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Investigating a gradual metathesis: Phonetic and lexical factors on /s/- aspiration in Andalusian Spanish

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Abstract

Metathesis has often been described as abrupt and sporadic and thus as an exception to neogrammarian sound change (e.g. Wang 1969), while others suggested metatheses to be gradual, phonetically based developments (e.g. Blevins & Garrett 1998). Andalusian Spanish provides an opportunity to study this issue. As in many other Spanish varieties, in Andalusian Spanish, syllable final /s/ is usually weakened to [h] or even deleted (pasta 'paste/pasta' [ˈpahta]). Traditional dialectological or sociolinguistic studies used to transcribe medial /sp, st, sk/ as pre-aspirated stops [hp, ht, hk] or geminates [pp, tt, kk]. However, post-aspirated stops [pʰ, tʰ, kʰ] have recently been reported for Western Andalusian Spanish (Torreira 2007a, 2012; Parrell 2012). Ruch & Harrington (submitted) found that younger Andalusian speakers produced /st/ with an important amount of post-aspiration, while older speakers produced a longer pre-aspiration.

In this study 11 Spanish words with medial /st/ followed by different vowels (e.g. pestiño, pestaña, estufa) are analysed in order to investigate whether the emergence of post-aspiration is favored by phonetic factors and/or by lexical frequency. By a semi-automatic procedure voice offset time (VOffT) was measured for pre-aspiration, and voice onset time for post-aspiration in the materials produced by 48 speakers (24 from Seville, Western Andalusia, and 24 from Granada, Eastern Andalusia, both divided into two age groups). In all words analyzed, younger speakers produced a shorter VOffT and a longer VOT than older speakers. The analysis of linguistic factors showed that a following high front vowel /i/ favored a longer VOT in all four speaker groups. /st/-sequences followed by /u/ showed a longer VOT in older, but a shorter VOT in younger speakers, compared to the other two phonological contexts _a and _i. Further analysis indicated an interaction between lexical frequency and phonological context, the influence of the latter being more marked in less frequent words. Our results suggest that metathesis can be the result of a regular and gradual process, which is, in the beginning, favored by phonetic factors. Only as the sound change advances further, lexical factors gain in importance.
Investigating a gradual metathesis: Phonetic and lexical factors on /s/-aspiration in Andalusian Spanish

Hanna Ruch*

1 Introduction

Metathesis can be defined as a reordering of segments (Buckley 2011:1380) and refers to both the process and the result of this sound change. The Neogrammarians postulated that most types of sound change are regular, phonetically conditioned and that they proceed in gradual, imperceptible steps (Hock 1991:660). The model of lexical diffusion (Wang 1969, Wang & Cheng 1977) states that sound change is, rather than regular, “phonetically abrupt but lexically gradual” (Wang 1969:9). A change that diffuses through the lexicon may not reach all words at the same time. Both approaches mention metathesis as an exception to regular sound change, as it is said to occur only sporadically and to be the result of a phonetically abrupt process (Osthoff & Brugmann 1878, Wang 1969, Labov 1994).

Other approaches (e.g. Ultan 1978, Hock 1985) describe metathesis from a typological perspective and stress the similarities of different types of metathesis among very different languages. Hock (1985) shows that metathesis can be regular if it serves a specific structural purpose. “This purpose may involve a general constraint on phonological structure, the elimination of a cross-linguistically disfavored sequence, or the establishment of a preferred syllable structure” (Hock 1985:529). A similar perspective is taken by Hume (2004), who provides examples of regular metathesis not only across, but also within a language. Hume demonstrates that the direction of a metathesis involving the same segments can vary across languages, and suggests two main aspects to be included for a cross-linguistic explanation of metathesis: 1) phonetic factors as the articulation or perception of sounds and sound sequences, and 2) the phonological system of the specific language: “The order of elements opposite to that occurring in the input must be an attested structure in the language” (Hume 2004:209-210).

