Extending Pillai Scores to Fricative Mergers: Advancing a Gradient Analysis of a Split-in-Progress in Andalusian Spanish

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Abstract

While vocalic mergers and splits have been analyzed acoustically since the inception of variationist sociolinguistics (Labov 1994, Labov et al. 1972, Labov et al. 1991), consonant mergers and splits have principally been analyzed impressionistically. Andalusian Spanish presents such a case wherein the fricative mergers ceceo and seseo, and their ongoing split into distinción, have been extensively documented via impressionistic analysis documenting the role of social and linguistic factors (García-Amaya 2008, Melguizo 2007, Moya Corral and García-Wiedemann 1995, Regan 2017a, Santana 2016, 2016-2017, Villena 1996), but there has been a lack of studies that acoustically analyze the gradience of this consonant demerger. In order to fill this gap, the current study utilizes a Pillai score analysis on a fricative split-in-progress in Andalusian Spanish, building on previous acoustic studies (Lasarte Cervantes 2010, Regan 2017b, in press a, in press b). The aims were two-fold: (i) to provide researchers a gradient sociophonetic approach to analyze the demerger of ceceo (or seseo) into distinción that can complement previous acoustic analyses; and (ii) to extend the use of Pillai scores to fricatives in order to incorporate consonant mergers and splits into the larger variationist discussion of mergers and splits as it is heavily biased towards English vowels (Gordon 2013). The study, based on read speech includes 19,420 tokens from 80 speakers, ages 18-87 (M: 43.7, SD: 17.2), balanced for gender (40 male, 40 female) and origin (40 Huelva, 40 Lepe). Independent variables included gender, age, education, occupation, origin, style, orthography, and following phonological context with speaker as a random factor. The acoustic measures considered in the creation of the Pillai scores were center of gravity (Hz), variance (Hz), skewness, and mean intensity (dB). The best explanation of the data was the Pillai score that incorporated only center of gravity and mean intensity, taking into consideration following phonological context. A mixed-effects linear regression found that this apparent time (Labov 1994:45) change in progress of ceceo into distinción is led by those with more formal education (secondary or university education), those employed in service or professionally oriented occupations, females, and in more formal styles. The current paper therefore extends the use of the Pillai score into a fricative split-in-progress, simultaneously advancing the sociophonetic analysis of Andalusian fricatives as well as providing a non-English and non-vocalic example to diversify the variationist discussion of mergers and splits.
Extending Pillai Scores to Fricative Mergers: Advancing a Gradient Analysis of a Split-in-Progress in Andalusian Spanish

Brendan Regan*

1 Introduction

The analysis of mergers and splits has held an exceptional place in variationist sociolinguistics as it provides insights into the mechanisms of sound change (Labov 1994, 2001, Labov et al. 1972, Labov et al. 1991). Since the field’s inception, vocalic mergers and splits have been analyzed acoustically, principally using the parameters of first and second formants (Hz), with a continued development in best practices and techniques (see Nyácz and Hall-Lew 2013). Different from vocalic analyses, however, there has been little acoustic analysis of consonant mergers and splits. While these impressionistic studies have yielded rich information regarding social and linguistic correlations, they have not been able to provide the same gradient analysis as those of vocalic mergers and splits.

Andalusian Spanish presents such a case wherein the traditional dialectal fricative mergers of ceceo and seseo, and their ongoing split into distinción (two-phoneme system of [s] and [θ]), have been extensively documented via impressionistic analysis (García-Amaya 2008, Melguizo 2007, Moya Corral and García-Wiedemann 1995, Regan 2017a, Santana 2016–2017, Villena 1996; inter alia). While these studies have meticulously documented the role of social and linguistic factors in the current split-in-progress throughout Andalucia, there lacks studies acoustically analyzing the gradience of this consonant demerger. As variationist theory of mergers and splits is heavily based on English vowels (Gordon 2013), it is important to advance a gradient sociophonetic analysis of non-English consonant mergers and splits in order to provide a more cross-linguistic perspective of mergers and splits. For example, several scholars (Moya Corral and Sosiński 2015:35, Regan 2017a:152, 2017b:259–261, Villena 2001:126, Villena and Vida Castro 2012:117–118) have posited that the splits of ceceo and seseo are exceptions to Garde’s and Herzog’s Principles (Garde 1961:38–39, Herzog 1965, Labov 1994:311–313). However, given that most studies have used impressionistic analyses, their findings have not yet been incorporated into variationist theory on mergers and splits.

