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# (In)complete neutralization in Western Andalusian Spanish

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## ABSTRACT

The present study addresses the occurrence of affrication in clusters other than /st/ in Western Andalusian Spanish, by means of production and perception tasks comprising /st/, /kt/, and /pt/. Our findings reveal incomplete neutralization in production, given that /kt/ presented a higher closure ratio and a lower VOT ratio than /pt/ and /st/. In perception, the three clusters were similarly labeled according to a pattern: /st/ > /kt/ > /pt/. Certain parameters such as closure and VOT ratios and center of gravity seemed to have an influence on perception. These results indicate that neutralization may be complete in perception and incomplete in production.

## KEY WORDS

affrication; consonant clusters; neutralization; Western Andalusian Spanish; phonetic change

## Neutralització (in)completa en l’espanyol andalús occidental

RESUM

Aquest estudi analitza la presència d’africació en espanyol andalús occidental, en clústers consonàntics que inclouen /st/, /kt/ i /pt/, mitjançant tasques de producció i percepció. En la producció, s’observa una neutralització incompleta, en tant que /kt/ presenta una ràtio d’oclusió més alta i una ràtio de VOT més baixa que /pt/ i /st/. En la percepció, en canvi, els tres clústers s’etiqueten de manera similar seguint el patró /st/ > /kt/ > /pt/, i diferents paràmetres com la ràtio d’oclusió i de VOT i el centre de gravetat semblen influir-hi. En conjunt, els resultats indiquen que la neutralització pot ser considerada completa en la percepció però incompleta en la producció.

MOTS CLAU

africació; clústers consonàntics; neutralització; espanyol andalús occidental; canvi fonètic

## 1. Introduction

One way to classify the different regional varieties or dialects of Spanish is in terms of their coda /s/ realizations: weakening vs non-weakening varieties. In Spain, varieties in the northern half of the country retain coda /s/, while varieties in the southern part of the country (among them, Andalusia) tend to weaken coda /s/.

In the western area of Andalusia, the realization of coda /s/ before unvoiced stops /p, t, k/ is generally carried out by means of post-aspiration, rather than pre-aspiration (Alvar, 1996; Gerfen, 2002; Torreira, 2007*b*, 2012). These realizations are characterized by longer post-aspiration (aspiration after stop closure) and shorter preaspiration than in other Spanish weakening dialects (Torreira, 2007*b*; O'Neill, 2009; Parrell, 2012; Ruch & Peters, 2016). Additionally, in the context of coda /s/ before /t/ there is an on-going process of affrication, primarily established among the younger population, by which post-aspirated [t̪ʰ] becomes affricated [t̪ˢ]. (Ruch, 2008, 2012, 2013; Vida Castro, 2015, 2016). Furthermore, Del Saz (2019*a*) previously reported the occurrence of both post-aspiration and mainly affrication in different contexts other than /s/ + /t/ clusters, obtained from semi-guided interviews to college students from Western Andalusia. These contexts comprised clusters of stops + /t/; namely, /kt/, /pt/, and /bt/. Even if the occurrence of affrication in these contexts was low (10%) compared to its occurrence in /st/ contexts, the most relevant aspect is that their mean center of gravity was significantly higher than in /st/ clusters (7600 Hz vs 6800 Hz).

To our knowledge, no other study on Western Andalusian Spanish has addressed this issue before. Nevertheless, there is some work on the Eastern variety of Andalusian Spanish (EAS) concerning a possible neutralization of /st/, /kt/, and /pt/ clusters in terms of aspiration. Bishop (2007) points out that in EAS "any coda obstruent is neutralized in the same manner, not merely /s/ … by gemination of a following consonant" (p. 1765). The author explored the possible neutralization of *hasta* ('until'), *acta* ('transcript'), *apta* ('apt'-fem.) to [ˈaht̪ːa] by manipulating the length of preaspiration and stop closure in these words and using them in a perception experiment. His conclusion was that "the length of a stop consonant following aspiration, but not the length of aspiration itself, can serve as a strong, disambiguating cue to listeners in making phonemic decisions as to an underlying coda" (p. 1765). In fact, Obediente (2007) also points out that coda stops and coda /s/ are neutralized in Venezuelan Spanish by means of aspiration as well.

In this current study, we explore the incidence of post-aspiration and affrication in *hasta*, *acta*, *apta*, and whether neutralization occurs in production and perception, in Western Andalusian Spanish.

### 1.1. Western Andalusian clusters

Consonant phonemes in coda position tend to be uttered with a lax pronunciation in the whole southern region of Spain, and even deleted in absolute final position. In word-medial position, several consonant sounds — among them, stops — tend to be dropped when followed by another consonant sound, giving way to the gemination of the second consonant, as in obturar [ot̪ːuˈɾaɾ], where /bt/ becomes [t̪ː] (Jiménez Fernández, 1999, p. 72).

Concerning coda /s/ weakening, Western Andalusian Spanish (WAS) is characterized by diverse solutions following this weakening. Although traditionally transcribed as [h], aspiration of coda /s/ is not only a matter of /s/ → [h] in this variety, as it tends to affect neighboring sounds in ways that may differ from other aspirating dialects of Spanish. In absolute final position, deletion is the most common solution; when followed by a vowel sound, it is commonly realized as [h] or even [s], giving way to resyllabification. Voiced stops, which are actually approximants in Spanish connected speech, become fricatives after aspiration of coda /s/; nasal, lateral, and fricative sounds can be accompanied by gemination after coda /s/ aspiration (Romero Gallego, 1995). Voiceless stops,

however, become post-aspirated [pʰ, t̪ʰ, kʰ], as we explain in the following section.

### 1.1.1. Post-aspiration

Torreira (2007*a*) was a pioneer in describing this phenomenon, although he acknowledges that two previous studies had already pointed in this direction (Maza, 1999; Vaux, 1998). His study first analyzed word-internal /st/ in laboratory-recorded speech of Mainstream Spanish and Western Andalusian Spanish speakers, and subsequently in spontaneous speech of Western and Eastern Andalusian Spanish speakers. In both cases, he observed higher VOTs for the Andalusian stop after aspiration in comparison to the Mainstream stop after sibilance. Despite variability found in the recordings, and factors such as speech rate, prosodic context, or syllable stress, his findings were consistent with the premise that Andalusian aspiration induces longer VOTs. Another factor that was derived from aspiration is that both stop closure and previous vowel were lengthened, if we consider the aspiration of coda /s/ as part of the vowel. Otherwise, as is the case with vowels before /s/, they were actually shorter.

Subsequently, Torreira (2007*b*) compared the production of word-internal /st/ of Western Andalusian Spanish with the production of the same sequence by speakers of Porteño (Buenos Aires, Argentina) and Puerto Rican Spanish. What he found is that Andalusian Spanish displayed shorter preaspiration and longer stop closure and post-aspiration periods than the other two Spanish dialects. Under the Articulatory Phonology framework proposed by Browman and Goldstein (1989), in which articulatory gestures are seen as phonological units, the author sought to provide an explanation for this phenomenon. This framework states that "gestures involved in syllable onsets tend to couple into an in-phase relationship, while gestures in coda position are left out of phase with respect to surrounding gestures" (Torreira, 2007*b*, pp. 118–119), i.e., at onsets, articulatory gestures tend to be simultaneous while, at codas, they tend to be more variable. His proposition is that of a gestural reorganization in which the glottal opening for the aspirated /s/ and the supraglottal closure for the following stop overlap instead of being sequential, as is the case with dialects with pre-aspiration. Finally, in 2012, Torreira (2012) further investigated aspiration before the three voiceless stops /p, t, k/ according to different speech rates and stress patterns. He found that, despite these two factors, VOT did not significantly vary in duration. Therefore, it seems that "the glottal and supraglottal gestures may be phased very closely even in conditions in which we would not expect much articulatory overlap, hence the lack of significant effects of speech rate and stress location on VOT" (p. 61). Parrell (2012) corroborated the claims by Torreira of a post-aspiration phenomenon in Western Andalusian Spanish, but he stated that the question of "whether this reduction is an online phonetic process or a phonological one has not been thoroughly investigated" (p. 37). Indeed, O'Neill (2009) also studied the sequence /st/ in Spanish from Seville (Western Andalusia), narrowing down the effect of aspiration to two most frequent productions: [ˈpaɦt̪ha] and [ˈpat̪ha], i.e., aspirated stops with or without pre-aspiration. What is interesting about his proposal is that the author considered the second realization as part of a new set of phonemes in the variety [pʰ, t̪ʰ, kʰ], working in opposition to their unaspirated counterparts. Instead of being the result of an overlap of gestures, as proposed by Torreira, "these pronunciations correspond to the phonetic realisation of a different sequence of phonemes" (p. 79), i.e., these set of sounds would be phonetic categories and not the result of coarticulatory gestures. In line with O'Neill, Gylfadottir (2015) argued in favor of phonologization and against the idea of gestural timing explanations, given that post-aspirated tokens seem to be shorter than their preaspirated counterparts.

