# Non-vibrant bilingual rhotics in a Creole-Spanish Contact Scenario

**Abstract**

This sociolinguistic study examines the non-vibrant rhotic realizations produced in a bilingual Spanish variety spoken by Creole-Spanish bilinguals in the Archipelago of San Andres, Colombia. These bilingual rhotic realizations were compared with the languages in contact, monolingual varieties of Spanish and Creole, in terms of the best acoustic predictors for discriminating between linguistic groups. A discriminant function analysis selected segmental duration and formant frequencies (F3 and F2) as the acoustic correlates with the best predicting capabilities. These acoustic predictors extracted from zero-occlusion rhotics were further contrasted between varieties revealing that the Spanish of Creole-Spanish bilinguals is placed in an intermediate position between the monolingual Spanish and Creole speakers. These findings corroborate the vernacular status of the bilingual variety and suggest that specific realizations seem to converge with each of the languages in contact. A discussion ensues on the nature of non-vibrant rhotic productions across varieties and the potential outcomes of contact within specific groups in the bilingual population.

*Keywords*: non-vibrant rhotics, Raizal Creole, Continental Spanish, Discriminant Function Analysis (DFA), language contact.

## 1. Introduction

This sociolinguistic study examines the variable realization of non-vibrant rhotics in the bilingual Spanish variety spoken by Creole speakers in the Caribbean Archipelago of San Andres, Colombia. In this Archipelago, three main varieties are in contact: an English-based Creole known here as 1) Raizal Creole[1]; 2) Continental Spanish[2], the immigrant, monolingual Spanish variety from mainland Colombia; and 3) the bilingual Spanish variety spoken by Creole-Spanish speakers, Raizal Spanish. This contact situation represents an opportunity to test the outcomes of contact at the phonetic level of a non-lexifier language in contact with an English-based Creole in this part of the Caribbean, and this is particularly the case of non-vibrant bilingual rhotics in the Creole communities of these Caribbean islands. The current study addresses this void in the field by comparing the highly variable use of non-vibrant rhotics in the Spanish variety spoken by bilingual speakers with the non-vibrant segments produced in the monolingual Raizal Creole and Continental Spanish varieties.

Rhotics are a category of r-like sounds that are produced with a vibration or lack thereof of a mouth articulator in natural languages. Precisely, rhotics in the Archipelago of San Andres and other Creoles in Central America and the Caribbean have been reported to be produced with no vibration of the apical portion of the tongue with the roof of the mouth (Bartens, 2013; Balam, 2013). Although in traditional terms, Spanish has a vibrant rhotic variant in its repertoire, a non-vibrant segment has also been documented in several Spanish varieties (Bradley and Willis, 2012; Willis and Bradley; 2008, Melero-Garcia & Cisneros, 2020). The present comparative analysis

[1] Ethnologue denotes this Creole variety as Islander Creole English (ICR): https://www.ethnologue.com/language/icr

[2] This term was chosen due to referring to immigrants arriving from Continental Colombia as opposed to the Islands of the Archipelago, and the fact that many Raizales use this alternative name to refer to them.

examines the bilingual and monolingual productions to determine the best acoustic predictors that distinguish the realizations of non-vibrant rhotics between varieties.

For this study, the Raizal ethnonym will be used to contrast between the three varieties under examination. This term (*Raiz* 'root' and *-al* 'belonging to' (belonging to the root)) corresponds to the denomination of the ethnic group of the Archipelago of San Andres whose genetic ancestry, history, culture, identity and language can be traced back to their African roots. The Raizal identification is widely used in juxtaposition from the relatively 'newly' arrived immigrants known as *Pañas*[3], who come mainly from coastal areas of continental Colombia. The ethnic marker of *Paña* also makes the distinction between islanders by birth mainly born to established immigrants from mainland Colombia and with no Creole heritage. In addition, the Raizal ethnonym was carefully chosen by this Creole community with the aim of being recognized as an indigenous ethnic group by Law 47 of 1993 and differentiate their history of slavery and creolization with other Afro-Colombian peoples from the continental Colombia. This categorization remains in use until the present work and will be included as the main term to distinguish between the rhotics produced in the groups under study.

The Archipelago of San Andres is composed of a set of three islands: San Andres, Old Providence, and Santa Catalina. San Andres is the biggest island of the Archipelago and the center of the provincial government, while Old Providence and Santa Catalina are the smaller islands of the Archipelago. Connected by a small bridge of roughly 705 feet (205 m), Santa Catalina is treated under the jurisdiction of Old Providence, and it will be referred as part of Old Providence throughout this paper (Figure 1).

[3] *Paña* is the name coined by Creole speakers and used to refer informally to *España* or Spanish-speaking immigrants from Colombia.

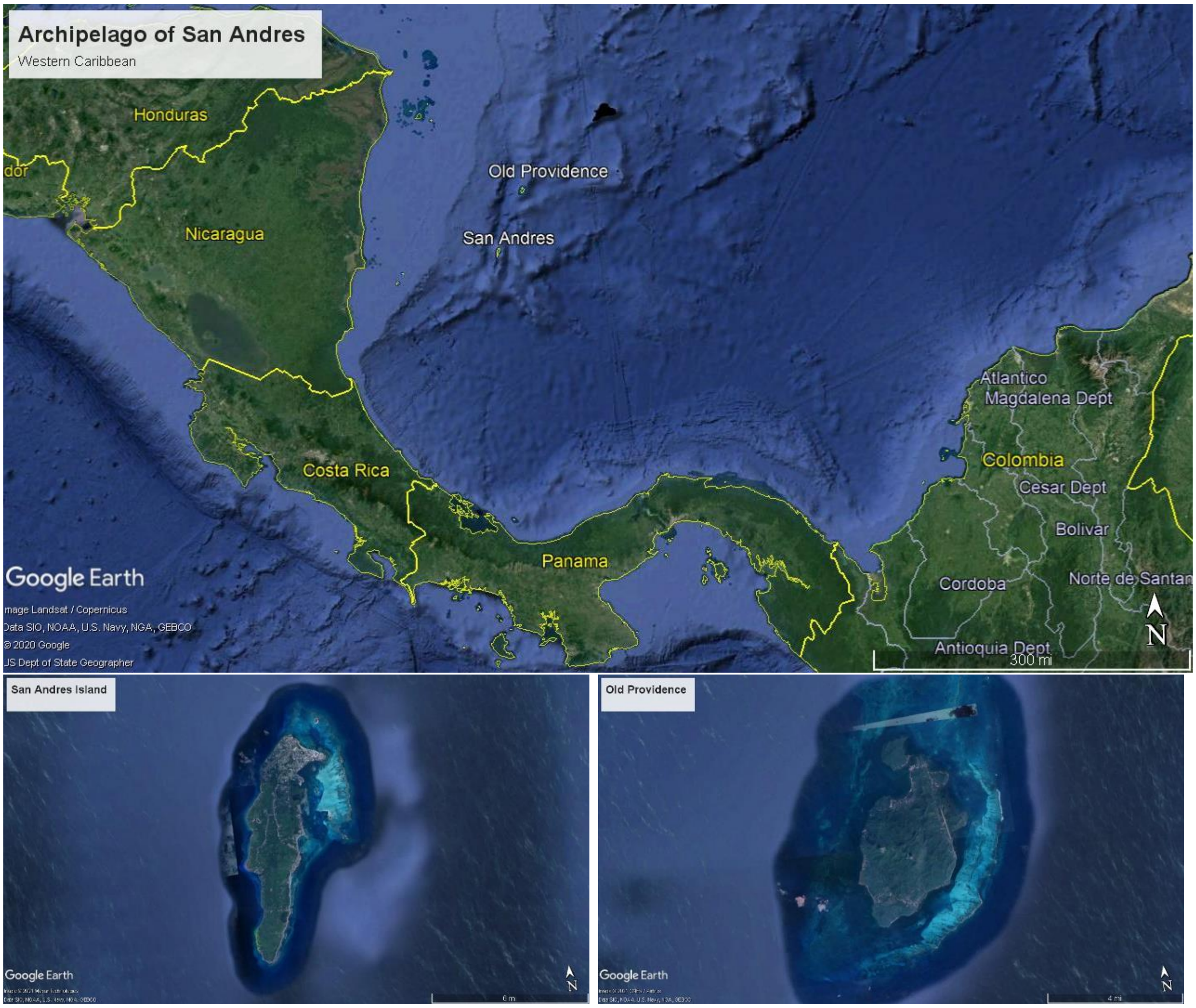


Figure 1. (Upper) Archipelago of San Andres in the Western Caribbean. (Lower) A close-up of the islands of the Archipelago (Google Earth, 2018).

