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Variation and Change in the Rhotics of Brazilian Portuguese

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VARIATION AND CHANGE IN THE RHOTICS OF BRAZILIAN PORTUGUESE

Iiris Emilia Rennicke

Tese submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em ESTUDOS LINGUÍSTICOS, como requisito para obtenção do grau de Doutor em ESTUDOS LINGUÍSTICOS, área de concentração LINGUÍSTICA TEÓRICA E DESCRITIVA, linha de pesquisa Linha H - Fonologia.

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Resumo

O objetivo desta tese é descrever o *status* e classe fonológicos dos róticos no português brasileiro (PB) falado em Minas Gerais, explorar os fatores que causam mudança sonora, e discutir a direção da mudança. A hipótese adotada é a de que mudanças em vários sub-sistemas da língua contribuem para uma trajetória geral de mudança sonora que atua principalmente através da redução atriculatória e realinhamento articulatório em palavras e construções frequentes no uso (conforme previsto pelos *Modelos de Exemplares*). A premissa desta tese é que a língua é um *Sistema Adaptativo Complexo* que consiste em vários sub-sistemas em constante mudança, podendo contribuir simultaneamente para mudanças graduais no sistema como um todo.

Entrevistas semi-estruturadas e uma tarefa de preenchimento de lacunas foram realizadas com 14 falantes do Sul e Centro-Oeste de Minas Gerais, gerando no total 7,765 contextos para róticos. Os róticos do PB incluem vibrantes, tepes, fricativas, aproximantes e aproximantes aspiradas em ponto de articulação alveolar, palatal, retroflexo/arqueado, uvular, e glotal. O cancelamento dos róticos também é frequente.

Os róticos do PB seguem duas trajetórias de lenição divergentes: uma anterior (alveo-palatal) e uma posterior (uvular e glotal). Ambas as trajetórias podem resultar no cancelamento. Fatores que promovem a lenição incluem a posição postônica, adjacência à fricativa desvozeada [s] e/ou as vogais altas [i ɪ u ʊ], e a posição final de sílaba, que apresenta mais variantes enfraquecidas e cancelamentos de róticos do que qualquer outro contexto. Portanto, a mudança sonora tem começado a generalizar-se nestes *atratores*, e poderá avançar para outros contextos róticos.

Os róticos do PB são mais bem definidos como uma rede de *relações familiares específicas de uma língua*, em que cadeias de reduções e realinhamentos articulatórios estabelecem ligações históricas entre variantes sincronicamente distantes. Como uma classe, os róticos são articulatoriamente e foneticamente não-especificados quanto a traços distintivos, e a sobreposição fonética entre con-

textos fonológicos faz com que o contraste entre variantes seja incompleto. Por este motivo, a representação fonológica dos róticos baseia-se em categorias posicionais sem limites nítidos que abrangem formas fonéticas variadas, e que são constantemente atualizadas em uso.

Abstract

The main objective of this dissertation is to describe the current state and classhood of rhotics in the Minas Gerais variety of Brazilian Portuguese (BP), explore the factors behind sound change, and discuss the direction of change. The hypothesis is that changes in various subsystems of the language contribute to a general sound change trajectory, which takes place mostly through articulatory reduction and retiming in frequently used words and constructions (as predicted by *Exemplar Models*). Language is seen as a *Complex Adaptive System* that consists of several subsystems, all of which undergo change and can contribute simultaneously to gradual changes in the overall system.

Semi-structured interviews and a sentence completion task with 14 speakers from southwestern Minas Gerais yielded a total of 7,765 contexts for rhotics. The rhotics of BP were found to include trills, taps, fricatives, approximants and aspirated approximants in alveolar, palatal, retroflex/bunched, uvular, and glottal places of articulation. Deletions also form a considerable part of the data.

BP rhotics have followed two diverging lenition trajectories: one anterior (alveo-palatal) and one posterior (uvular and glottal). Both trajectories can ultimately lead to deletion. Factors that promote lenition include post-tonic position, adjacency to the voiceless fricative [s] and/or the high vowels [i ɪ u ʊ], and coda position which involves more lenited *r*-variants and deletion than any other context. Once sound change begins to generalize in these *attractors*, it can also spread to other *r*-contexts.

BP rhotics are best modelled as a network of *language-specific family relationships*, in which chains of articulatory reductions and retimings establish diachronic connections between synchronically distant variants. As a class, rhotics are featurally, articulatorily, and phonetically unspecified, and phonetic overlap between contexts makes the contrast between *r*-variants incomplete. For this reason, the phonological representation of rhotics consists of fuzzy positional categories that encompass a variety of phonetic forms and that are constantly updated through language use.

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Iiris Rennicke

Eu prefiro ser
Essa metamorfose ambulante
Do que ter aquela velha opinião
Formada sobre tudo

– Raul Seixas

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Chapter 1

Introduction

1.1 Research topic

The focus of this dissertation is variation and change in the rhotics, or *r*-sounds, of a variety of Brazilian Portuguese (henceforth BP). More specifically, this study explores the factors that have changed and continue to change the rhotics of BP, using experimental data as a basis for phonological analysis.

14 speakers, 7 female and 7 male, were recorded in the town of Lavras, in the southern part of the state of Minas Gerais, Brazil. The speakers come from 9 different localities at a 150 km radius from Lavras, and were students at the Federal University of Lavras at the time of recording. Despite its dimensions, the region in question is thought to be more or less one single dialect area, and this classification is based mostly on coda rhotics (Zágari, Ribeiro, Passini & Gaio 1977; Zágari 1998). The speech data used in this dissertation consist of a sentence completion task, in which the participants filled in missing words in sentences accompanied by related images, and semi-structured interviews.

R-variation will be investigated in the broad context of sound change, the mechanisms and factors behind it, and what sound change in one category tells us about sound change in general. Rhotics, unlike other, more clear-cut sound categories such as stops, occupy a wide range of manners and places of articulation—in fact, rhotics can be considered somewhat of an “elsewhere” category (Scobbie 2006) since they can only be defined in terms of what they are *not* (oral lingual sonorant consonants that are *not* specifically palatal, lateral, or labial). Hence rhotics have a fairly wide articulatory range for variation and change before they begin to obscure phonological contrast. This range suggests that there is no unifying phonological feature for these sounds, and that listeners do not process the rhotics of an incoming speech signal based on features. This dissertation looks into the possibility that we process and store language as word-like units with intertwined form and meaning instead of sound sequences. More specifically, rhotic variation is seen in the wider context of Exemplar Models (e.g. Johnson 1997, 2007; Pierrehumbert 2001, 2002), a theory of speech processing and production that assumes phonological categories are based on multiple phonetic representations. This approach explains sound change at the individual level as automation and consequent reduction of articulatory gestures through repetition over time. Change at the individual level contributes to change at the level of the language system through speaker interaction. The Complex Adaptive Systems approach (Beckner et al. 2009; Bybee 2010; Kretzschmar 2010; Massip-Bonet 2013; Bybee & Beckner 2015; Cristófaro-Silva & Leite in press) will be used to explain how change in subsystems alters language as a whole.

1.2 Why study rhotics?

19% of the world's languages have a contrast between two or more rhotic phonemes (Maddieson 1984, p. 83). Portuguese is one of these languages because it has an intervocalic contrast of rhotics, similar to that of Spanish and other Iberian Romance languages. In BP, what is generally dubbed "weak-r" is an alveolar tap, and "strong-R" is usually a back fricative ranging from velar and uvular to glottal place of articulation. Minimal pairs include, for instance, *caro—carro* ('expensive'—'car'), *era—erra* ('was'/'era'—'errs') and *muro—murro* ('wall'—'punch'). Strong-R also occurs syllable-initially (*rato* 'mouse', *genro* 'son-in-law', *guelra* 'gill'), and weak-r in clusters (*prato* 'plate'). Rhotics are neutralised in syllable coda (*porta* 'door', *lugar* 'place'), meaning that variants associated with either weak-r or strong-R can occur in this context, in addition to other variants. This distribution is summarised in Table 1.1 which lists the three *r*-types, example words, and possible phonetic forms. Coda context includes three options in this table, and they reflect some of the possible variants in different dialects. The distribution of rhotics in BP will be discussed in detail in Section 2.4.2.

Context	Example	Transcription
Strong-R	*rato*	[ˈɦatʊ]
	carro	[ˈkaɦʊ]
	genro	[ˈʒẽɦʊ]
	guelra	[ˈgɛwɦɐ]
Weak-r	*prato*	[ˈpɾatʊ]
	caro	[ˈkaɾʊ]
Coda: neutralisation	*porta*	[ˈpɔhtɐ]∼[ˈpɔɾtɐ]∼[ˈpɔɻtɐ]
	lugar	[luˈgah]∼[luˈgaɾ]∼[luˈgaɻ]

Table 1.1: Distribution of rhotics in Brazilian Portuguese

As has been stated above, rhotics are phonetically very variable. What makes this variability intriguing is that it is often linked to sociolinguistic conditioning: in English, rhotic and non-rhotic varieties may be associated with different sociolinguistic factors depending on the speech community (Scobbie 2006). The case is no different for Brazilian Portuguese: geographical coda variation and the socio-economic stereotypes associated with different regions has led to the stigmatisation of all or some rhotic approximants (e.g. Leite 2004, 2010; Rennicke 2011), whereas alveolar taps and back fricatives are considered more desirable articulations in syllable codas. The data analysed in this dissertation come from an area sitting on a nationwide isogloss regarding coda rhotics (details in Section 4.4). To the southwest of this limit, coda rhotics are usually approximants and/or alveolar taps, whereas to the northeast coda rhotics tend to be back fricatives. Sociolinguistically, it is relevant to point out that in the context of the state of Minas Gerais, the Portuguese spoken in Belo Horizonte is the prestige dialect for most speakers. The existence of two different articulatory tendencies and their impact on speech production and phonological representations is at the core of the present study.

In addition to the geographic and sociolinguistic aspects of *r*-variation, BP rhotics are a compelling case for phonological analysis. How many rhotics does BP have if there is contrast only in intervocalic context, but

19 different phonetic variants (as will become apparent in Chapters 5–7)? This dissertation will discuss, from the point of view of Exemplar Models, how perception, categorisation and production take place in a language with this many *r*-variants that do not share a common phonetic feature.

Sound change in BP rhotics will be inserted into the context of general lenition trajectories that are taking place in the phonology of BP, and more specifically, in coda and in post-tonic position. All syllable-final segments of BP are undergoing lenition in one way or another, and rhotics are no exception. This dissertation will discuss how articulatory reduction has led to coda diversification through the trajectories of approximantisation and debuccalisation, and how the resulting segments coexist in a phonological system.

Lenition is also taking place in all unstressed vowels, but especially in post-tonic position where oxytone words and new consonant clusters are emerging as a consequence of vowel deletion (see Meneses 2012; Cantoni 2013; Dias & Seara 2013; Cristófaro-Silva & Leite in press). This means that the devoicing and deletion of post-tonic vowels and consonants is altering the stress pattern of BP from mostly paroxytone to oxytone, and forcing a re-organisation of the inventory of segments that can occur in (word-final) coda and in clusters. This dissertation will demonstrate that new voiceless, fricative and approximant *r*-variants are emerging in post-tonic intervocalic position, and these new variants can even occupy word-final coda position when post-tonic vowels are deleted. In addition, rhotics can be deleted from unstressed clusters together with the nucleus vowel, which gives rise to emergent clusters in both onset and coda position (e.g. *outros* [ˈowtɾʊs]→[ots] ‘others’, *precisa* [pɾeˈsizɐ]→[ˈpsizɐ] ‘needs [3S]’; ‘is necessary’).

1.3 Experimental approach to phonology

Most of the research on the rhotics of Portuguese relies on pre-established discrete categories into which data is fit perceptually. Consequently, the focus of many studies conducted so far has been that of formalist phonology, contrasted only by the descriptive nature of studies conducted from a phonetics point of view. The innovation of the present study is to analyse sound change in rhotics based on the detailed acoustic analysis of a speech corpus that compares two different speech styles.

This dissertation is constructed on the notion that experimental data is crucial to understanding the phonological patterns of speakers, and that the data should not be forced into discrete categories. Rather, gradient phonetic detail is assumed to be the foundation of phonological representations and sound change. This theoretical framework draws on the methodology and objectives of Laboratory Phonology (Pierrehumbert, Beckman & Ladd 2012; Cohn 2011; Pierrehumbert & Clopper 2010) and Sociophonetics (Foulkes, Scobbie & Watt 2011).

Laboratory Phonology questions the separation of Phonetics and Phonology into two fields: the assumption is that variation is inherent in any cognitive activity, and from this variation we are able to form abstractions. Therefore the analysis of experimental data (as opposed to introspection) is considered essential to understanding how we categorise speech sounds, which in turn implies that phonological categories may not be as clear-cut and based on articulatory labeling as perhaps previously assumed. The phonological interpretation of the results of this dissertation is carried out under the premises of Laboratory Phonology and Exemplar Models: the construction of phonological grammar is assumed to be a bottom-up process involving the same cognitive skills as any other human activity, that is, abstract phonological categories are formed on the basis of phonetic variation.

Sociophonetics, on the other hand, is a field of phonetics that aims at combining the techniques of phonetic studies with the knowledge on human social interaction that the field of sociolinguistics has produced since the latter half of the 20th century. It aims at combining the best of both worlds: attention to the appropriate recording conditions and techniques for the analysis of variation, but also a notion of the speaker as part of an intricate social system influenced by a myriad of factors including but not limited to gender, age, geographical origin, education, ethnicity and speech style. This way the disadvantages of both fields can be avoided: in the case of phonetics, the aim of recording "laboratory speech" (careful pronunciation that is not likely to present the same level of reduction and variation as spontaneous speech) and, in the case of sociolinguistics, the reduction of phonetic variation to pre-established discrete categories ("linguistic" or "dependent" variables) that fit into a statistical analysis of how social factors (“sociolinguistic” or “independent” variables) influence them.

Sociolinguistic methodology is present in this thesis in the choice of participants as well as the speech styles chosen to form the corpus. The participants were controlled for level of education and geographical origin: in order to establish a uniform pool of participants, seven women and men were chosen from a similar education background (university students) and from the same region. The pool of participants is uniform because the aim of this dissertation is not to explain differences in articulation based on social factors, but rather the opposite: how and why variation occurs between individual speakers who are from a similar background, and how this may contribute to sound change. Two different speech styles familiar from sociolinguistic tradition were included in the corpus: semi-structured interview and sentence completion. On the other hand, the methodology adopted for setting up the recording conditions and the acoustic analysis of gradient variation follow common practices in phonetic sciences as far as allowed by the field work conditions.

1.4 Hypothesis and research questions

This dissertation aims at describing the current state of the rhotics of one variety of Brazilian Portuguese, explore the factors behind sound change, and discuss the direction of change. Our hypothesis is that changes in various subsystems of the language contribute to a general sound change trajectory, which takes place mostly through lenition. Sound change in rhotics is expected to be influenced by structural factors (unstressed position, adjacency to certain segments, number of syllables in the lexical item, and distance from word stress), gradual articulatory reduction (by either retiming or reduction in magnitude), type and token frequency of lexical items, speech style, and inter-speaker differences in articulatory patterns, among others. The variety of factors contemplated in this dissertation places this study in the broad context of language as a Complex Adaptive System (Beckner et al. 2009; Kretzschmar 2010; Bybee 2010; Massip-Bonet 2013). This approach proposes that language, being a system in itself, consists of several subsystems, all of which undergo change and can contribute simultaneously to gradual changes in the overall system. This is the motivation for taking all the different factors into consideration: the hypothesis is that several of them contribute to sound change in BP rhotics.

In order to address all these aspects, each phonological context for rhotics will be analysed separately in the data sets obtained from the semi-structured interviews and the sentence completion task. This separation into interview and task data makes it possible to compare the type and level of lenition present in each corpus as an effect of speech style. Within these data sets, there will be an overview concentrating on the structural and articulatory factors causing lenition in rhotics, a section dedicated to the observation of inter-speaker similarities and differences, and a section for the analysis of lexical and frequency effects on lenition.

The results of these analyses will be the basis for further considerations on BP rhotics. The three main research questions of this dissertation all pertain to the phonological status of rhotics in one way or another. First, we are oriented by the question of how to model the rhotics of BP: what constitutes lenition in rhotics, and what are the phonological bases for linking the different rhotic variants? Second, we aim to explore how *r*-variants can be explained as pertaining to the same phonological class of rhotics: is this achieved through a feature-based analysis, or must we consider diachronic and lexical connections? Finally, this dissertation seeks to address previous formalist analyses of BP rhotics based on the data obtained by recording speakers in different settings, and question whether the phonetic reality of rhotics fits into a phonological system with only one rhotic, or if phoneme boundaries can sometimes be fuzzy (Hualde 2004; Mompeán-González 2004; Ladd 2006).

1.5 Dissertation structure

After this brief introduction into the dissertation topic, hypothesis and research questions, chapter 2 explores rhotics as a research topic: what sort of sounds make up this heterogeneous class, how lenition affects rhotics, and what can be said about the past and present of the rhotics of Portuguese and their phonological status. In chapter 3, the theoretical framework of this study—Complex Adaptive Systems, Exemplar Models, Laboratory Phonology, and Sociophonetics—and its application to data analysis will be explained. Chapter 4 covers the data collection and the procedures for analysing the data acoustically, qualitatively and quantitatively. The results are presented in three separate chapters: Chapter 5 presents the analyses for strong-R, Chapter 6 for weak-r, and Chapter 7 for coda rhotics. Chapter 8 presents a discussion of the results and the concluding remarks of this dissertation.

