http://dx.doi.org/10.17959/sppm.2020.26.2.279

Repair Strategies of Complex Onset by Spanish Learners of English in the Speech Accent Archive*

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Yoon, Tae-Jin. 2020. Repair Strategies of Complex Onset by Spanish Learners of English in the Speech Accent Archive. *Studies in Phonetics, Phonology and Morphology* 26.2. 279-301. This paper aims at analyzing strategies of adjusting non-permissible syllable structure by Spanish learners of English in the corpus of the Speech Accent Archive. Words exhibiting sC (where C stands for consonant) onset clusters in the elicitation paragraph were examined concerning repairs by 162 Spanish learners. Collocated words before the complex onset clusters were those ending with a vowel, an obstruent, or a voiceless alveolar fricative, which played different roles in modifying the illegal onsets, ranging from prosthesis even to deletion, which is rarely discussed in Spanish Interlanguage Phonology. Prosthesis is attested as the most frequent repair strategy, but with a much lower proportion than reported in earlier studies. A mixed effects logistic regression analysis suggests that the onset of age in English learning and the context of the preceding words best explain when prosthesis occurs. **(Sungshin Women's University, Associate Professor)**

Keywords: Prosthesis, Homorganic deletion, Repair of Syllable Structure, Spanish learners of English, Speech Accent Archive, Age of Onset

1. Introduction

This paper aims at observing in the Speech Accent Archive, a corpus of speech samples by native and non-native speakers, kinds of repair strategies employed by Spanish learners of English when confronted with English syllable onsets not permitted by their L1. Spanish syllables are more strained than those of English concerning what clusters are permitted in the initial position. Two-member onsets in the English syllable structure require either the onsets should begin with an obstruent followed by an oral sonorant (e.g., pl-, pr-, tr-) or /s/ should be followed by a non-continuant (e.g., sp-, st-, sk-) (Yavas 2020). In contrast to English, Spanish syllable

* This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2018S1A5A2A01036570).

structures allow different two-member onsets in that the first member of the onset must be an obstruent and an oral consonant sonorant must follow the obstruent (Harris 1983, Carlisle 1991, 1997, Baptista and Watkins 2006). Thus, Spanish, as in English, allows two-member onsets such as /pl-, pr-, tr-, kl-, kr-/, but does not allow onsets such as /sp-, st-, sk-/.

The reason Spanish does not allow the tautosyllabic onset clusters beginnings with /s/ can be explained by resorting to the sonority sequence principle, a phonotactic principle aiming to outline syllable structures in terms of sonority (Clements 1990). While English tolerates words beginning with /s/ + obstruent clusters even though those clusters appear to violate the sonority sequencing principle, Spanish sticks to the sonority sequencing principle.

When words with /s/-obstruent clusters are borrowed, those clusters seem to be subject to prosthesis, a type of epenthesis that adds a vowel to the beginning of the word. Examples of prosthesis are seen in Spanish cognates of English words like *school* and *Spanish*. The Spanish cognates always begin with [e] before the cluster, rendered as *escuela* and *español* (Carlisle 1991, 1997, Baptista and Watkins 2006).

Due to the different phonotactics between English and Spanish, when Spanish speakers learn English, they must deal with the tautosyllabic onset sequences which are not permissible in their L1. Thus, the onset sequences such as /sp-, st-, sk-/ may be modified accordingly. As is the case with cognates, previous studies showed that the difficulty in producing initial /s/-obstruent clusters by Spanish EFL speakers led Spanish learners of English to insert [e] before the /s/-obstruent cluster (Carlisle 1991, 1997).

A few noteworthy studies on prosthesis were made by Carlisle. Carlisle carried out several studies involving native Spanish-speaking learners of English as a second language. The Spanish learners were asked to read several randomly ordered sentences containing initial /s/-clusters. More specifically, Carlisle (1991) recruited five (4 female) native Spanish speakers from Colombia who had been living in the U.S.A. between one and seven months, and who were enrolled in ESL classes. He, then, examined epenthesis before three word-initial onsets in English: /sp/, /st/ and /sk/, considering the effect of previous environments (e.g., whether the previous word ends in a consonant or a vowel). The proportions of epenthesis were around 62% before these three two-member onsets (/sp/: 62.6%, /st/: 63%, /sk/: 61.3%). When preceding environments were taken into consideration, the proportion of epenthesis turned out to be higher after consonants (mean = 73.5%; sd = 8.9%) than after vowels (mean =

46.8%; sd = 21.3%), with statistical significance, $t(8) = 3.42$, $p < .01$. When scrutinizing the previous consonants using chi-square tests, he couldn't find any statistical significance between the sonorants and obstruents, and also between voiced obstruents and voiceless obstruents. The results showed that consonants before the target cluster seemed to induce more occurrences of prosthesis than vowels.

