Place of Articulation and Consonantal Strength

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Besides manner of articulation and glottal activity, which have been more studied, place of articulation also plays an important role in determining the relative strength of a consonant. This is so because the joint contribution of magnitude and duration of articulatory gestures (glottal, velo-pharyngeal, and oral) defines a global level of intraoral pressure that can be related to strength (Malécot, 1970).

This aerodynamic criterion has been used to explain the role that a back place of articulation can have in reducing oral volume and thus increasing intraoral pressure, namely strength. This can interfere with glottal activity (e.g. in passive devoicing).

I will provide examples of diachronic change in several languages which show a tight relationship between back places and strength. These examples are mainly from Semitic languages, such as Arabic, but also from some others, such as Samoan (Austronesian) and Vlach Romani (Indo-European).

A relation has been proposed between order of diffusion of linguistic change and place of articulation. However, there is controversy about the relative order between labials and coronals. I will examine different proposals and I will present articulatory, aerodynamic and perceptual data to support the idea that coronal consonants are weaker than labial consonants. The lesser the mass of the articulatory organ, the faster the movements and the shorter the duration of the gesture, which leads to weakness. In addition, certain kinds of coronals might be associated with a relatively descended position of the jaw, which can cause an increase of the oral volume and, consequently, a decrease of the intraoral pressure. Nevertheless, further study is needed on the link between jaw gestures and different types of labials and coronals. To finish, there are some optimal durations for the correct perception of each manner, which vary depending on the place of articulation, and these thresholds seem to favour the weakening of coronals much more than that of labials or dorsals (García Santos, 2002).

1 INTRODUCTION

Traditional research on lenition and fortition has usually dealt with the relationship between these phenomena, on the one hand, and manner of articulation and glottal activity, on the other, not focusing on place of articulation. This paper is an attempt to link this place of articulation to the other two factors and show the contribution of place to determining the relative strength of a consonant.

Articulatory Phonology (Browman and Goldstein, 1986, 1992) suggests that consonantal strength increases as magnitude and duration of articulatory gestures do so, these gestures being: glottal, velo-pharyngeal, and oral (in turn, oral gestures can be broken down into different gestures, corresponding to tongue body, tongue tip, lips and jaw). Though these gestures are quite independent of each other in some senses, the three help to define a global level of intraoral pressure that can be related to strength (Malécot, 1970).

A back place of articulation (as an aspect of oral gesture) leaves a short distance between the vocal folds and itself. The reduced oral volume causes an increase in intraoral pressure, and this explains the relative strength of dorsal consonants, for example. On the
other hand, front places of articulation have been pointed out as a factor of relative consonantal weakness (Blevins, 2004; Laver, 1994; Locke, 1983).

In the following sections, I will analyse the repercussions of back and front places of articulation on the strength level of consonants, their interactions with manner and glottal activity, and the implications for linguistic change.

2 BACK PLACES OF ARTICULATION

As has been said, back places of articulation imply a small volume of the resonance cavity in the mouth and, consequently, a tendency towards the rapid build-up of intraoral pressure.

This aspect of the oral gesture, by itself, entails a relative strength for the consonant. Moreover, it may interfere with the aerodynamics of the phonation processes and thus with glottal gesture. A great pressure may contribute to a passive devoicing, and the longer the duration of the (back, obstruent) oral gesture, the greater the possibility of devoicing. This occurs when supraglottal pressure equals or surpasses subglottal pressure, which prevents the vibration of vocal folds.

Vibration will [...] fail to occur if subglottal pressure is too low (e.g. the speaker is out of breath) or supraglottal pressure is too high (e.g. because air is impounded in the oral cavity by an articulatory closure), even if the vocal folds are in a position that would induce vibration under other conditions (Ladefoged and Maddieson, 1996: 49, my italics).

Typologically, /k/ is more frequent than its voiced cognate /g/. If a language has a defective phonological system with regard to plosives, it is most likely that it lacks /g/ (or /p/) (Locke, 1983: 146). According to Maddieson (2006), in the UPSID 451-language database there are 40 inventories with no /g/, which were expected to have it, as they have other velars and other voiced plosives; and 38 don’t have /p/.