Chapter 2

Rhotics as a Research Topic

This chapter serves as an introduction to rhotics as a research topic from various viewpoints. Section 2.1 reviews authors who have dealt with the classhood of rhotics and the arguments in favour of a class of rhotics. Section 2.2 questions past definitions and applications of lenition in rhotics, and proposes an initial lenition trajectory for rhotics in BP. Section 2.3 introduces different rhotic variants and their phonetic descriptions in BP and other languages. Section 2.4 provides details on sound changes that have already taken place in the rhotics of Portuguese, and reviews the phonological and sociolinguistic status of rhotics in BP. Section 2.5 concludes this chapter.

2.1 Rhotics as a class

Rhotics, or *r*-sounds, are a very heterogeneous group of sounds that are written with the letter R ("rho" in Greek) in Latin-based alphabets. This term based on orthography and not articulatory characteristics is due to the virtual impossibility of referring to these sounds based on the latter. Unlike natural classes in feature-based phonological theories, rhotics cannot be grouped into a single class based on a unifying feature. This is because they occupy a wide range of manners and places of articulation: trills, taps, flaps, fricatives and approximants; and alveolar, retroflex/bunched, and uvular places of articulation. In fact, rhotics can be seen as somewhat of an "elsewhere" category (Scobbie 2006) since they can only be defined in terms of what they are *not*: they are oral lingual sonorant consonants that are *not* specifically palatal, lateral, or labial.

Prior to Lindau's (1985) influential article on cross-linguistic rhoticity, a lowered F3 had been pointed out as a feature common to rhotics. However, Lindau's work on four Indo-European languages and seven West African languages shows that a lowered F3 is simply an indicator of the place of constriction of a rhotic, not of rhoticity *per se*. According to Lindau, a low F3 can be the result of constriction in the postalveolar-palatal region, lower pharyngeal region, or of retroflexion; a lowered F3 can also be produced by liprounding or lowering of the tongue tip. On the other hand, a high F3 indicates an alveolar or uvular constriction.

What in fact seems to unify the members of the rhotics class is the historical connection between sound and letter, and the "family resemblance" between the rhotics. Lindau (1985, p. 166-167) concludes:

> But there is no physical property that constitutes the essence of all rhotics. Instead, the relation between members of the class of rhotics are more of a family resemblance (Wittgenstein 1958). Each member of the rhotic class resembles some other member with respect to some property, but it is not the same property that constitutes the resemblance for all members of a class. Trills and taps are alike as to closure duration, the open phase of a trill resembles an approximant in the presence of formants, and tongue-tip trills and uvular trills resemble each other in their pattern of rapid pulses. Rhotics produced with the same constriction location(s) are alike in the distribution of spectral energy. In the class of r-sounds, member r1 resembles r2, which resembles r3, which resembles r4. Although members r1 and r4 may not be much alike, it is entirely possible to express their relationship as a set of steps across other members. [...] the reasons for membership of sounds in phonological classes must be sought in the phonological behavior of the sounds, and the relation between phonological and phonetic classes is considerably more complex than the one-to-one relation that is generally assumed.

The author provides an illustration of the family resemblances between members of the rhotic class, reproduced in Figure 2.1. The numbers represent articulatory and/or acoustic characteristics that link the sounds included in Lindau's consideration of rhotics. It can be noted that Lindau's selection of rhotic sounds is rather small and certainly does not encompass all the variants found in, for example, Brazilian Portuguese, as will become evident in Section 4.5.2. Furthermore, as pointed out by Sebregts (2014, p. 28–30), this model takes into consideration only synchronic data in establishing the class, when a good deal of information on the relationships is actually to be found in diachronic sound change.

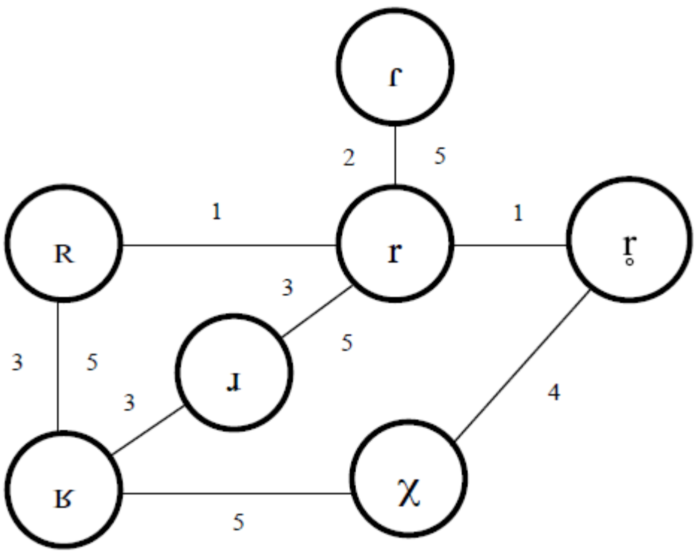


Figure 2.1: Parameter relations among r-sounds (after Lindau 1985, p. 167). 1 = pulse pattern (trill); 2 = closure duration; 3 = presence of formants (sonorant); 4= presence of noise; 5 = distribution of spectral energy (place of articulation).

Magnuson (2007) follows up on Lindau's model of family resemblances, adding more possible variants of rhotics and separating their laryngeal/ pharyngeal and oral vocal tract features. This model is illustrated in Figure 2.2. An obvious improvement in this model is that place of articulation appears organized on the horizontal axis, with front articulations to the left and back articulations to the right, and that manner of articulation is organized on the vertical axis, with full closure placed at the top and vowel-like, sustainable articulation at the bottom. Magnuson also makes a distinction between *momentary closure* and *sustainable articulation*, which makes it possible to distinguish taps and trills from one another: they both have *momentary closure(s)*, but only trills can be sustained. In Lindau's model, this was not possible since both rhotics were defined as having a similar *pulse pattern*.

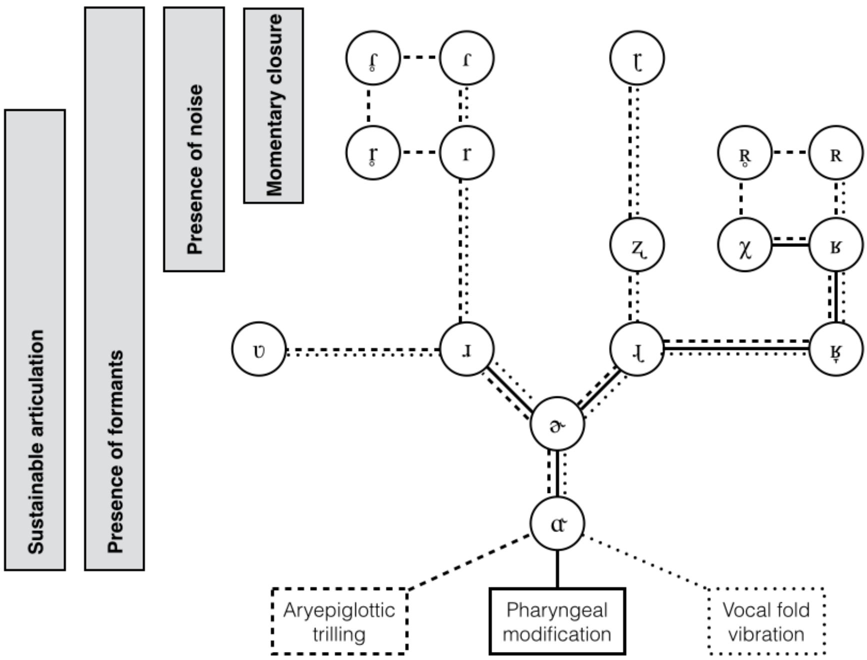


Figure 2.2: Interrelations among rhotics after Magnuson (2007, p. 1195)

Ladefoged and Maddieson (1996, p. 245) elaborate on Lindau's insight of family resemblance. The authors emphasize the fact that the articulatory and acoustic resemblances cannot be the only basis for establishing a class of rhotics, and that diachronic developments are essential to rhotic relations:

> Such family resemblances explain well several of the synchronic alternations and diachronic changes that connect different types of rhotics to each other, but equally close resemblances also extend to many sounds that are not traditionally considered members of the rhotic class. Sounds with similar constriction locations are likely to have similar spectral properties whether or not they are 'rhotic'. [. . .] Although there are several well-defined subsets of sounds (trills, flaps, etc.) that are included in the rhotic class, the overall unity of the group seems to rest mostly on the historical connections between these subgroups, and on the choice of the letter 'r' to represent them all.

Thus the link between different rhotics seems to be a historical one, one of sound change—more specifically, weakening or lenition. According to Barry (1997, p. 41), trills, taps, approximants, and fricatives are "articulatory siblings in different stages of development". This, in turn, is what triggers variation in rhotics synchronically (dialectal and idiolectal variation) and diachronically (sound change over time).

Sebregts (2014, p. 286–288) suggests that, instead of viewing rhotics as a bundle of speech sounds that *resemble* each other cross-linguistically, a more insightful approach would be to use the resemblances attested in one linguistic variety in order to trace and explain historical sound changes. In consonance with Ladefoged & Maddieson (1996), Sebregts sees that the only way to fully understand the rhotics of a particular language (in his case, Dutch) is to combine the methodology of synchronic phonetics and diachronic phonology. This means looking at *relationships* between sounds, as if investigating family lineage, instead of mere *resemblances*. The main point here is that rhotics are not a universal or fixed class of sounds; rather, they form a language-specific class defined by the phonotactics and phonetic variation of the language in question.

According to Ladefoged & Maddieson (1996), some sounds can be considered well-defined members of the rhotics class. These are listed in Table 2.1. However, some sounds may be rhotic in one language and non-rhotic in another. An example of this are back fricatives (e.g. [x χ h]) that are rhotic in Portuguese (variants of strong-R and coda rhotics) but allophones of /x/ (orthographic *j* and *g+e,i*) in Spanish, a closely related language. This comparison illustrates the arbitrariness of the label "rhotic": there are characteristically rhotic sounds such as trills, taps, flaps, and rhotic approximants, but ultimately rhoticity is defined by the phonology of the language under study. According to Scobbie (2006), taps and flaps can be rhotic in a language, but they may also be variants of stops (as in American English *latter* or *ladder* as [ˈlæɾəɹ]), laterals, or nasals. Similarly, a fricative may be the phonetic realisation of a phonological rhotic but it may also be a non-rhotic fricative. Scobbie concludes (p. 338) that, from the point of view of discussing the phenomenon of rhoticity, /r/ or (R) are "labels as good as anything else, so long as we recognize the descriptive and theoretical limitations arising from the use of this convenient international phonetic alphabet or orthographic symbol".

r	Voiced dental or alveolar trill
ɾ	Voiced dental or alveolar tap or flap
ɹ	Voiced dental or alveolar approximant
ɽ	Voiced post-alveolar flap
ɻ	Voiced post-alveolar approximant
ʀ	Voiced uvular trill
ʁ	Voiced uvular approximant
ɺ	Voiced dental or alveolar lateral flap

Table 2.1: IPA symbols for some rhotic consonants, after Ladefoged & Maddieson (1996, p. 216)

The heterogeneity of rhotics even within one single language poses a challenge to feature-based phonological models. Models such as Generative Phonology by Chomsky & Halle (1968) and Feature Geometry by Clements (1985) assume that underlying phonological representations consist of features. They may relate to syllabicity, constriction type, glottal states, manner and place of articulation. In the abstract representation of a sound, that is, a phoneme, these features are thought to be defined in binary values (+/-); the prediction is that no two speech sounds will have the same binary feature specification, and based on this specification different speech sounds are produced and perceived.

Attempts have been made to specify features that justify the classhood of rhotics on a phonological level cross-linguistically. Hall (1997) resorts to the feature [+rhotic], even though he admits that no such phonetic correlate can be identified in all the different rhotics presented as evidence. In a completely opposite approach, Wiese (2001) claims that rhotics are not specified by features at all; they are simply defined as occupying a position on the sonority scale (see Clements 1990) between laterals and glides, as follows:

obstruent < nasal < lateral < rhotic < glide < vowel

The points on Wiese's scale are not defined by features or natural classes. On the contrary, the points on the scale define the classes, such as rhotics. A different proposal by Walsh Dickey (1997) suggests that rhotics do not actually share features, but structure: they have a branching place node, and can thus be specified for both a coronal and a dorsal articulatory gesture.

Sebregts (2014, p. 232–234) points out some problems with these formalist attempts to characterize rhotics. Firstly, Hall's [+rhotic] feature is an *ad hoc* solution because it is unnecessary for any other phoneme and does not constrain the rhotic class: basically any speech sound could function as a rhotic in a language. It is also unclear how the association of the feature [+rhotic] to the surface forms of rhotics could be learned during acquisition. Second, when it comes to Wiese's proposal of defining rhotics as a specific point on the sonority scale independent of features, Sebregts sees that the sonority scale is a purely theory-internal construct if no link to actual articulatory characteristics is assumed. More specifically, he points out that fixing rhotics between laterals and glides is problematic due to the existence of glide and vowel-like rhotic variants in Dutch such as [j], [ə] and [ɐ]. Finally, Sebregts remarks that while Walsh Dickey's definition of rhotics as having a complex coronal-dorsal configuration is accurate in the case of approximant rhotics, taps and trills in some languages, it is difficult to sustain when it comes to purely uvular or pharyngeal rhotics such as those in French or Danish, but also labiodental *r* in English. According to Sebregts, a coronal gesture is likely to be absent from these articulations.

In the case of BP, it could be added that the abundance of fricative realisations for both strong-R and coda rhotics poses yet another challenge to a sonority-based definition of rhotics since they are obstruents and supposedly situated at the far left of the scale, as the least sonorous segments. In addition, the phonetic overlap between different rhotic categories in BP (to be discussed in further detail in Section 2.4.2) suggests that the various rhotics in BP, as different as they may be in articulatory terms, have a historical, phonological connection that cannot be captured by attempting to determine shared underlying features or place them on a sonority scale.

Studies conducted on the acoustics and articulation of rhotics in different languages—such as Delattre & Freeman (1968) on American and British English, Lindau (1985) on several Indo-European and West African languages, Scobbie & Sebregts (2010) on Dutch, and Leite (2004, 2010) on Brazilian Portuguese—have shown that rhotics may have extremely heterogeneous outputs not only cross-linguistically, but also within one speech community. Scobbie & Sebregts (2010) argue that phonological theory has relied heavily on articulatory labels for its categories and assumed broad phonetic transcription as a level of representation in itself, making it convenient to assume that data, which has been prepared at an appropriate level of granularity, are predictable from a simplistic feature specification. In the case of Dutch /r/, the authors conclude that the varying output is the result of a complex pattern of phonological and prosodic contexts in which articulatory and acoustic characteristics interact. In other words, the varying patterns found for the realisation of Dutch /r/ are not the automatic result of some strategy, such as preservation of contrast or ease of articulation, that deterministically alters an underlying feature-specified representation. This is to say that the data suggests there is a lack of determinism in rhotic output; formalist features and rules may be able to *describe* some of the attested phenomena, but can hardly *explain* (predict) them. Similarly, Lindau (1985) suggests that the search for a single phonetic correlate underlying a whole class of sounds (such as rhotics) may be an unprofitable task, and that the relationship between phonological and phonetic classes may not be as direct as feature-based phonological models have assumed.

Exemplar approaches to phonology, to be presented and discussed in Chapter 3, may be able to provide insight into justifying rhotics as a class of sounds. Instead of assuming a fixed, feature-specified underlying representation for speech sounds that is modified by phonological rules in order to generate an output, exemplar models assume that speakers' abstractions of sound structure are probabilistic and word-specific. The position of this dissertation is that rhotics as a class of sounds is justified and defined by the phonotactic and historical connections between the sounds that make up this class in a particular language. All rhotics may not share an articulatory or acoustic feature, but the link between them can be traced back in history based on general pathways of sound change in rhotics. Most of them can be interpreted as lenition, which will be the topic of the following section.

2.2 Lenition in rhotics

Lenition is a term often used in phonology to explain sound change although there does not seem to be a consensus on the definition of what constitutes a leniting sound change. According to Honeybone (2008), lenition groups together at least the following phonetic processes: spirantisation, approximantisation, gliding, debuccalisation, voicing and vocalisation. *Weakening* has been the name used of these processes in the Romance tradition, and *lenition* in the Germanic tradition, and the standard practice in current historical and theoretical phonology is to simply treat lenition and weakening as synonyms.

Sebregts (2014, p. 26–27) notes that the concept of lenition has been approached from both a phonological and phonetic point of view. A more phonological view on lenition usually attributes features or sonority values to sound classes, and then places these classes on a scale of abstract strength *versus* weakness. On the other hand, a phonetics-based approach sees lenition as decrease in the articulatory gesture or in the articulatory complexity of a segment—interestingly, even these two phenomena can be contradictory. In the following sections, some phonological and phonetic accounts of lenition will be presented, and the possibility of considering the retraction of rhotics from an alveolar to uvular place of articulation as an instance of lenition will be assessed. As a conclusion to this section, a possible solution to defining lenition in the case of rhotics will be elaborated.