In reference to the variability found in Andalusian aspirated stops, Ruch (2008) researched the production of /st/ in Seville. What she found were nine possible realizations for this sequence: two with sibilants [st], [st]; four with aspiration [ht], [htʰ],

[stʰ], [tʰ], one with assimilation [tː], one with complete deletion of /s/ [t], and finally, the affricated [tˢ] (further described and explained in the following section). The most common of these realizations was the post-aspirated stop [tʰ] (49.1%), followed by the affricated stop [tˢ] (22%). Additionally, Ruch and Peters (2012) conducted a sociophonetic study of the production of /t/ and /st/ in internal-word position with speakers from Western (Seville) and Estern Andalusian Spanish (Granada), considering their gender and their age. The authors concluded that young speakers produce post-aspiration significantly more frequently than older speakers not only in Seville, but also in Granada. They also produce less pre-aspiration, although this fact was only significant for speakers in Seville. Additionally, she found that female speakers showed greater differences in VOT values than male speakers. Finally, Horn (2013) investigated post-aspiration in a sentence reading task from various perspectives. First, she studied whether the post-aspiration reported for /t/ also extended to /p/ and /k/. In this regard, she found that place of articulation "is the only robust predictor of the presence of significantly long post-aspiration" (p. 81). Post-aspiration also extended to the velar sounds but not to the bilabial sound, opposite to the findings in Torreira (2012). Its duration was significantly shorter for /p/ than for the other two stops. Second, she aimed at analyzing the phenomenon from a social and linguistic perspective. The longest duration of post-aspiration was found when the preceding vowel was stressed and when in word-internal position; once more, in disagreement with Torreira's claims (2007*a*, 2012). Although the social factor had no effect in these realizations, there was a tendency for younger women with college education to reduce sibilance and produce longer post-aspiration. And third, she also interpreted these results under the Articulatory Phonology framework. Just as the previous studies, she concluded that there is a negative correlation between the presence of sibilance in coda position and post-aspiration.

### 1.1.2. Affrication

Before we delve into the affricated allophone of interest, we should also mention the affricate phoneme that exists in Spanish, as well as the fricative allophone that can also occur in Western Andalusian Spanish. As many other languages, Spanish has a voiceless affricate phoneme /ʧ/ in its repertoire. In several varieties of the language, this phoneme has undergone a process of lenition by which the closure of the affricate is weakened or deleted, giving way to a fricative allophone [ʃ]. Andalusian Spanish is one of these varieties, particularly in areas of Malaga, Cadiz, and Seville, i.e., Western Andalusia (Jiménez Fernández, 1999). Speakers in areas of *seseo* (merger of /s/ and /θ/ into [s]) are relatively conservative and avoid the lenition of /ʧ/, while speakers in areas of *ceceo* (merger of /s/ and /θ/ into [θ]) are more innovative, allowing the lenition of /ʧ/ (Villena Ponsoda, 2002). Fricative [ʃ] can also be used in expressive situations, with a variety of realizations that range from interdental/dental to palatal, being the pre-palatal version the most frequent. Although a minority phenomenon and the least prestigious solution, which speakers sometimes tend to avoid in formal situations, the fricative allophone is still identified as a stereotyped characteristic.

In the last decade, an on-going process in the context of /st/ has been documented, by which the cluster has evolved from post-aspiration [tʰ] to affrication [tˢ]. In this case, the cluster maintains a long VOT and displays a higher CoG, consistent with a sibilant. This affricated variant is primarily given in the western part of Andalusia and more frequently among the younger population and mid-class to high-class speakers (Moya Corral, 2007; Ruch, 2008, 2012; Ruch & Peters, 2012). Particularly, Ruch and Peters (2012) establish seven possible realizations of the sequence /s/ + /t/ in Seville: sibilance [st], pre-aspiration [ht], pre and post-aspiration [htʰ], post-aspiration [tʰ], gemination [tː], elision [t], and affrication [tˢ]. The last token is described as a dentoalveolar sound (Ruch, 2012). In Malaga (also Western Andalusia), Vida Castro

(2015, 2016) proposes five solutions for this sequence: [st], [ht], [tʰ], [tː], [tˢ]. The affricated sound, in this case, is described as alveolar. In both cases, post-aspiration and affrication are the most common surface representations among the younger population.

Explanations for this phenomenon show, once more, diverse views. Hualde and Chitoran (2016) see it as metathesis, by means of which the sibilant appears after the stop. Vida Castro (2015, 2016) describes it as resyllabification of /s/, resulting from the attempt to restore the mainstream pronunciation as a sign of prestige, while maintaining an open syllable. In this case, [ts] would be the onset of the following syllable. Gylfadottir (2015) proposes that affrication derives from phonologization and occurred as the result of a process of fortition of [tʰ], similarly to what happens in British English [tʰ] → [tˢ] (Buizza & Plug, 2012). Nevertheless, as Moya Corral (2007) pointed out, while the explanation for pre-aspiration and gemination is clear, by keeping the same place of articulation but not the manner in affrication is not so easily explained. In any case, the findings by Del Saz (2019*a*) suggest affrication goes beyond /st/ clusters and can also be present in stop + /t/ clusters.

### 1.1.3. Perception studies

Studies that address the perception of aspiration or affrication in Andalusian Spanish are scarce. Concerning post-aspiration, this phenomenon seems to be clearly identified as Sevillian (Western Andalusia) and associated to younger speakers (Ruch, 2018). Two studies on post-aspiration focused on the continuum *pata–pasta* specifically, with listeners from different language backgrounds. First, Ruch and Peters (2016) conducted an experiment with listeners from both Western and Eastern Andalusia, in which post-aspiration was identified as an underlying /s/ by both groups, with higher accuracy by those who also produced it. Previously, Ruch and Harrington (2014) found that Argentinian Spanish listeners, whose language variety has pre-aspiration but not post-aspiration, were sensitive to post-aspirated stops in Andalusian Spanish. However, Gilbert (2021) concluded that, while Sevillian listeners effectively used VOT length to determine the presence of an underlying /s/ (third-person singular verbs vs second-person singular verbs), Mexican Spanish listeners, whose variety retains the sibilant, mainly perceived an absence of /s/ even with the longest VOTs. Del Saz (2019*b*) found out that even native speakers of Western Andalusian Spanish identified post-aspiration in second-person singular verbs and plural nouns less accurately than they could identify sibilance present in Mainstream Peninsular Spanish.

Concerning affrication, Vida Castro and Villena Ponsoda (2016) conducted an identification experiment, with both real words and nonsense words comprising /st/, [t̪ˢ], and /ʧ/. Their findings revealed that shorter clusters and higher center of gravity leads to the identification of [ts], while the opposite leads to the identification of /ʧ/. Nevertheless, [tˢ] was usually perceived as /ʧ/ in nonsense words (i.e. *masta*), even though there are significant acoustic differences between [tˢ] and /ʧ/, while accurately identified in real words (i.e. *pasta*).

In terms of neutralization, O'Neill (2005) pointed out that vowel + coda /s/ and vowel alone are neutralized in absolute final position in Andalusian Spanish, where some type of aspirated phonation can be found in both instances (p. 156). Word-internally and for Eastern Andalusian Spanish, Bishop (2007) found that a longer closure duration was associated to /pt/ clusters, rather than /kt/ or /st/ clusters in perception, and that pre-aspiration was not relevant to the discrimination among these set of clusters.