Blevins & Garrett (1998, 2004) adopt a broader definition of metathesis and integrate both segment and feature metathesis in their explanation model. Blevins & Garrett are convinced that similar mechanisms underlie both types of metathesis. In their model, metatheses are, in a very similar way to regular gradual sound changes, the result of the interface between speech production and speech perception (cf. Ohala 1993, 2003). In such a model, acoustic features such as aspiration or nasalization (as the result of coarticulation) spread in the acoustic signal to neighboring segments. A perceptual error of the listener, assigning the feature erroneously to another segment, may give rise to a (perceptual) metathesis (Blevins & Garrett 2004:125).

A sound change in progress in Andalusian Spanish affords an opportunity to study both the issue of the process how metathesis takes place (phonetically gradual vs. phonetically abrupt), and the question of regular sound change vs. lexical diffusion.

Andalusian Spanish is spoken in the autonomous region of Andalusia, located in the Southern part of Spain, although several of its typical features extend beyond the political region of Andalusia and can also be found in numerous American varieties of Spanish. From a sociolinguistic perspective, Andalusian Spanish can be characterized as a gradatum of variation between the more conservative standard variety and the innovative local variety (Villena Ponsoda 2008:144). However, many of the Andalusian features, including /s/-aspiration, are used even in formal situations by speakers with a high educational level. This suggests that Andalusian Spanish functions as a local standard variety of Spanish (Villena Ponsoda 2008).

The term /s/-aspiration refers to the weakening of syllable-final /s/ in word-medial (e.g. *pasta ‘paste’; *pasta [’pahta]) and in word-final position (e.g. *patas ‘paws’ [’pahaj]). /s/-aspiration is probably the most studied phenomenon of Hispanic linguistics. Many studies transcribe /s/ + voiceless stop sequences with [h] (resulting from /s/-aspiration) as a segment preceding the voice-

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less stop (e.g. *caspa* ‘dandruff’ [ˈkahpa], *casco* ‘helmet’ [ˈkahko]). Nonetheless, older dialectological studies already emphasized the important amount of variation in the realization of /sp, st, sk/ in Andalusian Spanish. Traditional sociolinguistic and dialectological studies used to transcribe /s/ + voiceless stop sequences not only with [h] preceding the stop (in this paper referred to as pre-aspiration), but also as geminates ([pʰ, tʰ, kʰ]) with or without a certain amount of aspiration (e.g. Wulf 1889, Alther 1935, Alvar 1955). A further possible consequence of /s/-aspiration in Eastern Andalusian Spanish is the lengthening and/or opening of the preceding vowel (abertura vocálica), which may be associated with vowel harmony, e.g. *después* ‘afterwards’ [deˈhϕwɛ] (Alvar 1996, Narbona et al 2003). Vowel opening is an important feature that distinguishes Western from Eastern varieties of Andalusian Spanish (Salvador 1964, Mondéjar 1991).

In the last few years, phonetic studies have reported post-aspirated stops for /sp, st, sk/ of Western Andalusian speakers from Seville and Cádiz (Torreira 2007a, 2007b, 2012; Parrell 2012), and an affricated stops [tʰ] in the case of /st/ (Moya 2007, Ruch 2012). At the same time, closure lengthening and a constrained relationship between vowel and closure duration seem to be the main phonetic features of Eastern Andalusian /s/ + voiceless stop sequences (Gerfen 2002). A direct phonetic comparison between eight Eastern and eight Western Andalusian speakers confirmed the existence of different phonetic strategies to distinguish /sp, st, sk/ from their singleton counterparts /p, t, k/: while Western Andalusian speakers used primarily VOT for distinguishing /sp, st, sk/ from /p, t, k/, Eastern Andalusians used instead pre-aspiration and a longer closure duration (O’Neill 2010).