The present study aims to fill this need by utilizing a Pillai score analysis on a fricative split-in-progress in Andalusian Spanish, building on previous acoustic studies (Lasarte Cervantes 2010, Regan 2017b, 2020, in press). The aims are two-fold: (i) to provide researchers a gradient sociophonetic approach to analyze the demerger of ceceo or seseo into distinción that can complement previous acoustic analyses, and (ii) to extend the use of Pillai scores to fricatives in order to incorporate consonant mergers and splits into the larger variationist discussion of mergers and splits. Section 2 provides the background information. Section 3 presents the methodology, Section 4 the results, and Section 5 discusses the findings and promotes future research.

2 Background

2.1 Linguistic Feature

Discrepancies between Andalusian and Castilian Spanish in the pronunciation of the graphemes <s>, <z>, <ci>, and <ce>, that is, coronal fricative norms, are due to diachronic differences in the reduction of the four medieval Spanish sibilants /s/, /z/, /s/, and /z/ (Penny, 2000, 2002). In Andalusian Spanish, these four phonemes were reduced into a dental /θ/ (Penny 2000:118-119, 2002:124–125). Today, the dental /θ/ merger in Andalusian Spanish is realized as either seseo or ceceo. Seseo is realized with a (predorso-)alveolar [s̪] (Hualde 2005:153, Penny 2000:118), while ceceo is realized with a dental fricative represented as [s̪] (Penny 2000:118), [θ] (Villena 1996), or [θ] (Hualde 2005:153).

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2005:153) as it is perceptually similar to, but not quite as frontal as interdental [θ]. In Castilian Spanish, the four medieval sibilants were reduced into interdental /θ/ and apico-alveolar /s/ (Penny 2002:124–125), resulting in a direct grapheme-to-phoneme correspondence known as distinción of [θ] for <z,ci,ce> and [s] for <s>, giving rise to minimal pairs such as masa-maza ‘mass/dough-mace’. However, Andalusian speakers that follow the norm of distinción generally produce a (predorso-)alveolar [g] as opposed to Castilian speakers’ apico-alveolar [γ] (Narbona et al. 1998:156).

2.2 Previous Studies of Andalusian Coronal Fricatives

Although ceceo and seseo were the predominant norms in Andalucía through the mid-20th century (Alvar et al. 1973, Navarro Tomás et al. 1933), there is currently a change in progress from these mergers into distinción. Studies in the cities of Granada (Melguizo 2007, Moya Corral and García-Wiedemann 1995), Málaga (Ávila 1994, Lasarte Cervantes 2010, Molina 2019, Villena 1996), Jerez de la Frontera (García-Amaya 2008), Huelva (Regan 2017a, 2017b), and Lepe (Regan 2017b) have demonstrated that ceceo is splitting into distinción. It has also been found that seseo is splitting into distinción among certain speakers in Sevilla (Gylfadottir 2018, Santana 2016–2017), Málaga (Villena and Requena 1996), and Granada (Moya Corral and Sosiński 2015). The leaders of the splits of ceceo and seseo are younger speakers, those with more formal education, and females.

Most previous fricative studies have implemented impressionistic analyses, utilizing a binary dependent variable of [s] versus [θ]. However, acoustic analysis of Andalusian coronal fricatives began with Lasarte Cervantes (2010) who analyzed 399 fricatives from read speech from 4 university males (2 from Málaga; 2 from Cártama Pueblo). Coding was based on the author’s auditory analysis of fricatives as [s] or [θ], as opposed to graphemes (<s>, <z,ci,ce>). She found that urban speakers had a significant difference between coded [s] and [θ] for mean intensity (dB) while both groups demonstrated differences for maximum intensity (dB). Based on these findings, Lasarte Cervantes added ceceo as an intermediate realization between alveolar [g] and interdental [θ] to the fricative intensity continuum of Martínez Celdrán and Fernández Planas (2007:107). Building on these results Regan (2017b, 2020) analyzed 19,420 tokens from 80 speakers from Huelva capital and Lepe. Regan (2017b) found that center of gravity (henceforth COG) (Hz), mean intensity (dB), and variance (Hz) best explained the variation based on graphemes (<s> versus <z,ci,ce>). Similar to Lasarte Cervantes, Regan proposed a COG continuum with ceceo, [sθ], having intermediate realizations between [g] and [θ] (2017b:254). In analyzing seseo and distinción with 24 speakers from Sevilla, Gylfadottir (2018:57) also found COG and mean intensity (dB) to be the most robust acoustic parameters to show speakers with the split. She also found a Principal Component Analysis (PCA) useful in plotting each speaker “by the first two Principal Components” (2018:57).