On paper, both Raizal Creole and Spanish are the co-official languages of the Archipelago as per the Colombian constitution of 1991 (Constitución Política de Colombia, 1991) and subsequent language laws (Ley 47, 1993; Ley de Lenguas Nativas, 2010). However, the extent to which the laws are implemented is limited. Currently, Spanish is the language of the education system and there is little representation of Raizal Creole in the public sphere (Author X, 2020). This is exacerbated by the overpopulation of the islands, which by 2005, officially revolved around 60,000 inhabitants (59,573) of which 23,396 self-identified as Raizales in a territory of about 17 miles (Dirección Nacional de Estadística, 2005). However, the new 2018 national census registered a 20% decrease in population[4], which contrasts sharply with unofficial accounts which positions San Andres as the island with the highest population density per square mile in the Caribbean and the sixth worldwide (Instituto de Investigaciones Marinas y Costeras "José Benito Vives de Andréis", 2012). Despite the discrepancies between official and unofficial numbers, the population expansion of non-native immigrants has been an issue associated with territorial and cultural displacement of the Raizal population (Ross, 2007).

Phonological variants are very susceptible to language variation and change, as the properties of sounds provide speakers with a vast array of options to adapt and accommodate to social situations (Thomas, 2011). Particularly, rhotics represent a highly variable segment without a single physical property that unites them all, as they are produced with different articulatory mechanisms (Thomas, 2011, p. 129). The lack of unifying articulatory properties makes this sound particularly unique, both perceptually and articulatorily. Rhotics sounds are very diverse in their acoustic properties cross linguistically and can provide opportunities of research in contact situations, especially in scenarios where the languages that coexist are lexically unrelated.

## 2. Vibrant and Non-Vibrant Rhotics in Language Contact Scenarios

The term rhotics comes from the Greek letter *rho* to characterize a collection of r-like sounds, distinguished based on the manner of articulation in different languages. According to Thomas (2011), rhotics are a collection of sounds that can be realized as taps, trills, approximants or fricatives (p. 129). Precisely, vibrant rhotics refer to the use of a mouth articulator (i.e., the apical portion of the tongue or the soft tissue of the velum) producing a vibration or bouncing against another surface (i.e., the palate or tongue dorsum). In normative terms in Spanish, vibrant rhotics

[4] Updated ethnic data has yet to be publicly available in the 2018 census: https://sitios.dane.gov.co/cnpv/#!/

are classified based on segmental duration, the number of vibrations, and the phonotactics of the language (Zahler & Daidone, 2014; Bradley and Willis, 2012; Diaz-Campos, 2008; Hualde, 2005). Typical examples of vibrant variables are taps and trills. Both vibrant segments are easily recognizable in the spectrogram. Typologically, vibrant rhotics realized with one apical closure in the alveolar region are known as taps; vibrant rhotics that are produced with the realization of multiple vibrations of the tongue in the alveolar region or with the uvula in the tongue dorsum are known as trills.

Phonetically, taps and trills are produced with similar articulatory processes, but have specific aerodynamic conditions. Ladefoged and Maddieson (1996) describe the production of a trill as the vibration of a movable part of the vocal tract placed close enough to another surface so that a current of air with the right force narrowly passes through this configuration, producing the repeating closing and opening of the channel of air. When this vocal configuration produces a periodic vibration, then a trilling occurs. A canonical Spanish vibrant rhotic production requires specialized articulatory gestures and aerodynamic conditions to produce a prototypical vibrant trill. These conditions include a stable apico-alveolar closure with more apical retraction and predorsum lowering than the tap (Recasens and Pallares, 1999). The Spanish language makes a distinction in the number of vibrations of the articulator (i.e., the tongue) to distinguish between two types of vibrant segments. R-sounds with a single vibration and short duration are classified as taps, while longer segments with multiple vibrations of the tongue with the upper mouth surface are known as trills. Technically, both sounds can be identified as trills due to their vibration properties, but Spanish phonemically contrasts taps and trills in intervocalic positions.

Contrasting with a vibrant trill is a non-vibrant rhotic. These types of sounds are produced with no vibration of the articulators and are classified as either approximants [ɹ] or fricatives [ř], due to not displaying any type of occlusive phase. Solé (2002) notices that Spanish trills require "higher pressure build-up, greater magnitude of linguo-palatal contact and longer duration of the first closure" to be produced (p. 686). As a result, small variations in oral pressure results in a non-vibrant variant in Spanish.

In the Spanish language, the realization patterns of taps and trills respond to an asymmetrical distribution based on the contextual position within the word. Taps and trills are mutually exclusive in only two positions: taps appear exclusively in complex-syllable onset positions, while word-initial contexts correspond exclusively to trills. Table 1 illustrates the general distribution of Spanish taps and trills.

Table 1. Contextual distribution of rhotics in Spanish.

| **Context** | **Rhotic Use** | **Examples** |
|---|---|---|
| Word Initial | Trill | /ro.xo/ |
| Complex Syllable Onset | Tap | /tɾom.po/ |
| Preconsonantal Word Medial | Variable tap/trill | /bar.ko/ or /baɾ.ko/ |
| Word Final | Variable tap/trill | /kan.tar/ or /kan.taɾ/ |
| Intervocalic | Contrastive tap/trill | /ka.ro/ vs /ka.ɾo/ |

Although both segments also alternate in preconsonantal word-medial, and word-final positions, taps generally take these positions in spontaneous speech. On the contrary, taps and trills appear in phonemic contrast in intervocalic position. This contrast is supported by around 30 minimal pairs in the Spanish language, such as *ca/r/o* 'car' and *ca/ɾ/o* 'expensive' (Bradley & Willis, 2012).

Weakened non-vibrant rhotic variants are increasingly being reported in different monolingual varieties of Spanish, and there seems to be a trend toward this innovative production in spontaneous speech (Diaz-Campos, 2008; Henriksen, 2014). Several studies have identified a post-alveolar approximant rhotic [ɹ̠] in place of an apico-alveolar trill in Costa Rican Spanish [r] (Lipski, 2011), an assibilated variant [ř] in Central Valley Costa Rican Spanish (Adams, 2002) and in Highland Ecuadorian Spanish (Bradley, 2004, 1999), a velarized production [ʀ] in Puerto Rican Spanish (Campos-Astorkiza, 2012) and a continuum from fricatives [ř] to approximants [ɹ] in intervocalic trills in the Spanish of Argentina (Colantoni, 2006). The phenomenon of weakened rhotic variants is not exclusive to monolingual scenarios. Retroflex approximants [ɻ] have been reported in bilingual varieties of Spanish in direct contact with English-based Creoles (Balam, 2012; Lopez-Alonzo, 2016; Hagerty, 1979; Zimmer, 2011), coexisting with US English (Ramos-Pellicia, 2007), and with indigenous languages in the Yucatan peninsula (Lope-Blanch, 1975). Given the above, there are problems with the traditional categorization of Spanish trills and taps in terms of number of closures: they are not uniformly produced across Spanish dialects, and there is a trend towards innovative weakened variants.

The other monolingual variety in contact, Raizal Creole, has a direct kinship with the diaspora of the English-based Creoles of the Caribbean. Its most recent origins can be traced back to the second half of 1700s, with the arrival of colonists from parts of the British Caribbean, particularly from Jamaica. By the late 1800s, trade with Jamaica was prohibited by the Colombian government, and thus, halting the direct influence from Jamaican Creole. It is believed that during the second half of the 19th century, Raizal Creole crystallized into a separate mesolect (i.e., the intermediate variety between an early Creole to the standardized modern variety), which gave birth to the acrolect or standard variety spoken nowadays (Bartens, 2013; Dittman, 1992; Bickerton

1973). Therefore, Raizal Creole is directly derived from Jamaican Creole (Bartens, 2013). Compared to Spanish, Raizal Creole, which is lexically derived from British English, has been perceptually reported to make use of a non-vibrant English-like rhotic (Bartens, 2013). More recently, a study by Author X (2019) found that Raizal Creole produces a postalveolar retroflex constrained by different degrees of vocal cavity openness.