2.2.1 Phonological approaches to lenition

Lenition has been of interest to phonological theories such as Dependency Phonology and Feature Geometry. General lenition trajectories of consonants posited under these frameworks usually only consider stops as the starting point from which fricatives, approximants and, ultimately, elision arise. Quite surprisingly, rhotics of any kind are often absent from these trajectories. This is, perhaps, due to the fact that obstruents are somehow "prototypical" consonants that are weakened to approximants, after which the final stage of lenition is deletion. It also becomes apparent that lenition models based on the English language mostly only consider rhotics to be approximants (and therefore conveniently situated in the same manner of articulation and/or point on the sonority scale as other approximants). In addition, the possibilities of rhotic variation in an English-based lenition model are mostly limited to the observation of presence *versus* absence of rhotics in syllable codas (rhotic and non-rhotic varieties) as opposed to gradient allophony.

In the lenition trajectories by Lass (1984) within the Dependency Phonology framework, lenition is due to changes in one or both of the following parameters: a) *openness* (decreasing resistance to airflow) and b) *sonority* (increasing output of periodic acoustic energy). Stages of lenition can be ordered as follows (movement to the right is lenition, and movement to the left is fortition):

(1) a. stop < affricate < fricative < approximant < glottal fricative < zero
  b. voiceless < voiced

Lass explains that in a) each step to the right increases the permeability of the vocal tract to airflow as the constriction is opened, but he does not provide a clear explanation of how voicing constitutes lenition, other than the fact that "the frequency with which the change voiceless -> voiced is a precursor to opening of stricture argues for an essential similarity" (p. 177). In terms of Dependency Phonology, lenition is explained as an increase in |V|-prominence (i.e. periodical vocal-fold output or turbulence with some degree of formant structure) and a decrease in |C|-prominence. According to Lass, this is a way of explaining lenition in terms of something more precise than the "resistance to airflow" criterion. The author presents a simplified lenition scale (p. 283) from which approximants and glottal fricatives are absent (unlike in Example 1), but in which liquids are included:

(2) voiceless stop < voiced stop < voiceless fricative < voiced fricative < liquid < vowel

An initial problem in applying Lass' lenition trajectories is that rhotics either do not appear at all in them (Example 1) or they appear as the last stage of weakening (included in "liquids" in Example 2) before vocalisation. Nevertheless, as will be pointed out in Section 2.4.1, Portuguese strong-R and weak-r present diachronical and synchronical changes from trills and taps to fricatives and approximants which are clearly instances of lenition, not fortition. It is counter-intuitive to consider, for example, that a fricative or approximant articulation of an alveolar trill or tap is fortition considering that the latter involve full contact with the passive articulator (alveolar ridge) whereas the former do not. It is known that the configuration needed in the articulation of a trill—stricture size and airflow—has to fall within critical limits: the slightest deviation will cause the trilling to fail, and as a result, trills tend to vary with non-trilled articulations (Ladefoged & Maddieson 1996, p. 217). The same problem follows from the lenition trajectory proposed by Anderson & Ewen (1987), illustrated in Example 3. Again, fricatives are considered "stronger" than trills.

(3) voiceless plosive < voiceless fricative/voiced plosive < voiced fricative < trill < approximant < vowel

Another approach to lenition is the Sonority Cycle principle, introduced by Clements (1990) under the Feature Geometry framework with the aim of explaining why certain types of segments are more common in certain positions in a syllable, i.e. why lenition or fortition is more common in these positions. According to Clements, the sonority profile of the preferred syllable type rises maximally at the beginning and drops minimally at the end. Sonority is derived from basic binary categories (identical to SPE major class features in Chomsky & Halle 1968, supplemented with the feature [approximant]). The sonority scale based on major class features is illustrated in Example 4.

(4) obstruent < nasal < liquid < glide < vowel

The problem with Clements' definition of the sonority of segments is that it does not assign different sonority profiles to taps and trills, but rather groups them together under liquids. Similarly to Lass (1984) and Anderson & Ewen (1987), Clements' sonority cycle also considers fricatives as "stronger" than liquids. It is possible that, based on the English language, Clements defines *liquids* as consisting only of approximants.

Bonet & Mascaró (1997) make use of the Sonority Cycle in order to analyse the status of Spanish, Catalan and Portuguese rhotic phonemes. The authors explain the distribution of the two main variants, trill (strong-R) and tap (weak-r), as follows (p. 108):

> In the onset, the choice of the rhotic depends on its onset internal position. The trill (never the flap) occurs in syllable initial position, when it is the only element of an onset. On the other hand, the flap (never the trill) occurs in second position of an onset. The fact that the opposite distribution is never found is understandable if one can relate the trill and the flap to different positions in the sonority scale. If the flap, like glides, is more sonorous than the trill, which could be considered close to the obstruents in sonority, it is natural that the trill occurs as the only element of an onset, while the flap appears, like glides (or laterals), as the second element of an onset.

In light of this information, the authors propose the following sonority scale for Catalan:

(5) obstruent/trill < nasal < lateral < glide/tap < vowel

Therefore, the sonority increase in the transition from syllable-initial trill to a vowel will be maximal, and the sonority decrease in the transition from a vowel to a coda tap will be minimal, thus respecting Clements' Sonority Cycle principle. The sonority scale by Bonet & Mascaró (1997) based on phonotactics equates glides (or approximants) and taps to the same level of sonority, but in terms of articulatory effort or resistance to airflow as indicators of "strength", this position is difficult to justify: taps are produced with a full contact with the passive articulator, whereas approximants are vowel-like sounds with no articulator contact. On the other hand, Bonet and Mascaró situate trills at the same sonority level as obstruents (stops, affricates and fricatives) which seems correct in the sense that trills do include a full articulator contact much in the same way as stops. However, by assigning the same sonority level to trills and fricatives, this scale cannot be used as such to analyse the weakening of trills by frication, a diachronic change in Portuguese.

The trill and the tap are closely related rhotics in Portuguese (see Section 2.4.1 for details): in fact, the trill—tap contrast still present in some varieties of Portuguese derives from a former contrast between single and geminate trills. While the articulatory mechanisms of trills and taps are different, they can be considered perceptually closely related variants (Barry 1997). It would seem logical to place the tap and the trill, both full-closure articulations, close to each other on a lenition scale, followed only then by fricatives and approximants. It becomes evident that the Sonority Cycle is a feature-based tool that derives the relative "strength" and "weakness" of segments from the positions they occupy in the syllabic structure of a language. It is therefore an *ad hoc* definition of "strength": segments are strong because they more often than not occur in certain positions, and not because of the vocal tract configuration needed in their production.

The abstract approaches to phonological strength presented in this section, based either on vocalic/consonantal elements of which a segment is composed or SPE features, do not seem articulatorily precise enough in order to explain the sound changes already attested and in progress in the rhotics of BP. The next section takes a look at articulation-based approaches to lenition.

2.2.2 Phonetic approaches to lenition

Bauer (2008) remarks that lenition can be analysed as either the *outcome* of a sound change or the articulatory *process* that leads to the sound change in question. As we can see, the phonological approaches presented in the previous section concentrate on the resulting segments and their inherent properties compared to those of the original segment, but not on the actual articulatory change that lead to the resulting segment.

If we look at the articulatory factors behind sound change, authors such as Browman & Goldstein (1986; 1992), Mowrey & Pagliuca (1995) and Bybee (2001) consider that segmental reduction is caused by two types of changes in muscular activity patterns: *substantive reduction* (by which bursts of muscular activity diminish in amplitude), and *temporal reduction* (by which bursts of muscular activity become temporally more contiguous). In the case of consonants, an example of substantive reduction would be the change from a stop to a fricative or approximant in which the gesture to produce a full-closure articulation is reduced to an articulation with airflow (turbulent or periodic). An example of temporal reduction would be the nasalisation of a Vm∼Vn sequence to Ṽm∼Ṽn, where the velum begins to be lowered before the consonant constriction, resulting in an overlapping of the vowel and nasal gestures. The motivation for *why* the magnitude of articulatory gestures is reduced in spontaneous speech will be discussed further in Section 3.2.

Bauer (2008) sees lenition as simply articulatory underachievement since this definition provides a clear phonetic correlate and simultaneously allows the inclusion of both voicing and devoicing into the concept of lenition, as long as they occur in the appropriate environments. He underlines the importance of not confusing lenition as a process with phonological contexts likely or unlikely to undergo lenition. The important insight here is that lenition should be understood in context: a sound change, such as voicing of a voiceless stop, may be lenition in an intervocalic context, but fortition in word-final position. Bauer also points out that articulatory undershoot does not necessarily lead to a less complex articulation: it seems contradictory that the change from an intervocalic stop to fricative indeed implies a gestural undershoot, but actually results in an articulation arguably more complex and precise than a stop. Therefore the articulatory complexity or inherent "weakness" of the resulting segment should not define lenition; instead, the definition must be based on the process.

In this dissertation, lenition is seen as articulatory undershoot that manifests itself as both substantive reduction and temporal reduction. Lenition in rhotics needs to be assessed in the phonological context in which it occurs: the trajectories of word-initial and intervocalic rhotics as well as those in clusters and in word-medial and word-final coda are clearly different in the variety of BP under study. In addition to the mentioned phonological contexts for rhotics, an additional level of analysis is forced by the contrast between strong-R and weak-r, originally one of only duration, but currently one of duration and place of articulation (see Section 2.4.1).

2.2.3 Is retraction weakening?

The historically attested retraction, or backing, of alveolar trills to uvular trills in several Western European languages, such as French, German, Dutch, Danish, Swedish, Norwegian and Portuguese, calls for a reflection on the motivation behind such a sound change.

Alveolar trills [r] are the norm in many languages, but they are also articulatorily complex. The tongue body needs to be stiff, and the tongue tip has to be positioned close enough to the alveolar region so that a sufficiently strong current of air passes through the aperture (Ladefoged & Maddieson 1996, p. 217). The need to simultaneously tense the tongue blade and relax the tongue tip is difficult for some speakers, and in speech communities where alveolar trills are the norm, speech therapy may be offered to correct deviant pronunciations (Barry 1997).

In Sebregts' view (p. 135), the link between alveolar and uvular trills lies in perceptual similarity during acquisition and the lack of contrast between the resulting uvular trill and other segments. Both alveolar and uvular trills have a similar pulsing pattern (although there are acoustic differences: uvular trills have a higher third formant and may be longer than alveolars; see Ladefoged & Maddieson 1996, p. 226 for more details) that a child strives to produce during acquisition. In addition, even if the individual acquires the "wrong" trill (i.e. a uvular trill instead of an alveolar), it usually persists into adulthood because it does not threaten the system of contrasts in the language. This view is supported by data on the acquisition of alveolar trills in Finnish. Jokela (2000, p. 56–58) found that in 93 children between 6 and 8 years of age with an *r*-related speech defect, the four most common strategies for articulating Finnish [r] were the uvular trill (40 children, or 43%), lateral approximant (16 children, or 17%), alveolar fricative (14 children, or 15%), and substitution with another speech sound (13 children, or 6%). The author concludes that the uvular trill [ʀ] is the most frequent strategy for children to mimic the alveolar trill, and more importantly, it is a consistent substitute in children who have not received speech therapy. In other words, early on the uvular trill becomes a categorical substitute for the alveolar trill, and as Jokela adds, this is difficult to correct due to the lack of contrast with any other segment. For a review of other languages in which speech defects related to alveolar trills and the occurrence of uvular trills in individual speakers have been attested, see Sebregts (2014, p. 134–135).

Recasens (2002) argues that there may also be an articulatory connection between alveolar and uvular trills. Recasens sees the retraction of alveolar trills in Romance languages as a strategy for reducing tongue tip tension and resistance to airflow by hollowing the tongue body and elevating the postdorsum towards the soft palate. However, Recasens stresses that this is not an instance of weakening as articulatory reduction, since an electropalatographic study of Catalan alveolar trills demonstrates that these segments are not prone to significant coarticulatory changes in the alveolar contact or the low position of the tongue dorsum in onset or coda position (Recasens 2004). A UTI study by Rivera-Campos & Boyce (2013) also showed that most speakers of different Spanish dialects articulate the alveolar trill with a lowered predorsum, and a retracted (towards the back wall of the pharynx) and lowered postdorsum, while the only constriction is in the apico-alveolar region. However, some of the observed speakers produce trills in which there is a pharyngeal or dorso-pharyngeal constriction instead of an apico-alveolar constriction. In these articulations, trilling is not produced with the tongue tip, but with one lateral side of the tongue while the other lateral is held against the teeth. The tongue tip can be very low in these lateral trills at the same time that a constriction is formed in the dorsum. The participants were consistent in producing either tongue-tip trills or lateral trills, and both trill types were judged perceptually correct by Rivera-Campos & Boyce (although the rate of closure phases in lateral trills seemed perceptually faster than in tongue-tip trills).

Thus the alveolar trill is a complex sound during acquisition, which may lead to its substitution by uvular articulations. Even when an adult produces a non-uvular trill, different articulatory strategies may be used, forcing constriction in either the tongue tip or the dorsum. However, a secondary or alternative elevation of the tongue body does not explain such a categorical change of the trilling body mass (from tongue tip to uvula); rather, it is probable that a perceptual factor is involved in addition to the easing of articulatory complexity. Although the guiding principle of this dissertation is that all sound change finds its motivation in articulatory reduction by adults who have already acquired language, we have presented arguments here in favour of considering the emergence of the uvular trill in languages such Portuguese as perceptually and perhaps acquisitionally motivated. According to Bybee (2001, p. 203), substitutions that persist into late stages of acquisition can have a permanent effect on language. This seems to be the case in, for instance, Finnish children who have been found to still produce uvular trills at 6–8 years of age. A dialectal corpus of European Portuguese (see Section 2.4.1) also suggests that in this macro-variety of Portuguese, alveolar and uvular trills are categorical trill variants in variation with uvular and velar fricatives. To our knowledge, no articulatory studies have been conducted on *r*-production in any variety of Portuguese, which is why the possible articulatory link between alveolar and uvular trills (and between alveolar trills and velar/uvular fricatives) remains unexplored.

In terms of lenition, there is insufficient evidence to consider the backing of alveolar trills to be the result of mere articulatory undershoot. It is more likely that the relationship between alveolar and uvular trills is akin to that between alveolar trills and taps: the two variants are perceptually similar, but the change from the former to the latter is not achieved directly by substantive (decrease in gesture magnitude) or temporal reduction (decrease in time and/or overlapping of gestures). Rather, the latter is an articulatory reinterpretation of the former, produced with different articulatory gestures. The trill-tap relationship will be discussed further in Section 2.3.2.

In addition to articulatory, perceptual and perhaps acquisitional motivations, it is likely that the social prestige attached to the uvular trill was a deciding factor in its propagation across 17th-century Western Europe (Chambers & Trudgill 1998), and 19th-century Portugal and Brazil (Barbosa 1965; Noll 2008; see Section 2.4.1.2).

2.2.4 A lenition trajectory for rhotics

In light of the definition of lenition as articulatory undershoot, justified in the previous sections, and the conclusion that retraction from alveolar to uvular trills does not constitute lenition in these terms but can be considered an articulatory reinterpretation, we may begin to sketch a model for the lenition of rhotics in Brazilian Portuguese.

Sebregts' (2014) dissertation on the rhotics of Dutch offers a significant contribution to the analysis of rhotics as a class and the lenition trajectories they undergo. The model is illustrated in Figure 2.3. The key insight in Sebregts' model that builds on the rhotic resemblance models by Lindau (1985) and Magnuson (2007) is that of adding a historical dimension, one of *relationships* between the variants instead of mere *resemblances*. This adds a new level of connections, since variants with no apparent resemblance can be linked through a historical connection, be it perceptual or articulatory. Here lies another innovation in Sebregts' model: the type of relationship (articulatory, aerodynamic and/or perceptual) as well as the origin (acquisition or casual speech) appear between linked rhotics. Therefore the model succeeds in capturing the complex connections between members of the rhotic class that cannot be explained simply as resemblances. In addition, Sebregts' model organizes rhotics according to place of articulation (on the x-axis) and manner of articulation (on the y-axis).

There are two relationships defined as mostly perceptual in Sebregts' model. The first is the relationship between alveolar trills and uvular trills, already discussed above. The second is that between alveolar trills and taps. As will be discussed in the following section, the articulatory mechanisms for producing the two sounds are different: trills are produced with the aid of the Bernoulli effect, creating repeated contacts of the tongue tip against the alveolar ridge, whereas taps involve a "ballistic" movement of the tongue body and only one contact with the alveolar ridge. Therefore a tap cannot be considered a reduced trill, but the two sounds are perceptually quite similar, and the gesture involved in the production of a tap is certainly less complex than that of a trill (Barry 1997).