In a later study, Carlisle (1997) compared the production of /sC/ vs. /sCC/ clusters. The study controlled the environments before the onsets and the sonority relationships among the consonants in the onsets. Eleven Spanish learners of English were enrolled in intermediate classes at a community college in the U.S.A. The participants consisted of 8 women and 3 men, from Mexico, El Salvador, Spain, Venezuela, Peru, and Honduras. All participants were intermediate on their English proficiency scores. The results showed that for onsets, the mean proportion of epenthesis was 38% before /sC/ and 48% before /sCC/, with a statistically significant main effect for onset, $F(1, 20) = 7.60$, $p < .01$. As for the environment, the mean proportion of epenthesis was 51% after consonants and 35% after vowels, again with a statistically significant main effect for the environment, $F(1, 20) = 18.50$, $p < .001$. His findings reveal that more marked tri-literal clusters were more frequently modified than bi-literal clusters.

Carlisle's (1991, 1997) studies investigating the production of English initial /s/-clusters by Spanish speakers contribute to enhancing our understanding of the role of environments such as the segmental status of the preceding words and the markedness constraint in structuring interlanguage phonology.

Still some questions need to be answered regarding the repair strategies of illegal /s/-obstruent clusters by Spanish learners of English. The first question is the effect of the onset age of English learning. If we compare the proportion of epenthesis between Carlisle (1991) and Carlisle (1997), the participants in Carlisle (1991) showed more frequent occurrences of prosthesis than those in Carlisle (1997) in comparable conditions. For example, epenthesis was observed more than 73% after a consonant in Carlisle (1991), compared to 51% in the same condition in Carlisle (1997). It is possibly due to a higher proficiency level in the latter study.

Indirectly related to proficiency would be the age onset of L2 learning. In the literature on the acquisition of foreign accents, it is usually assumed that "overall the onset age of L2 remained the most important predictor of the degree of foreign accent in the assessment of child and adult learners (Hansen Edwards and Zampini 2008: 46)". Thus, it would be interesting to examine to what extent the onset age of

English learning by Spanish speakers plays a role if participants' record of proficiency is not available. The present study will examine the effect of the age of onset on accounting for the rate of repair strategies by L2 learners.

The second question is whether Spanish learners of English will show prosthesis as the only repair strategies for the complex /s/-obstruent clusters. Carlisle (1991) was one of the few earlier studies which tried to illustrate the importance of environments and was the one that revealed that not only the phonotactics of the target words but the segmental status of the preceding word was influential in accounting for the prosthesis in Spanish learners of English. Carlisle (1991) and again Carlisle (1997) showed that the consonants before the target cluster induced prosthesis more frequently than the vowels.

When adding a vowel before the /s/-obstruent cluster from the general phonological rules or constraints, it is a relatively unusual phonological adaptation and does not occur frequently cross-linguistically. More frequently attested repair strategies of the illegal /s/-obstruent cluster are either inserting a vowel after the first member of the cluster or delete one of the members to make the resulting syllable structure universal CV structures (Kager 1999). Nevertheless, Spanish is not the only language that exhibits prosthesis. A typologically related Brazilian Portuguese is another language reported to possess prosthesis (Robello 1997). Prosthesis is also reported for Iraqi Arabic in Broselow (1987). Broselow (1987) reports that native speakers of Egyptian Arabic and Iraqi Arabic produced the following forms, as a consequence of phonotactic constraints transferred from their L1 to the L2:

(1) Epenthesis (Broselow 1987)

English Target	Egyptian Arabic	Iraqi Arabic
Floor	[filor]	[iflor]
Three	[θiri]	[iθri]
Fred	[fired]	[ifred]

Here, native speakers of the two Arabic dialects employ different strategies for breaking up the unacceptable clusters. Egyptian Arabic speakers insert [i] by breaking up a consonant-liquid cluster, while Iraqi Arabic speakers insert [i] before a consonant-liquid cluster, exhibiting prosthesis (e.g., /flor/ → [iflor]). Though both of these strategies achieve a similar end, making the adjacent consonant and the liquid heterosyllabic, the resulting forms are not equal in its degree of markedness.

While the Egyptian Arabic learners of English conform to the unmarked syllable structure of CV, the Iraqi Arabic L2 learners result in a more marked VC structure.

Because the VC structure resulting from prosthesis was more marked, Carlisle (2001) went as far as to make sure that no instances of vowel insertion after the first member of the onset cluster were observed in a variety of Spanish Interlanguage phonology, including not only Spanish learners of English but also Spanish learners of Swedish, German, and Italian, languages that had complex onsets beginning with /s/ or /ʃ/ (Abrahamsson 1999, Carlisle 2001). Borrowing his words, "Spanish speakers will variably pronounce words such as *snow*, *slow*, and *steep* as [esno], [eslo], and [estip], a pronunciation that results in the words beginning with a VC syllable. In none of the studies did the participants ever produce forms such as [seno], [selo], or [setip] as might be expected if the participants really had a preference for the CV syllable independent of language transfer (Carlisle 2001: 7)." A conclusion made with these previous studies was that "when the target onsets were modified at all, they were modified by prosthesis nearly exclusively (Carlisle 2001: 8)."