A survey of the literature on rhotic variation in bilingual speech reveal the need for more studies on communities where languages are coexisting in the same environment. In a study on bilingual speakers, Henriksen (2015) described the zero-apical occlusion (i.e., non-vibrant rhotic) as "auditorily […] similar (but not identical) to the American English approximant rhotic" (p. 297). The manner of articulation of this variant was undetermined, and argued to be produced either as an assibilated rhotic or as a weakened approximant. Aikhenvald (2006) investigated the confluence of indigenous languages in the Vaupés region (Colombia) limiting with the Amazonian basin, which have resulted in accommodation of different rhotic-like sounds due to contact. In particular, the East Tucanoan family of languages has exerted an influence in the Tariana flapped /ɾ/ in contexts where it should appear, resulting in a reduction of the system and accommodation of variants when two flaps are present in the same word (e.g., warikiri 'young man' is produced as walíkiri) (p.40). Weisglass (2015) has shown that Spanish-Basque bilinguals produced mostly taps with only a few trills in onset cluster where a rhotic is present. She also demonstrated that voicing of the preceding consonant, rather than place of articulation and the subsequent vowel, had an effect on the realization of rhotics by these bilinguals. Likewise, she also reports that monolinguals produced mostly approximants, when the normative trill would be expected in monolingual production. Research on other phonetic variants has also shown effects in bilingual varieties. An early study on bilingual phonology was published by Flege (1987), who analyzed VOTs of initial

/t/ by French-English bilinguals living in the United States for 12 years. When contrasted with the VOTs of French and English monolinguals, the bilinguals produced intermediate VOT values higher than the French monolinguals. Following a similar procedure, Flege (1991) examined the VOT production of /t/ in late and early Spanish-English bilinguals. In contrast to late learners, early bilinguals were able to articulate comparable VOT values to English monolinguals, suggesting that these learners can establish native phonetic categories in the L2. In what seems a case of convergence (Klee and Lynch, 2009, p. 30; Bullock and Toribio, 2004), this research documented that bilinguals were able to detect the phonetic differences in the VOTs of the two languages but failed to establish a new phonemic category for the L2 English /t/.

The question remains as to the exact nature of non-vibrant rhotics produced by bilingual Raizal speakers that can be traced to a common language source. What this review of studies conducted on contact communities shows is that phonological change in bilingual speech follow a trajectory in which phonetic variants gradually coincide with those allophones of the dominant language, which constitutes a case of phonological interference (Thomason, 2001; Winford, 2003). Therefore, the driving assumption on the distribution of non-vibrant rhotics in the variety of Spanish spoken in the Archipelago involves the transfer of phonetic features in the bilingual speech that resemble those of the donor language. In other words, the realization of these rhotics in the vernacular speech would correlate to instabilities in the production of rhotics by Raizal Spanish speakers. Regarding a similar contact situation, a retroflex rhotic variant has been documented in Belizean Spanish (Balam, 2013) and in Limon Creole/Spanish bilinguals (Zimmer, 2011). It should be noted, however, that the reports on the Limon Creole retroflex approximant were mainly impressionistic. Therefore, the variability of rhotic production in these communities merits further empirical study. The current study addresses this void in the field by examining the highly variable use of non-vibrant rhotics in the Spanish variety spoken by bilingual Raizales emerged from extended contact between Continental Spanish and the English-based Creole.

### 3. The Acoustic Analysis of Non-Vibrant Rhotics

In order to determine the degree of phonetic transfer from a language source, the phonetic analysis of non-vibrant rhotics requires accurate identification of the main acoustic correlates of the rhotics produced in the three varieties. Non-vibrant rhotics can be measured according to how the oral cavity is configured to modify the airstream produced from the lungs. In this sense, the measurement of formants is a common practice for researchers looking for the configurations of rhotics cross linguistically. Typically, the second and third formants are informative enough to determine the characteristics of vowels and liquids (Kent and Read, 2002). English /r/ has the lowest F3 among English sounds, even to the extent that F3 patterns might be narrowly separated from F2 (Kent and Read, 2002). Hagiwara (1995) reports F3 mean measurements of 1500Hz among adult males, and 1950Hz in adult females. Generally, F3 formant values are distributed to the contiguous vowel segments producing, what is known, as r-coloring, which is associated as well with a low F3 closer to F2. In addition to a lowered F3 (Hagiwara, 1995), it has been suggested that the manner of articulation of English [ɻ] can be calculated by measuring the distances between F4 and F5: a greater distance between F4 and F5 in the vicinity of 1400Hz indicates a more retroflex articulation, while a smaller distance, around 700Hz, indicates a bunched-like rhotic (Zhou, Espy-Wilson, Boyce, Tiede, Holland, & Choe, 2008). Olsen (2012) found F4-F5 separation values ranging from 525Hz and 1603 Hz and a mean of 1052Hz. These values appeared within a continuum of retroflex and bunched [ɹ] in L1 English-speaking males learning Spanish as their L2. Such measures were also replicated in a contact Spanish variety spoken in Northern Belize (Balam, 2013). These formants are used in the measurement of the openness of the vocal cavity and are important to determine rhotic articulation in English-like languages, such as Raizal Creole. While formant measurements allow for the identification of the place of articulation, some studies have used spectral moments to obtain further information of the assibilation properties of rhotic segments. Three spectral moments can be obtained for identifying the degree of assibilation of these segments, and thus, the manner of articulation: the mean of the frequency or center of gravity (COG), which provides information about the average concentration of energy in the spectrum, the tilt of the energy distribution (skewness), and the peakedness of the energy distribution, kurtosis (Colantoni, 2006; Jongman, Wayland, & Wong 2000). Table 2 shows a comparison of COG and skewness values reported in previous studies for English sibilants and Spanish fricative trills.

Table 2. A comparison of COG values reported for English sibilants, Spanish fricative trills and the rhotics in the Archipelago.

| **English Sibilants (Jongman et al, 2000)** | **COG** | **Skewness** | **Spanish Fricative Trill (Colantoni, 2006)** | **COG** | **Skewness** |
|---|---|---|---|---|---|
| **/f, v/** | 5108 | 0.077 | [ř] | 1300 - 5500HZ | 0.8 -5.8 |
| **/s, z/** | 6133 | -0.229 | -- | -- | |
| **/ʃ, ʒ/** | 4239 | 0.693 | -- | -- | |

Consistent higher COG values correspond to English post-alveolar sibilants and Spanish fricatives, but lower values will show less assibilated realizations. Negative skewedness values are related to a positive tilt and increased energy in the higher frequencies (Jongman et al, 2000), suggesting more assibilated variants. Kurtosis is an indicator of the shape of the spectrum, either flat with negative values, or a defined spectrum with well-resolved peaks associated with positive kurtosis measurements (Jongman et al, 2000). In sum, formant frequencies and spectral moments are frequently and reliably used acoustic measurements to differentiate between places of articulation (i.e., alveolar and post-alveolar) and between the two manner of articulations in rhotics (i.e. approximant or fricative), respectively. The final acoustic measurement involves segmental duration. The duration of non-vibrant rhotic segments has implications for the classification of Spanish trills and taps. Based on Hammond's (1999) finding that trilling /r/ production in native Spanish speakers is rare, segmental duration has been used to determine whether phonemic contrast between taps and trills is being maintained or lost in different Spanish varieties (Bradley and Willis, 2012; Willis and Bradley; 2008, Melero-Garcia & Cisneros, 2020). It has been reported that the contrast between trill /r/ and tap /ɾ/ can be maintained through the overall duration of both segments when no lingual closure is present (Henriksen, 2015, in Chicagoland; Balam, 2013, in Belize Spanish; Bradley & Willis, 2012, in Veracruz Spanish; Willis and Bradley, 2008, in Dominican Spanish). Here, duration provides a measure for crosslinguistic differences in rhotic production.