Moving downwards in Sebregts' model in the direction of lenited forms, we find fricatives that can be considered reduced forms of alveolar and uvular trills according to the criterion of articulatory undershoot. Sebregts (2014, p. 339) explains that "their origin lies in the trade-off between the tight phonetic constraints that apply to trill production and the common processes of (temporal and gestural) reduction that take place in casual speech". The next stages of lenition, approximant and vocalic variants, are situated in the bottom half of the model. The shift from a fricative to an approximant implies, once again, articulatory reduction and opening of the aperture through which air flows. In the case of Dutch, Sebregts makes a distinction between "consonantal" approximants ([ɹ] and [ʁ̞]) and "vocalic" approximants ([j] and [ɻ]). The "consonantal" approximants are very similar to the alveolar tap and uvular fricative, respectively, and occur

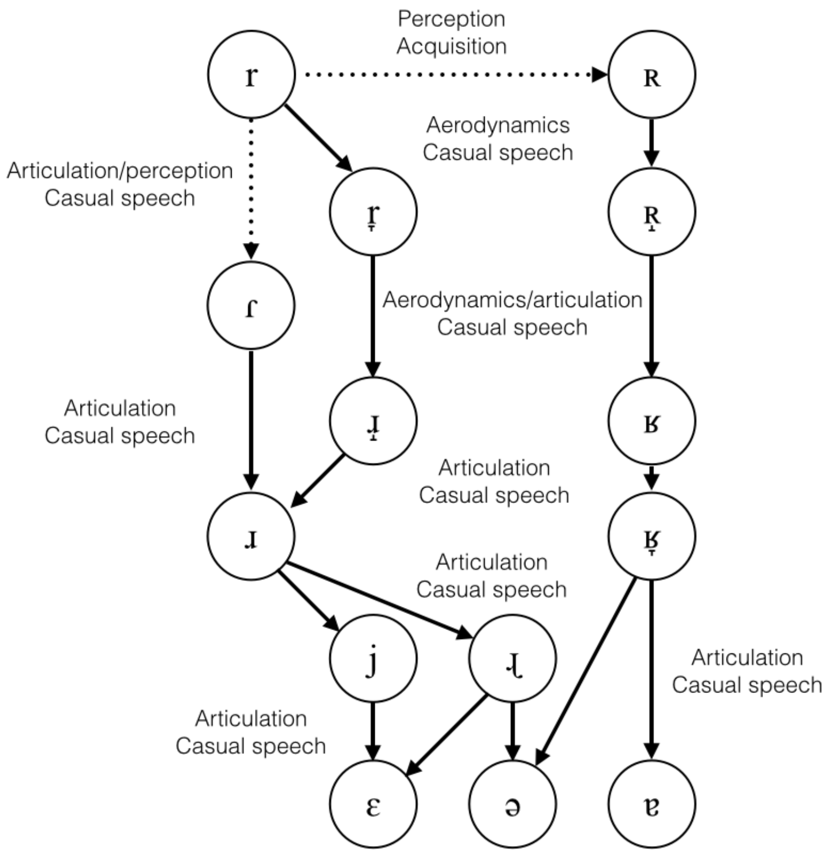


Figure 2.3: Family relationships between Dutch rhotic variants after Sebregts (2014, p. 281). Place of articulation on the x-axis, manner of articulation on the y-axis.

mostly in onsets. The "vocalic" approximants, in contrast, occur in codas, as do the fully vocalic variants (bottom row of Figure 2.3).

However, Sebregts sees that the lenition approach runs into trouble in the case of the retroflex/bunched approximant [ɻ]. This articulation is characterized by a low third formant, which can be produced with either retroflexion or bunching of the tongue body. The first problem is that an ultrasound study conducted by the author revealed that this articulation is relatively complex, as it involves at least two constrictions. This makes it difficult to defend its origin as a lenited form of the alveolar approximant. The second problem is that [ɻ] was a categorical coda allophone for Dutch speakers, meaning that it is not part of a continuum with other coda rhotics. Yet another problem is that [ɻ] was a coda variant both for speakers with alveolar rhotics in onsets, and speakers with uvular rhotics in onsets. Therefore assigning an origin by lenition to the retroflex/bunched approximant is questionable. Nevertheless, an acoustic link can be found between [ɻ] and some realisations of more "consonantal" apical rhotics such as trills and taps: they all have a lowering third formant. In addition, Sebregts finds that the gestural configuration of a retroflex approximant can be considered a reduced (more vocalic) variant of other alveolar rhotics, and cross-linguistic patterning suggests the retroflex/bunched approximant should be grouped under front and not back rhotics.

Sebregts argues that the more bunched configuration of [ɻ] in Dutch speakers is perceptually similar to, though articulatorily quite different from the more retroflex configuration: they both show a low third formant or a close proximity of the second and third formant, and they cannot be reliably distinguished in acoustics-only data.

Finally, the palatal approximant [j] and the three vocalic variants are strongly context-dependent in Sebregts' data, as they occur mostly in absolute word-final position and after front vowels.

In light of these relationships between rhotic variants in Dutch we can begin to plot an initial model for rhotic lenition in BP. As a starting point we can place known variants of rhotics in any phonological context into a flow chart, bearing in mind the relationships and lenition trajectories suggested by Sebregts (2014). An initial proposal for sound change trajectories of rhotics in BP can be found in Figure 2.4. Variants that are included in this model but not in the one concerning Dutch are the approximant tap, glottal fricative, and deletion. A more detailed discussion of the included variants as already attested rhotics in BP can be found in Section 2.4.

What is essential at this point is to establish the parameters according to which lenition is defined in the case of rhotics. In Figure 2.4, we assume that articulatory undershoot turns alveolar trills and taps into fricatives, and fricatives into approximants, and any variant can also be deleted. A

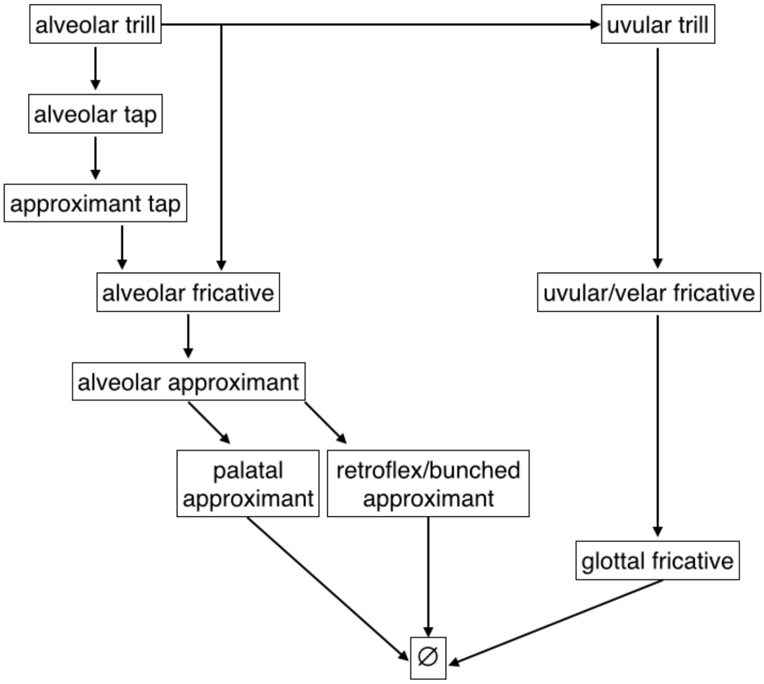


Figure 2.4: Initial proposal for sound change trajectories in BP rhotics

different type of relationship that most likely involves a perceptual aspect in addition to articulatory motivations can be traced historically between the alveolar trill and the alveolar tap, and also between the alveolar trill and the uvular trill.

2.3 The Articulation and Acoustics of Rhotics

This section is dedicated to an overview of the articulatory mechanisms and acoustics of rhotics in Portuguese and other languages. It covers trill, tap, fricative, and approximant rhotics, as well as vocalic variants.

2.3.1 Trills

Trills are produced with a vibration of one articulator against another. Rhotic trills can be either alveolar, when the tongue tip vibrates against the alveolar ridge, or uvular, when the uvula vibrates against the tongue dorsum. The mechanism used to produce trills is essentially the same as vocal fold vibration during voicing: rather than a muscular action controlling each vibration, an adequate airflow must run through a sufficiently narrow aperture. As Ladefoged & Maddieson (1996, p. 217) point out, this is why trills are often in variation with other, non-trilled variants: the slightest deviation in airflow or tongue position will cause trilling to fail, and leads to a fricative or approximant articulation in the constriction location. The duration, number of closures and voicing of a trill may vary depending on the language and speech style. Cross-linguistically, alveolar trills are much more common than uvular trills, which rarely occur outside Western Europe (Ladefoged & Maddieson 1996, p. 225).

Acoustically, trills appear in a spectrogram image as a succession of light vertical bars (corresponding to closure phases) and darker vertical bars (corresponding to the open or vocalic phases). Uvular trills tend to have a much higher third formant than alveolar trills, and uvular trills may be slightly longer than alveolars (Lindau 1985).

In Portuguese, trills can be found in some dialects of Portugal and Brazil. In the case of Portugal, Mateus & D'Andrade (2000) state that some speakers still use the uvular trill and alveolar trill in dialects other than that of Lisbon. In fact, Rennicke & Martins (2013) discovered that both the alveolar and uvular trill are rare in a dialect corpus covering all of Portuguese territory, and seem to be replaced by uvular and velar fricatives. Alveolar trills were found in Northern Portugal and the Algarve, whereas uvular trills occurred in Northern and Central Portugal. Interestingly, individual speakers in the corpus used only one type of trill, either alveolar or uvular, and never both. In BP, alveolar trills occur as variants of strong-R and in syllable codas in Southern Brazil and São Paulo (Cristófaro-Silva 2013, p. 39; Callou, Moraes & Leite 1996; Brescancini & Monaretto 2008; Noll 2008).

2.3.2 Taps and flaps

Taps and flaps are sounds produced with the tongue tip. They differ from trills by having only one closure, which appears as a light vertical bar in a spectrogram image, and also by the tongue position needed for their articulation. Ladefoged & Maddieson (1996, p. 230–231) distinguish between taps and flaps: in the articulation of a tap, the tongue tip is moved directly towards the alveolar ridge, whereas flaps are produced with a tangential strike of the tongue tip so that it touches the alveolar ridge in passing. The single-contact rhotic in languages such as Spanish and Portuguese is usually described as a tap.

Although taps are acoustically similar to the closure phases of a trill, the configuration needed to produce taps and trills is essentially different. While trills are articulated with a maintained and prolongable *posture*, taps are produced with a single ballistic flick *gesture* (Catford 1977, p. 130). In other words, a tap requires movement of the tongue body, but in a trill, the tongue body needs to remain fairly firm and unaltered. Therefore, as Barry (1997) points out, simply reducing the time available for a trill does not turn it into a ballistic tap. Barry adds that although a direct articulatory link cannot be established between trills and taps, in terms of diachronic development it can be assumed that in a given language, the tap can be derived from the trill due to perceptual similarity much in the same way as flaps have emerged as intervocalic variants of /t/ and /d/ in varieties of English. There is some evidence that one-tap trills can occur as variants of a trill target in Spanish: Blecua Falgueras (2001) finds that in a synchronic corpus of Peninsular Spanish, alveolar trills can occasionally be produced with only one closure phase (in which the constriction can be complete or approximant-like). Therefore the link between trills and taps could be not only perceptual, but also articulatory: a [r] target can have one-closure variants still produced with the relatively stable tongue configuration of [r], and as the lenition process advances over time, speakers may begin to produce those segments with a ballistic [ɾ] target.

Taps are usually voiced; however, Jesus & Shadle (2005) report a voiceless tapped alveolar fricative variant for European Portuguese weak-r (especially word-finally) and some tokens of strong-R. In the articulation of this variant, there is a very short constriction of the tongue tip against the alveolar ridge that is released, resulting in a low amplitude burst of friction noise.

In most varieties of BP, the tap is limited to intervocalic position (e.g. *caro* 'expensive') and consonant clusters (e.g. *prato* 'plate'). However, it can occur in coda position in Southern Brazil and São Paulo (Barbosa & Albano 2004). In clusters there is usually a vocalic segment between the consonants: Malmberg (1965, p. 39) explains it as a strategy to facilitate the articulation of clusters. Silva, Clemente & Nishida (2006) found that in the Portuguese of Curitiba (Paraná) the formant structure of the vocalic element in clusters is similar to that of the vowel in syllable nucleus; in other words, generally the vocalic element is not a schwa. In this variety of BP taps are found also in syllable coda followed by consonants, and the authors found that unlike in clusters, the vocalic element that emerges between a coda tap and a following consonant can be characterized as a central schwa-like vowel.

Leite (2010, p. 92) finds approximant taps as variants of coda rhotics in the dialect of Campinas. She describes these segments as having formant structure comparable to that of vowels. The difference between taps and approximant taps would then be that taps proper show up as an interrupted spectral shape (due to the full articulator contact), whereas the formant structure of an approximant tap is regular and continuous, yet at a lower amplitude compared to vowels.

2.3.3 Fricatives

Fricative rhotics can be alveolar, uvular/velar and, in the case of BP, glottal. They all have in common the fact that they are produced with turbulent airflow passing through a stricture at some point of the vocal tract. The noise caused by the turbulent airflow appears in a spectrogram image as random energy distributed over a wide range of frequencies, and those frequencies depend on the exact place of articulation (Ladefoged & Johnson 2011, p. 201, 204).

An alveolar fricative rhotic, transcribed as [ɹ̝] by (Ladefoged & Maddieson 1996, p. 233), occurs in Czech. Compared to the alveolar approximant [ɹ], it is produced with a narrower constriction slightly further forward. Silva (2002, p. 148) finds word-initial alveolar fricatives in speakers from Southern Brazil (Paraná and Rio Grande do Sul) and concludes that there is a continuum between alveolar trills and fricatives: speakers produced trills, trills in which there was one closure followed by friction (called "spirantized" trills by the author) and fricatives. This continuum is evidence for the claim by Ladefoged & Maddieson (1996, p. 217) that trills often have fricative and approximant variants due to the failure to achieve the precise aerodynamic conditions needed for their production.

Fricatives produced in the velar-uvular region are in variation with the uvular trill in many Western European languages, including European Portuguese. Cruz-Ferreira (1995), Jesus & Shadle (2005) and Rennicke & Martins (2013) report voiced and voiceless uvular fricatives and voiceless velar fricatives as the most common variants of strong-R in this variety of Portuguese. Jesus & Shadle (2005) found that the spectral peaks for voiceless uvular fricatives [χ] in European Portuguese occur at 1.0–1.6 kHz, 2.1–2.8 kHz and 3.2–4 kHz. According to the authors, the place of articulation of a fricative is represented in the overall spectral shape: the length of the front cavity is inversely proportional to the frequency of spectral peaks. Therefore, [s] has a broad peak at 8 kHz, [ʃ] at 3.5 kHz, and [χ] at 1.3 and 2.4 kHz. Nevertheless, Jesus & Shadle (2005) do not state for certain that the analyzed fricative tokens are uvular (hence "/r/, realized — as we believe — as [χ]" on p. 35) and not, for example, velar. Acoustic phonetics is not the appropriate tool for finding places of articulation; simple palatography techniques and observation of the speaker's mouth are more useful for this (Ladefoged 2003, p. 159–160).

Uvular and velar fricatives occur in BP as variants of strong-R and coda rhotics. Barbosa & Albano (2004) recorded a 21-year-old female speaker from São Paulo for their illustration of BP in the *Journal of the International Phonetic Association*. They indicate velar fricatives as most common variants of strong-R; they are voiced ([ɣ]) when adjacent to voiced sounds and voiceless ([x]) elsewhere. No acoustic correlates are mentioned as an indication of these fricatives being specifically velar (and not uvular, for instance).

Abaurre & Sandalo (2003, p. 168–169) show a spectrogram image of what they judge to be a velar fricative in word-medial coda produced by a speaker from Rio de Janeiro. The authors argue that a narrowing of the distance between F2 and F3 in adjacent vowels is characteristic of velar consonants, and visible in the example provided. This narrowing is called the "velar pinch" in phonetic literature (e.g. Ladefoged & Johnson 2011,

p. 199).

Although the cited references focus mostly on velar and uvular fricatives as variants of strong-R in BP, according to Callou, Leite & Moraes (2002) the most common variants of both strong-R and coda rhotics in many dialects are glottal fricatives [h]. It is quite rare for glottal fricatives to be associated with the rhotics class since usually they are variants of a non-rhotic back fricative category, such as /h/ in English or /x/ in Spanish. The sound changes that lead original alveolar trills to be articulated as glottal fricatives in BP will be further discussed in Section 2.4.1.

Barbosa & Albano (2004) describe the São Paulo strong-R as velar, but state that it can be realised as a glottal fricative in weak prosodic positions and especially in casual speech. Abaurre & Sandalo (2003) also argue that although the strong-R of BP (and especially of the Rio de Janeiro dialect) is often described as velar, acoustic analysis of data from young (under 40 years old) speakers from different parts of the country reveals that it is most often a glottal fricative. The argument for this is that the tokens of glottal fricatives analysed by the authors show continuous formant structure of the adjacent vowels, without the so-called "velar pinch".

2.3.4 Approximants

Approximants have a vowel-like formant structure because the stricture in their production is wider than in fricatives, hence permitting periodic sound waves. However, approximants tend to show less intensity than vowels. Their formant trajectories can be used to estimate tongue configuration (Ladefoged & Johnson 2011, p. 203–204): the incomplete constriction can be in the alveolar or uvular region, the tongue tip can curve backwards (retroflexion), or the tongue body can be bunched.

The International Phonetic Alphabet includes symbols for two lingual rhotic approximants: the alveolar approximant [ɹ] and retroflex approximant [ɻ] (IPA 2005). There is, however, discussion on the definition and inclusion of the retroflex approximant since articulatory studies have shown that retroflexion is not the only way of producing a post-alveolar rhotic approximant.