Considering the studies and findings described in this section, we pose the following research questions:

RQ1: To what extent does affrication occur in sample /st/, /kt/, and /pt/ clusters in Western Andalusian Spanish?

RQ2: Is there neutralization among these clusters?

We aim at addressing these questions by means of production and perception tasks, detailed in the following sections.

## 2. Production study

### 2.1. Methods

#### 2.1.1. Participants

Forty-six informants (mean age = 21.80; range 19–33) volunteered to participate in this study. They were all students at the Universidad de Sevilla and originally came from different areas in Seville, Huelva, Cadiz, and Malaga (Western Andalusia). Six of them were discarded for being raised outside Western Andalusia and/or having one or two parents born and raised outside the area (Eastern Andalusia, Central America, Catalonia). Thus, we considered the productions of 40 participants (30 females, 10 males), native speakers of Western Andalusian Spanish.

#### 2.1.2. Materials

The production experiment consisted of two different tasks in which three target words — *acta* ('transcript'), *apta* ('apt'-fem.), *hasta* ('until') — were included: informal sentences (Task 1) and words in isolation (Task 2).

Task 1 consisted of a list of 75 sentences. In three of them, the target words *actas*, *apta*, and *hasta* were embedded, respectively. These target words were selected following Bishop (2007), while the sentences were gathered and adapted from CREA (RAE, 2008). After pilot testing, we also included colloquial tags and expressions found in the oral corpus Val.Es.Co (Cabedo & Pons, 2012) to elicit spontaneity and naturalness from the participants. The resulting sentences were as follows:

(1) *pues por lo visto hasta que no suban las actas no están las notas*
(well, apparently, the grades won't be ready until they upload the transcripts)

(2) *¿cómo vas a llevar al niño a una peli no apta para menores?*
(how are you taking the kid to a movie not suitable for minors?)

(3) *y ya le dije "hasta aquí hemos llegado, hombre ya!"*
(and so I told him: 'that's enough already, man!')

Task 2 comprised 90 words in isolation, among which were the three target words, presented in a speeded PowerPoint presentation (inter-stimulus interval = 1 s) to prompt participants to speak as soon as they saw the word and not overthink its pronunciation.

#### 2.1.3 Procedure

Recordings were carried out in a soundproof booth at the Phonetics Laboratory of the Universidad de Sevilla (Spain), using a Zoom H6 portable recorder at 44,100 Hz and 16 bps sampling rate, in WAV format. Target words were segmented and labeled using *Praat* (Boersma & Weenink, 2001), and subsequently normalized to 70 dB. We then conducted a set of temporal and spectral acoustic analyses:

a) Closure duration of the stop. Ruch and Harrington (2014) analyzed Voice Termination Time (VTT), understood as a measure to determine pre-aspiration which comprises the period between the end of periodicity of the vowel before the target sound and the beginning of the closure of the stop or affricate. However, we understand VTT as the carryover voicing into the unvoiced stop closure "from a preceding sonorant is most common for stops, while a trough pattern (phonation that dies out and then begins again before the end of the closure) is more prevalent for fricatives" (Davidson, 2018, p. 331). In our tokens, we found evidence of carryover phonation in /kt/ and /pt/ contexts, rather than pre-aspiration, and therefore it was not analyzed here. As also found in Torreira (2007*a*), the end of pre-aspiration, in his case, and the beginning of the stop closure, in both his and my case, "was

marked with reference to high frequencies (4000–5000 Hz), where these spots were not perceived" (p. 115).

b) Voice Onset Time (VOT), as a measure of post-aspiration or affrication, carried out from the beginning of the stop or affricate burst to the beginning of periodicity of the vowel following the target sound. Specifically, we marked "the ending point of VOT at the downward zero-crossing before a whole first cycle could be perceived in the signal" (Torreira, 2007*a*, p. 115).
c) Absolute duration of occlusion and friction of the target sounds and their duration relative to the duration of the whole segment.
d) Center of Gravity (CoG), understood as the frequency that divides the spectrum into two halves such that the amount of energy in the top half (higher frequencies) is equal to that in the bottom half (lower frequencies). The CoG measures the mean concentration of energy of a sound; therefore, a sound with high-frequency energy will have a high value for CoG. The presence of affrication was determined at 4000 Hz, in which a sibilant (somewhat weakened) can already be perceived (Taylor, 2018). In fact, sibilance is clearly established at 6000 Hz and above, while not as clear-cut within the range 4000–6000 Hz (Del Saz, 2019*a*).

Figure 1 above shows the mainstream, post-aspirated, and affricated spectrograms and waveforms of the word *acta*.

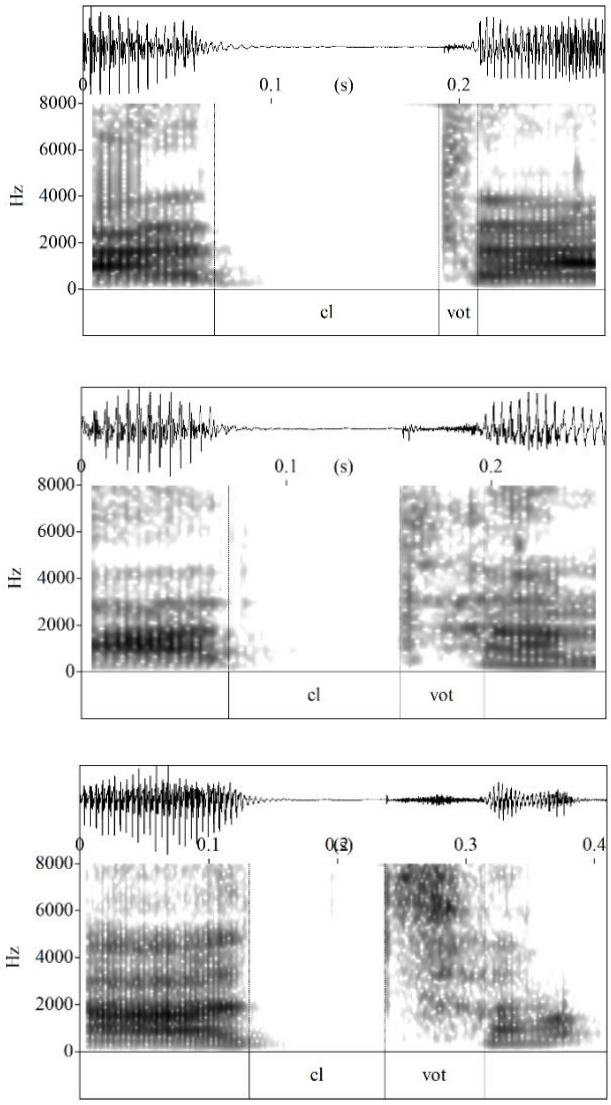



**Figure 1.** Spectrograms and waveforms of *acta* in its mainstream, post-aspirated, and affricated forms.

### 2.2. Results

The appearance of affrication was higher in the sentences than in the isolated words, which was expected, as the latter poses the most formal context of the two. Conversely, the isolated words presented the highest number of mainstream productions. The most frequent cluster where affrication appeared in the sentences was /kt/, while in the isolated words it was /st/. In both cases, /pt/ showed the lowest percentage of [t$^{s}$] occurrence. As far as the mainstream productions are concerned, the /pt/ context obtained the highest percentages, followed by the /st/, and then the /kt/ contexts. After analyzing each target word across tasks (sentences vs isolated words), the only statistically significant differences that were found concerned length values (segment, closure, VOT), i.e., as the formality of the context decreases, segments are shorter, but still maintain the ratios of closure and VOT, as well as similar CoG values. In Figure 2, we can observe the percentages of mainstream, post-aspirated, and affricated productions for each of the three target words.

As we can gather from Figure 2, affrication was the most prominent process in /st/ and /kt/ clusters (58.06%, 59.68%, respectively), while post-aspiration entailed the lowest percentages for all target words [*hasta* = 14.52%; *acta* = 11.29%; *apta* = 24.19%). The mainstream forms appeared primarily in the isolated words task and were the most salient in /pt/ clusters (48.37%). Table 1 displays the values for each of the parameters analyzed in each of the target words, according to the process shown in their productions.