Now back to the second question, it is well known, under the name of OCP (Obligatory Contour Principle) that it is not preferred to have identical elements appear next to each other (Myers 1997, Kager 1999). Then we may think of a context where the /s/-obstruent cluster is preceded by a homorganic /s/ ending words within the same prosodic domain (i.e., six spoons [sɪk**s** **s**punz]). Even in this environment, will the Spanish interlanguage phonology still stick to prosthesis? Isn't there a possibility to resort to the deletion of either one of the /s/ so that the resulting structure avoids sequencing of identical elements and abides by the putatively unmarked CV syllable structure?

The third question is the influence of different dialects of Spanish in the restructuring of the English syllable structure. As seen in (1), Iraqi Arabic and Egyptian Arabic learners of English differ from each other concerning the position of inserted [i]. Even though Carlisle didn't find remarkable differences among his Spanish learners of English from different regions, Robello (1997), adopting similar methods to that of Carlisle (1991, 1997), investigated Brazilian Portuguese-speaking learners of English, and obtained different results from Carlisle's. Prosthesis in Brazilian Portuguese-speaking learners of English was more frequently observed after vowels than after consonants. Thus, it would be interesting to observe whether there is any difference is repairing non-permissible /s/-obstruent clusters across different varieties of Spanish.

Answers to these questions can be restated as the following hypotheses:

1. Prosthetic epenthesis will be the dominant, if not the only, modification strategy for /#sC/ clusters in Spanish learners of English.
2. Identical segments will be broken up not only by prosthesis but also by deletion.
3. The occurrence of prosthesis will be negatively correlated with the onset of age in English learning.

These hypotheses will be tested using speech samples from a preexisting corpus in the Speech Accent Archive (Weinberger and Kunath 2011).

2. Data Analysis

2.1 Data: The Speech Accent Archive

A project for the Speech Accent Archive (http://accent.gmu.edu) was started at George Mason University in 1999 (Weinberger and Kunath 2011). Beginning as a teaching project for a graduate phonetics class, in which students were to gather, record, and analyze the speech of non-native speakers of English, the Archive has evolved to be a relatively large and comprehensive source of English speech accents by native and non-native English speakers. Currently, it catalogs a wide distribution of speakers (2,172 speakers for the version of the corpus used in this paper), and it is freely accessible to researchers.

Each speaker read the same elicitation paragraph, making sure that the various speech samples had a uniform consistency. For this, graduate linguistics students carried audio recorders with them when conducting interviews. They asked speakers to read an elicitation paragraph, shown in (2).

(2) Please call Stella. Ask her to bring these things with her from the store: six spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a snack for her brother Bob. We also need a small plastic snake and a big toy frog for the kids. She can scoop these things into three red bags, and we will go meet her Wednesday at the train station.

The paragraph consists of 69 common English words that most non-native speakers can recognize. According to Weinberger and Kanuth (2011), the paragraph contains almost all of the consonants and vowels of English. Besides, in the paragraph are numerous initial and final consonant clusters, which are known to cause production difficulties for many learners of English. As part of the elicitation protocol, each speaker could look over the paragraph in (2) for a minute and ask questions about the meanings of unfamiliar words to the interviewer.

The Speech Accent Archive can be accessible via a PHP web interface at https://accent.gmu.edu, and also downloadable from the Kaggle website (https://kaggle.com), a crowd-sourced platform where users can find and publish data sets, as well as explore and build machine learning models in a web-based data-science environment. To analyze audio speech samples, I opted for downloading from Kaggle.com mp3 files together with a csv file that contains each speaker's demographic information and a text file containing the same elicitation paragraph read by all speakers

Demographic information includes age, age of onset, native language, sex, country, among others. Of all things, age of onset, that is, the age at which the speaker was first exposed to sustained English language input, is regarded as one of "the most significant variables in second language acquisition studies (Long 2007, Weinberger and Kanuth 2011)". According to the demographic information, 2,172 speakers command 214 native languages. The speakers were reported to be from 177 countries. Female speakers comprise 48.2% (1,049 out of 2172) and male speakers 51.8% (1,123).