In order to best examine the most adequate acoustic measures, Regan (2017b, 2020), conducted paired Welch Two Sample t-tests with a Bonferroni correction to test seven acoustic measures per speaker per grapheme (<s> versus <z,ci,ce>). The rationale to examine so many acoustic parameters was two-fold: (i) the lack of acoustic studies on Andalusian coronal fricatives has left open the question of which parameters best distinguish [s] and [θ] (i.e. distinción); and (ii) in cases of near-mergers, it has been shown that some speakers who have lost a phonemic distinction on primary acoustic cues may utilize secondary cues to maintain a subtle phonetic separation between phonemes (Bullock and Nichols 2017, Di Paolo and Faber 1990). Regan found that COG, variance, skewness, and mean intensity proved to distinguish [s] and [θ] for most speakers, while spectral peak (Hz), duration (ms), and kurtosis did not appear to be adequate parameters for distinción, even for those speakers who demonstrated the split on the other four parameters.

Based on the t-test individual speaker results, Regan (2017b, 2020, in press) created a fricative Demerger Index by subtracting an individual’s mean per grapheme (µ<s> - µ<z,ci,ce>) for each speech style per acoustic measure in order to show the relative Euclidean distance (or lack thereof) between phonemes for each speaker. Regan found that the COG and mean intensity Demerger Indexes proved the best explanation of variation as seen by R-squared values (variance and skewness Demerger Indexes had the next highest R-squared scores). The Demerger Index has the benefit of quantifying the degree of demerger as individual t-tests only determine whether differences were significant or not. The Demerger Index also allows the researcher more opportunity to analyze different interactions as the raw COG or mean intensity mixed effects linear regressions must include.
orthography in interaction with all social and linguistic factors. Another reason for creating the Demerger Index was to avoid biological sex-related acoustic differences for spectral parameters as women generally have higher COG, higher variance, more negative skewness, and higher kurtosis than men (Jongman et al. 2000). Thus, in taking each speaker’s mean difference, it produced a relative distance score avoiding differences based on vocal tract size.

Most recently, Molina (2019) also examined which acoustic parameters best separate Andalusian [s] and [θ], based on a total of 480 tokens from 12 male speakers in Málaga. Separating participants into two educational groups (elementary studies, university studies), he conducted Mann-Whitney U tests per measure per educational group per grapheme (as well as per impressionistic categorization). Based on these findings he created a Polar Coordinate score per speaker per grapheme combining eight acoustic measures: spectral peak, skewness, kurtosis, variance, mean intensity, COG, duration, and zero crossings. Similar to Regan’s Demerger Index, he then subtracted differences between graphemes per speaker to create a single value to represent the Euclidean distances based on grapheme. While the inclusion of multiple acoustic measures is quite welcome, there are several acoustic measures in the model, specifically spectral peak, kurtosis, and duration, that do not appear to be robust acoustic measures for distinguishing these phonemes (Regan 2017b, 2020) and consequently could skew the results. Additionally, as Molina only included males, this model does not take into consideration biologically sex-related differences of spectral parameters, specifically spectral peak in which in general, [θ] has a higher spectral peak than [s], but women have an overall higher spectral peak resulting in many women’s [s] having a higher spectral peak than [θ], quite problematic as this is the opposite of men (Jongman et al. 2000). In fact, in Regan (2020), there were several men that demonstrated higher spectral peak for [s] than [θ]. A limitation of both Regan’s Demerger Index and Molina’s Polar Coordinates model is the use of Euclidean distance between grapheme means as it is averaged across linguistic contexts and therefore does not include phonological context in the models, nor random effects such as lexical items. Finally, both methods only account for distance, not overlap.