The question of a sound change in progress from pre-aspiration to post-aspiration raised by Torreira (2007a), O’Neill (2010) and Parrell (2012) was systematically addressed by Ruch & Harrington (submitted) in an apparent-time study with 48 speakers. They found for a Western (Seville Spanish) and an Eastern variety (Granada Spanish), younger Andalusians produced words with intervocalic /st/ (e.g. *estado*) with a longer post-aspiration and a shorter pre-aspiration than did older speakers. Although these age-dependent differences were more marked for Seville speakers, they indicate that a sound change from pre- to post-aspiration is taking place also in Granada Spanish.

The aims of this study are threefold: 1) to analyze the way in which pre-aspiration changes into post-aspiration, 2) to test whether phonetic factors such as the following vowel favor the emergence of post-aspiration, 3) to investigate the lexical diffusion of the new variant, particularly the effect of lexical frequency. The study has been carried out in the apparent-time paradigm, comparing two different age groups. In order to better quantify the effect of the linguistic factors, material of an Eastern and a Western Andalusian variety has been collected.¹

2 Method

2.1 Material

Seventeen isolated words from 48 Andalusian speakers were analyzed (see Table 1). The materials included eleven words with intervocalic /st/ (henceforth st-words) and six words with intervocalic /t/ (henceforth t-words). All target words were trisyllabic with lexical stress on the second syllable. For each vowel context (preceding the high front vowel /i/, the low vowel /a/, and the high back vowel /u/) both t- and st-words were included in order to compare the extent of pre- and post-aspiration with the realization of a singleton stop in the same vowel and stress context. All target words were repeated three times and randomized together with 72 target words for a related study and 97 fillers. This gave us a total number of 17 (words) × 3 (repetitions) × 48 (speakers) = 2448 target words.

<table>
<thead>
<tr>
<th>st-words</th>
<th>a</th>
<th>i</th>
<th>u</th>
</tr>
</thead>
<tbody>
<tr>
<td>estaba ‘to be’, 3rd person sg. imp.</td>
<td>destino ‘fate’</td>
<td>estuve ‘to be’, 1st person sg. indefinido</td>
<td></td>
</tr>
</tbody>
</table>

¹ The present study shares its methodology and parts of the materials with Ruch & Harrington (submitted).
Table 1: st-words and t-words according to vowel context.

2.2 Speakers

48 speakers were recruited and recorded in a sociolinguistic interview (cf. Ruch & Harrington, submitted). 24 speakers were from Seville, the capital of Andalusia, located in Western Andalusia, and 24 were from Granada, a city in Eastern Andalusia. In both cities we recorded twelve younger (age range 20-36 years) and twelve older (age range 55-79) speakers. The four speaker groups were equal in terms of gender (six women and six men in each group) and, as far as possible, they were comparable in terms of educational level.

2.3 Interview and recordings

The target words were embedded in a sociolinguistic interview. Every recording session took about 30 minutes and consisted of a semi-directed part, reading of a text and reading of 180 isolated words in three repetitions. Each item was displayed and read from a laptop monitor. Recordings were realized in a noise-reduced room at the University of Seville or the University of Granada or in a quiet room at the subjects’ residence or work place. The recordings were carried out with the SpeechRecorder software (Draxler & Jänsch 2004), using a portable computer, a USB device, and a headset microphone.

2.4 Analysis

The speech data were segmented automatically with the Munich Automatic Segmentation System (MAuS; Schiel 2004). In a second step, segment boundaries were corrected manually. From the 2448 items mentioned above, 268 had to be discarded because of hesitations, false starts, slips of the tongue or spirantized closure. For the remaining 1994 tokens, the voicing of the signal was calculated in Emu (Harrington 2010) based on the pitch (a pitch value of zero corresponds to a voiceless signal). The aim of this procedure was to find automatically the offset of voicing in V₁ (i.e. the start of pre-aspiration) and the onset of voicing after the closure (i.e. the end of VOT; see Figure 1). Although /s/-aspiration represents a very common phenomenon in Andalusian Spanish and is used by different speakers in informal and formal situations, some tokens were produced...
with an alveolar fricative [s]. As /s/-aspiration has been shown to be a gradual process (Erker 2010, File-Murieł & Brown 2011), we opted for a clustering procedure based on duration and zero crossing rate to separate full alveolar fricatives [s] from lenited tokens (for further details on method, see Ruch & Harrington, submitted). The 186 [s]-tokens identified by this automatic procedure were discarded from further analysis.