Despite the diverse countries and native languages, the data is not evenly distributed. Table 1 and Figure 1 shows the table and bar plot, respectively, of the native languages whose participants are more than 50:

Table 1. Native languages which have more than 50 participants

English	Spanish	Arabic	Mandarin	French	Korean
579	162	102	65	63	52

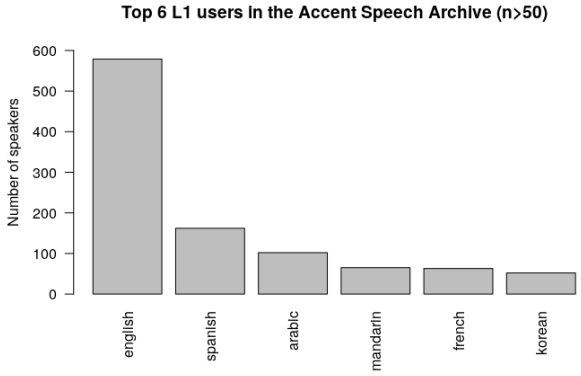


Figure 1. Bar graph for top 5 L1 users

This paper aims at examining the Spanish Interlanguage Phonology regarding the learning of complex onsets of /s/+obstruent clusters. Thus, we used the speech samples of 162 Spanish speakers, and chose the target words STELLA /stɛlɑ/, SPOONS /spunz/, and SCOOP /skup/ for our examination of repair strategies by Spanish learner of English, as these target words occur after words ending in a sonorant obstruent, a homorganic voiceless fricative, and a vowel.

2.2 Labelling of the Spanish speech samples

To examine the modification of syllable structure in complex onset by Spanish learners of English, I analyzed speech samples of 162 Spanish speakers, in according with the following steps: First, mp3 files, downloaded from Kaggle.com, were converted to wave files with the sampling rate of 11,025 Hz using Praat (Boersma and Weenink 2020). Down-sampling was necessary to meet the requirement of an automatic forced-alignment system. Each of the 162 down-sampled wave files and a text file that contains the elicitation paragraph in (2) were batch processed using a custom-made bash script to make time-aligned TextGrid files. Penn Phonetics Lab Forced Aligner for English (or P2FA for short; Yuan and Liberman 2008) was used for the forced-alignment process. The output of the forced alignment was manually checked and corrected using a custom-made Praat script. The custom-made Praat script was designed to open a portion of the speech file and the corresponding TextGrid centering a target word with the surrounding words (e.g., *call* ***Stella*** *ask*, *six* ***spoons*** *of*, *the* ***store****:*

six, where the bold-faced words are the target words). Using the Praat script that went through target words, I manually corrected misalignment of the time-aligned text information, and also observed changes such as insertion or deletion made by the Spanish learners of English. Note that the forced-alignment which resorts to built-in and predefined pronunciation dictionary could not deal with cases of insertion or deletion. When any silent pause is present, I manually inserted boundaries for the silent pause between a previous word and a target word. Figure 2 illustrates a few screenshots made after manual checking and correction. Figure 2(a) shows the target phrase *six spoons*. Here the final [s] of the preceding word and the [s] of the target word are demarcated by a dip in the intensity contour as indicated by the downward arrow. In Figure 2(b), the [s] in the onset of the target word *spoons* is deleted and marked as (S)P. The prosthesis is clearly shown in Figure 2(c), in which [e] with clear formant structure and F0 contour appears in the middle of *six* and *spoons*.

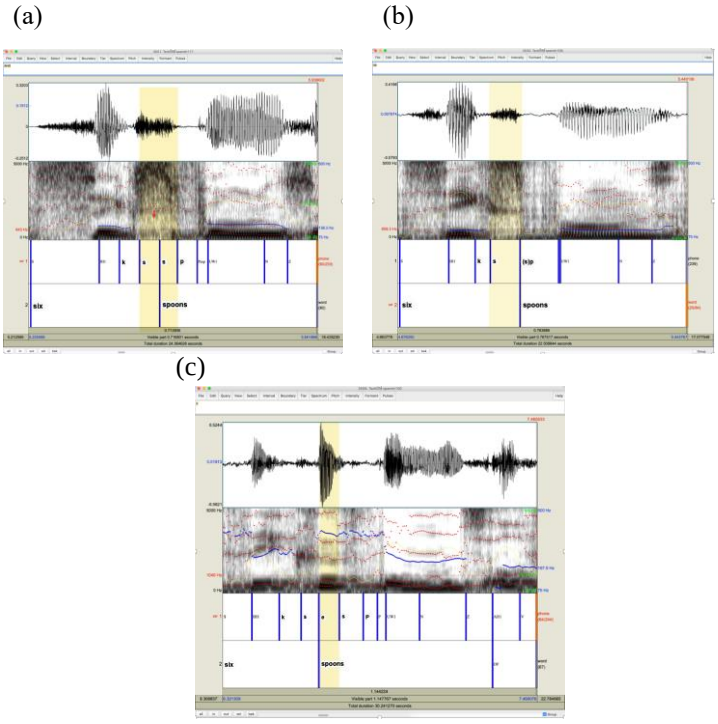


Figure 2. Illustration of target words

After the manual correction, Python packages Parselmouth (Jadoul, Thompson, and de Boer 2018) and tgt (Buschmeier and Wlodarczak 2013) each of which can control Praat and TextGrid within the general-purpose Python programming language (van Rossum and Drake 2009) was used and another custom-made script was written to elicit textual and acoustic information for each target word and its segmental makeups (e.g., duration, F1 and F2), as well as the textual information of the preceding word. After extracting the features, I merged the output with the corresponding metafile that containing demographic information including the onset of age, country, and first language, using Pandas (McKinney 2010) library in Python3. The resulting file was saved in a csv(comma separated variable) format and was fed to R (R Core Team 2013) for a series of statistical analyses.