2.3 Pillai Scores

The method of using Pillai scores was first used in linguistics by Hay et al. (2006) in the analysis of the NEAR-SQUARE merger-in-progress in New Zealand. The Pillai-Bartlett statistic is a type of MANOVA, multivariate analysis of variance, that incorporates two or more dependent measures. As Nycz and Hall-Lew (2013:5) state, “the Pillai does not represent distance so much as a more abstracted difference: Pillai score values range from 0 to 1 in all cases, with 0 indicating no difference between two clusters and 1 indicating no similarity.” This method has subsequently been promoted by Hall-Lew (2010) and used widely in variationist literature on vocalic mergers and splits as this allows the researcher to incorporate both F1 and F2, as opposed to running separate analyses per measure, or using the Euclidean distances between F1 and F2 averages. As scholars note (Hall-Lew 2010:3, Nycz and Hall-Lew 2013:5), in addition to the inclusion of two or more measures, there are several additional advantages such as the ability to incorporate linguistic factors such as phonological context into the model. That is, there is no need to average across linguistic factors. This is important as spontaneous speech does not always have a balanced number of tokens per context (Nycz and Hall-Lew 2013:3). Advantages notwithstanding, there are also some drawbacks including the inability to account for random effects and the lack of “perceptually meaning terms, such as Hertz” for linguists (Nycz and Hall-Lew 2013:5).

In addition to its wide use with English vocalic mergers and splits, it has been used in non-English languages such as on a German vocalic split (Sloos 2013) as well as mid-vowel mergers in Catalan in contact with Spanish (Amengual 2016) and mid-vowel mergers in Galician in contact with Spanish (Amengual and Chamorro 2015). Additionally, similar to its non-merger use in examining vowel fronting in English (Hall-Lew 2010:6-7), it has been used to examine vowel metaphony in Asturian (Barnes 2019). However, to the knowledge of the author, it has yet to be used for consonant mergers/splits. The current study seeks to extend the use of Pillai scores to a fricative split-in-progress in Andalusian Spanish.

3 Methodology
3.1 Participants, Materials, Procedure, and Processing of Data

This study uses data from Regan (2017b, 2020, in press). Participants were recruited during summers of 2015 and 2016 through the author’s contacts in Huelva and Lepe, Spain. There were 80 speakers included, balanced by origin (40 Huelva, 40 Lepe), gender (40 men, 40 women), and occupation, ranging in age from 18 to 86 (M: 43.7, SD: 17.2). Both communities were similar in age: Huelva (range: 18-70, M: 43.03, SD: 16.03) and Lepe (range: 18-86, M: 44.4, SD: 18.48).

While each recording included sociolinguistic interviews, a reading passage, word lists, metalinguistic questions, and demographic questions, always in the same order, only the passage reading and word lists are analyzed here. Participants were recorded in quiet locations with a solid-state digital recorder Marantz PMD660 (digitized at 44.1kHz and a 16-bit sampling rate) wearing a Shure WH20XLR Headworn Dynamic Microphone. The passage reading consisted of a 575-word text with 170 syllable-initial target tokens (97 <s>, 73 <z,ci,ce>) (Regan 2017b:279), while the word list consisted of 86 syllable-initial target tokens (44 <s>, 42 <z,ci,ce>) and distractors (Regan 2017b:281). Only syllable-initial tokens were considered as syllable-coda is generally aspirated or deleted (Villena 2008). The passage was relatively informal, focusing on local celebrations, rivalries, foods, and customs. All participants were able to read the word list, but two were unable to read the passage reading (one due to limited literacy and another due to lack of glasses during recording).

There was a total of 19,420 tokens (passage reading: 12,651, word list: 6,769) included in the analysis after eliminating several tokens due to participants skipping or misreading a word, or an overlapping noise (dogs barking, babies crying, phones ringing). The data were forced aligned using FASE (Wilbanks 2015). Upon completion of the alignments, the author manually corrected each fricative boundary in Praat following Jongman et al.’s (2000:1255) fricative segmentation guidelines as seen in Figure 1.

![Waveform, spectrogram, and textgrid of Andalusian distinción ([s] vs [θ]) produced by a 25-year-old female from Huelva (left) and a 29-year-old female from Huelva (right).](image)

3.2 Independent Variables

The analysis included six social factors: gender, age (18-86, based on year 2015), education, occupation, origin, and speech style. Education was based on the highest degree earned or actively pursuing. For occupation, speakers were divided into manual, service, or professional occupations. Speech style, following Labov’s (1972:99) attention to speech approach, was defined as the distinct levels of style between the passage reading and word list.