## 4. Methodology

While formant trajectories, duration, and spectral moments have been used to account for English-like retroflex variants, in this study all of these acoustic variables are analyzed to find the most reliable measures for the study of non-vibrant rhotics in this language contact setting. For this purpose, a discriminant function analysis (DFA) is conducted. A DFA allows to determine a set of continuous variables that are the best predictors to discriminate between different linguistic groups (Poulsen & French, 2008). In a DFA, the significance of the discriminant functions is tested first. Then, the classification of groups can follow according to the variables which means are different across groups. This analysis renders visible the relationship between the acoustic correlates in the rhotics of the Archipelago and the three varieties in contact, with the aim of predicting a group classification based on acoustic correlates (Grinstead et al, 2013). More importantly, the most significant acoustic variables in the rhotics of the Archipelago will be revealed and a comparison of the bilingual Spanish with the monolingual varieties can be investigated.

The analysis consists of 1) conducting a discriminant function analysis to determine the best acoustic predictors to distinguish group membership, and 2) using the acoustic properties selected in the DFA to compare Raizal Spanish with Raizal Creole, and Continental Spanish. The research questions guiding this work are enunciated as follows:

- what are the most significant acoustic variables selected in the DFA for the analysis of non-vibrant rhotics across Raizal Creole, Continental Spanish, and Raizal Spanish?
- How does the bilingual Raizal Spanish variety compare acoustically to the monolingual Continental Spanish and Raizal Creole?

It is hypothesized that Raizal Spanish will be placed in an intermediate position between the languages in contact due to its interlanguage status (i.e., the vernacular in sociolinguistics terms) as the bilingual variety in this contact setting (Aaron, 2010). Moreover, once this hypothesis is corroborated, results would show realizations of non-vibrant rhotics in Raizal Spanish approximating one of the languages in contact (i.e., either an approximant [ɹ] or a post-alveolar [ɹ̠]), which would signal an ongoing change in the production of bilingual rhotics within the bilingual Creole communities.

Fieldwork was conducted in the islands of San Andres and Old Providence (including Santa Catalina) over two consecutive visits in Spring and Summer 2017. Over 70 hours of speech data were collected through sociolinguistic interviews, a picture story narration task, the Frog Story (Mayer, 1969), and two information gap activities (Baker & Hazan, 2011; Thomas, Jianling, & Anja, 2005). Each recording took place in informal non-controlled environments and effort was made to obtain noise-attenuated recordings in closed spaces. Speech data was recorded with a

PCM recorder sampled at 44,100Hz/32-bit and an omnidirectional lavalier microphone with a frequency response from 80 to 20,000Hz. The microphone incorporated a mounted preamplifier and was placed as close to the mouth as possible. Sociolinguistic interviews were the main data collection technique used for obtaining the data in Spanish for monolinguals and bilinguals. These lasted between 60 to 90 minutes and covered a range of familiar topics for the informants, including work, education, family, life in the Archipelago, children, society, religion, and ethnic and territorial issues. During the additional tasks, informants engaged in information-seeking interactions, where they were requested to collaborate in finding missing words in a picture (Baker & Hazan, 2011). Words were controlled to elicit rhotics and other sound segments. These tasks were conducted in tandem, whenever two informants where available on site, mainly informants that were previously interviewed and their relatives and friends being present in the household. As a result, several language pairs were recorded, including Raizal Creole and Raizal Spanish interactions, separately. An additional lavalier microphone was used following the same recording process as in the sociolinguistic interviews.

Speech data in Raizal Spanish were collected from 45 island-born, long-time resident Raizal informants with ages ranging from 18 to 89. In total, the informants included 23 in San Andres and 22 in Old Providence (12 males in both islands, and 11 and 10 in San Andres and Old Providence, respectively). For the sake of comparison, representative sample data were collected from the monolingual varieties. Speech data for Raizal Creole were obtained from 5 informants, some of whom were also interviewed in Spanish, but were asked to narrate the Frog story in Creole (Mercer, 1969), interacted with other Raizal informants during the additional tasks or recounted Anansi stories. Anansi stories or the stories of the trickster spider are traditional folk stories originated from the Gold Coast in West Africa. Raizal Creole informants were composed of 3 females and 2 males with ages ranging from 34 to 84. Another eight speech samples were taken from monolingual Continental Spanish speakers who were either born or have lived in the islands for most of their lives (2 females and 3 males with ages ranging from 26 to 55).

The rhotics for this analysis involve the segments produced with no vibration in the three varieties. In Raizal Spanish and Continental Spanish, these segments were chosen based on the absence of occlusion in the spectrogram and inspecting the abrupt changes in the waveform in Praat (Boersma and Weenik, 2018). Rhotics with one occlusion and with an approximant r-coloring phase were excluded from the analysis. Both non-vibrant taps and trills were sampled regardless of position within the word. Likewise, rhotics in Creole were extracted by inspecting changes in the waveform and the lowering of F3 in the spectrogram. Attention was paid to formant transitions from vowels to liquid and r-coloring of contiguous vowels (Morgan and Sessarego, 2016; Bradley and Willis, 2012). Likewise, the relative low onset frequency for F3 also served as a cue to identify this phone (Kent and Read, 2002). Praat spectrogram and oscillogram representations of rhotics from each of the three varieties are presented in Figures 2-4.

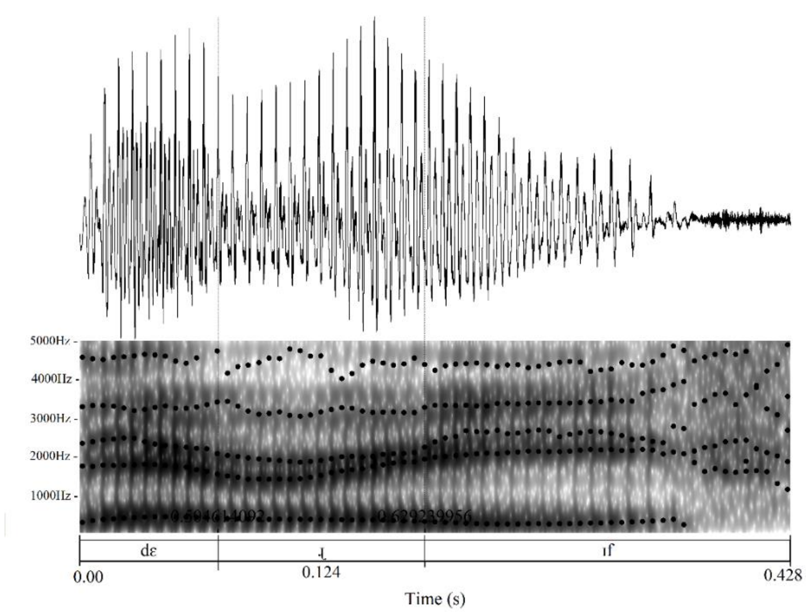

Figure 2. Praat capture of the rhotic produced in initial position in the phrase 'dih reef' in Raizal Creole. Note the F3 lowering curve getting closer to the second formant (F2). There is also coarticulation of the preceding vowel segment (i.e., /i/), which surrounds the rhotic between vowels.

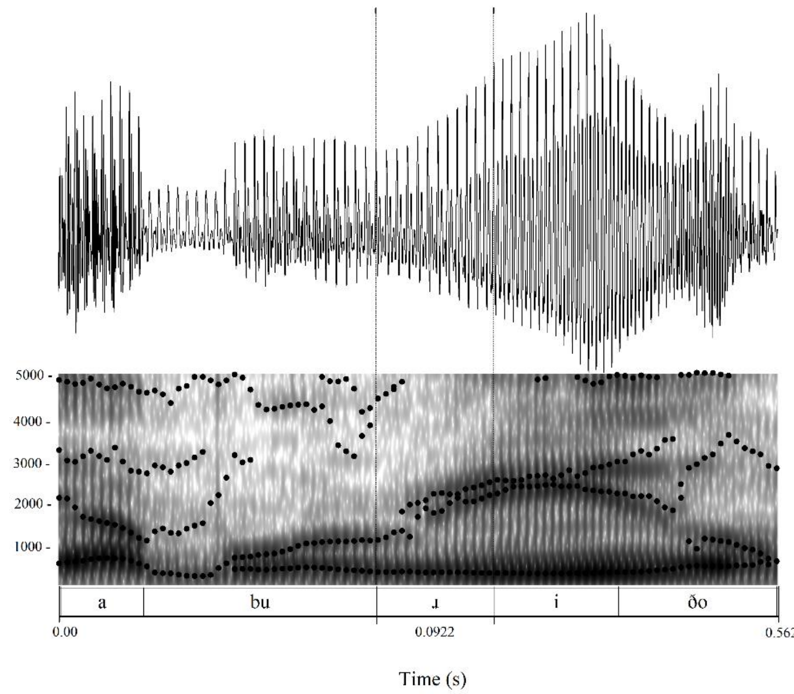


Figure 3. Praat capture of the intervocalic trill in the word *aburrido* 'boring' in Raizal Spanish. Note the lack of occlusions and the rising F2 line reaching a lowered F3.

