Towards a dynamical representation for gradient allophony of Brazilian Portuguese rhotics

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ABSTRACT

Brazilian Potuguese (BP) rhotics occurring word-initially exhibit a gradient allophony that is prosodically conditioned, i.e., rhotics that are adjacent to strong word boundaries tend to be produced as trill variants. On the other hand, rhotics occurring after a weak prosodic boundary tend to be produced as fricative variants. Phonological models that take categorical primitives, like features, cannot handle with numerical facts, such as the ones we observe. Therefore, we propose a representation for BP rhotics in terms of their gestural scores, following Browman & Goldstein's Articulatory Phonology [1] and also Albano's [2] Acoustic-Articulatory Phonology, in assuming that the gestural scores that represent each variant stay in the lexicon of the language and that the speaker selects one specific gestural score using a feed-forward mechanism, that allows him to "see" the prosodic structure of the sentence.

1. INTRODUCTION

Silva & Albano [3] pointed out that Brazilian Portuguese rhotics occurring word-initially are sensitive to prosodic structure, especially to boundary strength. Data from a BP speaker, who was born in the South Region of the country and was 49 years old at the time of data collection, exhibited a variation among trilled and fricative variants. In the vicinity of strong prosodic boundaries, that were sintactically oriented (see Silva & Albano [3]), he produced a segment tending to a trill, or a "spirantized trill", i.e., a segment that has the acoustic structure of a trill, with oral closures and openings[1], but with some fricative noise superimposed to that structure. On the other hand, in the vicinity of weak prosodic boundary, the speaker produced spirantized trills with more fricative noise superimposed on the trill structure, or a posterior fricative itself. An example of this gradient variation is given in Figure 1 bellow.

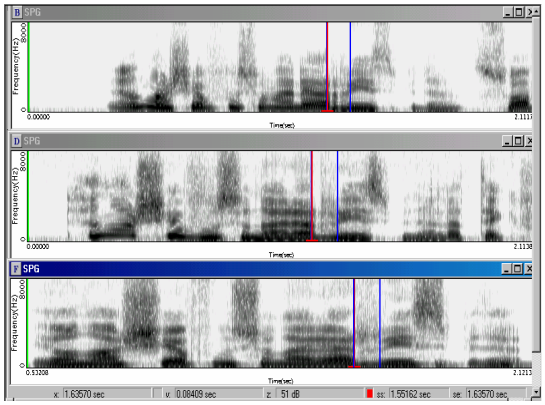

Figure 1 – Upper, between solid lines, alveolar trill; at the middle spectrogram, "spirantized trill"; bottom, posterior fricative, in the clause *funcionária ríspida* ("rispid attendant").

Notice that in the upper spectrogram there is a strong prosodic boundary, elicited by the syntactic relationship between the noun (*funcionária* – "servant") and the adjective (*ríspida* – "severe"): c-command does not apply on the two constituents. The other two spectrograms illustrate the same clause with a different syntactic relationship, i.e., c-command applies on the noun and the adjective. As a result, we expect no prosodic boundary and,

[1] For a more detailed description of the acoustical structure of rhotics, see Recansens [4], relative to Catalan, and Silva [5], relative to BP.

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consequently, a posterior fricative (bottom spectrogram). Spirantized trills, like the one in the middle spectrogram can occur in both conditions, with differing degrees of noise superposition, i.e., in the vicinity of strong prosodic boundaries there seems to be a tendency for those segments to present less fricative noise than in the vicinity of weak prosodic boundaries.

Notice also that there is a *continuum* that departs from a structure with clear oral openings and closures towards a continuous and noisy speech signal. The question, then, is how to "translate" numbers into symbols, since the *continuum* is not random, but depends on the grammatical structure of the language.

Phonological models that adopt categorical primitives, like features, cannot provide such a representation, because of the nature of the primitive. Our proposal, then, is to represent the *continuum* in dynamical terms.