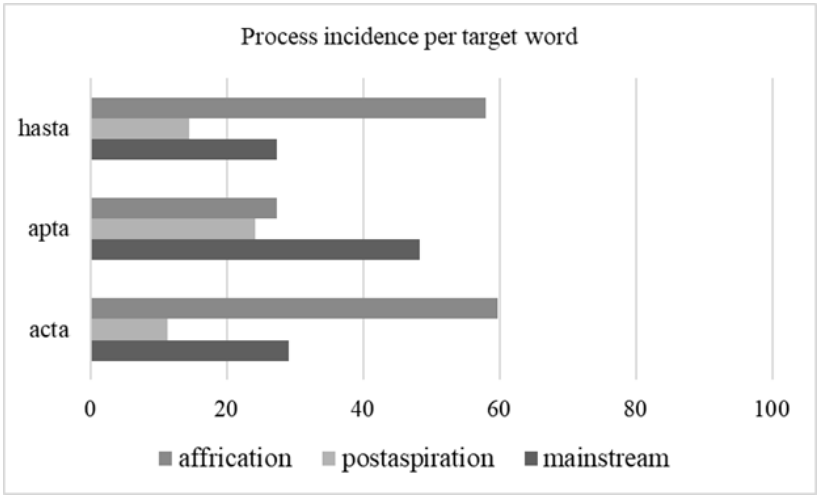



**Figure 2.** Percentages of process incidence for *hasta*, *apta*, and *acta*.

| | Cluster | CL ratio | VOT ratio | CoG |
|---|---|---|---|---|
| **Mainstream** | /kt/ | 0.879 | 0.121 | 3182 |
| | /pt/ | 0.879 | 0.121 | 3130 |
| | /st/ | 0.510 | 0.122 | 3247 |
| **Post-aspiration** | /kt/ | 0.732 | 0.268 | 2475 |
| | /pt/ | 0.767 | 0.233 | 2306 |
| | /st/ | 0.665 | 0.335 | 2788 |
| **Affrication** | /kt/ | 0.639 | 0.361 | 7010 |
| | /pt/ | 0.564 | 0.436 | 6393 |
| | /st/ | 0.560 | 0.440 | 7052 |

**Table 1.** Closure, ratio, VOT ratio, and CoG measurements by target cluster and process.

We now proceed to describe the three target words according to each of the three processes analyzed, starting with the mainstream productions of the speakers. The affricate phoneme in *hacha* ('ax') was also analyzed to assess whether confusion can take place between the affricated clusters and the affricate phoneme. As we can see in Table 1, the mainstream productions of the three target clusters displayed similar values for segment duration, VOT ratios, and CoGs. Nevertheless, the closure ratios for /kt/ and /pt/ were significantly higher than for /st/ [$\chi^2(2) = 31.703$, $p < 0.001$, $\varepsilon^2 = 0.587$], which was expected as both clusters comprise two consecutive stops, while /st/ consists of only one stop. For post-aspiration, the three target words displayed similar values for all parameters measured: segment duration, closure ratio, VOT ratio, and CoG, which were lower than in their mainstream counterparts. While the overall closure ratio and VOT ratio were similar for the three words, they could be considered on the verge of significance between the /pt/ and /st/ clusters [$\chi^2(2) = 6.08$, $p = 0.048$, $\varepsilon^2 = 0.203$], i.e, closure ratio slightly longer, and VOT ratio slightly shorter, for *apta* than for *hasta*. Finally, concerning affrication, the only parameter that was similar for the three target words was CoG. Results indicate that *acta* had a significantly longer segment duration [$\chi^2(2) = 8.42$, $p = 0.015$, $\varepsilon^2 = 0.094$] and a higher closure ratio [$\chi^2(2) = 12.21$, $p = 0.002$, $\varepsilon^2 = 0.136$] than *apta* and *hasta*. In turn, *hasta* and *apta* displayed longer VOT ratios than *acta*.

Concerning *hacha*, the vast majority of the participants produced this token with the canonical affricate sound /ʧ/ (only 2 females and 2 males provided instances of the fricative allophone [ʃ], and only in the task comprising target words embedded in sentences, not in the task consisting of words in isolation). The affricate /ʧ/ had a mean duration of 138 ms, a mean closure ratio of 0.489, a mean VOT ratio of 0.511, and a mean CoG of 5392 Hz. This means *hacha* had a similar duration to the three affricated tokens of the target words, a higher VOT ratio, and a lower closure ratio than these [$\chi^2(2) = 41.5$, $p < 0.001$, $\varepsilon^2 = 0.267$], while also lower CoG values [$\chi^2(2) = 38.8$, $p < 0.001$, $\varepsilon^2 = 0.249$] than the affricated *acta* and *hasta*, but similar to *apta*. Therefore, differences seem enough not to cause confusion.

Figure 3 shows the waveforms and spectrograms of *hacha* and affricated *hasta*, in which differences in closure and VOT durations can be appreciated, as well as in the concentration of energy after the stop burst.

### 2.2.1. The effect of phonetic process

The following four figures compare each of the three target words across the three processes observed in our data. Word 1 is *acta*, word 2 is *apta*, and word 3 is *hasta*. Process 1 is mainstream production, process 2 is post-aspiration, and process 3 is affrication.

