second vowel and stress of the second vowel. However, there was a significant interaction between the height of the second vowel and stress ($p = 0.02$). Specifically, glottalization is favored when the second vowel is low and stressed (0.668), when the second vowel is an unstressed mid-vowel (0.615), and when the second vowel is high and unstressed (0.557) (Table 6). Figure 7 shows the percentages of glottalization according to height and stress of the second vowel for the bilingual participants; 52% of the tokens with a second low stressed vowel, 47% of the tokens with a second mid unstressed vowel, and 29% of the tokens with a second, high unstressed vowel were glottalized.

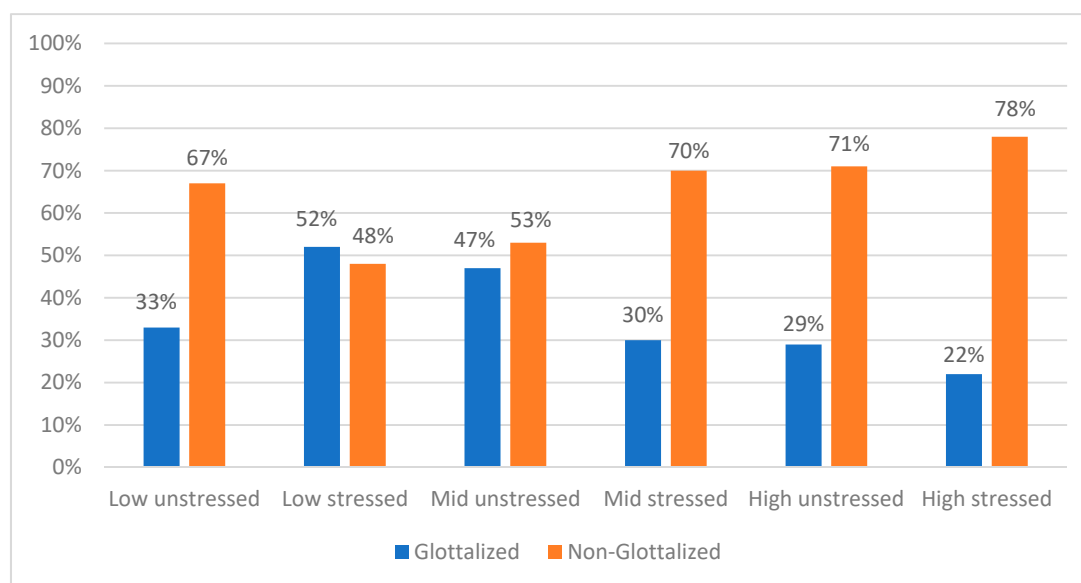


Figure 7. Glottalization rates for the bilingual participants according to height of the second vowel (low, mid, high) and stress of the second vowel (unstressed, stressed).

A significant interaction was also found between the height of the first and that of the second vowel ($p = 0.05$). Specifically, the following vowel combinations favor glottalization: two low vowels (0.706), a mid-vowel followed by a high vowel (0.663), two mid-vowels (0.613), and, to a lesser extent, a high vowel followed by a low vowel (0.565) (Table 6). According to the ranges, the strongest linguistic predictor of glottalization in the bilingual participants was the interaction between the height of the first vowel and that of the second vowel (range: 46). As shown in Figure 8, 67% of the sequences of two low vowels, 37% of the sequences consisting of a mid-vowel followed by a high vowel, 47% of the sequences of two mid-vowels, and 47% of the sequences of a high vowel followed by a low vowel were glottalized.

The model examining the effect of the extralinguistic variables for the bilingual participants included 'Speaker' and 'Phrase' as random effects, and Language dominance ('Spanish', 'Arabic') and Bilingual type ('simultaneous' vs. 'early sequential') as the independent variables. Table 7 provides a summary of results for the extralinguistic variables for the bilingual group.