According to Ladefoged & Maddieson (1996, p. 233–235) alveolar approximant rhotics are typical of Southern British English in prevocalic position, whereas in most varieties of American English, rhotics can be alveolar, retroflex or "bunched" approximants. The authors claim that speakers of American English combine several articulatory mechanisms to produce a low third formant for whichever rhotic variant they employ. Those mechanisms and their acoustic correlates will be discussed next.

Approximant rhotics often have a lowering third formant (Scobbie 2006). A low F3 can be the result of constriction in the postalveolar-palatal region, lower pharyngeal region, or of retroflexion; it can also be produced by liprounding or lowering of the tongue tip (Lindau 1985). A high F3 is an indication of an alveolar or uvular constriction.

A cineradiographic study of the rhotics in English by Delattre & Freeman (1968) has been essential to understanding the articulatory configuration of approximant rhotics. The authors discovered eight types of tongue shapes in their experimental participants. Two of these are more common in British English, and six in American English. The latter have in common the fact that there are always two constrictions: one at the palate, and one in the pharynx. The types differ in the degree of bunching of the tongue or retroflexion of the tongue tip, and the degree of pharyngeal constriction and lip rounding. The interesting result of comparing the articulatory and acoustic features of the different configurations is that no clear correlation was found between tongue shape (retroflex or bunched) and the lowering of formants, providing evidence for the idea that speakers use multiple strategies to achieve a similar acoustic output. Similarly, an experiment by Gick & Campbell (2003) using video and ultrasound to study the gestural timing of rhotics in several varieties of English (Canadian, American and British) showed that speakers use lip rounding/protrusion, tongue body raising and tongue root retraction in the production of rhotics.

An ultrasound tongue imaging (UTI) experiment was conducted also by Scobbie & Sebregts (2010) (reported also in Sebregts 2014) concerning Dutch rhotics. Of the five studied speakers, three used retroflex or bunched approximants in coda categorically, one speaker alternated a bunched approximant with uvular trills, and one speaker alternated retroflex approximants with alveolar approximants and fricatives. Both bunched and retroflex constrictions were accompanied by pharyngeal constriction. As for acoustic effect, Sebregts discovered that a low F3 is the target also for Dutch coda rhotics, and that, in fact, the two configurations used by the speakers to achieve that target—bunched or retroflex—cannot be identified based on acoustic-only data.

In phonetic and dialectological work on BP, *erre retroflexo* ('retroflex *r*') and *erre caipira* ('hillbilly *r*')—the former articulatorily-based, the latter obviously indicating social stigma (see Section 2.4.3)—have been the terms used for the approximant rhotics that are common in some Brazilian dialects. However, naming these variants retroflex is purely impressionistic because, at least to our knowledge, the exact articulatory configuration has not been studied by means of palatography, UTI or other techniques. In addition, the acoustic correlates of what is called the retroflex *r* in BP vary, especially with respect to the third formant, which is why it can be assumed that the retroflex configuration may not be the only one used. For these reasons, the broad term "rhotic approximant" will be used in this dissertation to refer to these segments in BP.

The first mention, in 1920, of rhotic approximants in BP is by Amaral (1976) in his description of the *caipira* dialect of the São Paulo region. Amaral calls the intervocalic and coda *r*'s to be found in this dialect "linguo-palatal" and "guttural", and explains that the tongue "extremity" (most likely the tongue tip) is elevated, creating a sound similar to the coda *r*'s in English. Decades later, Head (1987) takes up this description, generally interpreted as a retroflex sound, and argues that retroflexion most likely does not encompass all possible ways of producing these peculiar sounds. He explains that in the production of *caipira r*'s, there is a lowering of frequencies where the acoustic energy concentrates due to articulation. He does not specify this any further, but it is safe to assume that he is referring to the third formant. Head goes on to argue that this acoustic effect is due to two possible tongue positions in BP: either retroflexion or raising of the tongue body. This seems compatible with the descriptions of different retroflex and bunched configurations attested in English (Delattre & Freeman 1968) and Dutch (Sebregts 2014).

In the Portuguese spoken in Southern (in the states of Paraná, Santa Catarina, Rio Grande do Sul), Southeastern (São Paulo, Southern and Western Minas Gerais), and Midwestern Brazil (Mato Grosso do Sul, Mato Grosso, Goiás and Rondônia), rhotic approximants occur especially in syllable codas (Noll 2008). Isolated occurrences of rhotic approximants can also be found in Northeastern Brazil, namely in Bahia (Rossi 1965), Sergipe (Ferreira et al. 1987), and Paraíba (Aragão 1984).

Descriptions regarding rhotic approximants in codas have been provided by Penha (1974-1975) in São Domingos (Minas Gerais), Almeida (2004) in Cuiabá (Mato Grosso), Oliveira (2007) in a linguistic atlas of Mato Grosso do Sul, Leite (2004, 2010) in Campinas (São Paulo) and Ferraz (2005) in Pato Branco (Paraná). In the Piracicaba (São Paulo) dialect described by Rodrigues (1974), rhotic approximants can also occur intervocalically (as a variant of weak-r) and in clusters. This pattern was confirmed more recently in the towns of Capivari, Itu, Porto Feliz, Santana de Paraíba, Pirapora do Bom Jesus, Piracicaba and Tietê in the state of São Paulo by Garcia (2013).

The descriptions by Leite (2004, 2010) and Ferraz (2005) are based on acoustic data, and their relevant findings will be summarized here. Leite's (2004) study focuses on the acoustics and sociolinguistics of coda rhotics in the speech of university students from São José do Rio Preto who live in Campinas (both cities in the state of São Paulo), and her (2010) study includes speakers only from Campinas. In the interview data of the (2004) study, Leite finds the following coda variants: retroflex approximant [ɻ], alveolar approximant [ɹ], r-coloured vowel (see Section 2.3.5 for details), tap [ɾ] and palatal approximant [j]. According to the author, the acoustic correlate of the retroflex approximant is a lowered F3 close to F2. The alveolar approximant, on the other hand, has a raised F3 close to F4. In the reading corpus of her (2010) study, the recorded speakers used retroflex approximants, r-coloured vowels and palatal approximants. Leite does not provide an acoustic description of the palatal approximant, but it is apparent from the spectrographic images provided (2004, p. 85; 2010, p. 91) that these segments show rising F2 and F3. This is consistent with the fact that high F2 and F3 are characteristic of the high front vowel [i], the syllabic counterpart of [j] (on average 2250 Hz and 2890 Hz, respectively, in male speakers of American English according to Ladefoged & Johnson 2011, p. 193).

Ferraz (2005) set out to measure the acoustic parameters of rhotic approximants in the Portuguese spoken in Pato Branco (Paraná), with a specific interest in determining if a low F3 was in fact the main feature of retroflex approximants in this dialect. For male speakers, the author could not establish an absolute point of "low" F3 due to the variability: preceded by front vowels, the F3 of coda retroflex approximants was usually above 2000 Hz, but preceded by back vowels, F3 was usually below 2000 Hz. Therefore the acoustic correlate of these segments is better defined in qualitative terms as a *lowered* F3 compared to the adjacent vowel, and not *low*. When compared with tokens of palatal approximants, Ferraz finds that retroflex approximants have an F3 that is on average slightly lower.

Leite (2010, p. 80–82) explains that the difference in the F3 values of rhotic approximants following front and back vowels is due to the fact that the tongue body needs to be retracted—much in the same way as in back vowels—in the articulation of a retroflex or bunched approximant. Therefore if the preceding context is a back vowel, it contributes to an even lower F3 of the following rhotic. On the other hand, the gestures needed to produce a front vowel and retroflexion are quite different, often leading to a reduction either in the degree of frontness of the vowel or in the degree of retroflexion. This type of centralisation and merger to [ɚ] of the prerhotic vowels /ɪ/, /ʌ/, /ɛ/ of Scottish English was studied by Lawson et al. (2013) using ultrasound tongue imaging. They found that in speakers who use a bunched approximant, early in the production of the prerhotic vowel the tongue is already in a configuration and location similar to that of the bunched approximant, and from this point on only minor configurational changes need to be made in order to achieve the bunched target (e.g. raising and fronting of the tongue body, retraction of the tongue root and formation of a dip in the postdorsal region). This sort of coarticulatory influence on the prerhotic vowel was less evident in retroflex approximants, possibly indicating that speakers with non-centralized pre-rhotic vowels may be using a different (i.e. retroflex) mechanism for producing the rhotic approximant than those who produce centralized vowels or syllabic *schwars* (i.e. bunching).

2.3.5 Vocalic variants

A vocalic variant is understood here as either a syllabic vowel-like segment that can be rhotic in nature (often called *r-coloured* or *schwar*), or a neutral schwa-like vowel in syllable coda. They occur as variants of a vowel+rhotic rhyme (hereafter VR).

2.3.5.1 Rhotic vowels

According to Ladefoged & Johnson (2011, p. 94–95), r-coloured vowels can be stressed ([ɝ], e.g. *herd*) or unstressed ([ɚ], e.g. *sister*) in American English, and their r-coloring can be produced in at least two ways: some speakers raise the tongue tip, some elevate and bunch the tongue body, and in addition to one of these configurations there is usually a constriction in the pharynx caused by the retraction of the tongue root. Thus the mechanism is similar to that of retroflex/bunched approximants, described in Section 2.3.4.

In American English, the rhoticity of the vowel may not be evident at the beginning of the vowel, when characteristics of the original nucleus vowel can still be observed. In terms of the vowel space parameters high–low and front–back, the r-coloured vowel can be described as mid-central. (Ladefoged & Johnson 2011, p. 94–95)

The r-coloured vowel has been documented as a rhotic variant in BP by Leite (2004, p. 89–90). She describes this articulation as a vowel that has its formant structure modified due to coarticulation: F2 and F3 are conflated. Rhoticity can be perceived either during the entire duration of the vowel, or only at the end.

2.3.5.2 Non-rhotic vocalic variants

The coda of a VR rhyme can also be cued by a schwa [ə], a central vowel. It occurs in standard BBC English (Ladefoged & Johnson 2011, p. 94–95), with a word such as *there* being pronounced as [ðɛə]. Scobbie (2006) explains that this type of diphthongisation is closely linked to the diphthong-like nature of vowel-retroflex sequences. Acoustically, a retracted or retroflex approximant has long formant transitions flanking it, especially when adjacent to a high or front vowel. These transitions make for a diphthong-like sequence in which the transitions help cue the presence of a rhotic as much as reaching the target does. The retroflex/bunched target can thus be replaced by a centering diphthong, and the link between retroflex/bunched approximants and schwa is established.

Sebregts (2014, p. 248) and Lawson, Scobbie & Stuart-Smith (2015) find schwa-like coda variants for rhotics in Dutch and Scottish English, respectively. Based on ultrasound data, the link between the lingual approximants and schwa in coda seems to lie in a minimal modification of articulatory timing. As the maximal anterior constriction gesture is delayed in relation to the dorsal gesture, the resulting acoustic and perceptual quality is mainly produced by the dorsal gesture. The result is a more evenly spaced formant pattern, corresponding to a neutral vowel, instead of a low F3 or F2/F3 conflation.

2.4 Rhotics in Portuguese

This section takes a closer look at the particularities of rhotics in Portuguese. Section 2.4.1 concerns the sound changes undergone by Portuguese rhotics, Section 2.4.2 reviews the debate on the underlying representation of rhotics in formalist approaches, and Section 2.4.3 provides information on the sociolinguistic status of different rhotics in BP.

2.4.1 Sound changes in the rhotics of European and Brazilian Portuguese

Based on the existing literature, the sound changes affecting the rhotic system in Portuguese can be divided into three main changes. The first of these is the substitution of an intervocalic single—geminate contrast ([r] : [rː]) by a manner contrast ([ɾ] : [r]); the second is the addition of a place contrast ([ɾ] : [ʀ]∼[ʁ]∼[ɦ]) in most varieties of Portuguese. The third concerns the diversification of coda rhotics in BP: depending on the dialect, coda rhotics have either remained apical, retracted to [ʁ]∼[ɦ] much in the same way as strong-R, or developed into a third rhotic category composed of approximants (mainly [ɹ]∼[ɻ]∼[j], as will be explained below).

The two rhotics that contrast intervocalically in Portuguese are usually referred to as *vibrante simples* ('simple trill') and *vibrante múltipla* ('multiple trill') by Portuguese authors, and *r-fraco* ('weak-r') and *R-forte* ('strong-R') by Brazilian authors. Two arguments can be made in criticism to the terminology adopted in European Portuguese: as already discussed in Section 2.3.2, the articulatory mechanism for producing trills and taps is essentially different; furthermore, as stated in Section 2.3.3, the most common variants of strong-R in Portuguese (European or Brazilian) are back fricatives. Therefore taps can hardly be referred to as "simple trills", and "multiple trills" are also almost extinct in these two varieties of Portuguese. Hence a more abstract naming practice, such as the one generally used in Brazilian linguistics, is more permissive of the sort of variation encountered in present-day Portuguese.

However, it must be clarified here that in using weak-r and strong-R, we do not assume that the realisations of either category are inherently "weaker" or "stronger" than those of the other category. These names are simply mnemonics for the two contrasting rhotics, of which one used to be simple/a tap (and consequently "weaker") and the other, geminate/trill (arguably "stronger" or of a more complex articulatory nature). As we will see, however, the realisation of weak-r as mostly tap-like articulations in contemporary BP is undoubtedly articulatorily more complex than the realisation of strong-R most commonly as a glottal fricative, as the former requires full articulator contact whereas the latter does not.

2.4.1.1 From trills to taps

The story of the rhotics of Portuguese begins with a simple—geminate contrast in the intervocalic consonants of Latin. According to Mattoso Câmara Jr. (1953), the Latin *r* was an apical trill that could be either simple or geminate intervocalically (e.g. *ferum—ferrum*). When geminate, the two *r*'s belonged to two different syllables like any other geminate. During the passage from Latin to Vulgar Latin, intervocalic consonants underwent lenition: geminates turned into simple consonants (e.g. [tː] → [t]), voiceless simple consonants were voiced (e.g. [t] → [d]), and voiced simple consonants could be deleted (e.g. [d] → ∅). Similarly, intervocalic [r] → [ɾ] (or "weak-r"), and [rː] → [r] (or "strong-R"). [r] was maintained word-initially, and the contrast between tap and trill is neutralized in coda. As was already suggested in Section 2.3.2, the change from a trill to a tap cannot be considered lenition resulting from direct articulatory undershoot due to the difference in their articulatory mechanisms; rather, an intermediate phase of one-tap trills is likely. At any rate, the tap can be considered a simpler and shorter articulation at the same place of articulation as the trill.

2.4.1.2 From alveolar to uvular

The second interesting change regarding Portuguese rhotics began to emerge in the 19th century. The first reference to a posterior pronunciation of strong-R is by Gonçalves Viana in his 1883 *Essai de phonétique et de phonologie de la langue portugaise d'après le dialecte actuel de Lisbonne* (1973, p. 102). He states that a uvular trill is found in the speech of some individuals—even those who are able to pronounce weak-r as an apical—despite the fact that, unlike in French and German, the lingual "rr" is never guttural in Portuguese, Spanish or Italian. Two decades later, Gonçalves Viana (1903, p. 19) describes the uvular trill as an articulation of strong-R that is still considered erroneous, but spreading quickly from town to town. It remains unclear if the spreading of the uvular trill had its motivation in acquisition or if it was being adopted by adults.

Noll (2012) suggests that there is an even earlier reference to a retracted strong-R to be found in the *Introduction à l'atlas ethnographique du globe* (Balbi 1826, p. 173). Balbi includes in his description of the Portuguese language some observations made by the Viscount of Pedra Branca—a Brazilian diplomat in France at the time seeking the recognition of the independence of the Empire of Brazil—regarding the differences between the Portuguese spoken in Portugal and Brazil. According to the Viscount, the word *cecia* (*sécia* in modern-day Portuguese orthography) means *action de grasseyer* in Portugal, but *minaudière* ('affected or coquettish woman') in Brazil. Noll argues that this is a reference to a retracted strong-R in European Portugues because, by this point in time, *grasseyer* had changed its meaning in French from 'pronouncing some letters erroneously' to 'pronouncing some letters and especially *r* erroneously', and in much the same way in Portugal the word *cecioso*, originally referring to posh men and women with an erroneous pronunciation of sibilants, had shifted to only encompass the letter *r*. In the French language, *grasseyer* is a verb still in use and generally refers to rhotics, whereas the verbs *cecear/ciciar* and the adjective *cicioso* still exist in Portuguese but are arguably of very rare usage and refer only to sibilant and whispering sounds.

Noll's argument is based on the French-language translation of whichever speech defect the Viscount was referring to, and since there are no examples of the type of *grasseyer* it encompassed, it is difficult to establish a direct link. Furthermore, a different point of view on this mannerism affecting sibilants and rhotics can be found in Gonçalves Viana's detailed examples of Portuguese pronunciation in the late 19th century. Noll (2012) refers to these same accounts but seems to omit the examples that could lead to a different conclusion on the semantics of *cecear/ciciar*.

In his 1883 *Essai*, Gonçalves Viana (1973, p. 102) states that some individuals are producing uvulars (as already discussed above), and in the following paragraph refers to another, fricative way of pronouncing strong-R:

> Quelques fois je prononce le *r* initial comme une fricative sonore, une espèce de *rz* (non pas *rž* comme le *rz* polonais). J'ai rarement trouvé cette particularité dans la prononciation d'autres individus portugais. Ce *r* fricatif sonore est cependant assez fréquent dans la prononciation des Brésiliens, et remplace chez eux le *r* vibrant ; je ne saurais dire, toutefois, jusqu'à quel point cette prononciation est individuelle ou dialectale ; je l'ai surtout remarquée chez des naturels de Pernambuco et de São Paulo.