<table>
<thead>
<tr>
<th></th>
<th>Recorded tokens</th>
<th>Discarded tokens (false starts, etc.)</th>
<th>Discarded tokens (/s/ not aspirated)</th>
<th>Tokens in the corpus</th>
</tr>
</thead>
<tbody>
<tr>
<td>/st/-words</td>
<td>1584</td>
<td>190</td>
<td>186</td>
<td>1208</td>
</tr>
<tr>
<td>/t/-words</td>
<td>864</td>
<td>78</td>
<td>78</td>
<td>786</td>
</tr>
<tr>
<td>Total</td>
<td>2448</td>
<td>268</td>
<td>186</td>
<td>1994</td>
</tr>
</tbody>
</table>

Table 2: Analyzed and discarded tokens.

An acoustic, semi-automatic method was preferred over a manual and categorical one for the following reasons: 1) Finding manually the onset of pre-aspiration is a very difficult task, and consistency across 48 subjects is difficult to achieve. 2) An acoustic procedure allows analyzing both pre- and post-aspiration in a gradual manner without presupposing phonetic categories such as [ht] or [tʰ] (see File-Murieł & Brown 2011 for further discussion of gradient vs. categorical analysis of /s/-aspiration). In this paper we will use voice offset time as equivalent to pre-aspiration. What has to be further tested is how far this parameter corresponds to pre-aspiration, especially in the perception of native speakers of Andalusian Spanish.

3 Results

3.1 Duration of pre- and post-aspiration

Figure 2 shows mean values for voice offset time (VOffT, i.e. pre-aspiration), closure duration and voice onset time (VOT, i.e. post-aspiration) for each speaker. It is apparent that in both varieties, younger speakers produced a longer VOT, while older speakers produced a longer VOffT in /st/-words. However, as Figure 2 shows, also younger speakers produced some amount of pre-aspiration, even though they produced in general a longer VOT.

![Figure 2: Averaged and time-normalized values of voice offset time (white), closure duration (grey) and voice onset time (dark grey) in eleven /st/-words. One bar represents the mean values of VOffT, closure duration and VOT for one speaker.](image)

An ANOVA with VOT as the dependent variable and age and variety as factors was run to test whether the differences in VOT among the four speaker groups were statistically significant. The test showed a significant effect of age (F[1,44] = 44.2, p < 0.001) and variety (F[1,44] = 19.32, p < 0.001) as well as an interaction between the factors (F[1,44] = 5.17, p < 0.05). The same model with VOffT as the dependent variable showed a significant impact of age (F[1,44] = 9.47, p < 0.01), but not of variety (F[1,44] = 0.425, p = 0.52) and no interaction between them. For /t/-words
(etapa, retira, etc.) there was no significant effect of age or variety on the dependent factors VOT and VOft.

These results suggest a change from pre-aspiration to post-aspiration in apparent-time that is more advanced in Seville than in Granada Spanish and that confirm the findings of Ruch & Harrington (submitted) for a larger database. The different impact of age and variety on pre- and post-aspiration suggests no direct relationship between duration of pre- and of post-aspiration. In the next chapters we will test if phonetic factors favor the lengthening of post-aspiration. If the emergence of post-aspiration is favored by the following vowel, we would expect its impact to decrease as the sound change advances.