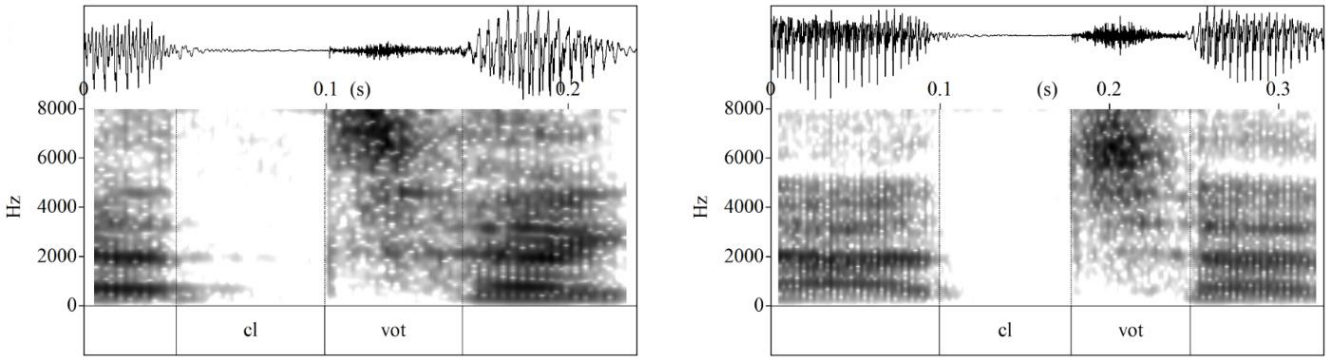



**Figure 3.** Waveforms and spectrograms of affricated *hasta* and affricate *hacha*.

Figure 4:
Segment length

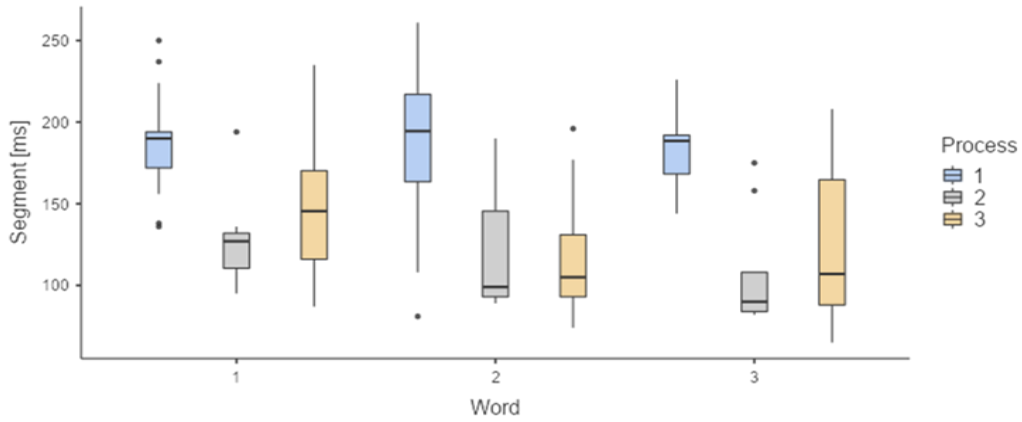



Figure 5:
Closure ratio

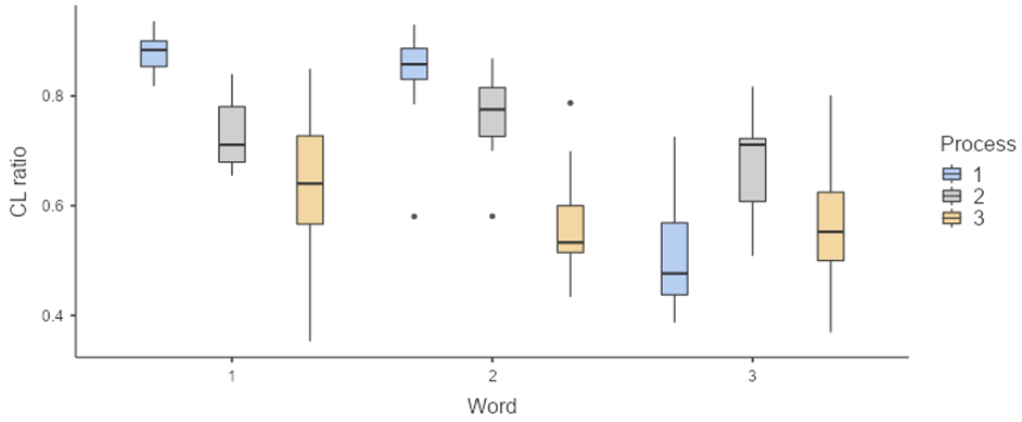



Figure 6:
VOT ratio

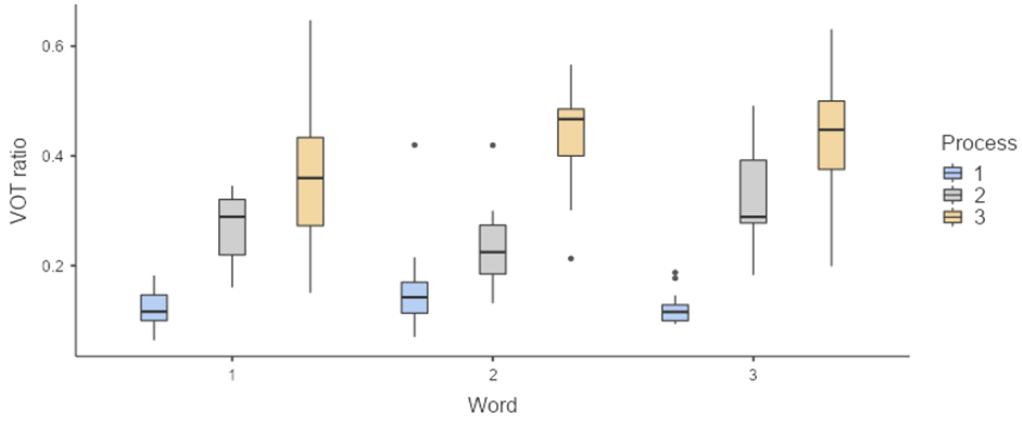
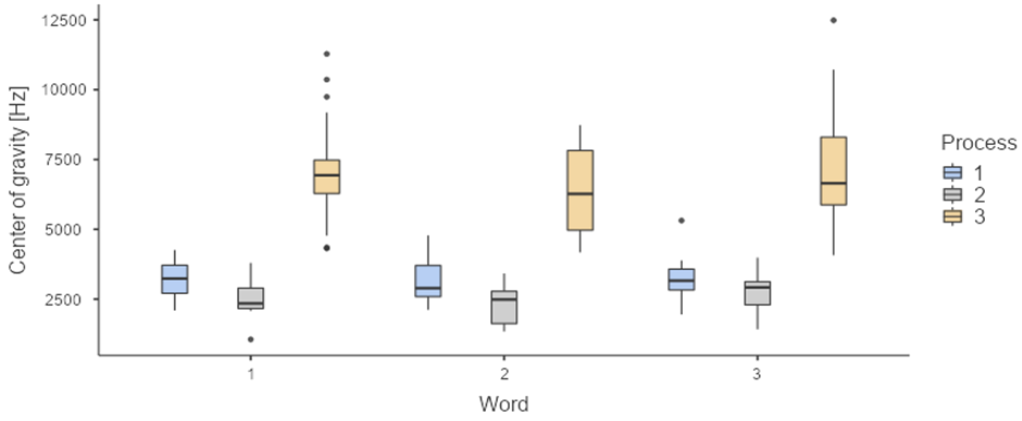



Figure 7:
GoG ratio




**Figures 4–7.** Segment length, closure ratio, VOT ratio, and CoG of mainstream, post-aspirated, and affricated tokens of *acta*, *apta*, and *hasta*.

Segment length (Figure 4) was significantly longer for mainstream *acta* (187 ms) than its post-aspirated (129 ms) and affricated (145 ms) counterparts [$\chi^2(2) = 16.1$, $p < 0.001$, $\varepsilon^2 = 0.264$]. The same was true for *apta* (184 ms, 120 ms, 116 ms) [$\chi^2(2) = 21.5$, $p < 0.001$, $\varepsilon^2 = 0.391$] and *hasta* (184 ms, 107 ms, 124 ms) [$\chi^2(2) = 17.97$, $p < 0.001$, $\varepsilon^2 = 0.310$].

In terms of closure ratio (Figure 5), mainstream *acta* was significantly higher (0.879) than its post-aspirated (0.732) and affricated (0.641) counterparts [$\chi^2(2) = 37.6$, $p < 0.001$, $\varepsilon^2 = 0.616$]. For *apta*, closure ratio significantly decreased with each process (0.849, 0.767, 0.564) [$\chi^2(2) = 38.2$, $p < 0.001$, $\varepsilon^2 = 0.695$]. For *hasta*, post-aspiration rendered the highest values (0.665); higher than its mainstream production (0.510) and slightly higher than affrication (0.560) [$\chi^2(2) = 9.71$, $p = 0.008$, $\varepsilon^2 = 0.167$].

As for VOT ratios (Figure 6), the three words underwent similar changes from mainstream to affrication, i.e, VOT ratio increased significantly as the tokens deviated further apart from their canonical forms. Thus, mainstream productions showed the shortest ratios, while affricated tokens displayed the highest ratios [*acta*: $\chi^2(2) = 37.6$, $p < 0.001$, $\varepsilon^2 = 0.616$; *apta*: $\chi^2(2) = 38.2$, $p < 0.001$, $\varepsilon^2 = 0.695$; *hasta*: [$\chi^2(2) = 34.69$, $p < 0.001$, $\varepsilon^2 = 0.598$].

Concerning the Center of Gravity (Figure 7), the three target words showed a similar tendency: the CoG in their affricated tokens was significantly higher than in their mainstream and post-aspirated counterparts [*acta*: $\chi^2(2) = 44.0$, $p < 0.001$, $\varepsilon^2 = 0.721$; *apta*: $\chi^2(2) = 37.9$, $p < 0.001$, $\varepsilon^2 = 0.690$; *hasta*: [$\chi^2(2) = 40.44$, $p < 0.001$, $\varepsilon^2 = 0.697$].

## 3. Perception study

### 3.1. Methods

#### 3.1.1. Participants

The forty speakers that participated in the production tasks also took part in the perception task. The stimuli used in this experiment were recorded by seven additional speakers of Western Andalusian Spanish (mean age = 22.86; range = 19–33), who did not take part in the perception task.

Table 2 shows the demographics and pronunciations of the seven speakers.