3. Result

There are 162 Spanish speakers in the dataset. In total, there must be 486 instances which contain the target words *Stella, spoons*, and *store*. But three tokens are thrown away, leaving 483 for further analyses. The three are tokens of *Stella* unexpected pronounced. Three speakers pronounced *Stella* as either "SHILLA [ʃɪlɑ]", or "SELLA [sɛlɑ]," thus treated in this paper as outliers and excluded from further analyses. Table 2 shows the frequency of modification of the /s/-obstruent clusters, if any, after three different environments.

Table 2. Distribution of modification of target clusters

	No change	Prosthesis	Deletion	Total
call Stella	119	41	0	159
six spoons	98	41	23	162
the store	157	5	0	162

Table 2 clearly shows that L1 is negatively transferred to English for some speakers, but with different degrees depending on the context. That is, the preceding vowel induced the least prosthesis. Even though the presence of a consonant in the preceding context was conducive to prosthesis, deletion which is a type of repair that hasn't been reported in the Spanish interlanguage phonology literature was attested (23/162 = 14%) after the homorganic voiceless fricative /s/, probably to avoid

identical segments. When the deletion was counted by sex, male speakers tended to delete more than female speakers (15 for male vs. 8 for female).

Focusing on the prosthesis below, I will first examine the acoustic characteristics of the prosthetic [e] and then focus on predictor variables for prosthesis, including gender, age, age of onset in English learning, countries of the Spanish speakers. As for statistical modeling, Mixed Effects Logistic Regression will be used to model binary outcome variables (i.e., presence or absence of prosthesis). In the model, the log odds of the outcomes are modeled as a linear combination of predictor variables when there are both fixed and random effects. The Mixed Effects Logistic Regression was tested using the glmer command in the lmerTest package (Kuznetsova et al. 2015).

Phonetic quality of prosthetic /e/: The Spanish vowel system is traditionally described as a simple, symmetrical, five-vowel system that is stable especially in comparison to English (Hualde 2005). Ronquest (2012) provided acoustic descriptions of Spanish vowels. Presented are in Table 3 are duration and formant values of the Spanish /e/ by male and female speakers, as reported in Ronquest (2012).

Table 3. Example Acoustic values of /e/ in Spanish (from Ronquest 2012: 146)

	Duration(in ms)	F1(in Hertz)	F2(in Hertz)
Male	64.75(20.73)	474.32(47.57)	1777.03(183.90)
Female	74.54(28.37)	548.98(72.07)	1958(241.55)

Figure 3 shows the histogram of the prosthetic /e/ in the current study. The median value of 70.3(ms) is indicated as a dotted vertical bar in the figure.

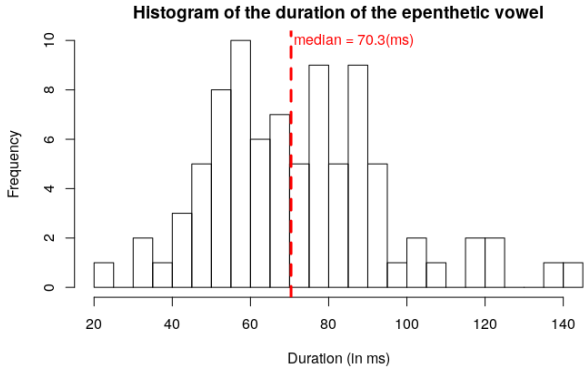


Figure 3. Histogram of the duration of the epenthetic vowel /e/

Below in Figure 4, the median values of F1 and F2 from the prosthetic [e] are plotted and encircled by a red circle. The other two [e]'s are the mean values reported for male and female speakers in Ronquest (2012: 146), and are plotted together with the prosthetic [e] for comparison purpose.

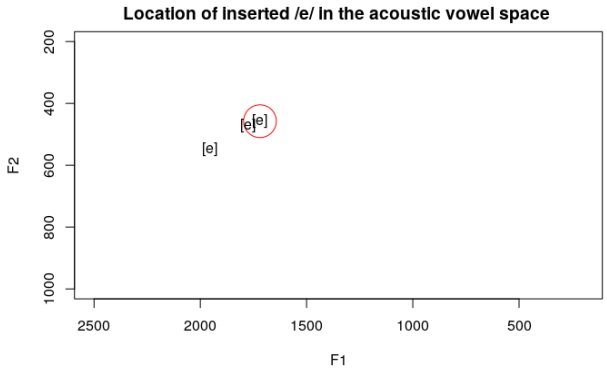


Figure 4. The location of the prosthetic /e/ in the acoustic vowel space

Countries: Now let us look at the distribution of the prosthetic [e] by countries which the speakers in the corpus are from. Figure 5 shows the distribution of prosthesis relative to no changes in the complex onset clusters by countries. Fisher's Exact Test for count data with simulated p-value based on 2000 replicates indicates that the ratio of epenthesis differs by countries with statistical significance ($p < 0.05$).