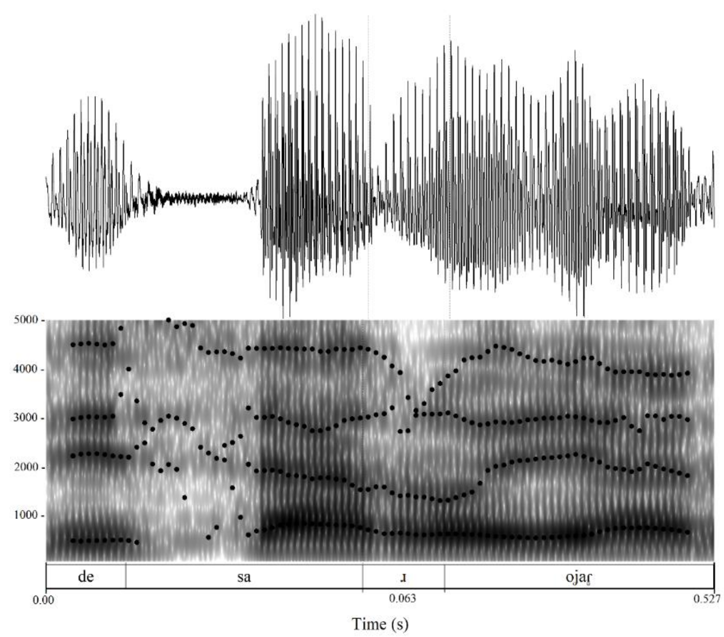

Figure 4. Praat capture of the non-vibrant rhotic produced in intervocalic position in the word *desarrollar* ‘to develop’ in Continental Spanish. Note the lack of occlusions and the continuity of the second formant. The F3 formant trajectory seems to be briefly interrupted.

Figures 2-4 showed samples of zero occlusion rhotics in the three varieties under study. As seen in these Figures, there are different formant trajectories for F3 and F2. Raizal Creole rhotics appear to have a narrow distance between F2-F3. Raizal Spanish rhotics appear with a similarly small F3 lowering and F2 rising, while Continental Spanish presents a stable formant pattern. Moreover, duration values contrast sharply cross-linguistically, as the Spanish varieties were classified with shorter segments than the Creole. Following the visual inspection of the tokens, each rhotic segment was labeled in the TextGrid. For the Spanish varieties, both non-vibrant taps and trills were included in the analysis when a measurement was possible. Table 3 shows the distribution of the vibrant vs. non-vibrant tokens in the corpus for each variety.

Table 3. Distribution of tokens compared with non-vibrant vs vibrant in Raizal Spanish and Continental Spanish. *Raizal Creole only contains non-vibrant variants in its phonemic inventory. 37% of tokens for this group are composed of elided variants (r-elision).

| **Groups** | **Tokens (Non-vibrant/vibrant)** | **Total non-vibrant (%)** |
|---|---|---|
| Raizal Creole | 328/523* | 63% |
| Raizal Spanish | 1450/3925 | 37% |
| Continental Spanish | 150/690 | 22% |

As seen in Table 3, a considerable amount of non-vibrant rhotics were found in the datasets. For Raizal Creole, the vast majority is composed of non-vibrant rhotics, while the rest are elided variants. Elision occurs mainly in word final positions where they become a centralized vowel (e.g. *waata* ‘water’). It is worth noting that these variants were assumed to be inherited from the lexifier language. However, the true nature of this variant needs to be fully explored and falls outside of the scope of this work. Likewise, over a third of the tokens are composed of non-vibrant variants in the bilingual Raizal Spanish (37%), while only 22% were found in the monolingual

Spanish variety. Despite the unbalanced distribution of tokens collected in the monolingual varieties, these data are considered representative and will serve to examine the bilingual production and determine its place between the monolingual varieties. Thus, only a small sample was needed.

In a second step, three Praat scripts were used to automatically extract the acoustic information of the labeled segments. Spectral properties were automatically obtained using a Praat script that extracts the spectra information of labeled rhotic segments (DiCanio et al, 2013). The same procedure was used to obtain formant frequencies (Kawahara, 2010), and duration values of rhotic segments (Lennes, 2002). Once obtained, these measurements were further analyzed to determine the best acoustic properties for the analysis of non-vibrant rhotics produced in the different varieties of the Archipelago. Finally, data was submitted to R and SPSS for statistical analysis and visualization (R Core Team, 2013; SPPS, 2011). Results are presented in the next section.

## 5. Results

Here, I present the results of the DFA first. Once the best acoustic correlates for predicting group membership are obtained, the analysis focuses on comparing the bilingual variety with the monolingual varieties, Raizal Creole and Continental Spanish. This last part of the analysis will reveal the status of bilingual non-vibrant rhotics as compared with the monolingual production.

### *5.1 Discriminant Function Analysis*

The results of this test permit a comparison of the most important acoustic predictors with the best predicting capabilities to distinguish between linguistic groups. First, a Box's M test of equal group variance revealed a significant value lower than $p=0.001$, suggesting an unequal group variance (Table 4). A visual inspection of the data in the form of histograms revealed a non-normal distribution of the acoustic measurements. Extreme outliers were found in the data that either fail to represent the speakers' measurements or could be a sign of individual differences worth keeping in the statistical analysis.

Table 4. Test of null hypothesis of equal population covariance matrices with a significant value lesser than 0.001.

| **Box's M Test Results** | | |
|---|---|---|
| | Box's M | 843.791 |
| F | Approx. | 19.877 |
| | df1 | 42 |
| | df2 | 618976.170 |
| | Sig. | .000 |

It is worth mentioning that some of the assumptions of this analysis involves the equal variance of the linguistic groups and the normal distribution of the data. Failing to satisfy these assumptions might become a potential limitation of this analysis. Although the sample size for each group is unequal (Creole = 328, Continental Spanish = 150, Raizal Spanish= 1450), extreme outliers that fall outside the interquartile range were excluded for this specific analysis in order to satisfy the assumption of normality (Poulsen and French, 2008). The occurrence of these datapoints is mainly due to the nature of the fieldwork procedures and the rationale of this sociolinguistics project of collecting naturalistic data on site[5]. This situation produced the collection of extreme outliers that highly diverged from the measurement centers. As a result, the data cleaning procedure involved the removal of outliers that fall outside the 1.5 interquartile range (1.5*IQR), keeping the values that remain in the inner quartiles spread within 25% below and above the mean and excluding outliers in the low and high end. As a result, the violation of the normality assumption is not fatal, and the ensuing results of this test are still reliable as non-

[5] Although every effort was made to collect the acoustic samples in a relatively noise-reduced environment, this was not always possible due to the informal setting of the research site, where data were collected sporadically in the informants' dwelling located next to busy streets.

normality is caused by data skewness and not outliers (Tabachnick & Fidell, 1996). The relationship between the predictor variables and the predictive model is reported with a correlation coefficient of $R^2$=0.31 for the first function and a $R^2$= 0.10 for the second function, but with a significant value of p=0.000 at the Wilk's Lambda test for both functions, indicating that this group of predictor variables make predictions that are statistically accurate.

After establishing that the predictive model satisfactorily meets the validity criteria, the analysis additionally identified the individual acoustic measurements with the highest predicting capabilities for group membership. This structure matrix is presented in Table 5.