From this comparison with Polish *rz*, it is possible to infer that Gonçalves Viana is referring to some kind of alveolar or postalveolar fricative. In addition, he states that it is a frequent substitute of the alveolar trill among Brazilians from Pernambuco and São Paulo. In his *Exposição da pronúncia normal portuguesa para uso de nacionaes e estrangeiros* published nine years later (1892, p. 40), Gonçalves Viana again mentions two fricative variants:

> [...] o *r* esporádico que resulta da assimilação parcial de *z* a ʀ, como por exemplo **os reis** [...]; o *rz* polaco, sendo porém êste mais cacuminal, [...], assimilação parcial de ʀ a *j*, e não de *j* a ʀ. Pode ser também figurado com *ř*.
>
> [...] êste mesmo, ciciado, como o *r* final de muitos dialectos brasileiros, entre elles o do Rio-de-Janeiro, por ex.: em *mar, ser*. Ambos os *rr* assibilados se ouvem dialectalmente em inglês depois de *d, t,* por ex.: em **dry**, **try** [...], quási pronunciados

> como se estivessem escritos *jy, chy,* isto é, *djȧi̊, tẋȧi̊.*[1]

This time Gonçalves Viana compares the fricative *r*'s to the Polish *rz*, but also to the fricated rhotic in the English words *dry* and *try*. He calls both variants "assibilated" and the latter also *ciciado*, and states that they are common word-finally in many Brazilian dialects, including that of Rio de Janeiro. Noll (2012) takes these to be descriptions of a velar fricative like that of French due the supposed semantic shift of the verb *ciciar* in much the same way as *grasseyer* in French. However, Gonçalves Viana's explicit comparison of this pronunciation with sounds in Polish and English, and his description of it as a sort of "*rz*" and "assibilated" both strongly point to this articulation being a fricative in the alveolar or postalveolar region. Not much can be said about the development of this anterior fricative variant in European Portuguese since there seems to be no mention of it in the literature. However, as already cited in Section 2.3.2, Jesus & Shadle (2005) found tokens of a voiceless tapped alveolar fricative as variants of strong-R and in word-final coda, indicating that an alveolar fricative variant may still be used by some speakers. The implications of Gonçalves Viana's descriptions for BP will be discussed further below.

If in 1903 Gonçalves Viana described the uvular trill as a pronunciation spreading quickly across Portugal, as we reach the mid-1900s, Barbosa (1965, p. 187–208) states that the alveolar trill is still frequent among older speakers, but disappearing from the Lisbon dialect. According to Barbosa, the uvular trill [ʀ] is the most frequent variant of strong-R in the Lisbon area at this point in time, and the velar fricative [x] an emerging trend among young speakers.

A more recent study by Rennicke & Martins (2013) on strong-R in European Portuguese found that in a corpus consisting of recordings made between 1994 and 2012, uvular and velar fricatives ([ʁ], [χ], [x]) were the most common variants used by 76%, 24% and 16% of the speakers, respectively. The alveolar and uvular trill were present in the speech of 22% of the speakers, yet no speaker seemed to use both trills: they were either the only variant of strong-R captured in the recording, or one of them (alveolar or uvular) varied with the mentioned back fricatives. This would

[1] Minor typographic adaptations have been made in this quotation without compromising the original content.

seem to support the idea, already put forth in Section 2.2.3, that during acquisition the articulatory target of trilling is achieved either as apical or uvular. Since the realisation of trills by an individual speaker in this corpus is categorical rather than gradient, the link between these two variants is more likely to be perceptual than articulatory.

In the descriptions of Portuguese rhotics by Gonçalves Viana in the late 19th century already cited above (1973, p. 102; 1892, p. 40), he mentions that a fricative *rz*-like articulation is common in Brazilian Portuguese as a variant of the alveolar trill and word-finally, and that it occurs in the dialects of São Paulo, Rio de Janeiro and Pernambuco. He points out, however, that he is not aware if this pronunciation is idiolectal or generalized. Noll (2012) interprets this description as the earliest clue to the fricativisation and backing of BP rhotics, but as was pointed out before, the example words provided by Gonçalves Viana do not support this view. In fact, Noll is understandably surprised by the indication of São Paulo as a region where the supposed velar fricative would have been common, since São Paulo is arguably one of the regions—along with the Southern states—where more archaic variants of rhotics can be found. An alveolar fricative variant of strong-R, similar to the one described by Gonçalves Viana, has indeed been documented recently by Silva (2002, p. 148) in speakers from the Southern states (see Section 2.3.3 for details).

In any case, the change from alveolar to uvular trills seems to have also started in Brazilian Portuguese in the late 19th century (Callou et al. 2002, p. 544). However, no linguistic references are available to evaluate the pace at which this backing took place. All we can say is that at some point in the 20th century, the uvular trill began to weaken furthermore into velar/uvular fricatives, which in turn have weakened to glottal fricatives. In the 1977 edition of *Para o estudo da fonêmica portuguesa*, Mattoso Câmara Jr. already describes strong-R as predominantly posterior in BP (p. 79).

2.4.1.3 Coda diversification in Brazilian Portuguese

The third sound change mentioned in the beginning of this section concerns the coda rhotics of BP. In European Portuguese and some varieties of BP (mostly in São Paulo and the southern states of Paraná, Santa Catarina and Rio Grande do Sul), coda rhotics are still tap-like apical segments.

From an areal point of view, Noll (2012) sees this as an archaism restricted to a specific region on Brazilian territory. In most of Brazil the original apical coda rhotic has either been retracted and fricated (in the same way as strong-R), or become a rhotic approximant. To the north of Rio de Janeiro and central Minas Gerais, coda rhotics are back fricatives, and to the south of Western Minas Gerais, coda rhotics are mostly alveolar taps and/or rhotic approximants.

Let us take a closer look at the possible sound change trajectories that lead to these two tendencies. It was argued in Section 2.4.1.2 that a perceptual link between the alveolar and uvular trill lead to the initial backing change; then, due to articulatory undershoot, the uvular trill was weakened to fricatives first in the velar/uvular region, and then to glottal fricatives. Therefore, if this link is to be established also in coda position, a documented description of uvular trills in coda could be taken as evidence that the same sound change took place also in codas.

In fact, the studies of BP coda rhotics by Callou, Leite and Moraes (1996, 2002) may shed light on this issue. The analyzed recordings are from the NURC (*Norma Urbana Culta*) database, a project initiated in the 1970s in order to record educated speakers for a variety of linguistic analyses. The authors do not specify the time frame during which the analyzed recordings were made, so we must assume they are from the 1970s.

Callou et al. find small percentages of uvular trills word-medially in São Paulo, Rio de Janeiro, Salvador and Recife, and word-finally in São Paulo, Rio de Janeiro, and Recife. This seems quite consistent with the fact that word-initial strong-R is known to be mostly a back fricative in these cities (with the exception of São Paulo), whereas the alveolar trill still co-occurs with back fricatives in southern Porto Alegre (Noll 2012)—a city where Callou et al. (1996) did not find uvular trills in codas. Thus in BP dialects in which coda rhotics have retracted, the following trajectory can be established: r → ʀ → χ → h.

The other innovative coda tendency in BP, that of rhotic approximants, can be explained as an undershoot of the alveolar trill articulation. As already discussed in Section 2.3.4, this tendency was first mentioned in the literature in 1920 by Amadeu Amaral, who thought it was a phonetic loan from the native languages with which the settlers of São Paulo had contact. However, as Noll (2012) points out, the Tupi-Guarani languages of this region only have apical rhotics. In spite of this, the myth of a phonetic loan has persisted until today and is reflected in the fact that the origin of coda approximants as lenited variants of apical trills and taps is hardly ever discussed in Brazilian linguistics.

A review of relevant studies on rhotic approximants in BP was given in Section 2.3.4. It is apparent that the phonetic form of this macro-class is varied: it encompasses alveolar, retroflex/bunched, and palatal approximants as well as r-coloured vowels. As already argued in Section 2.2.4, these approximants are articulatorily linked to front apical rhotics (trills and taps) and can be traced back to them as lenited variants.

The tendency for coda rhotics to be deleted in BP has been documented extensively (e.g. Callou et al. 1996; Huback 2006; Oliveira 1997). Deletion is most advanced word-finally in infinitive verb forms (e.g. *falar* 'to speak', *fazer* 'to do', *sair* 'to leave') of any number of syllables. Huback (2006) finds that in Belo Horizonte BP, deletion is rare in monosyllabic words (e.g. *mar* 'sea', *dor* 'pain') but increases in probability with the syllable count. According to Huback, the rate of deletion is also closely linked to lexical item (with high-frequency words such as *a partir* 'starting from', *qualquer* 'any', *apesar* 'despite', and the suffix *-dor* leading the change) and the patterns found in individual speakers (with some individuals deleting coda rhotics more than others). This dissertation aims at providing further information on the lexical and articulatory factors that lead to coda deletion, and a comparison with deletion rates found in previous studies will be presented in Section 8.5.

2.4.2 Phonological status of rhotics in BP

We have chosen to use the fairly broadly defined terms strong-R and weak-r to refer to two positional variants of rhotics in BP. As was explained in the beginning of Section 2.4.1, strong-R stands for the (mostly) back fricatives that can occur word-initially, word-medially after laterals, nasals and sibilants, and intervocalically; and weak-r refers to the tap-like segments that can occur in clusters and intervocalically. As all these variants can occur in codas in BP, along with other types of segments, we have been referring to this last context simply as "coda". Examples of these three categories were provided in Table 1.1. The choice to not define these three categories in terms of features has been deliberate since the assumption of this dissertation is that speech processing takes place at word-level (i.e. the different rhotic variants are not derived from a feature-specified underlying form), and that variation of phonetic detail is inherent and present in word-level representations.

The sound changes discussed in the previous section have left the Portuguese rhotic system at the same time predictable and unstable from the point of view of formal phonology: most of the time, it is possible to foresee what kind of rhotic will occur in the positions for strong-R and weak-r. On the other hand, the contrast between the rhotics is incomplete (as the only minimal pairs are to be found for intervocalic rhotics), and this in turn makes it possible for variants of one macro-category to occur in positions that traditionally belonged to the other category: such is the case of taps occurring word-initially (Noll 2008, p. 71), taps occurring after vocalized laterals (Oliveira & Cristófaro-Silva 2002), and coda where either one can occur.

This incomplete contrast in BP and other Iberian Romance languages has intrigued phonologists and led to a debate as to the underlying representation of rhotics. Some approaches will be discussed in the sections below, grouped under the assumed underlying representation (weak-r, strong-R or two rhotic phonemes). This will be followed by conclusions on the phonological interpretation of rhotics in BP.

2.4.2.1 Underlying /ɾ/ or weak-r

Approaches in the Generative or Autosegmental tradition have usually assumed that the tap [ɾ] is the underlying form of all rhotic realisations. The assumption is that in any context—word-initial, cluster, coda, intervocalic—a rule generates the output, be it strong-R or weak-r. The arguments in favour of this view will be listed below and are extracted from Mateus & D'Andrade (2000, p. 15-16) and Monaretto, Quednau & Hora (2005, p. 215-220).

1. In BP, both weak-r and strong-R can occur word-finally (e.g. *ma*[ɾ] ∼ *ma*[ɦ] 'sea'), but only the tap can occur when a plural or derivative morpheme is added (*ma*[ɾ]*es* 'seas'; *ma*[ɾ]*ítimo* 'maritime').

2. Since the two rhotics can appear intervocalically, an approach that assumes only one underlying rhotic must also assume that rhotics have the same underlying representation in all positions.

3. If only the tap is underlying word-finally (argument 1), it must be underlying also in word-medial coda due to the fact that, in Portuguese, the same segments that can occur in word-final coda also occur in word-medial coda.

4. In dialects with back fricatives in syllable coda, they do not assimilate to the voicing of the following consonant (e.g. *ca*[x]*ga* 'load'), whereas other fricatives do (e.g. *mu*[z]*go* 'moss'). Therefore, the back rhotics are not "regular" fricatives and must be represented by underlying /ɾ/.

5. Only the tap can occur in clusters (e.g. *p*[ɾ]*ato* 'plate').

6. Intervocalic strong-R is underlyingly a geminate tap (/ɾ.ɾ/). This phenomenon is also behind the occurrence of strong-R in words such as *in+regular*, in which the final /n/ of the prefix assimilates to the initial /ɾ/ of *regular*, and surfaces as a strong-R in *irregular* ('irregular').

7. The interpretation of intervocalic strong-R as underlying /ɾ.ɾ/ is supported by the fact that Portuguese does not allow proparoxytones when the penultimate syllable is heavy: this is why *a.gár.ra* ('grabs [3S]'), *em.púr.ra* ('pushes [3S]') and *so.cór.ro* ('help') are allowed, but words such as **á.gar.ra*, **ém.pur.ra* and **só.cor.ro* would not be allowed.

Of these, argument 1 is the only rather convincing explanation in favour of an underlying weak-r word-finally. This argument will be discussed in the concluding section. Arguments 2 and 3 are circular, and arguments 4, 5, 6 and 7 can be challenged with detailed acoustic analysis and/or grammaticality judgements.

In reference to argument 4, Abaurre & Sandalo (2003, p. 174) point out that the majority of phonological studies on Portuguese are based on transcription by ear, which is far less reliable than an acoustics-based analysis. The authors show a spectrogram of the word *carpa* ('tent') in which the velar fricative in coda is voiced even when followed by a voiceless stop, making the point that voicing judgments need to be based on acoustic analysis. Furthermore, it seems quite inconsistent to assume that because a segment is "never voiced" (in this case, back fricatives in coda), it must be derived from an underlying form (the alveolar tap) that is specified as [+voiced].

In fact, Abaurre & Sandalo (2003, p. 164-165) note that the glottal fricatives of BP are segments that easily assimilate to the voicing of adjacent vowels. Based on the corpus of this dissertation it could be said, however, that the glottal fricatives of BP assimilate to the voicing of adjacent *segments*. Word-initially preceded by a voiceless segment (e.g. *mais ruim* [majs hũj̃] 'worse'), BP strong-R is usually also voiceless as voicing starts closer to the following vowel. However, the glottal fricative can also be voiced in this context, if voicing starts slightly earlier ([majs ɦũj̃]). What is interesting in this case is that the glottal fricative, if voiced, usually does not voice the preceding sibilant (*[majz ɦũj̃]) like other BP consonants (e.g. [majz buˈnitʊ] 'more beautiful'). Thus the voicing of BP back fricatives is very unstable, and should not be a deciding factor in their phonological definition.

As for argument 5, it is quite categorical to claim that only the tap can occur in clusters. A few cases of trills—supposedly the "original" variants of strong-R—were found in clusters in the corpus of this dissertation. Trills may also occur as emphatic variants of intervocalic taps, as pointed out by Abaurre & Sandalo (2003, p. 172).

Arguments 6 and 7—strong-R as an underlying geminate justified by the "heavy syllable argument"—is criticized by Bonet & Mascaró (1997). First, it seems unlikely that a language with virtually no surface geminates would have geminates at the underlying level. Second, the definition of strong-R as an underlying geminate because it attracts stress would mean that the phonemes /ʎ/, /ɲ/ (and /x/ in the case of Spanish) are also underlyingly geminate. The authors note that informant intuition is not conclusive on the acceptability of proparoxytone words with one of these segments in the onset of the last syllable. They admit that etymologically these consonants emerged from sequences of segments, some of which were geminates (/ll/, /jl/, /jn/, /nj/, /ɾɾ/, etc.) and that they attracted stress in Latin and Vulgar Latin, but the synchronic relevance of this effect still needs to be studied.

2.4.2.2 Underlying /r/ or strong-R

Contrary to the authors cited in the previous section, some phonologists have argued in favour of strong-R as the only underlying rhotic. In the first edition of *Para o estudo da fonêmica portuguesa*, Mattoso Câmara Jr. (1953) sees that BP has an underlying trill, which always occurs syllable-initially. When intervocalic, the trill would be underlying /r.r/ that surfaces as [r], and weak-r would be /r/ that surfaces as [ɾ], or a "weakened positional variant" in the author's words.

Abaurre & Sandalo (2003) also argue in favour of an underlying /r/ from a generativist point of view. In intervocalic position, strong-R would be the result of two adjacent rhotics (/r.r/) that do not surface as such due to the Obligatory Contour Principle, but are simplified to [r]; weak-r, on the other hand, would be a weakened form due to the loss of the feature [+continuant]. The realisation of underlying /r/ as [h] in BP is explained as debuccalisation (loss of the original place of articulation), leaving the segment [-consonantal]. The authors add that [-consonantal] features are preferred in BP codas since similar changes have taken place in laterals (e.g. *Brasil* [bɾaˈziɫ] → [bɾaˈziw]) and nasals (e.g. *ponta* *[ˈpontɐ] → [ˈpõtɐ] 'tip'). According to Abaurre & Sandalo, this is why coda rhotics are [-consonantal] segments such as glottal fricatives and coronal approximants in most BP dialects; "real" consonants, such as the velar fricative [x] in Rio de Janeiro and the tap [ɾ] in Southern Brazil and São Paulo, are less common.