Given the figure, it appears that speakers from El Salvador insert the vowel [e] to conform to the L1 phonotactics.

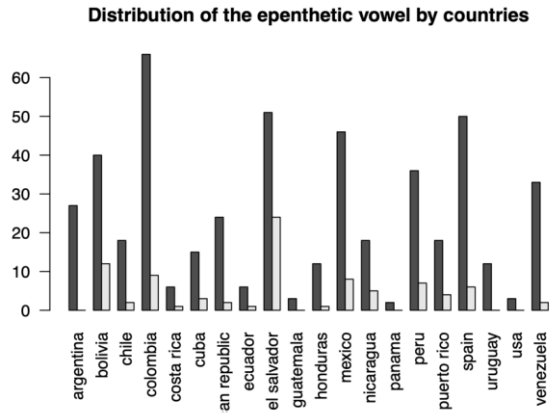


Figure 5. Bar plot of the distribution of the prosthesis by countries (white bar indicates the distribution of prosthesis and dark bar shows no changes in the complex onset clusters)

The proportion of the prosthesis in the current paper is compared with those reported in Carlisle (1991, 1997). The epenthesis in the current study is 25% after sonorant consonant, and 3% after vowel and the percentage is much lower than those reported in Carlisle's previous studies (73% after consonants and 36% after vowels in Carlisle 1991; 51% after consonants, and 35% after vowels in Carlisle 1997). Note that in spite of differences from the previous studies, the three words selected in this study is in accordance with the general trend of prosthesis reported for the Spanish phonology. Thus the finding can be analyzed not as a lexical effect of particular word items, but as general phonological repair strategies. Table 4 is the result of Mixed Effects Logistic Regression with the previous word as a fixed effect and countries as a random effect and the presence or absence of prosthesis as a response variable. In the table, the intercept is when the previous word is CALL, and with CALL as an intercept, the proportion of epenthesis is 0.257(=exp(-1.35580) or 25.7%). According to the result in the table, the previous word ending with a sonorant consonant is statistically different from one ending with a vowel, whose proportion is 0.08(=exp(-2.50746), but not from the previous word whose ending is an obstruent.

Table 4. Fixed Effects of previous words on prosthesis

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-1.35589	0.27967	1.25e-06 ***
SIX	-0.04042	0.28225	0.886
The	-2.50746	0.51069	9.11e-07 ***

Gender Difference: Gender has long received attention from L2 phonology researchers (cf. Asher and García 1969). However, in the present study, gender was not found to be statistically significant, as seen in Table 5. According to Pearson's chi-squared test, no difference between male and female speakers was observed ($\chi^2(1)=2.4711$, $p > 0.1$).

Table 5. Cross-tabulation of prosthesis and gender

	Male	Female	Total
No prosthesis	238 (84.6%)	157 (77.7%)	395
Prosthesis	43 (13.4%)	45 (22.3%)	88
Total	281	202	

Age: The result of Mixed Effects Logistic Regression with age as a fixed effect and countries as a random effect and the presence or absence of prosthesis as the response variable is in Table 6. The intercept has the proportion of 0.07 or 7% (=exp(-2.655391)) regarding the prosthesis. Age has a statistically significant effect of increasing the prosthesis proportion from 0.07027136 to 0.07172069 (i.e, about 0.001 (or 0.1%) more chance of inserting [e]) per year.

Table 6. Fixed effects of age on prosthesis

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-2.655391	0.373279	1.13e-12 ***
age	0.020415	0.008345	0.0144 *

Figure 6 shows the scatterplot that shows the correlation between the age and age of onset in learning English. The Spanish speakers have English onset ages that range from 1 to 53 years, but mostly before 20.

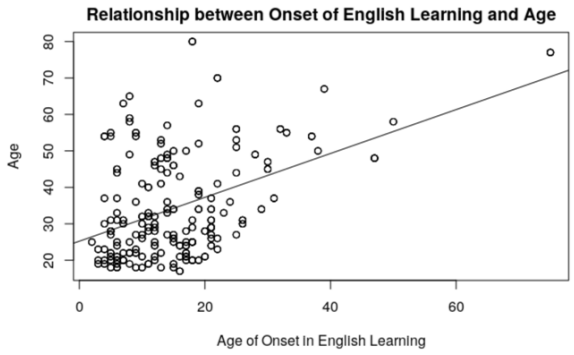


Figure 6. Scatterplot of Age and Age of Onset

It may be the case that the longer a speaker resided in the English-medium country, the less likely he or she is prone to prosthesis. The length of residence in the U.S.A. is calculated by subtracting Age from Age of Onset. Figure 7 shows the duration during which the speakers resided in the U.S.A., with the median length being 17 years.