The linguistic factors included were orthography (<s> versus <z,ci,ce>), preceding phonological context (pause, consonant, /i/, /e/, /a/, /o/, /u/), and following phonological context (/i/, /e/, /a/, /o/, /u/). While preceding and following phonological contexts were original coded for in Regan (2017b), they were discarded from the analyses as there lacks words containing all possible contexts per grapheme (i.e. <z>+/u,o/ is quite uncommon as compared to <s>+/u,o/>).

3.3 Dependent Measure(s)

The study used an automated Praat script (Elvira-García 2014) that measured the following acoustic parameters: COG (Hz), variance (Hz), skewness, kurtosis, spectral peak (Hz), mean intensity (dB), and duration (ms), among others. The script uses a Filter pass Hand band (1,000, 11,000, 100) and for the spectral moments creates an averaged power spectrum using the “to Ltas” function in line with previous studies (Forrest et al. 1988, Jongman et al. 2000, inter alia). As most experimental
studies of fricatives have focused on English, and of these, only a few have directly compared alveolar /s/ to (inter-)dentals /θ/ (for a review, see Regan, 2017b, 2020), it was for this reason that several spectral, amplitudinal, and temporal parameters were analyzed in order to ascertain the best means of distinguishing Andalusian coronal fricatives. As mentioned in Section 2, Regan (2017b, 2020) found that COG and mean intensity were the most robust parameters to demonstrate a separation in phonemes, followed by the parameters of skewness and variance. Thus, this study only utilizes these four acoustic measures in the creation of Pillai scores.

Following previous studies (Hay et al. 2006, Hall-Lew 2010, Nycz and Hall-Lew 2013), Pillai scores were created for each speaker using the `manova()` function in R (R Core Team 2019). Instead of basing Pillai scores on lexical word sets, as is done with English vowels (COT-CAUGHT, PIN-PEN), here the Pillai scores were based on orthographic word sets (⟨s⟩ versus ⟨z,ci,ce⟩). While both following and preceding phonological context were originally included in the Pillai scores, the final model only used Pillai scores with following phonological context as preceding context had little effect on the Pillai scores. A Pillai score was created per style per speaker, one for the passage reading and one for the word list. These scores served as the dependent measure.

3.4 Statistical Analysis

A mixed effects linear regression model was conducted using the `lme4` (Bates et al. 2015) and `lmerTest` (Kuznetsova et al. 2014) packages in R including all social factors as fixed factors and speaker as a random factor (each speaker has one value per style). Style was run in interaction with each social factor and other interactions were tested in the models. Within each model any factor or interaction that was not statistically significant was removed from subsequent models. Estimated marginal means (Lenth et al. 2018) were used to conduct post-hoc analyses between predictors with more than two levels. Both marginal R-squared values (R^2m) and conditional R-squared values (R^2c) were obtained in order to assess the goodness-of-fit of the variation (Nakagawa and Schielzeth 2013). One model was conducted with a Pillai score composed of two acoustic measures (COG, mean intensity) while another with a Pillai score of four acoustic measures (COG, mean intensity, variance, skewness). As the Pillai score with two acoustic measures (R^2m: 0.474, R^2c: 0.842) slightly better explains the variation than that with four measures (R^2m 0.427, R^2c: 0.83), the analysis presents the results from the Pillai score including only the spectral parameter of COG and the amplitudinal parameter of mean intensity. All images were created in `ggplot2` (Wickham 2013).

4 Results

Pillai scores ranged from 0.002 to 0.921 with an average of 0.51 (SD: 0.31) for the passage reading, and from 0.012 to 0.945 with an average of 0.57 (SD: 0.29) for the word list. The best-fit mixed effects linear regression model for the fricative Pillai scores is shown in Table 1, which displays the estimated marginal means (EMM), estimate, standard error (SE), t-value, number of tokens per level (n), and p-value. Positive estimates indicate a higher Pillai value compared to the reference level, while negative estimates indicate a lower Pillai value compared to the reference level.