3.2 Phonological context

![Figure 3: VOT in /t/-words (left) and /st/-words (right) across different vowel contexts and among the four speaker groups.](image)

Figure 3 shows the VOT values across the four speaker groups and three vowel contexts. The VOT values were averaged across speaker and across phonological context in order to get three data points for each subject. As Figure 3 shows, VOT varies with vowel context: all four speaker groups show the longest VOT when /st/ is followed by the high front vowel /i/ (e.g. in pestiño, estima). For the other two contexts differences across the two varieties and two age groups appear to exist. Older Granada speakers seem to show the biggest difference between /i/- and /a/-context, while younger speakers of both varieties show a more important difference between /i/- and /u/-context. At the same time, VOT seems to be longer for younger and Seville compared to older and Granada speakers. Among the /t/-words, VOT values are not only much shorter, but also much more balanced across speaker groups and phonological context.

A repeated measures ANOVA with VOT as the dependent variable, vowel as within-factor and age and variety as between-factors showed a highly significant effect of age (F[1,44] = 42.4, p < 0.001) and variety (F[1,44] = 19.9, p < 0.001). The ANOVA further showed a significant influence of vowel context on the dependent variable (F[2,1,90.1] = 27.5, p < 0.001) and an interaction between vowel context and age (F[2,1,90.1] = 7.4, p < 0.01). A Tukey-test with VOT as the dependent variable and vowel as factor showed a significant difference between /sti/- and /sta/-words (t = 6.4, df = 47, p < 0.001) as well as between /sti/- and /stu/-words (t = 6.2, df = 47, p < 0.01), but not between /sta/- and /stu/-words (t = 1.0, df = 47, p = 0.92).

In order to test the influence of the vowel context among the different speaker groups, a second Tukey-test was carried out with VOT as the dependent variable, vowel as within-factor and age and variety as between-factors. The test showed for Granada a significant difference between older and younger speakers for /sta/-words, but not for the other two contexts. Older and younger Seville speakers differed significantly in /sti/- and /sta/-words (both p < 0.01), but not in /stu/-
words (p = 0.05). The difference in VOT between the two age groups was therefore largest in those words where /st/ was followed by the low vowel /a/ (e.g. estado, estanco). A RM-ANOVA confirmed that for /t/-words none of the tested factors (age, variety, phonological context) was significant.

In a RM-ANOVA with voice offset time (i.e. pre-aspiration) as the dependent variable, vowel context as within-subjects-factor and age and variety as within subjects factors there was no significant effect vowel context on pre-aspiration duration (F[2.1,92.1] = 1.0, p = 0.37). A significant effect of age (F[1,44] = 9.8, p < 0.01) confirmed that younger speakers produced /st/-words with a shorter pre-aspiration than older speakers.

As a second step we will now test whether the impact of the following vowel is greater in older and Granada compared to younger and Seville speakers. VOT mean values in the different phonological contexts were subtracted pairwise for each speaker:

\[
\text{diff}_{\text{ia}} = \text{VOT}_{\text{sti}} - \text{VOT}_{\text{sta}}
\]

\[
\text{diff}_{\text{iu}} = \text{VOT}_{\text{sti}} - \text{VOT}_{\text{stu}}
\]

\[
\text{diff}_{\text{au}} = \text{VOT}_{\text{sta}} - \text{VOT}_{\text{stu}}
\]