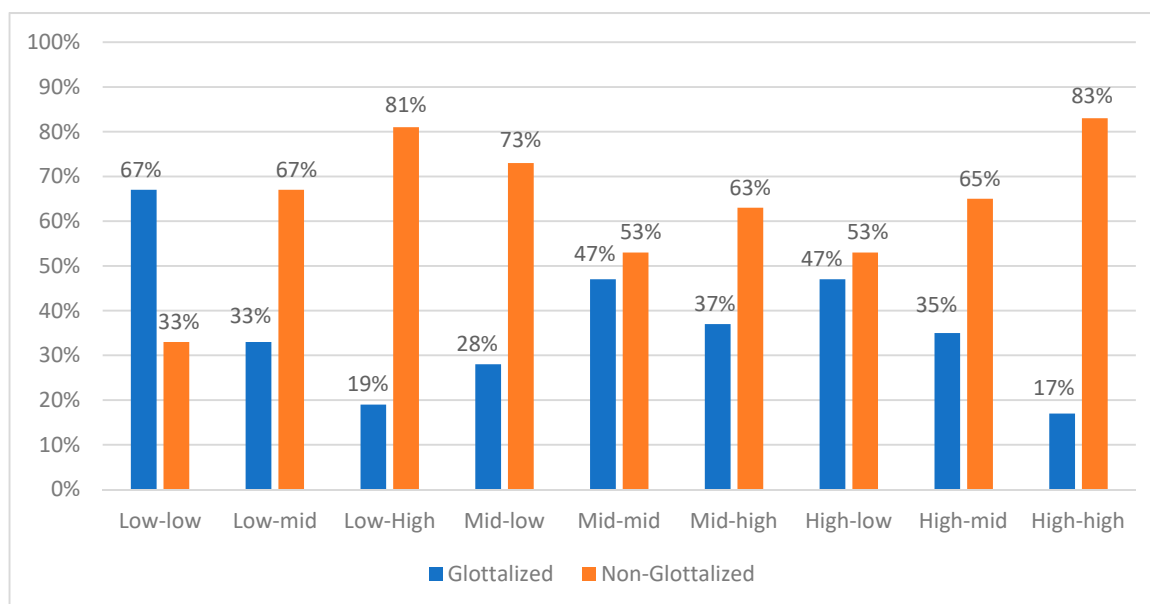


Figure 8. Glottalization rates according to vowel combination (height of first vowel-height of second vowel) in the bilingual participants.

Table 7. Results for the extralinguistic variables Language dominance and Type of bilingual for the bilingual group.

Factor Group	Log Odds	Tokens	Factor Weights	p-Value
Language dominance				<0.001
Arabic	1.236	93	0.775	
Spanish	−1.236	385	0.225	
Range			55	
Bilingual type				0.07
Early sequential	0.472	292	0.616	
Simultaneous	−0.471	186	0.384	
Range			23	

The results show that language dominance was significant ($p < 0.001$). Specifically, dominance in Arabic favored glottalization (0.775), whereas dominance in Spanish disfavored it (Table 7). The Arabic-dominant bilingual glottalized 60% of all tokens, whereas the Spanish-dominant bilinguals only glottalized 28% of the tokens (see Figure 9). The variable type of bilingual had no significant effect on the rate of glottalization.

After examining the linguistic and extra-linguistic variables in two separate models, we combined them into one model in order to test for interactions between these variables; however, there were no significant interactions.

In short, there were no significant differences in the rate of glottalization between bilinguals and monolinguals. In the monolinguals, the height of the second vowel had a significant effect on glottalization, with a low second vowel favoring it. For the bilingual participants, there were significant interactions of stress and the height of the second vowel, with mid unstressed, high unstressed and low stressed second vowels being more conducive to glottalization, as well as between the heights of both vowels, with a sequence of two low vowels, a sequence of two mid vowels, a mid vowel followed by a high vowel, and a high vowel followed by a low vowel favoring glottalization. Language dominance was also significant, with dominance in Arabic favoring glottalization. The following section discusses these results in more detail.