The main effect of gender indicates that women have a higher Pillai score than men (p < 0.001). The main effect of style indicates that the word list has a higher Pillai score than the passage reading (p < 0.001). The main effect of education indicates that both those with university education (p < 0.01) and secondary education (p < 0.05) have higher Pillai scores than those with primary education, but there was no significant difference between those with university or secondary education (Figure 2a). The interaction between gender and age\(^1\) indicates that while both men’s and women’s Pillai scores increased with younger generations, this increase is greater among women than men (Figure 2b). The gender by style interaction indicates that the Pillai score is greater for the word list than the passage reading for men (p < 0.001), but not for women (p = 0.09). However, the women’s passage reading Pillai score is greater than that of the men (p < 0.001) and the women’s word list Pillai score is also greater than that of the men (p < 0.01) (Figure 2c). Regarding the occupation by style interaction, both those with manual (p < 0.001) and service occupations (p < 0.01) had significantly

\(^1\)Age is used in the regression analysis, but birth year in the visualization in order to better display the apparent time change.
higher Pillai scores for the word list than the passage reading, but there was no difference between the styles for those with professional occupations. Thus, while those with professional occupations had the highest overall Pillai scores, there was no change based on style (Figure 2d).

<table>
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<th>EMM</th>
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<th>SE</th>
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Table 1: Summary of mixed effects linear regression for Pillai score, speaker as random factor, n = 158 (R²m: 0.47, R²c: 0.84).

Figure 2: Main effect of education (a), age by gender interaction (b), gender by style interaction (c), and occupation by style interaction (d) for Pillai scores.
To visualize how well the Pillai scores capture the overlap or distinction between phonemes, here we examine the scatterplots of mean intensity by COG for the highest, the lowest, and the mid-value Pillai scores of the passage reading in Figure 3. Rocio\textsuperscript{2}, a 25-year-old woman from Huelva, had the highest Pillai score of 0.921. Adeli, a 51-year-old woman from Huelva, had a mid-value Pillai score of 0.531. Finally, Trini, a 51-year-old woman from Lepe, had the lowest Pillai score of 0.002. Rocio was born in 1989, studied through high school and completed a year of university before pursuing her career as a *cantaora* ‘flamenco singer’ that has led her to travel and live outside of Huelva, providing her ample dialect contact. Adeli and Trini were both born in 1964. This is an important year as it is when the *Polo Industrial* ‘industrial plant’ arrived in Huelva resulting in an influx of immigrants from the north of the province and the rest of Spain. These immigrants are thought to have brought *distinción* into the city (Morillo-Velarde 1997:209). Adeli studied through high school and has worked as an administrative assistant. Trini, however, only studied through elementary school and has worked as a field worker and a cleaner. Of note is that Adeli is the mother of Rocio. Even though Adeli presents relatively little overlap between her two phonemes, one can observe the even further split of [s] and [θ] in her daughter’s realizations. Thus, the Pillai scores, using COG and mean intensity, appear to provide a very accurate account of the degree of overlap.

Figure 3: Scatterplots of mean intensity (dB) by COG (Hz) for the highest Pillai score (Rocio, 0.921), the mid Pillai score (Adeli, 0.531), and the lowest Pillai score (Trini, 0.002).

As a case study of this apparent time change, it is worthwhile to consider the rest of the family of Rocio and Adeli (Figure 4). It should be noted that all Pillai scores here refer to the passage reading. Rocio’s sister María, a 29-year-old teacher (born in 1985) with a university degree, has a Pillai score of 0.856. Different from Rocio, she has not lived outside of Huelva capital, but still demonstrates one of the largest Pillai scores in the sample. Their father (husband of Adeli), Paco, has a much lower Pillai score of 0.159. Paco, 57 years old (born in 1957), studied through primary education and is a machine operator in a factory in the Industrial Plant. Looking at Paco’s extended family, his sister Carmen (61 years-old, born in 1953), a stay at home mother who studied through primary education, has a Pillai score of 0.473, slightly less than her sister-in-law Adeli, but still much higher than her brother. Carmen’s daughter, Miriam (26 years-old, born in 1989), cousin of Rocio and María, studied through high school and is a cashier worker in a supermarket. She has a Pillai score of 0.686, higher than all members of the generation above her, but still less than her two cousins. Finally, Manolo, (68 years-old, born in 1947), brother of Paco and Carmen, studied through high school and worked in various jobs throughout his career in a pharmacy, a construction company, and a bank. Similar to his brother, he has a low Pillai score of 0.116. Thus, the apparent time split of *ceceo* into *distinción* as seen through one Huelvan family demonstrates gender differences, generational differences, and occupational differences perhaps due to the linguistic capital required in more professional occupations, particularly among younger speakers (Sankoff and Laberge 1978).