#### 3.1.2. The task

The perception experiment consisted of a multiple forced choice listening task (ExperimentMFC 7) using *Praat* (Boersma & Weenink, 2001). The speakers recorded seven stimuli each: *hasta* (‘until’), *apta* (‘apt’-fem.), *acta* (‘transcript’), *ata* (‘he/she/it ties’), *alta* (‘tall’-fem.), *harta* (‘fed up’-fem.), *hacha* (‘ax’). The stimuli were presented one at a time, and each was played three times in random order (7 stimuli × 7 speakers × 3 times = 147 tokens per listener).

| | **age** | **birthplace** | **/kt/** | **/pt/** | **/st/** | **/ʧ/** |
|---|---|---|---|---|---|---|
| **F1** | 21 | Seville | [kt̪] | [pt̪] | [st̪] | [ʧ] |
| **M1** | 22 | Cadiz | [kt̪] | [pt̪] | [t̪ˢ] | [ʧ] |
| **F2** | 25 | San José de la Rinconada (Sev.) | [t̪ˢ] | [t̪ˢ] | [t̪ˢ] | [ʃ] |
| **F3** | 21 | Seville | [kt̪] | [pt̪] | [t̪ˢ] | [ʧ] |
| **M2** | 19 | Pilas (Sev.) | [t̪ˢ] | [t̪ˢ] | [t̪ˢ] | [ʧ] |
| **F4** | 19 | Morón de la Frontera (Sev.) | [t̪ˢ] | [t̪ˢ] | [t̪ˢ] | [ʃ] |
| **F5** | 33 | Seville | [t̪ˢ] | [pt̪] | [t̪ˢ] | [ʧ] |

**Table 2.** Demographics and key pronunciations of the seven speakers who produced the stimuli used in the perception task.

There were seven forced choice options of answer per stimulus (the same orthographic options as the recorded stimuli). Listeners had to click on a 'next button' to listen to the following stimulus, which played as soon as they clicked the button. Reaction times were also measured.

### 3.1.3. Stimuli description

The values for the three target words in their mainstream and affricated forms are reported in Table 3. Following the tendencies described in the tokens from the production experiment, mainstream productions were longer than the affricated words. Closure ratio values decreased, while VOT ratio and CoG values increased, in the affricated tokens.

Comparisons among the three affricated tokens show there were no statistically significant differences for any of the four parameters analyzed. Nevertheless, an important aspect was the variability found in their values, which is also explored in the results below. For example, closure ratio ranged from 0.468 to 0.701 (SD = 0.103) for /kt/, from 0.413 to 0.747 (SD = 0.172) for /pt/, and from 0.391 to 0.696 (SD = 0.117) for /st/. Likewise, VOT ratios were also variable, ranging from 0.299 to 0.532 (SD = 0.103) for /kt/, from 0.253 to 0.587 (SD = 0.172) for /pt/, and from 0.304 to 0.609 for /st/ (SD = 0.117). CoGs also followed this tendency: 5172–8516 Hz for /kt/, 5312–8187 Hz for /pt/, and 6203–9489 Hz for /st/.

### 3.2. Overall results

In this section, we first report the percentages of accurate identification per affricated target word and their distribution of answers. The word *hacha* in its canonical form was also considered to identify possible confusion between the affricated tokens and the affricate /ʧ/. The word *hacha* with the fricative allophone is also reported, given that it was also present in the stimuli. Results (Table 4) indicate that both exemplars of *hacha* obtained the highest identification scores; therefore, there does not seem to be a problem in discriminating the affricate – or the fricative – from the affricated tokens overall. From the three target words, *hasta* presented the highest percentage of identification accuracy (49.60%), followed by *acta* (32.38%), and finally *apta* (14.29%) [$\chi^2(2) = 6.93$, $p = 0.031$, $\varepsilon^2 = 0.577$].

| | Stimuli | CL ratio | VOT ratio | CoG |
|---|---|---|---|---|
| **Mainstream** | *acta* | 0.894 | 0.106 | 2783 |
| | *apta* | 0.888 | 0.112 | 3192 |
| | *hasta* | 0.586 | 0.414 | 688 |
| **Affrication** | *acta* | 0.575 | 0.425 | 7166 |
| | *apta* | 0.556 | 0.444 | 7004 |
| | *hasta* | 0.534 | 0.466 | 7485 |

**Table 3.** Closure ratio, VOT ratio, and CoG of stimuli.

| | Stimuli | | | | |
|---|---|---|---|---|---|
| **Answer** | **acta** | **apta** | **hasta** | **hacha /ʧ/** | **hacha [ʃ]** |
| *acta* | **32.38** | 33.33 | 31.96 | 0.27 | 0.00 |
| *apta* | 11.66 | **14.29** | 12.56 | 0.27 | 0.00 |
| *hasta* | 43.10 | 40.95 | **49.60** | 0.27 | 0.48 |
| *hacha* | 12.86 | 11.43 | 5.88 | **99.18** | **99.52** |

**Table 4.** Distribution of answers per stimuli: affricated tokens and *hacha*.

| Response | Predictor | *estimate* | *SE* | *Z* | *p* |
|---|---|---|---|---|---|
| *acta* | Intercept | –0.4397 | 0.0904 | –4.8615 | < 0.001 |
| | *acta – hasta* | 0.1539 | 0.1451 | 1.0602 | 0.289 |
| | *apta – hasta* | 0.2338 | 0.1595 | 1.4656 | 0.143 |
| *apta* | Intercept | –1.3735 | 0.1259 | –10.9055 | < 0.001 |
| | *acta – hasta* | 0.0668 | 0.2044 | 0.3269 | 0.744 |
| | *apta – hasta* | 0.3204 | 0.2141 | 1.4963 | 0.135 |
| *hacha* | Intercept | –2.1321 | 0.1739 | –12.2623 | < 0.001 |
| | *acta – hasta* | 0.9226 | 0.2330 | 3.9603 | < 0.001 |
| | *apta – hasta* | 0.8559 | 0.2564 | 3.3375 | < 0.001 |

**Table 5**. Multinomial logistic regression for the distribution of responses to affrication.

However, we can see that the distribution of responses for each of the words followed a similar pattern: each token was first identified as *hasta* (40.95–49.60%), then as *acta* (31.96–33.33%), and finally as *apta* (11.66–14.29%) [$\chi^2(2) = 1.50$, $p = 0.473$, $\varepsilon^2 = 0.00110$], or even *hacha* (5.88–12.86%). A multinomial logistic regression (Table 5) showed that there was a preference for *hasta* over the other two target words when the stimuli were affricated; however, this preference was not statistically significant.

Concerning *hacha*, data show there was no confusion between the affricate and the affricated tokens; which seem to corroborate that acoustic differences found among them in the production task were enough to guarantee discrimination. Additionally, listeners identified [ʃ] as <ch> very accurately, even if the majority of them produced the standardized affricate form.

Closure and VOT ratios, when considered as covariates, proved to play a significant role in the identification outcomes. Longer closure ratios were associated with a preference for /kt/ [*estimate* = 3.128, *SE* = 0.641, *Z* = 4.878, $p < 0.001$] and /pt/ [*estimate* = 3.244, *SE* = 0.864, *Z* = 3.756, $p < 0.001$], rather than for /st/ clusters. The opposite was true in relation to VOT ratios. Concerning CoG, higher values tended to be associated with /st/ clusters, rather than /kt/ [*estimate* = –1.41e–4, *SE* = 9.37e0–6, *Z* = –15.082, $p < 0.001$] and /pt/ [*estimate* = –1.25e–4, *SE* = 1.31e0–5, *Z* = –9.554, $p < 0.001$].

### 3.2.1. A closer look at the stimuli

After reporting the overall results, we could also observe certain behaviors according to the stimuli and/or specific speakers. The correct identification of *acta* ranged from 20.95% to 55.24% [$\chi^2(3) = 32.2$, $p < 0.001$, $\varepsilon^2 = 0.077$]. Speaker M2 (male) obtained the highest score, whose production displayed the following values: Segment duration = 164 ms, closure ratio = 0.701, VOT ratio = 0.299, CoG = 5172 Hz. The remaining answers were distributed between *hasta* (32.38%) and *apta* (12.38%). Conversely, the lowest score was attributed to Speaker F2 (female), with the following values: Segment duration = 139 ms, closure ratio = 0.468, VOT ratio = 0.532, CoG = 6597 Hz. This token was rather identified as *hacha* (44.76%), *hasta* (32.38%) or *acta* (14.29%).