The Sonority Cycle approach to Iberian Romance rhotics by Bonet & Mascaró (1997) as well as our criticism of it have already been explained in Section 2.2.1. These authors take strong-R (or trill) to be the underlying rhotic that surfaces as a tap when syllable structure so requires. Intervocalic [ɾ] would then be an exception derived by a rule.

These approaches that see strong-R as the underlying form and the tap as a weakened form by loss of features or sonority due to an additional rule seem less flawed than the approaches assuming intervocalic gemination of the tap. However, any rule formulated specifically to account for one context is an *ad hoc* solution. Similarly, as already commented in Section 2.2.1, sonority approaches to lenition usually derive the properties of segments from their position in the syllable rather than the other way around: furthermore, the sonority scale proposed by Bonet & Mascaró (1997) assigns equal sonority values to manners of articulation that can justifiably be considered lenition stages in rhotics.

2.4.2.3 Two phonemes

In the second edition of *Para o estudo da fonêmica portuguesa*, Mattoso Câmara Jr. (1977) reconsiders his one-phoneme analysis and argues in favour of two rhotic phonemes that contrast only in intervocalic position, and are neutralized in other positions. He states (p. 79) that phonemics cannot distance itself from phonetic reality, and phonetically there is no intervocalic gemination in BP rhotics.

2.4.2.4 Conclusions

Of all the approaches presented in this section, Mattoso Câmara Jr.'s (1977) view of two rhotics contrasting intervocalically and neutralized in other positions seems the most data-oriented. We have already seen that there is great variation in codas, where taps, trills, fricatives and approximants can occur; word-initial rhotics may be taps (variants considered weak-r and not strong-R) in Rio Grande do Sul (Noll 2012); there are varieties of BP in the state of São Paulo where rhotic approximants can occur not only in coda, but also intervocalically as variants of weak-r, and in clusters (Rodrigues 1974, Garcia 2013); and strong-R is being replaced by weak-r when preceded by an original lateral (e.g. *guelra* [ˈɡɛɫɦɐ] → [ˈɡɛwɦɐ] → [ˈɡɛwɾɐ] 'gill') (Oliveira & Cristófaro-Silva 2002). As Mattoso Câmara Jr. puts it, phonemic analysis can never distance itself from phonetic reality, and in this case the reality is that there is much more variation and phonemic overlap than formal phonology has wanted to admit.

On the other hand, there are contexts where no such overlap has been reported in any variety: strong-R ([χ]∼[h]) does not occur in clusters (e.g. *prato* [ˈpɾatʊ], but never *[ˈphatʊ]), and intervocalically weak-r and strong-R cannot overlap in one variety because the contrast must be preserved through either duration, place or manner of articulation. The search for a pan-Iberian or even pan-Brazilian underlying representation or articulatory target for rhotics in different phonological contexts is therefore a rather futile task since the system of contrasts and possible positional variants varies from one dialect to another. Therefore the definition of rhotic representation must be based on data collected from a specific variety, and the definition can be representative of only that variety. This, in turn, suggests that articulatory targets are reinforced through practice and that they are essentially generalisations over lexical items.

With respect to word-specific phonetic form, we now return to argument 1 of Section 2.4.2.1. According to this compelling argument put forth by Monaretto et al. (2005), the only underlying rhotic in BP word-final codas is /ɾ/ because only the tap can occur when a plural or derivative morpheme is added (*ma*[ɾ] ∼ *ma*[ɦ] 'sea'; but *ma*[ɾ]*es* 'seas', *ma*[ɾ]*ítimo* 'maritime'). This argument is valid in a model that assumes that plural or derivative morphemes are not part of word-level representation: in this case, the speaker would be assumed to have a word-level representation of only /maɾ/ to which morphemes are added. Consequently, such a model would have to posit a rule or other derivational mechanism for every possible coda realisation other than a tap (approximant, fricative, trill, etc.) surfacing in the language. In an exemplar-based phonological approach, however, we can consider that the speaker has various representations—in this case, "roots"—of a word such as *mar* that the speaker has stored in memory: for singular, it may be [maɾ] ∼ [maɦ] ∼ [maɻ] ∼ [mar], but for adding the plural marker, for instance, only [maɾ]. This explanation takes into account phonetic detail and variation, and is more economic than a rule transforming all coda rhotics in non-derivational contexts. An Exemplar Model would also assume that the derived words *mares* and *marítimo* have their own independent exemplar clusters represented in memory, dispensing with the derivational link to *mar*.

An additional argument sometimes presented in favour of the underlying tap has been that the coda tap emerges even at word boundary when followed by a vowel due to resyllabification: e.g. *mar azul* [ma.ɾa.zuw] 'blue sea'. This argument relies on careful speech, and does not take into consideration the actual variation found in word-final rhotics followed by vowels. As will be seen in the corpus of this dissertation, in spontaneous speech word-final tap-like segments are most common in fixed expressions, or *chunks*, whereas other rhotics (fricatives and approximants) and deletion are more common between lexical items that do not necessarily have the same frequency of co-occurrence as chunks, and especially in infinitive verb forms. These tap-maintaining chunks often include the preposition *por* 'by/for': *por isso* 'that's why', *por ele/ela* 'for him/her', *por aqui* 'around here', *por aí* 'around there', etc. In this kind of word pairs, the word-final tap is processed as intervocalic because the *chunk* is processed as one word. The notion of *chunks* will be further discussed in Section 3.2.

2.4.3 Sociolinguistic status of rhotics in BP

The articulation of coda rhotics is one of the most salient features for determining the geographical and socioeconomic origin of a speaker of BP. The pronunciation of radio and television presenters, actors and other public figures reflects the Portuguese spoken in the business and media capitals of southeastern Brazil, that is, Rio de Janeiro and São Paulo. In the former, coda rhotics are mostly back fricatives, and in the latter, taps. However, as we will see, rhotic approximants are gaining prestige in São Paulo and making their way into the speech of all layers of Brazilian society.

Leite (2004, 2010) has focused on the sociolinguistics of rhotics in the city of Campinas, São Paulo. Campinas, an important industrial hub with a renowned university but situated away from the state capital, is an interesting setting for the study of language attitudes. In her (2004) study on the language attitudes of students from São José do Rio Preto living in Campinas, she found that the students recognize the stigma of the retroflex approximant in syllable coda, and that they wish to modify their speech to an "intermediate" pronunciation, that of Campinas. This intermediate pronunciation seems to be the r-coloured vowel, which is more frequent in the speech of students that have lived in the city for some years, as opposed to students who have recently moved to Campinas and still use more retroflex approximants. Leite's (2010) study on the rhotics of Campinas natives shows that they, too, see the retroflex approximant as an undesirable pronunciation. However, 90.6% of the coda rhotics produced by these speakers were retroflex approximants, and they viewed the r-coloured vowel as a prestige pronunciation. When the speakers were asked to produce the prestige variant, most of the time they produced the same retroflex approximant they were using before.

According to Leite (2010), the retroflex approximant—or *erre caipira* ‘hillbilly *r*’—is going through a kind of revitalisation due to the recent appreciation of the *caipira* culture in Southwestern and Midwestern Brazil. The notion of *caipira*, originally a name used of small-scale farmers of mixed race, has begun to change meaning and gain prestige as these regions have come to be known for large-scale agriculture and animal husbandry, cowboy and rodeo culture, traditional *caipira* music played with a *caipira* guitar, and the transformation of this musical style to a popular country music style called *sertanejo universitário*. All of these phenomena are marked, in the Brazilian linguistic landscape, at least partly by a speech style with rhotic approximants in syllable codas.

Moving on to the highly urban setting of the state capital of São Paulo, Oushiro & Mendes (2013) also report on the generalisation of rhotic approximants in coda. In a corpus collected between 2009 and 2011, comprising several education levels, age groups, and central and peripheral neighbourhoods, the authors analyze the distribution of coda rhotics: 28% taps, 13.9% rhotic approximants, 54.8% deletion, and 0.4% back fricatives (the remaining 2.9% comprised foreign words and metalinguistic occurrences). The tap and rhotic approximants being the main characteristics of São Paulo BP (as word-final deletion especially in infinitive verb forms is common throughout Brazil), the authors focus on these two variants and find that rhotic approximants are more frequent in speakers that are less educated, male, from peripheral neighbourhoods, with less mobility in the city, and born in families that are less rooted in the city (i.e. migrants from other regions of São Paulo or Brazil). Older speakers and women from any neighbourhood or education level use less approximants and more taps. As the formality of the speech event increases, young speakers from central neighbourhoods use mostly taps and almost no approximants. All in all, there seems to be a moderately growing preference for the rhotic approximants in the city of São Paulo, except among young speakers from central neighbourhoods. The authors conclude that both variants are associated with different positive and negative values in different social settings, leading to the diverging preferences in codas.

In the neighbouring state of Minas Gerais, a language attitude test was conducted by Rennicke (2011) in the state capital, Belo Horizonte. Natives of the greater Belo Horizonte area, the state prestige dialect in which coda rhotics are mainly glottal fricatives [h ɦ], evaluated the speech of two voices (male and female) from Belo Horizonte and two voices (male and female) from midwestern Minas Gerais with rhotic approximants in coda. The test revealed that the subjects were able to identify the urban or rural origin of the voices based on coda rhotics. The Belo Horizonte voices were judged higher in status, competence and, above all, level of urbanisation than the voices with rhotic approximants. This translates to an impression of low education, low intelligence and rural origin of speakers who use rhotic approximants in Belo Horizonte. Solidarity was the highest judged characteristic of the voices with rhotic approximants; however, it was still lower than that of the Belo Horizonte voices. This result is interesting as it seems to repeat a result commonly found in language attitude studies: prestige dialect speakers tend to score higher in characteristics related to power and status, whereas regional, non-prestige dialects score higher in solidarity.

In other regions of Brazil where rhotic approximants are not the most common coda variants, they are usually used by speakers who are older and/or have a lower level of education. This has been found to be the case, for instance, in Paraíba, where coda rhotics are mostly back fricatives (Skeete 1997), and southern Brazil (Paraná, Santa Catarina and Rio Grande do Sul) where they are mostly alveolar taps (Monaretto 1997).

The cited studies show that if rhotic approximants coexist with other variants (taps or back fricatives) in a dialect or region, their use is usually considered less prestigious if not stigmatized. However, in a setting such as Campinas, where several approximant-like articulations can occur in syllable coda, speakers may be able to assign different social values to the degree of retroflexion/bunching or syllabicity of approximant variants.

2.5 Conclusions

This chapter on rhotics began with a discussion of rhotics as a class. As no common feature can be assigned to all possible rhotic variants, it was established that the rhotic class is defined by the phonotactic and historical connections between the sounds that make up this class; it is always language-specific; and the link between members of the class can be traced back in history based on pathways of sound change. Sound change in rhotics is mostly lenition, defined in this dissertation as articulatory undershoot that manifests itself as both substantive reduction and temporal reduction; however, a perceptual motivation was suggested for the articulatory changes from alveolar to uvular trills, and from alveolar trills to taps.

Based on the defined leniting changes and perceptual links, an initial sound change trajectory for BP rhotics was proposed. The sound changes in Portuguese rhotics may be traced back to the alveolar trills of Latin that were reduced to a tap—trill contrast intervocalically. This contrast has been replaced since the 19th century by a contrast between the tap and the uvular trill, which weakened further into a glottal fricative in BP. The coda rhotics of BP have also undergone substantial sound changes, as both taps and back fricatives can occur in this position in some dialects; in other, rhotic approximants have emerged in this context. It was argued that in general, rhotic approximants are not prestige variants in dialects of BP where other coda variants exist.

In order to explore the topics discussed in this chapter, and to address theoretical issues brought up in the next chapter, it will be necessary to examine data on BP rhotics from a region where both rhotic approximants and back fricatives are used in coda, the latter being the prestige pronunciation (see Section 4.4). The analysis of the variants used by different speakers in different speech styles not only in coda, but also other phonological contexts, will shed light on the possible mechanisms of sound change in rhotics and enable us to draw a more accurate picture of the possible paths of sound change. This picture must not contemplate only articulatory and perceptual factors, but also the social values attached to the different rhotic variants.

Chapter 3

Theoretical Framework and Application

This chapter discusses the theoretical assumptions behind data collection and their application to phonological analysis in this dissertation. First, the broad perspective of interpreting language as a Complex Adaptive System is introduced in Section 3.1. Next, Section 3.2 presents the main ideas and evidence for the exemplar organization of linguistic elements from the point of view of phonology, discusses how linguistic elements may be stored, and distinguishes different points of view inside Exemplar Models. In addition, this section will discuss frequency effects on linguistic representations, as well as sound change and the production-perception loop within an the Exemplar framework. The methodological principles of Laboratory Phonology and Sociophonetics that guide this dissertation will be presented in Section 3.3. Finally, Section 3.4 concludes this chapter by outlining the application of this theoretical framework to the rhotics of Brazilian Portuguese.

3.1 Language as a Complex Adaptive System

In a broader perspective, language is seen as a *Complex Adaptive System* (CAS) (Beckner et al. 2009; Bybee 2010; Kretzschmar 2010; Massip-Bonet 2013; Bybee & Beckner 2015; Cristófaro-Silva & Leite in press) in this dissertation. CAS is a transdisciplinary concept used in fields as varied as physics, ecology, economics, neurology, astronomy, biology and social sciences in order to understand the complex nature of interactions that form many of the phenomena observable around us. These phenomena are understood to be *complex* because they arise from the interplay of countless factors in complex ways, and they are *adaptive* because they are constantly changing and adapting to new circumstances. Finally, they are *systems* due to the order that emerges from this complexity and adaptation.

The concept of CAS came about as an explanation for phenomena that seem impossible to account for as the result of simple cause-and-effect relations. A CAS is an open non-equilibrium system, meaning that it is open to the influence of outside factors, and due to this openness it is in a state of constant instability and change. A CAS consists of several subsystems at different levels of hierarchy, and all these subsystems are interconnected and can therefore affect each other. Since a CAS is open to outside influences and diverse factors, unlike a closed (i.e. deterministic) system, it is fundamentally non-linear and non-deterministic because change takes place locally (in the subsystems) and gradually as the elements of the system *self-organise*, and these changes may or may not impact other subsystems or the system as a whole. Therefore a CAS is an essentially bottom-up approach to understanding change in a system, as opposed to a top-down approach in which the system is thought to aim deliberately towards a goal.

As Kretzschmar (2010) points out, the fact that language seems to be simultaneously systematic and variable is paradoxical for linguistics as a science: we can formulate rules but somehow there always seem to be exceptions. Because of our capability of abstraction and categorization, we see regularities where an unconstrained analysis finds irregularities—which is why, according to Kretzschmar (2010, p. 281), "linguistic systems [...] are objects whose existence comes from our perception of reality, not from reality itself". If we approach language as an ever-changing system moulded by a myriad of factors (speakers, pragmatics, society, values, articulation, acquisition, perception, frequency of use, cognition, etc.) we can begin to shape a model that accommodates gradual and/or irregular language change and patterns.

Beckner et al. (2009) explain that language is a *complex* system that consists of multiple agents (speakers) interacting with each other; and it is *adaptive* in the sense that speakers' behaviour is based on their past interactions, which together with current interactions feed forward into future behaviour. According to the authors, a speaker's behaviour is the consequence of competing factors ranging from perceptual mechanics to social motivations, and the structures of language emerge from interrelated patterns of experience, social interaction, and cognitive processes. The cognitive processes behind language are thought to be the same as those behind any other human behaviour: these *domain-general cognitive processes* include, for instance, shared attention, imitation, sequential learning, chunking, and categorization (Beckner et al. 2009). Therefore most linguists working under the CAS framework reject the idea of a Language Acquisition Device, i.e. a cognitive domain specific to language, as suggested in the generativist framework.

A CAS approach to language emphasises the fundamentally social and variable nature of language use: language is a means of interaction, and therefore the root of all change lies in actual language use by its speakers. According to Beckner et al. (2009, p. 14–15), language exists both in individuals (as idiolects) and in the speech community (as communal language), and these levels are interdependent: idiolects emerge from social interaction with other users of the communal language, and the communal language emerges as the interaction of the idiolects. Language change may be observable at the communal level, but the mechanisms driving it may not be present in all individuals in the same way or at the same time. Beckner et al. explain that this is why a CAS approach assumes no ideal representing agent (speaker) for the system: each idiolect is the consequence of the individual's unique language experience and exposure.

This view of language as emergent and in constant change due to individual exposure also makes it possible to conceive language change as something that takes place within speakers during their lifetime. Whereas in the generativist approach language patterns are thought to be fixed in the early stages of life and thereafter only modified by rules, a CAS approach allows us to treat language—be it at the level of idiolect or communal language—as a system in a permanent state of change, meaning that speakers' linguistic representations change throughout their lives.

Two core concepts of the CAS approach are useful in the analysis of language change. A *state space* (or *phase space*) is the set of possible outcomes and directions for change that exist in the system at a given point in time. When a specific direction of change begins to involve more and more elements of the system, this direction becomes an *attractor* (Bybee 2010; Massip-Bonet 2013; Bybee & Beckner 2015). Similar attractors that have been observed to recur in several languages of the world are called *attractor trajectories* by Bybee & Beckner (2015, p. 184). These diachronic paths of change are thought to arise from the universal cognitive processes cited above. Bybee & Beckner (2015) mention the change from oral fricatives to glottal fricatives through debuccalization and the palatalization of consonants before front high vowels and glides as common cross-linguistic consequences of two *attractor trajectories*: articulatory reduction (in debuccalization) and overlap (in palatalization).