In order to compensate for the trend towards passive devoicing, speakers may turn to several strategies, such as lowering their larynx, relaxing their mouth muscles to let them expand the oral cavity if necessary, or descending the lower jaw. All these strategies reduce the supraglottal pressure by increasing the resonance cavity volume.

As we can see, then, back places of articulation are attributed a great consonantal strength, owing to an aerodynamic criterion of intraoral pressure. The relationship between changes towards back articulations and strength is observable in diachronic evolutions of quite a lot of languages. Here are some examples.

We will first comment on Pre-Samoan (t > k). At a first stage, there were only two stop consonants, /p/ and /t/. Probably, place of articulation would be distinguished by means of VOT (lower for the labial), rather than by transitions. Provided that transition clues had no relevance, [t] and [k] would start to freely alternate, and [k] was a better option, as it showed a more different VOT from /p/. That’s how /k/ became phonological (Blevins, 2004: 124). According to this explanation, we can see that the backward shift in place of articulation is truly linked to a strengthening process, because it has to do with an increase in VOT (which implies a longer duration of glottal aperture gesture, a gesture related to strength, cf. Lahoz, 2006).

In Vlach Romani, dental stops became velar stops, at the end of a complex evolutionary process which turned the former into affricates and later deaffricated them. The strength of the affricate was substituted for the strength associated with the backward shift in place. The following examples are from Hancock (1991: 104):

(1) buti > buṭi > buṭi > buki > buki
    ‘work’
(2) stadi > stadji > staṭi > staagji > stagi
    ‘hat’
Pharyngalisation is a common process in Semitic languages, e.g. in Aramaic, Hebrew, Phoenician, Old Akkadian, Soqotri, Tigrinya, Harari, and, of course, Arabic. Some authors, as Goman (1979: 28) or Laver (1994: 327 ff.), link this Semitic pharyngalisation to consonantal emphasis. In Arabic, indeed, there is a trend to associate the most backward places of articulation with the strengthening of consonants (Isabel Abad, personal communication). Emphatic consonants are characterised by a greater magnitude in oral gesture, and by a greater accumulation of intraoral pressure. Cantineau (1960) deals with this kind of strengthening, which he calls

\[ \text{vélératisation emphatique dont l’arabe et le berbère fournissent de bons exemples: à des consonnes normales s’opposent des consonnes présentant, outre leur point d’articulation principal, un rapprochement entre la racine de la langue et le voile du palais qui donne à la consonne un timbre particulier (op. cit.: 163, original italics).} \]

This correlation has affected the consonant inventory in different synchronic slices through the history of Arabic. However, some alternations are consolidated and can be regarded as diachronic changes. For example, in Semitic there was an alveolar trill, which is still in Old Arabic. Nevertheless, in Old Arabic a new, emphatic r appeared, as an allophonic variant in the context of /ɑː, u/ (i.e. back vowels) or some other emphatic consonant. Nowadays, in Maghreb Arabic, it has become phonological, due to some analogical changes that have introduced certain level of opacity in the alternation. Thus we have some contrasts such as the following (after Cantineau, 1960: 50):

(3) /daːɬ/ ‘he has done’

(4) /daːɬʕ/ ‘he has come back’

All these examples show the validity of the relationship posited to exist between back places of articulation and consonantal strength.

3 FRONT PLACES OF ARTICULATION

Labial and coronal consonants are articulated in a front place within the mouth, thus leaving quite a large resonance cavity between the vocal folds and the narrowing point. Such a big volume is a factor of relative weakness, because it contributes to a lower level of intraoral pressure.

Following this reasoning, labials should then be the weakest among consonants, provided that their place of articulation is the furthest possible from the vocal folds. Nevertheless, there are data that may suggest that coronals are weaker than labials. In this section, I will explore the possible reasons for this.

A relation has been proposed between order of diffusion of linguistic change and place of articulation. Some authors (e.g. Laver, 1994; Locke, 1983) support an order dorsal-coronal-labial, and others (e.g. Banczerowski, 1978; Zubritskaya, 1997) support dorsal-labial-coronal. As can be deduced from the preceding section, it seems uncontroversial that dorsals go first; however, these proposals differ in the relative order between labial and coronal. Supporters of the order dorsal-coronal-labial mainly adduce instances of voicing

1 [emphatic velarisation, of which Arabic and Berber give good examples: in contrast to normal consonants, there are some consonants which show, besides their main place of articulation, a rapprochement between the tongue root and the soft palate, which provides the consonant with a particular timbre].