Table 5. Structure matrix of individual predictors with weighted predicting capabilities. A minus sign indicates a discriminant function coefficient with a negative correlation.

| **Structure Matrix** | | |
|---|---|---|
| | Function | |
| | 1 | 2 |
| duration | **.778** | **.338** |
| F3 | **-.687** | **.498** |
| F3-F2_distance | **-.461** | **.373** |
| F4-F5_distance | .375 | .225 |
| F2 | -.361 | .209 |
| F5 mean | .334 | .048 |
| F4 mean | -.143 | .052 |
| COG | -.042 | .350* |
| Skewness | .053 | -.281* |
| Kurtosis | .050 | -.223* |

The highest coefficient loadings determine those predictor variables with the most abilities to predict group membership. Due to having more than two groups and more than one variable the analysis shows two discriminant functions: each one representing a dimension. As can be seen in Table 5, duration and formant frequencies (mainly F3 and the distance between F3-F2) present the highest predicting values. As shown here, both Creole and Spanish show highly distinctive segmental durations, as well as formant frequencies of non-vibrant rhotics. These results are consistent with previous findings and the differences are expected when comparing an English-based Creole and Spanish (Zhou et al, 2008; Kent and Read, 2002; Hagiwara, 1995). In contrast, spectral moments seem to have the lowest predicting effect in this analysis. The lowest predicting capabilities of spectral moments seems to be due to the fact that all three linguistic varieties share similar spectral properties. As a result, spectral moments are the acoustic variables with the lowest predicting capabilities to assign group membership from all the acoustic measurements.

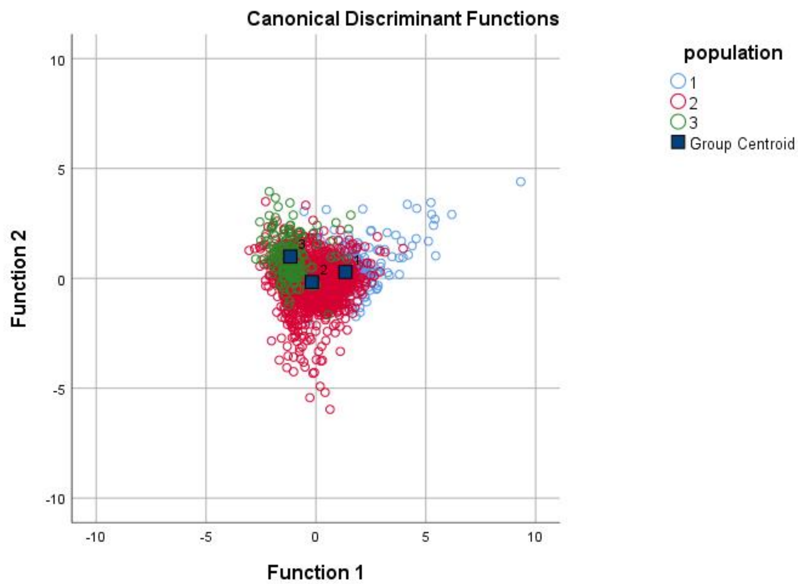


Figure 5. Graphic representation of population differences in terms of the acoustic correlates submitted for the analysis. Population group 1 refers to Raizal Creole, group 2 identifies Raizal Spanish, and group 3 is assigned to Continental Spanish.

Visually, this can be seen in Figure 5 where the predictor variables submitted for the analysis accurately differentiate between all linguistic groups. Raizal Creole and Continental Spanish appear to be in opposite positions, while Raizal Spanish remains in between both Islander and Spanish, suggesting that the bilingual variety gravitates in an intermediate position. The last table resulting from the analysis involves the final classification results on Table 6.

Table 6. Final classification results. 62.0% of cross-validated grouped cases were correctly classified.

| Classification Results | | | | | | |
|---|---|---|---|---|---|---|
| | | **Population** | **Predicted Group Membership** | | | **Total** |
| | | | Creole | Raizal Sp. | Cont. Sp. | |
| Cross-validated | Count | Creole | 237 | 82 | 9 | 328 |
| | | Raizal Sp. | 260 | 846 | 344 | 1450 |
| | | Cont. Sp. | 7 | 30 | 113 | 150 |
| | % | Creole | **72.3** | 25.0 | 2.7 | 100.0 |
| | | Raizal Sp. | 17.9 | **58.3** | 23.7 | 100.0 |
| | | Cont. Sp. | 4.7 | 20.0 | **75.3** | 100.0 |

Table 6 shows the degree of accuracy of the model to predict group membership, and thus, displays how well the predictor variables are suited to discern between population groups. In the cross-validated section, 72.3%, 58.3%, and 75.3% of the acoustic measurements in Raizal Creole, Raizal Spanish, and Continental Spanish, respectively, correctly predict their corresponding population group. The lower prediction rate in Raizal Spanish indicates that the acoustic correlates included in the analysis present more variability in the bilingual variety, and thus, the model has more difficulty in accurately predicting Raizal Spanish membership. Due to its status as the bilingual variety, this is something expected in Raizal Spanish as bilingual speakers appear to have more variable production differences in non-vibrant rhotic articulation. Results of this test also revealed the strongest predictors for discriminating group membership in all linguistic populations. Particularly, segmental duration and formant frequencies were found statistically significant in the model, and thus, the comparison of these acoustic correlates between varieties is warranted in the next subsection.

### *5.2 A comparison of the formant and duration properties of non-vibrant rhotic realizations in the Archipelago*

In the previous DFA, it has been established that duration and formant frequencies in the form of F3 and F3-F2 distance appear with the highest prediction capabilities of group membership. Here, these acoustic correlates will be compared across varieties in the Archipelago.

When we compare the segmental duration of rhotics in Raizal Spanish with the two contact varieties, a clear distinction between Spanish and Creole is observed, as non-vibrant Creole rhotics are realized with longer durational cues.

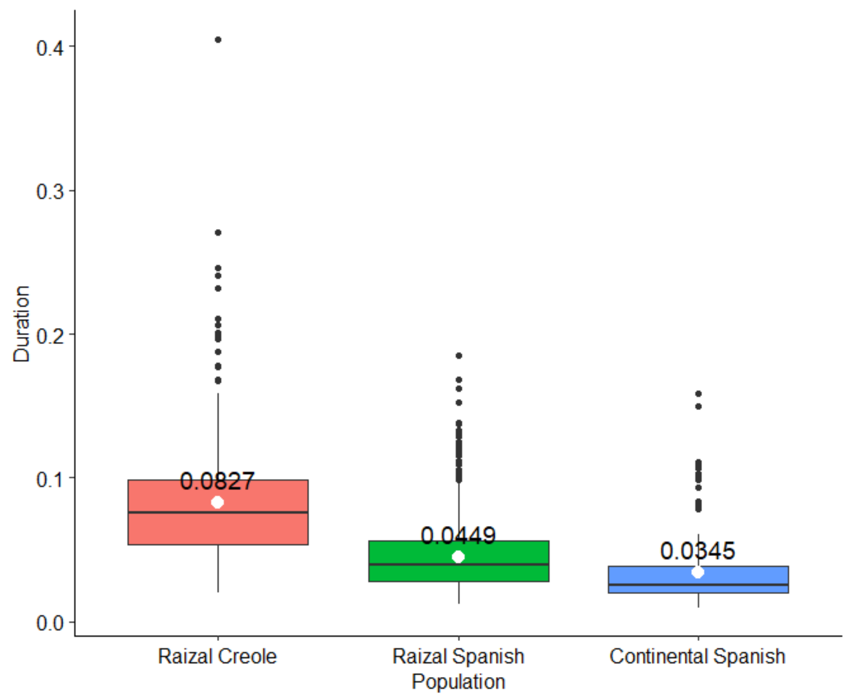


Figure 6. A comparison of rhotic duration in milliseconds between varieties.

As seen in Figure 6, these differences seem to be language specific, since both bilingual and monolingual varieties of Spanish appear with similar duration values diverging from the Creole standard. However, when durational values in taps and trills are compared separately in the Spanish varieties, there appear to be certain similarities and differences with Creole rhotics. Figure 7 shows a comparison between Spanish taps and trills and Creole rhotics.