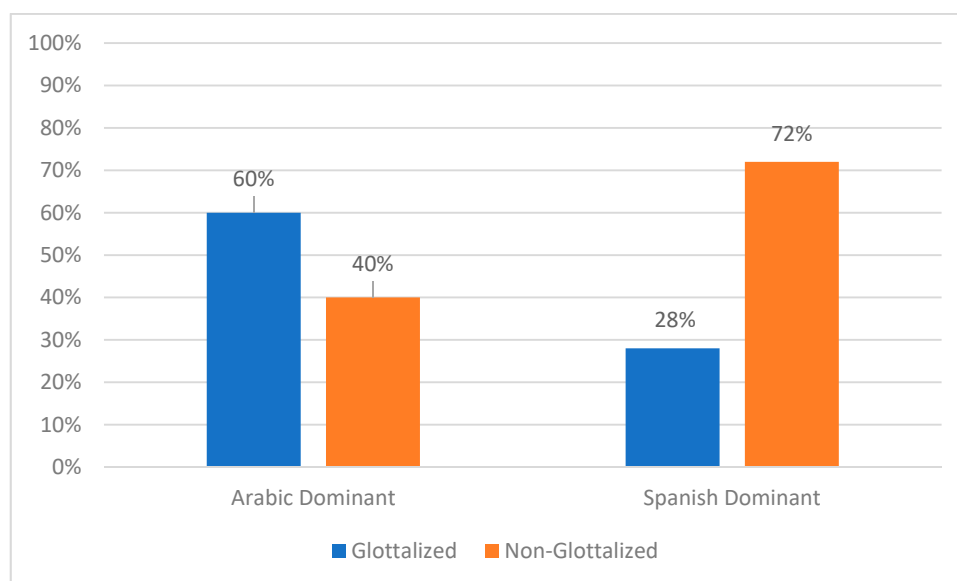


Figure 9. Percentage of glottalized vs. non-glottalized tokens in Arabic-dominant vs. Spanish-dominant participants.

4. Discussion and Conclusions

The current study was a first exploration into the epenthesis of the glottal stop [ʔ] in Arabic-Spanish bilinguals and Spanish monolinguals in Puerto Rico. We aimed to answer the following research questions:

1. How do Arabic-Spanish bilinguals compare to Spanish monolinguals regarding glottal stop epenthesis across words in Spanish?
2. Do vowel height and stress play a role in the realization of glottal stop epenthesis across word boundaries?
3. What is the effect of language dominance and bilingual type on the use of the glottal epenthesis strategy in Arabic-Spanish bilinguals in Puerto Rico?

Our findings show that both groups glottalized approximately a third of all tokens investigated. For monolinguals, sequences where the second vowel was low were conducive to glottalization. This is consistent with the typological trend for glottalization and low vowels to pattern together (Brunner and Żygis 2011). However, this glottalization pattern differs from that reported for Nicaraguan, Yucatan and Paraguayan Spanish, where glottalization is favored before /o/ (Chappell 2013; Michnowicz and Kagan 2016; Trawick and Michnowicz 2019), and from Guatemalan Spanish, where glottal epenthesis is more frequent before /a/ and /o/ (Mckinnon 2018). Our findings provide evidence that glottalization is favored by low and/or mid-rounded vowels, depending on the Spanish dialect. In addition, stress was not found to significantly impact glottalization in our monolinguals, unlike in previous studies ((Chappell 2015a; Gonzalez and Christine 2017), among others).

In the bilingual group, glottal stop epenthesis is favored in various vocalic contexts, predominantly when both vowels are low, consistent with typological tendencies (Brunner and Żygis 2011). The vowel combinations mid-high, mid-mid, and, to a lesser extent, high-low, also favor glottalization. We suggest an alternative way of interpreting these interactions as a dispreference for glottalization in high-high and high-mid vocalic contexts, which typically would favor diphthongization and related hiatus resolution strategies in Spanish ((Barbería 2012; Hualde 2005), among others). Significant interactions between vowel height and stress were also found in the bilingual group: specifically, a second vowel that is low and stressed, a second vowel that is mid and unstressed, and a second vowel that is high and unstressed are conducive to glottalization. While the finding that a low, stressed second vowel is conducive to glottalization is clear, as it corroborates the findings of previous research

(Chappell 2015a; Gonzalez and Christine 2017; Michnowicz and Kagan 2016; Trawick and Michnowicz 2019), the latter findings are not. Further analysis of the data might provide additional insight.

Language dominance was found to have a significant effect on glottal stop epenthesis, consistent with previous studies (Amengual and Chamorro 2015; Simonet 2011, 2014; Van Coetsem 1988). Specifically, speaker 2, who is dominant in Arabic, glottalized significantly more than the Spanish-dominant bilingual participants (speakers one, three, four and five). Glottalization for speaker 2 averaged 60% of all the tokens for this participant; cf. a 28% average for Spanish-dominant participants. The second pattern is closer to the average glottalization rates reported for speakers of other Spanish dialects ((Chappell 2015a; Mckinnon 2018), among others). This suggests that glottal epenthesis for speaker 2 is a result of transfer from Arabic. Note also that this speaker gave the highest self-ratings for Arabic proficiency, spent the most time in the Middle East and was able to master Arabic reading and writing. This may suggest that proficiency plays a role in glottalization in addition to language dominance, warranting further investigation.