VOT-differences according to variety and age are shown in Figure 4. The boxplots in the leftmost part of the figure show a consistent difference of ca. 5 ms between /sti/ and /sta/-words among all speaker groups. An ANOVA with \(\text{diff}_{\text{ia}}\) as the dependent variable and age and variety showed a non significant effect of the fixed factors (age: F[1,44] = 0.1, p = 0.80; variety: F[1,44] = 0.1, p = 0.71). \(\text{diff}_{\text{iu}}\) values (center figure) are mostly positive and clearly differ among older and younger speakers. An ANOVA with age and variety as factors confirmed the observed tendency of higher \(\text{diff}_{\text{iu}}\) values for younger compared to older speakers (F[1,44] = 9.9, p < 0.01). The effect of variety was not significant (F[1,44] = 1.9, p = 0.17). The boxplots on the rightmost part of the figure suggest VOT to be longer in /sta/- compared to /stu/-words for young Seville speakers, but not for the remaining speaker groups. The boxplot for older subjects from Granada instead shows an opposite tendency. An ANOVA with \(\text{diff}_{\text{au}}\) as the dependent variable and age and variety as factors confirmed statistically the effect of age (F[1,44] = 10.7, p < 0.01). As for \(\text{diff}_{\text{ia}}\) and \(\text{diff}_{\text{iu}}\), there was no significant effect of variety (F[1,44] = 1.0, p < 0.31); rather, the impact of vowel context on VOT was more marked in younger than in older speakers, and there was no significant difference between Seville and Granada Spanish.

The analysis suggests that the impact of vowel context changes over time. If the sound change is favored by the following vowel, we would expect its impact to be greater in older and Granada speakers. However, differences in VOT according to vowel context were more marked in younger and Seville subjects. There might be other factors that influence the realization of /s/-aspiration in /st/-sequences, and the diffusion of post-aspiration in Andalusian Spanish. In the next chapter the question will be addressed of whether lexical frequency may further explain the unexpected results for phonological context.
3.3 Lexical frequency

In order to test the influence of lexical frequency on VOT and VOoFT we first divided the target words into two categories: frequent and less frequent words. The division was undertaken based on the occurrences of the target words in the *Corpus de referencia del español actual* (Real Academia Española 2012). Lemmas with 1000 or more occurrences were classified as frequent, all other lemmas were classified as less frequent, which followed in a distribution as displayed in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th></th>
<th>Frequency</th>
<th></th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>estaba</td>
<td>high</td>
<td>destino</td>
<td>high</td>
<td>estuve</td>
<td>high</td>
</tr>
<tr>
<td>estado</td>
<td>high</td>
<td>estima</td>
<td>high</td>
<td>estufa</td>
<td>low</td>
</tr>
<tr>
<td>pestaña</td>
<td>low</td>
<td>pestiño</td>
<td>low</td>
<td>estucha</td>
<td>low</td>
</tr>
<tr>
<td>estanco</td>
<td>low</td>
<td>estío</td>
<td>low</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Distribution of the target words among two categories of lexical frequency.

Figure 5: VOT in frequent and less frequent /st/-words, according to vowel context and variety.

Figure 4 shows VOT as a function of vowel context and lexical frequency. For both Granada and Seville speakers there is an interaction between lexical frequency and phonological context: in less frequent words, the impact of phonological context appears to be more important than in frequent words. As mentioned above, some speakers produced syllable final /s/ as a full alveolar fricative in some tokens, with the result that the dataset is slightly imbalanced. For this reason, mixed models were used for this part of the analysis. A mixed model with VOT as the dependent variable, lexical frequency and vowel context as fixed factors, and speaker and word as random factors confirmed that lexical frequency interacted significantly with vowel context ($\chi^2[2] = 6.8$, $p < 0.05$). A Tukey-test showed for less frequent words a highly significant difference between /sti/- and /sta/-words as well as between /sti/- and /stu/-words ($p < 0.001$). Among the more frequent words the only significant difference was found between /sti/- and /sta/-words ($p < 0.01$).