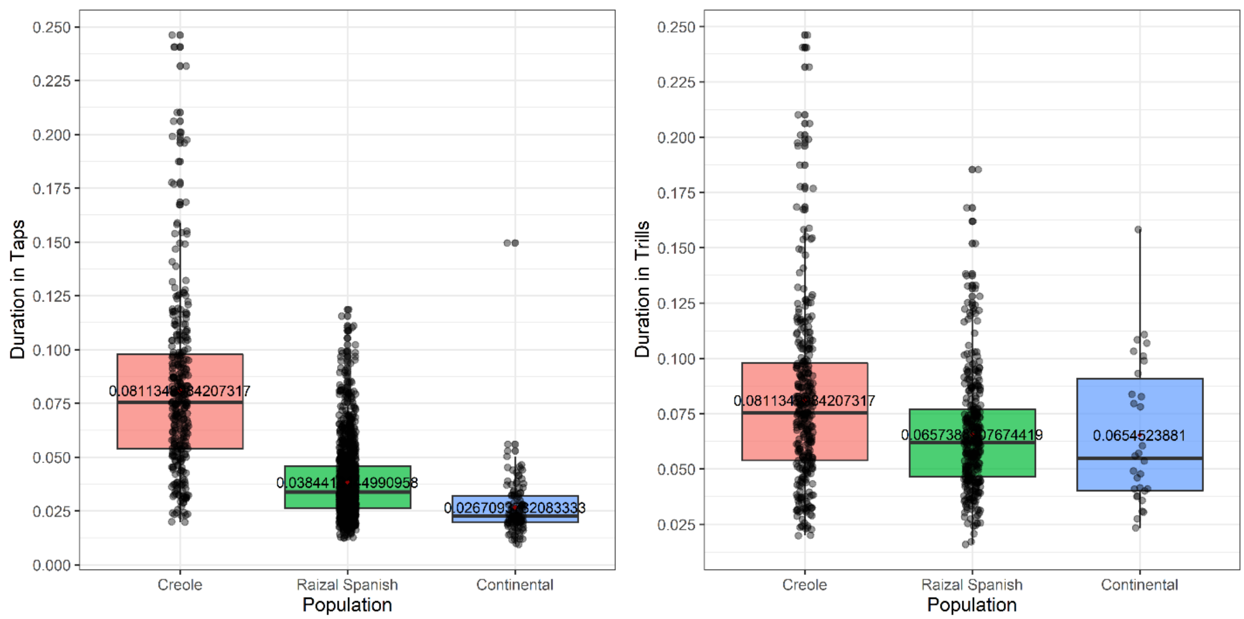


Figure 7. A comparison of non-vibrant tap and trill durations between Spanish varieties and Raizal Creole. (Left) Duration for taps. (Right) Duration for trills.

As seen in Figure 7, taps in both Raizal Spanish and Continental Spanish are clearly realized with shorter duration values, while trills appear longer than taps and closer to Creole rhotics. Despite this, rhotics in Raizal Creole still appear with greater variation and with higher mean durations than the monolingual and bilingual Spanish varieties. For trills, mean duration values are comparable in the bilingual and monolingual Spanish varieties. However, the main difference appears in taps between the Spanish varieties, as Raizal Spanish seems to have longer mean duration values than Continental Spanish. As expected, trills seem to maintain a distinction with taps by means of duration and this contrast seems maintained in Continental Spanish. However, shorter non-vibrant trill values with comparable duration to taps are visible in this Figure, particularly, in certain subgroups of the Raizal Spanish speech community, which could also suggest a neutralization of the tap/trill contrast. Although testing such observation is outside of the scope of this work, further research should examine the possible cross-generational neutralization of the tap/trill contrast in Raizal Spanish.

Now I turn to the comparison of formant frequencies, which also serve to distinguish between linguistic groups. The boxplots in Figure 8 reveal that there is greater variability in the bilingual group compared to the monolingual Continental and Creole groups.

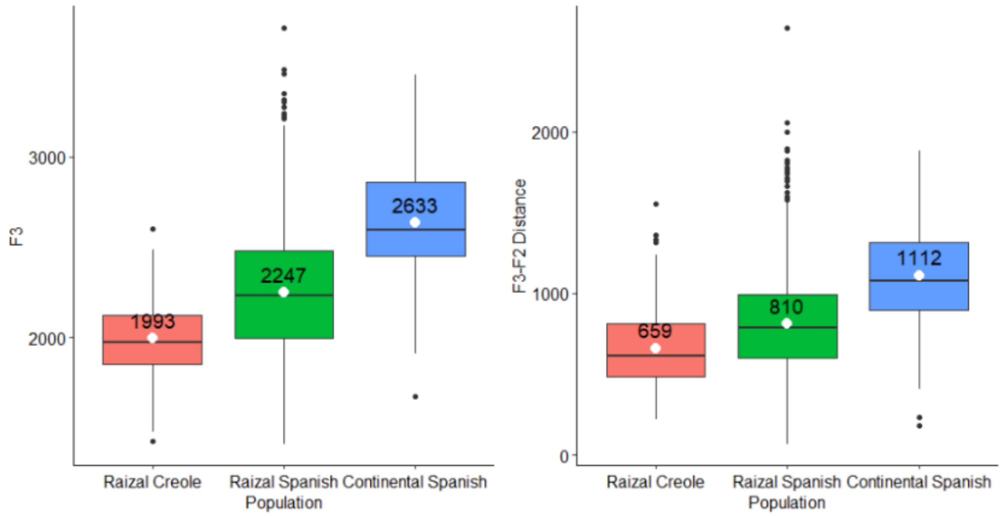


Figure 8. Boxplot with mean values of formant frequencies in all varieties. F3 measurements are compared in the left. A final measurement corresponds to the distance of F3 minus F2.

Continental Spanish appears to have higher formant values on average, whereas Creole rhotics present the lowest means. At the same time, the bilingual variety is placed in intermediate position between the monolingual varieties. The values reported here for Creole are also consistent with a narrower F3-F2 separation when compared to the other two varieties due to F3 lowering. Lower F3 frequencies indicate a shorter vocal tract length, while F2 increases as tongue moves forward (Kent and Read, 2002). As happens with Creole rhotics, the lower F3 and F2 values suggest a more backed rhotic realization than bilingual and Continental rhotics, and it seems that the lingual gesture takes place in the postalveolar region, a commonplace of articulation in approximant postalveolar rhotics in English varieties.

Continental rhotics are produced with a mean around the 2600 Hz, close to the value reported by Borzone de Manrique (1980) for Spanish trills (2500Hz). Similarly, the F3-F2 separation values for Continental rhotics appear relatively higher compared to all varieties, which suggest a more fronted place of articulation for Spanish rhotics. Formant values for the bilingual Raizal Spanish rhotics are gravitating between the frequencies of Creole and Spanish suggesting the existence of an unstable interlanguage status permeable to contact in bilingual rhotics. To corroborate this assumption, Figure 9 makes a comparison of F3 and F2 formants and displays these frequencies with a regression line between all varieties. Furthermore, these values are separated according to the two islands of the Archipelago.

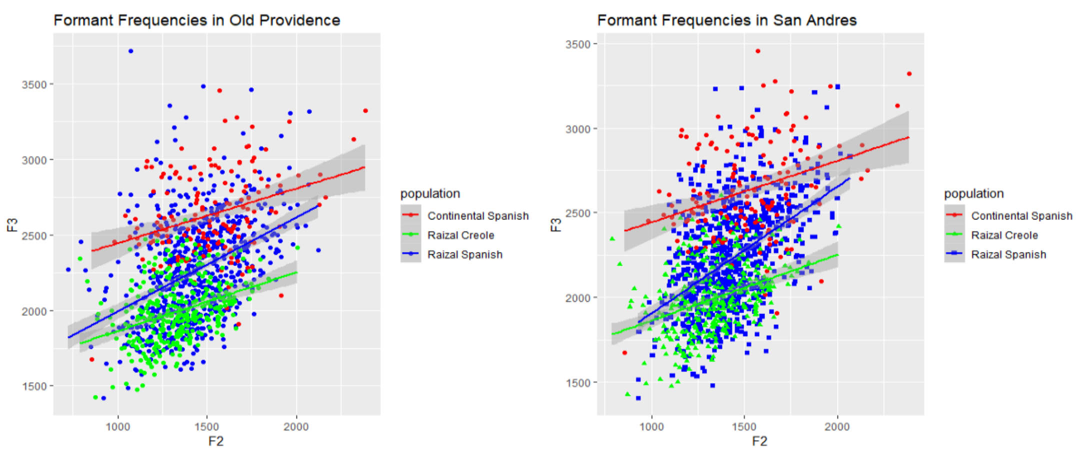


Figure 9. Scatterplot with regression lines of formant frequencies in Continental Spanish, Raizal Creole, and Raizal Spanish in San Andres and Old Providence.