2 – DYNAMICAL REPRESENTATION FOR BP RHOTICS

We base our proposal in two complementary models: Browman & Golstein's [1] Articulatory Phonology and Albano's [2] Acoustic-Articulatory Phonology, assuming, as the first authors, that speech sounds are organized in terms of the articulatory gestures that constitute them. Following Albano [*op. cit.*], we assume that gestures are organized in terms of their "acoustic-articulatory space", and not in terms of sets of articulators, as Browman & Goldstein claim. The main reason for that difference, according to Albano, is that we can infer articulatory characteristics of a speech sound by its acoustic characteristics, but the inverse does not happen. We also assume, in the light of Albano's proposal that gestural scores are all in the lexicon. As a consequence, the speaker can select the gestural score according to the prosodic structure of a sentence.

Another assumption of our proposal is that rhotics are characterized by more than one articulatory gesture, following Sproat & Fujimuras's [6] findings relative to English laterals, i.e., that those sounds are produced by means of an apical gesture, that is responsible for tongue tip action and also a dorsal one, that is responsible for the action of tongue dorsum. This observation is confirmed by Gick [7], who adds that also r-sounds and glides in English are produced by the action of more than one articulatory gesture.

We assume that BP rhotics are characterized by the following gestures: coronal; dorsal; pharyngeal; glottal. Coronal gesture for tongue tip constriction location and for tongue tip constriction degree is responsible for the action of the tip of the tongue, that in the case of trills has to reach the alveolar ridge. We predict that the time of activation of the coronal gesture is briefer than the time of activation of the other gestures. The result of this prediction is a ballistic gesture, typical for trills and taps. We also predict a dorsal gesture to be activated concomitantly to the coronal gesture. The dorsal gesture makes the tongue move in the direction of the palate, making a constriction. Notice that the dorsal constriction is generated by the "critical" description for the gesture. Another prediction our proposal is that the coronal gesture and the dorsal one have the same magnitude, in the case of trills and taps.The prediction of the activation of a dorsal gesture follows directly from Albano [2], who says it is necessarily involved in the production of rhotics, making some constriction in the pharyngeal region of the vocal tract. Also, we predict that dorsal and pharyngeal gestures have the same magnitude and remain activated during an equal time interval. It is worth noting that this is an *ad hoc* decision, since the motor equivalence between tongue dorsum and tongue root still needs to be confirmed in articulatory terms. If they really are equivalent, we can then think of posing a unique acoustic-articulatory region[2]. But this is topic for further investigation.

Finally, the presence of a glottal gesture in the gestural score we propose aims at capturing the identity between trills and glottal fricatives, a fact that has a historical basis, as referred by Callou [8].

An example of the gestural score contrasting taps and trills, according to our proposal, is given in Figure 2 bellow.

[2] Contrary to this hypothesis are the various degrees of vowel aperture, existing, e.g., in English and also in Portuguese.

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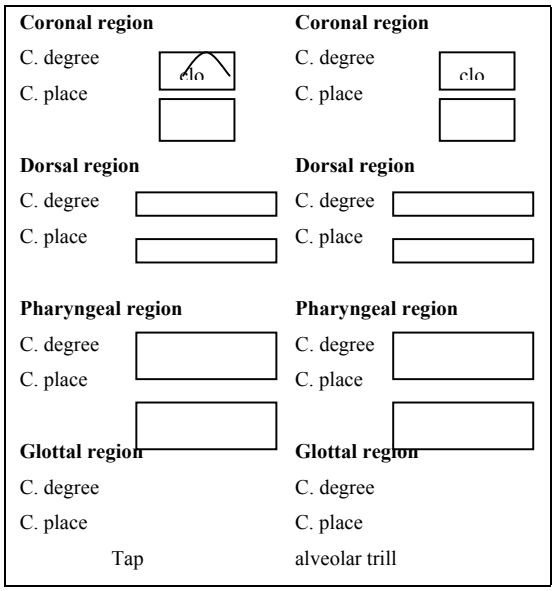

Figure 2 – Gestural score for taps and trills in BP.

According to Figure 2, the only difference between the tap and the trill lays on the damping parameter, i.e., tap is less damped than the trill, which is represented in the gestural score by the senoid specific for the constriction degree of the coronal region for taps. Also, the difference in the magnitude of the gestures in the dorsal region is responsible for no fricative noise superimposed to the formant structure of both taps and trills. Let's turn now to fricatives' gestural score in Figure 3.