2 Or just the opposite, depending on whether the change is triggered by a strengthening or a weakening process.
processes as an argument in favour of their theory. On the other hand, those who back an order dorsal-labial-coronal base this proposal on a wider range of processes, including degemination, approximantisation, and debuccalisation, as well as voicing. The reason why labials may favour voicing is clear: it is due to the long distance from the place of articulation to the vocal folds. However, the existence of data that may bear out the relative weakness of coronals (as compared to labials) needs further explanation, since logic points to the contrary.

In what follows, I will present articulatory, aerodynamic and perceptual arguments with which I will try to justify why coronals can be weaker than labials.

3.1 Articulatory arguments

Banczerowski (1978: 68-69) suggests that place of articulation is a relevant parameter in determining the strength of a given segment, due to the mass of the corresponding articulatory organ. The lesser the mass, the faster the movements and the shorter the duration of the gesture, which leads to weakness. On the contrary, an organ with a greater mass will move more slowly, the gesture will last longer, and this is likely to contribute to a greater accumulation of intraoral pressure. According to Banczerowski, labials are stronger than apicals, owing to the fact that the mass of the lips exceeds that of the tongue tip.

The same opinion is found in Kaplan (1960: 361), who posits the following order for the articulatory organs, from the fastest to the slowest: tongue tip, jaw, tongue body, and finally, sharing position, the lips and the velum.

When Blevins (2004: 121) comments on the order of diffusion of debuccalisation (and glottalisation) of [p, t, k], she says the following:

The fact that closure durations may differ for stops at different points of articulation means that debuccalisation itself may occur first with the stops of shortest duration, and only later with those whose closure durations are longer. Coronal closure durations can be shorter than those for labial and velar stops, and tongue-tip movements show higher velocities than tongue-dorsum or lip movements.

This means that the weakest sounds with regard to the duration of oral gesture are precisely the likeliest to undergo debuccalisation. The Articulatory Phonology framework predicts that these sounds are the coronals, due to the high velocity of the tongue-tip movement, versus that of other articulatory organs. On the one hand, this prediction suits English data, as glottalisation of [t] has spread in many dialects, whereas for the other places of articulation ‘variation is still found between final [p’/ʔ] and [k’/ʔ]’ (ibid.). Moreover, this statement on place of articulation is specially interesting for us, since it adds arguments in favour of the relative weakness of coronals versus labials.

3.2 Aerodynamic arguments (or the role of the jaw)

Throughout this paper we have been using an aerodynamic criterion to define the strength, namely the level of intraoral pressure, and we have made it depend on the volume of the resonance cavity. However, we have paid attention to only one dimension in determining this volume, that is the horizontal axis from the rear to the front of the mouth. The vertical axis (top to bottom) should also be taken into account, and not only with respect to tongue movements, but also to jaw movements, which are very important, but have been little studied, at least in comparison with other aspects.

If we could prove that coronals are pronounced with the jaw in a relatively descended position, that would be an extra argument to back their weakness. However, there are several studies that point at the contrary (though some clarifications will be made below).
Tuller et al. (1981) ran some EMG experiments with four speakers of American English and checked that ‘during the onset of consonant constriction the mandible was highest for /t/ and /f/; slightly lower for /p/ and lowest for /k/’ (op. cit.: 180). Of course, the range of consonants analysed is too small, but these results are to be borne in mind, because they suggest a larger volume of the resonance cavity for labials (rather than coronals, setting apart the odd case of /f/ – see footnote 3). This larger volume is not only due to the horizontal axis, but also to the vertical one (more precisely because of the jaw movement). As for /k/, even though the jaw is placed in a low position, the volume of the resonance cavity is quite small, this time owing solely to the horizontal axis.

These results agree with those obtained by other authors, such as Brownman (1994), who posits an order \( s > t > p > k \) (from highest to lowest position of the mandible).