The trend lines seen in Figure 9 reveal that Raizal Spanish rhotics are realized with formant frequencies that lie between Continental Spanish and Raizal Creole. Moreover, they are produced with greater variability in the F3 range than in the other two varieties, showing a more tilted regression line approaching either Continental or Creole at both ends of the slope, respectively. A simple linear regression was calculated to predict the formant frequency values across population groups. Results indicated that there is a significant effect between F3 frequencies and population ($F(2, 1925) = 226.2$, $p < 0.001$, $R^2 = .19$) The individual predictors were examined further and indicated that Continental Spanish ($t = 104.42$, $p = 2^{e-16}$), Raizal Creole ($t = -21.02$, $p = 2e-16$), and Raizal Spanish ($t = -14.57$, $p = 2^{e-16}$), were significant predictors in the model. The same statistical analysis was conducted for the distance between F3 and F2 between population groups

($F(2, 1925) = 122.7$, $p =< 2^{e-16}$, $R^2 = .1122$), revealing significant differences in all varieties (Continental Spanish $t = 46.43$, $p=<2^{e-16}$, Raizal Creole $t = -15.66$, $p = <2^{e-16}$, and Raizal Spanish $t = -11.98$, $p=<2^{e-16}$).

Although the results of these tests reveal significant overall differences between varieties, the visual display in Figure 9 indicates that some Raizal bilinguals are associating their non-vibrant rhotic production with either Continental Spanish or Raizal Creole. Precisely, results of a Pearson correlation test indicated that there is a significant positive association between F3 and F2 that increases across varieties: first in Raizal Spanish ($r(1448) = .44$, $p = < 2.2^{e-16}$), then in Raizal Creole ($r(326) = .36$, $p = < 2.2^{e-11}$), and in last place Continental Spanish ($r(148) = .32$, $p = < 4.467^{e-05}$). Thus, it appears that rhotics produced within certain subgroups of Raizal Spanish are increasingly resembling the formant frequencies present in the two contact varieties. However, this effect seems more robust in San Andres than in Old Providence, where the slope of the trend line is more pronounced, as seen in Figure 9.

The overall analysis of the acoustic properties of the non-vibrant rhotics of the Archipelago of San Andres has revealed significant differences in the three linguistic groups. Furthermore, such finding correlates with the strongest predictors of group membership in a previous discriminant function analysis. Along with specific formant frequencies, segmental duration has the best predicting capabilities to classify between linguistic groups. I will discuss these findings in more detail in the following section.

## 7. Discussion and Conclusion

The examination of non-vibrant rhotic variants in the languages of the Archipelago of San Andres has shed light on the outcomes of contact in the Spanish speech of the Creole communities of these Caribbean islands. First, a preliminary DFA selected acoustic correlates with the best predicting capabilities for discriminating between linguistic groups. Among the vast array of continuous variables obtained from the measurements, duration and formant values in the form of F3 and the narrowing of F3-F2 appear as the most significant for the analysis. This is consistent with previous research on the acoustic of rhotics (Balam, 2013; Hagiwara, 1995; Kent & Read, 2002; Zhou et al, 2008). Their predicting capabilities ranged between 72.3% and 75.3% for the monolingual Raizal Creole and Continental Spanish, respectively. In contrast, the analysis also showed that a little over 58% of the Raizal Spanish data could be account with the selected acoustic variables. Due to its status as a bilingual Spanish variety, non-vibrant taps and trills in Raizal Spanish seem to be produced with unstable articulatory properties between specific population groups. As such, future research should investigate further into the specific sociolinguistic groups converging towards the monolingual varieties in contact. Thanks to the DFA, the specific acoustic variables selected merited the second analysis pursued in this research consisting of the comparison between the bilingual group and the monolingual varieties. These findings directly respond to the first research question posited in this work.

Secondly, the comparison between varieties showed differences in terms of segmental duration and formant frequencies. Certainly, the patterns of segmental duration present robust differences between languages. Duration values for Raizal Creole appear consistently higher compared to Continental Spanish and Raizal Spanish. A detailed comparison of segmental duration between Raizal Spanish and Continental Spanish showed that the tap/trill contrast is clearly defined in monolingual informants, but the segmental boundaries appear weaker in the bilingual Spanish variety. Such observation should be tested further in future studies in this contact scenario. In addition, higher F3 and F2 values for Continental Spanish in the range of 2600Hz and 1500Hz, respectively, contrast with lower values in Raizal Creole (i.e., 1993HZ for F3 and 1334Hz for F2) and a shorter distance between F3-F2 in the vicinity of 650Hz. Such measurements suggest a rhotic realization consistent with a backed production in Raizal Creole and a fronted realization in Continental Spanish.

Articulatorily, these two variants differ in both languages: Raizal Creole produces a variant of its phonemic rhotic, which correspond to a postalveolar segment with a lingual retraction resulting in lower F3 due to shorter vocal length tract and consistent with what is expected of an English-based Creole, a trait of lingual shape also found for rhotic production in American English (Berkson, de Jong, & Lulich, 2017). On the contrary, Continental Spanish produces an allophonic variant of the tap/trill alveolar rhotic that lacks the aerodynamic conditions to produce lingual closures. Given the non-significant results for spectral moments due to presenting the lowest predicting weight in the DFA for discriminating between the rhotics of the Archipelago, these results indicate the lack of differences in the manner of articulation across all varieties. Thus, there are no indications that Continental rhotics, or the varieties spoken by the Raizales, are produced with the presence of a turbulent airstream. Rather, Spanish non-vibrant segments are realized by means of an 'insufficient narrow constriction' and by the lack of precise aerodynamic conditions for vibrant tap/trill production (Colantoni, 2006, p. 22). Results for the rhotics in these varieties suggest a manner of articulation consistent with an approximant production that lacks the fricative properties of a sibilant rhotic. While for Raizal Creole this rhotic is the natural production of a postalveolar approximant, for Continental Spanish an alveolar approximant rhotic is an innovative realization of a vibrant /r/. This resonates with previous reports on weakened, non-vibrant variants in other monolingual Spanish varieties (Diaz-Campos, 2008; Henriksen, 2014; Lipski, 2011; Adams, 2002; Bradley, 2004, 1999; Campos-Astorkiza, 2012; Hammond, 1999).

Again, results for the bilingual Raizal Spanish variety indicates formant values that lie in between both languages in contact. As seen in the analysis for Raizal Spanish, formant frequencies present a more pronounced regression line that approximates either Continental Spanish or Raizal Creole at both ends. Additional statistical tests revealed significant differences between varieties in terms of F3 and the narrowing between F3-F2. This suggests that, while the monolingual varieties are significantly different, certain bilingual informants are approaching the formant frequencies of the variants produced in either monolingual Spanish or Creole. Further research should establish whether a cross generational pattern in this formant frequency is present in San Andres and Old Providence that might signal a change in progress in the Archipelago of San Andres. Thus, non-vibrant rhotics in Raizal Spanish seem to gravitate between a backed and fronted realization. This finding shed further light to previous untested reports on the nature of Raizal Spanish rhotics (Bartens, 2013) and other bilingual Spanish varieties in Central America (Balam, 2013; Zimmer, 2011). Precisely, these findings respond to the final research question concerning the testing of the selected acoustic correlates in Raizal Spanish and comparing them to the monolingual Raizal Creole and Continental Spanish rhotics.

There are several implications for language change in this contact scenario. Results show potential influence from the languages in contact in non-vibrant rhotics in Raizal Spanish, as certain formant frequencies are converging or diverging toward Continental Spanish or the English-like acrolect. The backed/fronted alternation in places of articulation seems to be predominant in certain sociolinguistic groups, suggesting that transfer of phonetic features from the source language to the recipient bilingual Spanish is in place (Thomas, 2001; Thomason, 2001; Winford, 2003). In sum, these preliminary findings seem to indicate that the change has been partially produced due to the influence of the languages in contact. This assumption needs to be further tested in future research. A caveat from this study lies in the unbalanced sample data obtained for the monolingual varieties in the Archipelago and the assumptions of contact-induced change need to be taken with caution. Nonetheless, this work has contributed to deepen our understanding of sound variation and change in language contact settings and opens the path for sociophonetic research in the Archipelago and other areas of the Caribbean.

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