The lowest perception score for *apta* was 4.76%, while the highest was 27.62% [$\chi^2(2) = 24.2$, $p < 0.001$, $\varepsilon^2 = 0.077$]. Again, Speaker M2 rendered the highest score, with the following values: Segment duration = 170 ms, closure ratio = 0.747, VOT ratio = 0.253, CoG = 5311 Hz. This token was rather identified as *acta* (46.67%) and to a lesser extent *hasta* (25.71%). In turn, the lowest score was for Speaker F4 (female), with these values: Segment duration = 189 ms, closure ratio = 0.413, VOT ratio = 0.587, CoG = 8187 Hz. Most responses for

this item were distributed between *hasta* (57.14%), *acta* (30.48%), and *hacha* (7.62%).

Finally, the perception of *hasta* ranged from 34.29% to 60%. The two lowest ratings (34.29% and 41.90%) derived from male speakers, while the two highest ratings (60% and 59.05%) were for female speakers and were significantly more accurate than the lowest score [$\chi^2(5) = 20.8$, $p < 0.001$, $\varepsilon^2 = 0.033$]. The values for the two highest scores were as follows: Speaker F3 (female): Segment duration = 125 ms, closure ratio = 0.696, VOT ratio = 0.304, CoG = 7540 Hz; Speaker F4 (female): Segment duration = 202 ms, closure ratio = 0.391, VOT ratio = 0.609, CoG = 9480 Hz. Listeners' second choice for these tokens was *acta* (29.52% and 22.86%, respectively). On the other hand, the lowest score was for Speaker M1 (male), whose vales were Segment duration = 151 ms, closure ratio = 0.497, VOT ratio = 0.503, CoG = 7089 Hz. Listeners' first choice in this case was *acta* (40%).

### 3.2.2. Reaction times

We additionally measured reaction times for each of the three target words (in their mainstream and affricated forms), in terms of correct and incorrect answers. Table 6 shows the average duration and standard deviation for each:

| | | **Affrication** | **Mainstream** |
|---|---|---|---|
| | | **Mean (SD)** | **Mean (SD)** |
| **Correct** | ***acta*** | 2.78 (1.78) | 1.79 (0.96) |
| | ***apta*** | 3.09 (2.64) | 1.74 (0.71) |
| | ***hasta*** | 2.53 (1.79) | 1.82 (0.74) |
| **Incorrect** | ***acta*** | 2.56 (2.15) | 2.44 (1.15) |
| | ***apta*** | 2.71 (2.23) | 2.65 (2.26) |
| | ***hasta*** | 2.80 (2.14) | 4.51 (3.64) |

**Table 6.** Reaction times per stimuli according to correct and incorrect responses.

There were no significant differences among the reaction times for the affricated words, whether correct [$\chi^2(2) = 4.29$, $p = 0.117$, $\varepsilon^2 = 0.009$] or incorrect [$\chi^2(2) = 2.67$, $p = 0.263$, $\varepsilon^2 = 0.003$] answers were concerned. The same holds true among the mainstream words [correct: $\chi^2(2) = 0.464$, $p = 0.793$, $\varepsilon^2 = 5.87e{-}4$; incorrect: $\chi^2(2) = 3.03$, $p = 0.220$, $\varepsilon^2 = 0.063$]. Differences appeared within the correct responses, where reaction times were significantly longer for the affricated tokens than for the mainstream tokens [$\chi^2(2) = 102$, $p < 0.001$, $\varepsilon^2 = 0.079$].

## 4. General discussion

The present study aimed at exploring whether there is neutralization among three sample words with /st/, /kt/, and /pt/ clusters when affricated in Western Andalusian Spanish. Del Saz (2019*a*) first described the incidence of post-aspiration and affrication in stop + /t/ clusters in this variety, while Bishop (2007) previously found that there is an incomplete neutralization among these contexts after aspiration in Eastern Andalusian Spanish. Considering these studies, we conducted production and perception experiments with speakers of Western Andalusian Spanish, which comprised *acta* ('transcript'), *apta* ('apt'-fem.), and *hasta* ('until') as target words.

Concerning production, the data gathered and analyzed from the tasks revealed that affrication was the most common process found in the target words, particularly in *acta* and *hasta*. Interestingly, post-aspiration was the least frequent one, which may indicate that at least the younger generations have evolved and adopted the new phenomenon as their main variant, although there is variation within and across speakers. Mainstream productions were primarily found in the context of isolated words — the most formal task of the two — and in *apta*. Up to this point, the ongoing sound change seems to be well established in /kt/ and /st/, but not in /pt/.

For all three target words, post-aspirated and affricated productions were shorter than their mainstream counterparts, which coincides with the claims by O'Neill (2009) and Glyfadottir (2015). Additionally, their closure ratios gradually decreased from post-aspiration to affrication, while

their VOT ratios increased. As pointed out by Torreira (2007*a*, 2007*b*, 2012) and other authors, there seems to be a trade-off between closure length and VOT length, which further advances with the appearance of affrication. Finally, their CoG values in affrication are coincidental with the presence of sibilance (6–7kHz). Comparing the target words within each process, the three of them presented similar values in post-aspiration; thus, it seems neutralization takes place under this process. However, in affrication, the /kt/ cluster displayed longer duration, higher closure ratio, and lower closure ratio than /pt/ and /st/, while CoG values remained similar for the three clusters.

In terms of perception, our findings indicate that the affricated token of *hasta* presented the highest scores of identification accuracy, followed by *acta*, and then *apta*. Nevertheless, overall, listeners linked all three affricated tokens to the /st/ cluster primarily, which is the most common one and the declared precursor of this phenomenon, followed by /kt/, and finally /pt/. This seems to mismatch the direction of the diffusion in production, as perception follows a pattern from the most common consonant coda to the least common one of the three in Spanish (Brown, 2006; Bybee, 2002) Additionally, upon consulting the list of the 10,000 most frequent words in Spanish (Real Academia Española, 2008), we can see that *hasta* ranks 48, *acta* ranks 5702, and *apta* is not included on the list. This can definitely contribute to our results, even though in the academic world *acta* ('transcript') and *apta* ('apt'-fem.) are very common words, as they are related to transcripts and grades. Particularly, several speakers mentioned they usually say the sentence used in the production task that contained the word *actas* ('transcripts'). However, some tendencies also appeared concerning differences in the stimuli. A higher closure ratio was associated to stop + /t/ clusters, specifically /kt/. This coincides with the results from the production experiment, in which the affricated token of /kt/ presented a significantly higher closure ratio than /st/ and /pt/. Conversely, higher VOT ratio and CoG values were associated to the /st/ cluster. Once more, we can see how the /pt/ cluster is the least associated to the sound change, which corresponds to the lesser incidence in production. It seems that in isolation, without disambiguation from context, listeners preferred the high-frequency word *hasta* and cluster /st/ as the candidate for affrication and were also inclined to select *acta* /kt/ when the closure ratio was higher.

How did this sound change also appear in /kt/ and /pt/ clusters? We considered explanations on sound change concerning production, perception, and social factors, as well as those already offered to explain these phenomena in /st/ clusters. From a production point of view, a plausible explanation is that gemination, as a common denominator, served as a starting point. As described in the introduction, one of the possible realizations of /st/ clusters in Andalusian Spanish is [t̪ː], and stop + /t/ clusters are also commonly realized as [t̪ː] in this variety. The appearance of a longer VOT may be due to a long stop closure resulting "in a higher intra-oral pressure … leading to more prominent stop release" (Ruch & Peters, 2016, p. 28). Alternatively, there might be neutralization between stop and /s/ codas into aspiration in informal speech, just as in Venezuelan Spanish (Obediente, 2007) or Eastern Andalusian Spanish (Bishop, 2007). In this case, "the coordination between the glottal and the oral gesture is more variable in the offset of the consonant … [it] would permit an earlier release of the oral stop, with the consequence of a greater voice onset time" (Ruch & Peters, 2016, p. 29). Therefore, following the more advanced processes given in /st/ clusters, by means of phonetic analogy (De Schryver et al., 2008) there would be an ongoing phonetic change with lexical diffusion, established in /kt/ and emerging in /pt/.