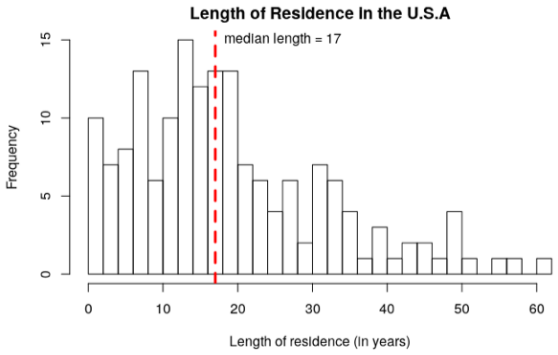


Figure 7. Histogram of the length of residence in the U.S.A.

However, the length of the residence didn't result in any statistical significance, as seen in Table 7.

Table 7. Fixed effects of length of residence (in the U.S.A.) on prosthesis

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-1.680803	0.263446	1.77e-10 ***
Length	-0.012176	0.009705	0.21

Most linguists agree that there is an age-sensitive period of time for completely acquiring a language. After this period, which is commonly called as Critical Period Hypothesis (CPH; Singleton and Lengyel 1995), it remains unlikely that a human can become a native speaker. In the dataset, the median age of onset is 14.

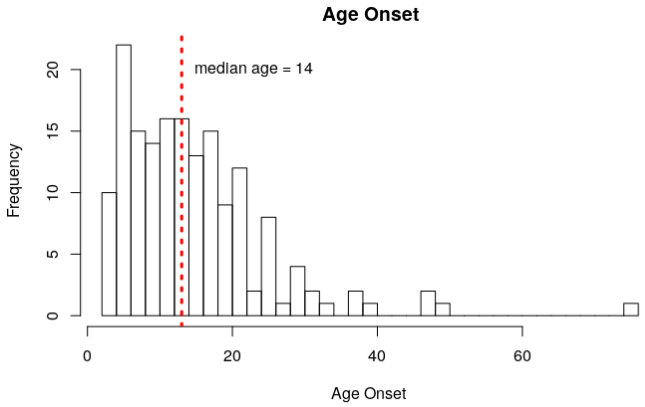


Figure 8. Histogram of the Onset of Age in learning English

The Mixed Effects Logistic Regression result is in Table 8, in which Age Onset is the response variable. The statistically significant result can be interpreted as follows: The later the speaker began to learn English, the more likely he or she was to put an extra [e] at the beginning of the complex onset cluster (difference: 0.06923491 (=exp(-2.67025)) - 0.07248323 (=exp(-2.67025 + 0.04585)) = 0.00324832). That is, the interpretation of the table indicates that Spanish learners of English are about 0.3% more prone to prosthesis per year.

Table 8. Fixed effects of age onset on prosthesis

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-2.67025	0.26213	< 2e-16 ***
Age onset	0.04585	0.01018	6.7e-06 ***

4. Discussions

The analysis in Section 3 indicates that Spanish learners of English are influenced both by the phonotactics of their L1 requiring prosthesis and also by the universal preference of CV structure over VC structure by resorting to deletion. The acoustic characteristics of the epenthesized vowel, that is, the duration and formant structures, show that the vowel is inserted not as an excrescent or transitional vowel, but as a full vowel the beginning of the /s/-obstruent cluster of English words due to the phonological reason of satisfying Spanish phonotactics. Besides, as reported in Carlisle (1991, 1997), prosthesis was affected by language-internal environments, such that obstruents in the preceding word induced more occurrences of prosthesis than preceding vowels. Even though the proportion of prosthesis was much lower than the two previous studies, the present study showed similar trends concerning the effects of preceding environments.

With regard to a much lower rate of repairs of the complex onset in the current study, one may think that the elicitation method in the Speech Accent Archive will be the cause. Paragraph reading is quite unlike naturally occurring spontaneous speech and also participants were allowed to have one minute to skim through the elicitation paragraph before uttering. Thus, it would be possible to think that the speech style would influence the resulting types of phonological processes produced by the speaker in the current study. Nevertheless, it is worth noting that phonological repair strategies are still observed.

In addition to prosthesis, which is one of the most discussed and reported phenomena in Spanish Interlanguage phonology, the present study reported that when a condition is met such as two identical segments (that is, voiceless alveolar fricatives) are in adjacency, the Spanish learners of English can opt for an alternative strategy of deleting the first element of the /s/-obstruent cluster, in order both to abide by the phonotactics of L1 and to avoid the OCP effect making the resulting structure as CV syllable structure, rather than VC.CV syllable structure.

The occurrence of epenthesis was further scrutinized by using countries, gender, age, length of residence, and also the onset of age in language learning. Even though the effect of sex and length of residence did not reveal any statistical significance, other variables such as age and onset of age appeared to function as important predicting variables.