Keating, Lindblom et al. (1994) ran another experiment with speakers of English and Swedish, and tested a wider range of consonants: /f, b, t, d, s, n, l, r, k, h/ for both languages (though they recognise that there are quite a lot of differences between the two languages from the phonetic and phonotactic points of view). As a result, they found that ‘in both languages the alveolar obstruents and /f/ are in the higher half of the consonants while /b/, /l/, /k/ and /h/ are in the lower half, but details of the rankings differ’. These rankings are as following:

(5) English: \( s > t > d > r > f > \delta > n > b > k > h \)

(6) Swedish: \( s > t > d > f > n > r > b > k > l > h \)

Lee (1995) provides data on three languages different from the previous ones: Arabic, French, and Korean. Again, coronal consonants are characterised by a higher jaw position than labial consonants, for all three languages. This is true for fricatives and affricates, above all. Labiodental /f/, when tested (only in French), patterns with coronals in jaw height.

On the other hand, several of these authors (e.g. Keating, Lindblom et al. 1994) state that the higher the mandible, the lesser the influence of vocalic context on the jaw height of the consonant. That is, as a norm, consonants display higher positions than vowels but the exact position may vary whether the contiguous vowel is, for example, /a/ or /i/; however, coronals are the least prone to this variation.

Surprisingly, sometimes an alveolar consonant can even reach its highest jaw position when the context is the vowel /a/. Following Imagawa et al. (1985; apud Keating, Lindblom et al. 1994), this is so because the jaw movement reaches such a high velocity to pass from one extreme to the other that the intended target is overshot, and the jaw reaches a higher position than usual.

Such velocity, however, is not exclusive of alveolars. Löfqvist and Gracco (1997) have documented it for labials too.

The lips were moving at high velocities at the instant of oral closure. As a consequence, the lower lip was continuing its upward movement after the closure had occurred. During this time, the upper lip often showed an upward movement that appeared to result from a mechanical interaction between the two lips. [...] This] suggests that the virtual target for the lips in making the stop is a region of negative lip

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3 We will point out certain particularities of /f/ later.
4 This is an articulatory characteristic typical of guttural sounds as a class, although jaw height is always phonologically undefined for gutturals (Goldstein 1994; Nolan 1995).
5 English /l/ is pronounced in quite a backward position in the mouth (it’s a dark /l/), whereas Swedish /l/ is a light one. This explains the different order in the hierarchy between both languages. The most common jaw height, however, must be that of Swedish, according to Stone and Vatikiotis-Bateson’s (1995) explanation that a low position of the mandible is needed to guarantee that the air tube be open in the laterals of the mouth.
aperture – that is, to reach the virtual target the lips would move beyond each other (op. cit.: 891).

In fact, it appears to be the case that a high velocity that guarantees the formation of a complete closure (and thus the build-up of air pressure) is a requisite for all stop consonants, regardless of their place of articulation (ibid.). On the other hand, according to Löfqvist and Gracco (1997), labiodental fricative /f/ is also characterised by a high velocity of the upward jaw movement, which suits the previous data about the jaw height of /f/ patternning with that of coronals. Probably, this is so because of the great compressibility of the tissue of the lower lip. Moreover, labiodental articulation implies a retraction of the lower jaw in order to place the lower lip under the upper teeth. According to Vatikiotis-Bateson and Ostry (1995), there is a correlation between jaw retraction and upward movement (as well as between jaw protrusion and downward movement). I suggest that this correlation may contribute to the relatively high jaw position of /f/.

In general, fricatives show quite a high velocity, though not so high as stops, ‘even when the displacement is of equal magnitude’ (Löfqvist and Gracco, 1997: 891). Continuing this series, we may hypothesize that the mandible movement must be yet slower for approximants. Moreover, we may suppose that the intention is – contrary to stops – to keep the mandible at a relatively low position in order to reduce the contact between the active and the passive articulators. Nevertheless, further research is necessary to verify this hypothesis and to measure the exact positions for each place of articulation (as far as I know, no experiments have been done for approximants).