\textsuperscript{2}All names are pseudo-nyms to protect the identity of each speaker.
5 Discussion and Conclusion

The analysis of the Pillai scores demonstrates an apparent time (Labov 1994:45) change in progress from the ceceo merger into distinción. The leaders of this change are those with more formal education (secondary or university education), those employed in service or professionally oriented occupations, women, and in more formal styles. These results are quite similar to those found in Regan (2017b, 2020, in press) for the raw COG and mean intensity mixed effects linear regression analyses as well as the COG and mean intensity Demerger Indexes. Some notable differences are that the current Pillai score analysis did not find speaker origin (Huelva versus Lepe) to be significant even though this was significant in the raw COG and mean intensity analyses as well as the mean intensity Demerger Index. Another major difference is that the Pillai score analysis found an additional significant interaction, that of style by gender, which was not significant in the other types of analyses. These differences could be due to the inclusion of following phonological context or perhaps the inclusion of two acoustic measures as opposed to one measure per analysis. Also, both COG and mean intensity Demerger Indexes as well as the Pillai scores demonstrate a significant main effect of style and significant interaction of style by occupation, neither of which were significant in the raw COG or mean intensity analyses. Given the variation found in aperiodic noise such as fricatives, this suggests that stylistic differences are best observed through methods analyzing distance or overlap as opposed to all realizations. These differences notwithstanding, the overall results are quite similar to the analyses using either raw COG or mean intensity or the COG or mean intensity Demerger Indexes.

As stated by Nycz and Hall-Lew (2013:13), the use of Pillai scores versus Euclidean distance measures depends upon whether or not “it is the distance or overlap, which best captures the difference between word classes.” As Nycz and Hall-Lew (2013:15) propose, for scholars examining mergers or splits, one should consider “at least two different ways of operationalizing category distinction in the exploratory stages of their analyses” as each model has its advantages and disadvantages. Using a single measure such as raw (or normalized) COG or mean intensity scores allow for the incorporation of random effects such as lexical effects, but cannot account very well for unbalanced phonological environment or multiple interactions between social factors as it must take orthography into account for all interactions. Regan’s Demerger Index helps normalized biologically related sex-effects in providing a relative Euclidean distance per acoustic measure between graphemes per speaker in looking at the distance between phonemes while still providing linguistically relevant dependent measures (i.e. Hz, dB), but lacks the ability to take phonological environment (or other linguistic factors) into consideration as it is averaged across all linguistic contexts. Molina’s Polar Coordinate model allows for the inclusion of multiple acoustic measures, but lacks the inclusion of phonological context. Pillai scores provide the researcher a relative score (0–1) regarding the overlap of phonemes utilizing two or more dependent measures with the ability to account for phonological environment, but lack random effects and perceptually relative scores (i.e. Hz, dB). Another benefit of the Pillai scores, is that it allows the researcher to compare fricative mergers to vocalic mergers utilizing the same relative scale to compare degree of overlap.

Future work on the split of ceceo or seseo into distinción should use Pillai scores to complement mixed effect linear regression models with single acoustic measures (Regan 2017b, 2020), a fricative Demerger Index analysis (Regan 2017b, 2020, in press), or a Polar Coordinate analysis (Molina 2019), at least at a preliminary stage, as suggested by Nycz and Hall-Lew (2013), in order to decide
which analysis best fits the researcher’s data. Similar to best measurements of vowels (Nycz and Hall-Lew 2013), each fricative measurement method has advantages and disadvantages. For Pillai scores, while the difference is relative per speaker between graphemes, scholars may want to normalized COG before using it in the Pillai score to examine if this provides improvements to the model. Different combinations of dependent measures such as COG, mean intensity, variance, and skewness should also be tested. And finally, while the current Pillai score model only included following phonological context, future models should incorporate other linguistic factors into the analysis such as assimilation, syllabic stress, and functionality. In conclusion, the current paper has extended the use of the Pillai scores, previously only used for vowels, into a fricative split-in-progress, simultaneously advancing the sociophonetic analysis of Andalusian coronal fricatives as well as expanding the cross-linguistic analyses in the variationist discussion of mergers and splits.

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