Gender effect: In sociolinguistic studies, gender has been considered as an important variable. For example, Adamson and Regan (1991) examined the acquisition of the {-ing} variable by Vietnamese and Cambodia immigrants to the US. The variant pronunciation of [iŋ] as opposed to [ɪn] was regarded as the prestige variant of {-ing}. Besides this variant was also present in the learners' L1. Results showed that women had greater use of the prestige variant [iŋ] for {-ing} while men used [ɪn] more. Thus, differences between men and women were observed in the use of the variants.

However, the present study does not find any gender effect on prosthesis, and this lack of gender difference is not an isolated finding but seems to be in line with a review of research on accent by Piske et al. (2001: 200) who concluded "the results obtained for gender do not lead to any strong conclusions." That is, the studies reviewed in Piske et al. (2001) did not show gender to be a strong predictor of pronunciation accuracy. It remains to be a problem to solve what makes gender either play or does not play a role in L2 phonological learning.

Age effect: There are many age-related factors including speaker's age, speaker's age onset in beginning a foreign or second language, speaker's period of residence in the country where the second language is dominantly used. Some of these factors are considered one of the most important predicting variables in the assessment of a foreign accent. An earlier study related to the age in language was that of Asher and García (1969). In their study, they assessed the accents of 71 Cuban learners of English. Results indicated that those who had entered the U.S.A. at age 6 or earlier had the highest probability of being judged native (Ioup 2008: 45). A similar early study was conducted by Oyama (1976). She tested 60 Italian immigrants with lengths of residence between 5 and 18 years. Results were more or less similar to Asher and García (1969). Only those who began L2 acquisition before age 10 were judged to perform in the range of the native speakers. Other variables measured such as length of residence in the L2 environment did not correlate with performance.

Other accent comparison studies also confirmed the same negative correlation with age in the accent ratings (cf., Flege et al. 1997). Overall the onset age of L2 remained

the most important predictor of degree of foreign accent in the assessment of child and adult learners. However, there are studies that challenge to the role of onset age. For example, Mayo et al. (2003: vii) claimed that "there [was] evidence in favor of the hypothesis that the longer the exposure to the language, the more native-like performance becomes." They further asserted that "an earlier start [did] not produce significantly better results in a situation of FL acquisition."

Singleton and Ryan (2004: 9) also cited a range of studies that have focused on older beginners attaining very high levels of L2 proficiency. For example, Bongaerts et al. (1995) demonstrated that Dutch learners of English who began learning English in a formal instructional setting after age 12 were able to attain English pronunciation ratings within the same range as those attained by native-speaker controls. Some learners whose experience of an L2 begins after age 12 can, nevertheless, acquire an L2 accent which is perceived as native by native speakers.

Like some speakers in Bongaerts et al. (1995), there may be a few speakers who successfully suppressed prosthesis and attaining proper pronunciation of English complex onsets in the current study. But the results reported in this paper corroborate the position that in the general negative transfer of L1 phonology by Spanish learners of English is negatively correlated with age, and especially the age of onset. The length of residence in the English-mediated country does not influence accent reduction in a statistically significant way.

5. Conclusion

In this paper, the speech samples of Spanish speakers in the Speech Accent Archive were analyzed for the well-known prosthesis and other possible repair strategies. The archive is constructed as a research tool, as well as a teaching tool. The Speech Accent Archive is established to uniformly exhibit a large set of speech accents from a variety of language backgrounds. Native and non-native speakers of English all read the same English paragraph and are carefully recorded (Weinberger and Kanuth 2011). Despite the consistency in the orthographic level, lack of variable pronunciation dictionary of the foreign accented speech materials hinders researchers from applying an automatic forced alignment system to the phonologically variable speech samples. Thus, manual checking and correction was done on the output of the forced alignment before further phonological analysis was applied to the carefully crafted paragraph and accompanying meta information.

With the preexisting corpus, the study could identify that Spanish speakers exhibit not only prosthesis due to the effect of L1 phonotactics but also deletion of the first element to conform to the putatively universal CV syllable structure. Narrowing the focus to prosthesis, the paper also identified that even if gender and length of residence in the English-mediated country is not a predictive variable, age-related factors such as younger age and younger age of onset in learning English were statistically significant predictors in accounting for a lower proportion of epenthesis, thus succeeding in learning the complex onset structures in L2.

This study examined only Spanish interlanguage phonology using tokens of /s/-obstruent clusters has been examined. Other clusters such as /s/-sonorant consonant clusters are worth examining to observe the effect of the sonority hierarchy. Besides, similar prosthesis has been reported in Broselow (1987) in Iraqi Arabic, as mentioned in the introduction. Given that Arabic speakers were the third largest interviewees in the Speech Accent Archive, it may be worth exploring epenthesis in the complex onset clusters by a variety of different Arabic learners of English.

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Received: July 14, 2020
Revised: August 21, 2020
Accepted: August 22, 2020