It is believed that post-aspiration and affrication in /st/ clusters originated when followed by the high vowel /i/ (Ruch, 2013), as is the case of assibilation in other languages (Hall & Hamann, 2003; Hall et al., 2006; Hume, 2018; Kim, 2001; Żygis et al., 2012), and then spread to less favorable vowel contexts (Del Saz, 2019*a*; Ruch, 2013). We posit this change was first phonetically conditioned, starting with high-frequency words and phonetic contexts

and then beginning to spread to low-frequency words and phonetic contexts, based on the claims that "[c]hanges that affect high-frequency words first are the result of the automation of production", while low-frequency words "are more susceptible to analysis and change on the basis of other forms" (Bybee, 2002, p. 271). While it seems that this phenomenon was triggered phonetically, the influence of lexical factors "raises the question of the social awareness of the phonetic change" (Ruch, 2013; p. 178). In this respect, Vida Castro (2015) defends the resyllabification of /s/ from coda to onset position as a sign of prestige /s/ → [t̪s], in an attempt from speakers to restore the mainstream production while maintaining an open syllable. Indeed, when different variants coexist, "if social value is associated with the distinction between the two forms, at some point one of the variants may displace the other" (Solé & Recasens, 2012, p. 12). In this case, post-aspiration and affrication are clearly associated to Sevillian speakers (Ruch, 2018), while our pool of speakers came from different towns and cities in Western Andalusia to study at the Universidad de Sevilla. It may be then that these speakers are adopting the Sevillian pronunciation, given that "when a particular variant pronunciation is aligned with a certain indexical meaning, that particular pronunciation is likely to be promoted" (Solé & Recasens, 2012, p. 13), or that the formality of the context, i.e., an experimental setting in a laboratory prompted them to approach a more prestigious speech within the community. However, one speaker in our study overtly and consistently (and proudly) produced stigmatized *ceceo*, i.e., she produced /θ/ instead of /s/, giving way to homophones in pairs such as *casa* (house) and *caza* (hunting). As she put it: "I can't produce /s/; I wouldn't know where to place my tongue". Nevertheless, she still consistently produced [t̪ˢ] in both /st/ and stop + /t/ clusters. Therefore, we partly question prestige as the baseline motivation to produce affrication, at least when we can find cases like the one described above. According to Dimov et al. (2012), personality types can help promote or prevent sound change, i.e., those listeners with a low sense of empowerment are more likely to adopt the variants detected in speech than listeners who feel more empowered.

The idea of prestige is also related to restoration. Obediente (2007) claims that neutralization between coda stops and /s/ codas does not constitute true neutralization because speakers can restore the underlying forms in careful speech. However, speakers from weakening varieties may fail to reproduce the mainstream representations; therefore, "in restoring a consonant in the coda, since the linguistic standard is not within their reach, speakers default to the most frequent pattern" (Bongiovanni, 2019, p. 1). In our pool of participants, we found cases of hypercorrection in words other than our targets, but still related. For example, one of the speakers attempted to produce the word obtuso (obtuse) with mainstream pronunciation and restored the cluster to /st/ instead of /bt/, finally saying [oʂˈt̪uso]. It may be then that, upon hearing [t̪ˢ], some listeners can assume it is a /s/ coda by default, characteristic of mainstream Spanish, prestigious, and the most common (underlying) coda in the language.

Certainly, the unvoiced dental stop context is peculiar in Spanish, given that the less conservative varieties, i.e., those that favor coda weakening, usually maintain a closed syllable before /t/, while Andalusian Spanish parallels the rest of the codas and favors an open syllable (Moya Corral, 2007). Additionally, we should consider that the Spanish affricate phoneme /ʧ/ evolved from the Latin cluster /kt/ by means of the palatalization of /t/ (Álvarez 2007; Méndez, 2017). Moya Corral posits that affrication [tˢ] may have appeared in the same manner, after the stop articulation changes from apical to dorsal. In this sense, most of the previous research points at /st/ as the initiator of post-aspiration and affrication in Western Andalusian Spanish; however, we believe /kt/ could be a plausible context worth exploring as well, which has not been approached before.

Concerning perception, post-aspiration has been extensively explained. Ruch and Peters (2016) claimed that post-aspiration started precisely with

the dental stop /t/, "possibly due to a higher perceptual prominence of post-aspiration in this context, and that post-aspirated stops in Andalusian Spanish are on their way to being phonologized" (p. 1). In this context, listeners may have been able to detect aspiration from the signal and be unsure as to where it is placed (before or after the closure). Pre-aspiration may then be weaker in terms of salience, and post-aspiration results in a more efficient manner to produce coda /s/ (Cronenberg et al., 2020). As Ruch (2018) puts it:

> Post-aspiration can be considered to be acoustically more salient than pre-aspiration because it represents a noisy phase at the syllable onset between acoustic silence (i.e. the oral stop closure) and the following vowel, with abrupt transitions on either side. In contrast, pre-aspiration occurs at the syllable offset and is characterised by gradient transitions to neighbouring segments (p. 49).

As mentioned in the introduction, authors such as Gylfadottir (2015) and O'Neill (2009) defend the idea of new phonemes rather than allophones resulting from gestural timing adjustments, based on the fact that post-aspirated and affricated items are actually shorter than their mainstream or preaspirated counterparts, and uttered as a single phoneme, which coincides with our findings. Gylfadottir specifically advocates for this view given that she found instances of *Está bien* (It's okay) uttered as [t̪ʰa] bien or [t̪ˢa] bien, which would not be possible according to Spanish phonotactics. She proposes that, if we understand these new phenomena as target phonemes, fortition of [t̪ʰ] takes place the same way it does in English, favored by /t/ (Buizza & Plug, 2012). However, while this may be true for /st/ clusters, specifically concerning the verb to be, this claim does not comprise other stop + /t/ clusters; therefore, is there an explanation for this? Affrication may have been triggered sporadically (Parrell, 2012) by a combination of production and perception factors (Ohala, 2012; Ruch & Peters, 2016; Żygis et al., 2012), i.e., in certain favorable phonetic contexts — such as /i/ and /t/ — affrication was produced and/or perceived as such, whether consciously or not. These contexts may have altered the articulation and acoustic properties of the clusters, and/or the listener (or fine-attuned listeners) may have reinterpreted this articulatory variation and consequently started to employ different target gestures. With sufficient use, affrication may have been adopted as a group marker (in Western Andalusia, or in Seville specifically) and given certain prestige. Once established in high-frequency words and phonetic context /st/, it then spread to stop + /t/ clusters and low-frequency words, given that similar variants among these clusters and /st/ exist (gemination, aspiration) and can promote analogy or lexical diffusion (Bybee, 2017). This would "suggest an articulatory mechanism for sound change, since neuromotor activities that are highly practiced tend to lead to greater fluency, expressed by overlapping and reduction of gestures" (Solé & Recasens, 2012, p. 13). Subsequent language use may be beginning to change the underlying representations of the speakers.

## 5. Conclusions

Affrication is present not only in /st/ (*hasta*), but also in /kt/ (*acta*) and /pt/ (*apta*) clusters in Western Andalusian Spanish; however, while it seems to be well established in /st/ and /kt/, it is still emerging in /pt/ clusters. Affricated *apta* and *hasta* showed similar values, but *acta* seemed to differ in terms of length and closure and VOT ratios. Thus, neutralization is incomplete in production. In perception, there seems to be a misalignment with production, as listeners tended to associate affrication to /st/ mainly, regardless of the underlying cluster, even when /kt/ rendered a slightly higher number of affricated productions. However, when closure ratios were higher, they tended to label the stimuli as /kt/, which corresponds with the results obtained in the production task. Once more, /pt/ was seldom associated to [t̪ˢ]. This phenomenon seems to be more advanced in production than in perception, which may have to do with the frequency of the three codas, related to lexical frequency, and/or dependent on certain social factors. The motivation behind this change is worth exploring, be it phonetic (articulatory and perceptual),

structural, or social. In any case, we are now witnessing a sound change in progress in the sociophonetic landscape of Western Andalusian Spanish.

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