The same statistical model with pre-aspiration as the dependent variable showed no effect of vowel context ($\chi^2[2] = 1.0$, $p = 0.62$) and lexical frequency ($\chi^2[1] = 3.6$, $p = 0.06$) and no interaction between the fixed factors ($\chi^2[2] = 1.4$, $p = 0.51$). Despite the interaction found between lexical frequency and vowel context, as is apparent from Figure 6, younger speakers of both varieties produced all 11 /st/-words with clearly longer VOT than older speakers.
4 Discussion

In this corpus of 11 Spanish words with intervocalic /st/, younger Andalusian speakers produced a shorter voice offset time but a longer voice onset time than older speakers. Within the apparent-time paradigm, this difference between younger and older speakers reflects a sound change in progress from pre- to post-aspiration. The results of this study confirmed the findings of a sound change in progress in Western- and, to a lesser degree, also in Eastern Andalusian Spanish (cf. Ruch & Harrington, submitted) with a larger database. As has been shown in chapter 3.1, the fading of pre-aspiration and the emergence of post-aspiration are best described as two gradual processes that in the beginning may be independent from each other. Of special interest is the fact that in Andalusian Spanish the result of the metathesis is not an attested structure but a new sound, as voiceless stops are in this language usually unaspirated. In this respect, the Andalusian sound change does not correspond to the general patterns of metathesis proposed by Hume (2004). It is possible that historical aspiration metatheses such as Sanskrit hásta to Pali hatthā (Vaux 1998) also emerged in a similar gradual way.

As our analysis in 3.2 showed, the following vowel had a significant effect on post-aspiration, but not on pre-aspiration: VOT was longest in words such as pestiño where /st/ was followed by the high front vowel /i/. This result is in line with findings from other languages such as English (Ohala 1981, Docherty 1992, Morris et al. 2008) and can be explained with aerodynamic constraints (Ohala 1983, Morris et al. 2008). They further accord with diachronic processes such as the development of post-aspiration in voiceless stops when followed by a high vowel (see Mathangwane 1999, 152-153 for the Bantu language Ikalanga; refered to in Ohala 2003).

The emergence of post-aspiration in Andalusian Spanish seems to spread from a phonetically favorable context (_i, u) to a less favorable context (_a). The differing influence of the following vowel in older, compared to younger, speakers supports this view: the most important difference between older and younger speakers was found in the phonetically less favorable context _a. However, our data did not confirm the idea that the impact of the phonological context decreases as the sound change advances. Vowel context had a more important impact on VOT among younger speakers, which turned out to be the opposite of the expected trend. Further analysis showing an interaction between lexical frequency and vowel context shed light on this issue. In frequent stu-words VOT was longer than in less frequent /stu/-words. As the sound change takes hold, other factors such as lexical frequency seem to gain importance, but still the phonetic factors seem to be the stronger predictors (see also Bybee 2012). The growing impact of lexical factors raises the question of the social awareness of the phonetic change. The fact that in the beginning, phonetic factors play a more important role, and only later lexical frequency starts to have an impact suggests that the sound change starts as a change from below and later spreads as change from above (cf. Labov 1994). Perception experiments on the implicit and explicit indexical knowledge of Andalusian speakers might shed light on this issue. Despite the mentioned interaction between age and vowel context, younger speakers of both varieties produced longer VOT values among all three contexts and among all 11 /st/-words, which suggests the Andalusian sound change is of a regular more than of a sporadic nature. Further research is needed to test the interaction between phonetic and lexical factors within a larger database.
Our results suggest that feature metathesis can be the result of a gradual and phonetically-driven process. The traditional view of metathesis as a sporadic discrete sound change may originate from the type of linguistic data analyzed, as the study of historical sound changes is usually restricted to the input and the output of processes (Wireback 2002:313). The investigation of ongoing sound change in terms of acoustic instead of categorical data allows a more detailed view on the mechanisms of sound change.

5 Conclusion

A semi-automatic procedure allowed an acoustic, continuous study of a sound change in progress in Andalusian Spanish. The results of the present study provided evidence that an aspiration + stop metathesis can be the result of a gradual process in which post-aspiration gradually increases while pre-aspiration decreases. The Andalusian aspiration metathesis not only appears to be the result of a gradual process, but seems to share further characteristics of regular sound change: the emergence of post-aspiration is favored by phonetic factors (a following high front vowel) and affects more than just isolated words. Only as the sound change advances does lexical frequency gain in importance.

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