I would like to suggest an interaction between place and manner of articulation. Coronals show a higher position of the mandible than labials when they are stop consonants, but it may be the reverse when they are approximants. For example, if we think of Spanish stop [d], whose place of articulation is dental, versus approximant [ð], whose place of articulation is interdental, it may be logical to suppose that for the latter the jaw will protrude slightly with respect to the former, in order to favour interdental position of the tongue. Following the same reasoning as for /f/ above (but just the opposite in this case), because jaw protrusion correlates with lowering, the final position of the jaw may be lower for coronal [ð] than for labial approximant [β], for which there is no need of protrusion (nor retraction) to align the upper and the lower lip. However, as said above, all these proposals require further experimentation.

To sum up, the role of the jaw is important in that it helps to define the volume of the resonance cavity (by lengthening or shortening the vertical axis), and thus the level of intraoral pressure. Several authors point out the higher position of the jaw in coronal stops, affricates, and fricatives, with respect to labial cognates. However, we have suggested that this may be the reverse for approximants. Further measurements are needed, but if we could confirm this hypothesis, that would provide an argument for the relative weakness of coronal approximants.

3.3 Perceptual arguments

For Articulatory Phonology, lenition processes that affect manner of articulation (such as degemination, fricativisation, approximantisation, etc.) are explained together with voicing processes as a reduction in the duration of articulatory gestures. Laboratory Phonology has provided the opportunity to empirically check that, by reducing little by little the duration of a sound, the result is successively perceived as a (voiceless) geminate, a (simple) voiceless stop, a voiced stop, and finally a (voiced) approximant.

García Santos (2002) explored the mechanism of these processes in the history of Spanish and tested the relationship between duration and what was perceived. Velars and
bilabials patterned together, whereas the dental series differed considerably from the other two. In the following chart, we provide the optimal durations (in milliseconds) for the perception of geminates, simple voiceless stops, and voiced approximants at all three analysed places of articulation. Between each category, the perceptual threshold is inserted.

<table>
<thead>
<tr>
<th></th>
<th>Geminates (optimal)</th>
<th>Threshold</th>
<th>Voiceless (optimal)</th>
<th>Threshold</th>
<th>Voiced (optimal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEILARS</td>
<td>210</td>
<td>150</td>
<td>95</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>BILABIALS</td>
<td>210</td>
<td>150</td>
<td>95</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>DENTALS</td>
<td>* no info *</td>
<td>210</td>
<td>150</td>
<td>95</td>
<td>70</td>
</tr>
</tbody>
</table>

Table 1

Perceptual effects of duration for velars, bilabials, and dentals in Spanish

As can be seen, these thresholds clearly favour the weakening of dentals much more than that of bilabials or velars, and they do so for a wide range of processes, including degemination and approximantisation, as well as voicing.

4 CONCLUSIONS

In this paper we have illustrated that consonantal strength is influenced not only by manner of articulation and glottal activity (as has been well studied), but also by place of articulation, though this interacts with the former two in processes such as, for example, debuccalisation or passive devoicing, respectively.

Back places of articulation are characterised by a relatively small volume of the resonance cavity, which helps to build up air pressure more quickly, so these consonants are stronger. We have seen some typological consequences of this, such as the trend of consonantal inventories to lack /g/ (or /p/) if some plosive is to be missing. And we have provided examples of linguistic change from several languages in which backward shifts in place of articulation are associated with an increase of strength.

As for front places, we have examined the controversy about the relative order of labials and coronals, and we have offered articulatory, aerodynamic, and perceptual arguments to justify why coronals can be weaker than labials, despite the relatively backward place of articulation with respect to these. The lesser mass of the tongue tip (in comparison with that of the lips) allows faster movements of the articulator, a factor of weakness. Moreover, we have pointed out the need for more studies to take into account the contribution of jaw movements, since the global volume of the resonance cavity is not only defined by the horizontal axis, but also by the vertical one. Several authors support the idea that coronals are pronounced with the jaw in a higher position than labials, at least when the consonant is a stop, an affricate or a fricative. We have suggested that the reverse may be possible for approximants, due to several arguments about jaw velocity and jaw protrusion. However, further measurements are needed. As for the perceptual data, the durational thresholds clearly favour the weakening of coronals versus labials or dorsals.

All these considerations yield the following order of diffusion of linguistic change: dorsal-labial-coronal when the change is triggered by an increase of strength, or just the opposite when it is caused by weakness.
REFERENCES


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