Bilingual type was not a significant factor, supporting Mora and Nadeu (2012), who propose that through time, as early sequential bilinguals use one language substantially more than the other, they undergo a shift, favoring L2 pronunciation. Presently, although the early sequential bilinguals were exposed to only Arabic for 4 years, once they matriculated into school, their language dominance and use shifted. All participants except one reported that Spanish was their dominant language. An overview of the questionnaires showed that both early sequential and simultaneous bilinguals (excluding speaker two) use Arabic with family, and for religious purposes only. For work, school, and socializing, however, Spanish is the primary language used. Nevertheless, our results show a trend for early sequential bilinguals to favor glottalization slightly more than simultaneous bilinguals, in line with Amengual's (2019) research, possibly due to having been exposed to only Arabic longer than simultaneous bilinguals. It is expected that the analysis of data from additional Arabic-Spanish bilingual participants will provide further information regarding the impact of bilingual type on glottal stop epenthesis in Puerto Rican Spanish.

Our findings appear to support phonetic transfer, at least for Arabic-dominant speakers of Spanish, since the rate of glottalization is much higher than in monolingual and Spanish-dominant participants. In addition, the comparison of linguistic factors in the monolingual and bilingual group shows that low second vowels consistently favor glottal stop epenthesis in the former, but in the latter glottalization is found in more contexts. For us, this suggests that bilingual participants, particularly if Arabic-dominant, transfer this aspect of syllable structure from Arabic, as suggested in Broselow (1984) and Biondi Assali (1989b). Examination of data from a larger number of participants will shed more light on the relevance of transfer in glottal stop epenthesis in Arabic-Spanish bilinguals.

The present study serves as a starting point for research on language contact between Arabic and Spanish in the Caribbean. One limitation in the current study is the sole use of controlled formal speech (a reading task), as similar studies have found a role for formality (Chappell 2015b). However, this study is only a small portion of a larger ongoing investigation of Arabic-Spanish bilinguals in Puerto Rico. In addition to a larger participant pool, future research will aim to compare formal controlled speech to informal speech elicited from sociolinguistic interviews. We will also acoustically examine additional syllabification strategies employed by these bilinguals, and how they compare to monolinguals.

Future research should incorporate data from late sequential bilinguals or late L2 learners of Spanish and compare their glottalization rates to simultaneous and early sequential bilinguals. It is possible that early sequential and simultaneous bilinguals fall along a continuum, in that they are not completely like Spanish monolinguals nor like late bilinguals, as shown in Fowler et al. (2008). The inclusion of these participants would paint a clearer picture of Arabic-Spanish bilinguals in Puerto Rico and bilingualism more generally. In addition, future research should investigate the Arabic production of Arabic-Spanish bilinguals in order to examine if having access to different resyllabification strategies

in Spanish plays a role in how these participants syllabify vowel sequences across word boundaries in Arabic as well.

We recommend replicating this study in other countries where Arabic and Spanish are in contact, as this would help clarify the results on glottalization rates in those who are dominant in Spanish as opposed to Arabic. Lastly, although it was not examined here, we suggest that future investigations examine the role of religion, identity and language maintenance. While conducting the current study, we noticed that there was a difference in proficiency and tendency to assimilate to Puerto Rican culture across practicing Muslims, non-practicing Muslims and Christians. We also noticed that non-practicing Muslims were less likely to feel accepted by their practicing counterparts, forcing them to look to other groups for community. In short, there is still much left to be investigated within the Arabic-Spanish bilingual community in Puerto Rico; however, the present study has aided in the general understanding of Arabic-Spanish language contact and how Arabic can have an effect on spoken Spanish.

Author Contributions: Conceptualization, S.M., C.G. and A.M.; Formal Analysis, S.M., C.G. and A.M.; Funding acquisition, S.M., C.G. and A.M.; Investigation, S.M.; Methodology, S.M., C.G. and A.M.; Project administration, S.M., C.G. and A.M.; Supervision, C.G. and A.M.; Visualization, S.M., C.G., and A.M.; Writing (original draft), S.M.; Writing (review and editing), S.M., C.G. and A.M.

Funding: This research has been funded by a Language Learning Dissertation Grant (RF02995), and a Winthrop King Research and Study Summer Travel Grant.

Acknowledgments: We would like to thank the audience at the 3rd conference on Bilingualism in the Hispanic and Lusophone world (BHL), two anonymous reviewers, and the editors of this Special Issue for their valuable comments and suggestions. All remaining errors are our own.

Conflicts of Interest: The authors declare no conflict of interest.

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