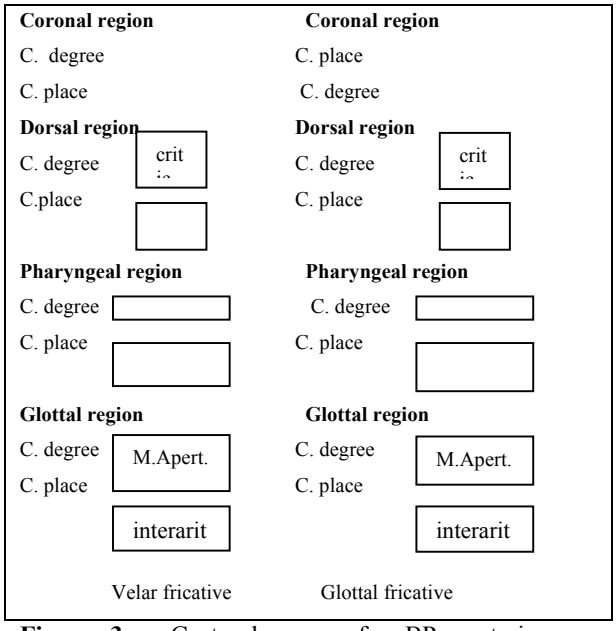

Figure 3 – Gestural scores for BP posterior fricatives.

This proposal follows directly from Albano's Acoustic-Articulatory Phonology [2], except for the fact that it predicts the action of gestures in the glottal region. This prediction attempts to capture the identity among BP fricative variants articulated in the posterior portion of the vocal tract within themselves (a current dialectal fact) and with anterior trills (a historical fact).

Furthermore, the gestural score in Figure 3 introduces a gestural descriptor characterizing the constriction place for the gesture in the glottal region that we called "interaritenoids[3]" and another one, characterizing the constriction degree for the same gesture, the "maximum opening". This is due to the hypothesis that the production of posterior voiced fricatives requires maximum glottis opening, through the arytenoids, in order to reduce air stream.

Differently from the gestural scores in Figure 2, the gestural scores in Figure 3 do not have activated the gesture in the coronal region, although they predict the possibility of its activation. This fact captures the identity of fricative variants and trills, a fact that remains clearly visible in dialects spoken in the South region of Brazil, such as the dialect of our subject who, as mentioned in the Introduction, alternates those variants in word initial position.

Relatively to the identity of trills and fricatives in word-initial position in BP, our proposal predicts that in the dialects that alternate those variants, the gestures in the coronal region decrease in magnitude, concomitantly to the increase in magnitude of the gestures in the dorsal region.

As the activity of the gestures in the dorsal region increases, the fricative noise increases also. Notice that we predict, at the same time, gestural activity for trills and for fricatives. As an acoustical result, we have the spirantized trills, i.e., trills with fricative noise superimposed on their acoustical structure. When the gestures in the dorsal region achieve their maximum magnitude, our prediction says that gestures in the coronal region achieve their minimum magnitude. It follows, then, a fricative sound, since there is the activity of tongue dorsum, only.

So, the data of our subject result from the activation of a gestural score: 1) having the gestures in the coronal region activated, and the gestures in the dorsal region with minimum magnitude; 2) with the gestures in the dorsal

[3] In the case of voiceless posterior fricatives, another gestural descriptor, the "glottal" is predicted, considering that these sounds require a wide-opened glottis.

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region activated with maximum magnitude; 3) with gestures from both the coronal and the dorsal region activated In the first two cases, the result of the gestural scores is a categorical segment, i.e., a trill or a fricative. In the last case, the results are segments that lye in a *continuum* intermediary to the categories. It is worth noting that a natural consequence of the differences in the magnitude of gestures in the coronal region or in the dorsal one is more or less superposition of fricative noise on the trill structure. The speaker selects the lexicalized gestural score according to the prosodic structure of the sentence.

3 – FINAL REMARKS

The proposal presented in this paper takes into account word-initial rhotics, but word-final rhotics still have to be investigated. In that position, BP usually alternates taps and fricatives and, sometimes, especially in forms of infinitives of verbs, /r/ is said to be deleted. The question, then, is to know whether the variation occurring in that position is also gradient and, if so, whether the same gestural scores for word-initial rhotics apply.

Another question that still has to be answered is how the speakers establish the boundaries of the *continuum*. Maybe, according to Albano [2], perception has a very important role on that, but we still do not know how it works. This is one of the next topics of our research

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