To illustrate these concepts with a simplified example, imagine a small community of people living in an isolated village with no paved roads. The only way to the outside world is by a network of footpaths. The different paths and their combinations is the *state space* of locomotion possibilities for the people in that village. Initially, all footpaths most likely emerged the same way: one person first established them by stepping on vegetation, sand and rocks, and others followed. However, over time some of those paths are used by more people and consequently become broader, while other paths remain narrow and are rarely used. This is because an *attractor* is encouraging people to use some paths in detriment to others: it could be a popular destination at the end of those paths, a shorter distance to some destination often visited, better walking conditions or view on those paths, or all of these factors. If a preference for certain type of footpaths and their motivations can be observed in many different communities, this establishes an *attractor trajectory*.

3.2 Exemplar-Based Phonology

3.2.1 Introduction

What is called Exemplar-Based Phonology in this dissertation stems from a larger body of publications on the organization of linguistic structure whose main claim is that repetition and frequency of use create linguistic representations that are *a.* interconnected through phonetic and semantic properties; *b.* under constant updating and consequent modification; *c.* processed in the same way as the mental representations of any other human experiences.

According to Johnson (2007), Exemplar-Based Phonology is concerned with the cognitive grounding of phonological knowledge. The exemplar-based orientation to sensory memory has a long history in cognitive psychology, and it is considered one of the mainstream approaches to modelling memory. Essentially, every instance adds sensory memories, and new experiences are recognised as being similar to old experiences by a partial re-experiencing of images or instances in memory. When applied to phonology, Johnson (2007) explains that the sound system of language is seen to be represented in the set of phonetically detailed exemplars of speech that the hearer/speaker has experienced. Therefore phonological generalizations emerge from the detailed exemplars. The radical claim of the model is, according to Johnson, that phonology is represented in phonetic detail rather than in featural abstraction. The exemplar organization of speech sounds was incorporated by Bybee (2001) in her Usage-Based Phonology that extends the exemplar model to encompass and explain, among other aspects, the semantics-phonetics interconnection, the emergence of morpho-phonological patterns through schemas, and sound change.

3.2.2 Storage of linguistic elements

It is important to distinguish two different types of memory in order to discuss how language is stored in memory. Grammatical knowledge resides in the *recognition* or *implicit* memory (also called procedural by Bybee 2001), not in the *declarative* or *explicit* memory (Johnson 2007). The latter is made up of one's knowledge of expressible facts (e.g. 'The capital of Brazil is Brasília'), and obviously, some linguistic knowledge is of this type—we can cite the meanings of words, for example. Recognition memory, on the other hand, is knowledge acquired through direct experience of an event or an object; it is detailed but hard to express in words. Linguistic knowledge is thought to be of this type. Other examples of recognition memory would be recognizing close friends at a glance (but finding it extremely difficult to explain to a stranger all the details of your mental representation of that friend), driving a car, or tying your shoelaces (Johnson 2007; Bybee 2001). It is the sort of implicit knowledge that cannot be transmitted orally: a native speaker can form acceptable sentences automatically, but be unable to explain how this was done or what the properties of an acceptable sentence are.

Once we have established that linguistic structure is emergent and resides mostly in the recognition memory, we must discuss what the basic unit of storage is. What are the building blocks of “linguistic forms” and “structure”? For Pierrehumbert (2001, 2002), the stored exemplars are of speech sounds: each sound category is represented in memory by a large cloud of remembered tokens of that category. The phonological system would then be a mapping between points in a phonetic parameter space and the labels of the categorisation system. A sound token may be simultaneously subject to various categories related to speaker identity, speaker gender, the word in which the sound occurred, the sentence, etc. Frequent categories are represented by more tokens than infrequent categories, and this is the stuff of frequency effects in exemplar-based models.

However, if exemplars come from experience, it can be argued that what people experience is words (or lexical items), not sounds. Johnson (2007) and Bybee (2001, 2006) note that non-linguists tend to focus on words, their meanings and pronunciations, instead of patterns that occur on a sub-word level because words are the smallest units that are complete both phonologically and semantically. However, a phonological “word” can consist of several separate words and form what is known as a *chunk*, a frequently repeated sequence of elements that becomes a single processing unit. This is the case of formulaic language and idioms, but also conventionalised collocations. Chunking occurs in the same direction as production, that is, a word can “pull in” words uttered after it, which is also why the first element of a chunk is highly predictive of the following elements (Bybee 2001, p. 191). An example of a possible *chunk* could be *I don't know*: a stretch of speech that has gone through reductive sound changes as one unit (e.g. [airəɾ̃o]; Bybee 2001, p. 30), and has a beginning that is highly predictive of the following elements (the chance that *I don't* be followed by *know* in spontaneous speech is high).

A study by Morais et al. (1979) showed that language is most likely not processed as sequences of sounds by testing the ability of adults to add and delete speech sounds at the beginning of existing words and nonwords. Illiterate Portuguese industrial workers performed very poorly in the manipulation of real Portuguese words, and none of them managed to manipulate non-words correctly. Adults from a similar environment who learned rudimentary reading skills as adults performed better in both tasks. This brings us to two possible observations: first, the fact that manipulation of non-words seems to be more difficult than that of real words implies that sound structure and semantic content are intertwined. Second, phonological variation and sound change must take place in lexical items with semantic content, not in abstract phonological categories and their features.

According to exemplar-based phonological models (Johnson 1997, 2007; Bybee 2001, 2006), when a lexical item is encountered, a new exemplar of that lexical item is stored into the mental representation. Simultaneously, phonetic and semantic connections are made between the exemplar and exemplars of other lexical items. Figure 3.1 exemplifies this sort of representation with BP words ending in the plural suffix [s]. A new encountered token of a lexical item such as [ˈhuɐs] 'streets' is obviously associated with the singular form [ˈhuɐ]. The ending of the new exemplar, [s], is connected to other words with a similar ending, leading to phonetic, semantic and morphological generalisations or *schemas*. In this case, the schema is one of plural formation through the suffix [s], also present in words such as [ˈkazɐs] 'houses' and [ˈmezɐs] 'tables'. The essential difference of this approach to a formalist model is that a category of phonetic, semantic and/or morphological nature (such as the plural) emerges through usage and is an inherent part of the (redundant) representation of lexical items, as opposed to an individual morpheme of which there is only one representation that is added to singular forms.

In addition, semantic connections may be formed with other words of the same semantic field (e.g. 'road', 'motorway'), and phonetic connections may be established with other lexical items starting with [h] (such as [ˈhatʊ] 'mouse' and [ˈhɐ̃mʊ] 'branch') and their corresponding plural forms, and so on. Phonetic connections can also be formed between [ɐ] at the end of all these words, and [z] in [ˈkazɐs] and [ˈmezɐs]. All this goes to show that the representation of lexical items is a complex network, and category abstraction emerges on-line (as speech is being processed and produced). Categories are also updated continuously as the speaker processes and produces speech, which is radically different from the innatist

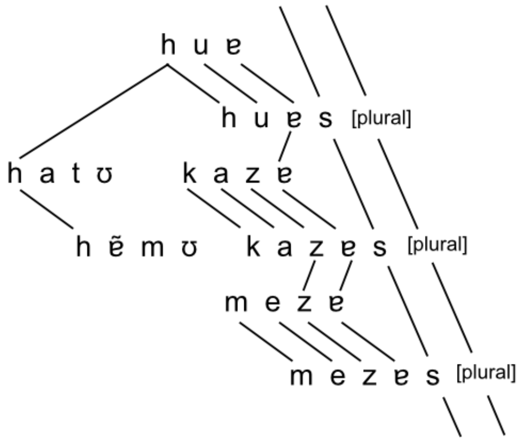


Figure 3.1: Emergence of the [s] plural as a schema in Brazilian Portuguese (adapted from Bybee 2001, p. 23–24)

view of category formation and fixing during acquisition. The fact that usage updates categories means that high-frequency patterns will have a more robust representation than low-frequency representations. Frequency effects on phonological representations will be discussed in Section 3.2.3.

The separation of the lexicon from rules assumed in formalist models in order to reduce redundancy is called the "rule/list fallacy" by Langacker (1987, p. 42; 392) (also cited by Bybee 2001, p. 20–21). There is reason to believe that grammatical categories are learned within lexical items that contain them, and new items with predictable properties are also mapped onto the memory representation of previous similar or identical experiences. Therefore exemplar models expect that predictable properties (redundancy) are stored in memory within the respective lexical items, whereas a formalist approach would assume they are present only in rules.

Everyday examples of the sort of semantic-phonetic network sketched in Figure 3.1 can be found in three different phenomena. First, we can think of instances in which we produce the wrong lexical item from the appropriate semantic network: saying *up* instead of *down*, *right* instead of *left*, calling a friend/child by the name of another friend/child, and so on. The words are retrieved from the correct semantic network, though erroneously. In a similar fashion, we can accidentally produce a word that is similar in sound structure to the intended word but semantically inappropriate (known as a *malapropism*): saying *fire distinguisher* instead of *extinguisher*, *hold someone hostile* instead of *hostage*, etc. In this case, a phonetically similar but semantically erroneous word is retrieved. Further evidence of this two-fold memory structure is the tip-of-the-tongue phenomenon: we know the semantic content of something we wish to express, and maybe even remember the sound with which the lexical item begins or ends or the number of syllables it has—indicating that meaning and form are connected in representation—but cannot produce it.

Rule-based approaches to language, such as Generative Phonology (Chomsky & Halle 1968), came about at a time when computation had not reached the dimensions and speed it has today. If we assume that data processing is a slow and perhaps overwhelming task, it seems reasonable to suggest that language processing is similar in nature: we would need to abstract the incoming signal to the extreme in order to be able to complete the process, using our limited memory resources. In a rule-based approach to phonology, the speaker does not need to memorise every encountered token; instead, generalisations are sought among pronunciations in order to formulate rules that describe those generalisations.

Johnson (2007) explains that in an exemplar-based approach, multiple exemplars containing phonetic detail are assumed to form the cognitive basis of language, and based on those exemplars speakers compute generalisations flexibly on-demand. Johnson provides an analogy regarding the rule-based and exemplar-based approaches using numbers. In order to remember important numbers, such as birthdays, telephone numbers, addresses, and codes, a rule-based cognition model would predict that we formulate a mathematical rule to later derive all these numbers when we need access to them. An exemplar-based approach, however, would explain that we simply memorise these sequences with no rule necessarily attached. We may make associations with other memorised patterns or categories, but it is repetition that fortifies the representation of a given number sequence in memory.

3.2.3 Frequency effects

Frequency of use is a central concept in exemplar-based phonology because it is assumed to have a major effect on the formation of mental representations. It is necessary to distinguish between *token frequency* and *type frequency*. Token frequency is the occurrence of a unit—usually a lexical item—in a specific form in a corpus. Type frequency is the occurrence of a pattern, such as a stress pattern, an affix, or a sound sequence, in a corpus. For example, the English past tense suffix *-ed* has a much higher type frequency than the pattern found in past tenses such as *broke, spoke, wrote, rode*, etc.

According to Bybee (2001, 2006), high token frequency has been shown to automate neuromotor patterns and thus lead to phonological reduction (the *reducing effect*). This type of change is phonetically gradient. However, high token frequency can also "protect" lexical items from analogical change (which is phonetically discrete); this can be verified in the fact that the most frequent words in a language are often irregular (the *conserving effect*). In addition, morphologically complex forms of high token frequency can lose their internal structure as they become autonomous from etymologically related forms (the *autonomy effect*): such is the case of English *be going to* that has suffered both phonological reduction and become semantically autonomous. High type frequency, on the other hand, is linked to productivity in language: the more lexical items a pattern encompasses, the stronger it is and therefore more available for application in new items. Type frequency is also related to acceptability of linguistic forms: patterns with high type frequency are more likely to be judged acceptable in nonce words than low-frequency patterns (Bybee 2001, p. 13).

In general what is referred to as "frequency" in exemplar-based models has no numerical definition in terms of where low frequency ends, and where high frequency begins (Bybee 2006). It should also be noted that there is no frequency of use that is "shared" by all speakers in a speech community: frequencies vary according to speaker, speech community, register, event, and so on. It would be a misconception of Exemplar Models to state that, based on a shared list of frequencies, speakers construct a shared, abstract communication system. On the contrary, speech perception and production and their effect on mental representations are dynamic and essentially individual and probabilistic actions that never function according to exceptionless rules (Kretzschmar 2010). This is why an exemplar-based approach to phonology expects the speech of different individuals to change at different paces and possibly in different directions. However, the shared communication needs of individuals in a speech community will direct language change in a common direction (see *attractors* in Section 3.1).

3.2.4 Sound change

The rule-based and exemplar-based approaches are essentially different in how they explain sound change. Bybee (2001: 39) explains that, in Generative Phonology, underlying representations are very simple while rule systems are considered to be quite complex. In an Exemplar Model, stored representations are complex and interact in complex ways, but access to these representations is relatively direct and not mediated by derivational rules. The patterns found in stored forms are represented in schemas (cf. Figure 3.1), which are emergent generalisations over complex representations.

However, as Kretzschmar (2010) points out, categorical rules always misinterpret the facts of language in use since no linguistic phenomenon is absolutely consistent. This is why rules are problematic also when applied to sound change. If sound change is viewed as rule addition ("X becomes Y in context Z"), as in Generative Phonology, it is assumed that underlying forms remain unchanged. The prediction is thus made that if the sound change was halted or the rule became unproductive, underlying forms would resurface. However, sound changes cannot be undone because they have a permanent effect on the lexical representation (Bybee 2001, p. 59). Therefore, if for speakers of dialect A the change X $\rightarrow$ Y / Z has taken place but for speakers of dialect B the representation and output are still more or less X, the speakers of A and B do not understand each other because they still "have the same underlying representation" (X). Instead, the mental representation of this sound for speakers of dialect A is Y, and for speakers of dialect B it is X. Speakers of these two dialects may still understand each other perfectly if they have encountered speakers of the other dialect and stored exemplars of a different pronunciation for a lexical item that is conceived as semantically the same.

Pierrehumbert (2001, 2002) points to another problem of rule-based phonology regarding sound change. In a generative grammar, the lexicon is distinguished from the phonological grammar: phonetic detail arises when a word is retrieved from the lexicon and processed by phonological rules. This leads to two predictions: *a.* all words with a potential phonological context will be processed by the same rule; *b.* since the only direction of influence is from the lexicon to articulation, the generative model cannot account for the influence of articulation on mental representations. However, it is well known that sound change can apply through lexical diffusion, that is, it can gradually affect the lexicon, a process influenced by frequency of use. All lexical items with the appropriate phonological context in them do not change overnight, and it seems logical to assume that the items that have been affected by sound change have had their mental representation changed by articulatory patterns.

Therefore what takes place in sound change, according to exemplar-based phonology, is that the frequency of use of different exemplars (lexical items articulated on-line in a certain way) affects stored mental representations by shifting the centres of phonological categories (Pierrehumbert 2001, 2002). The majority of sound change is articulatorily motivated, consisting of gestural reductions and retimings, both of which take place as articulation proceeds, and is consequently automated over time. A counterexample for this view would be people who become surrounded by a dialect that is different from their own for a long period of time, but do not acquire the new dialect completely—if frequency shifts representation, why does it not happen in this case? Bybee (2001, p. 57–58) argues that neuromotor patterns of articulation are practised and reinforced since childhood and are difficult to change later in life. However, most people accommodate their speech to some degree in a new dialect environment, but because they maintain some salient features from the original dialect, it may seem that their speech has not shifted.

Scobbie & Sebregts (2010) remind us that traditional phonological theory relies heavily on articulatory labels for its categories, defining segments in terms of manner and place of articulation. Nevertheless careful observation of the acoustics and articulation (by means of ultrasound imaging, for instance) of speech reveals inconsistencies between the two: sometimes the acoustic signal implies deletion of an articulation when gestures are actually only weakened or delayed; in some cases, the vocal tract configuration can take various forms and there can be secondary articulations, yet there is no perceivable difference in the signal. This serves to remind us that the mechanisms behind language variation and change can be much more complex than the addition or deletion of an articulatory property, contrary to what is suggested by rule-based models that rely on simplistic articulatory definitions.

According to Bybee (2001), the two main *mechanisms* of sound change are gestural reduction and gestural retiming (or temporal reduction). These two mechanisms, building on the works of Browman & Goldstein (1986; 1992) and Mowrey & Pagliuca (1995), were addressed in Section 2.2.2. Bybee sees that these mechanisms are universal in the sense that they are behind the majority of sound change in any human language, and they form common cross-linguistic *paths of change* (Bybee 2001, p. 206–210). One of these is the tendency towards weakening of coda consonants and consequent emergence of open syllables. The central issue here is whether the processes that give rise to synchronic patterns or the patterns themselves are universal. In a formalist approach, languages tend towards universal patterns (such as CV syllables), meaning that the patterns are universal, while the sound changes leading to them (or away from them) are less relevant. In Bybee's approach, it is the *mechanisms* that are universal, and they may or may not contribute to similar (but not identical and/or consistent) *paths of change* across languages: for instance, not all languages at all stages of development prefer open syllables. In terms of the CAS approach introduced earlier in this chapter, the mechanisms of change can become *attractors* in a particular language, and if similar changes come to establish paths of change across languages, they can be considered *attractor trajectories*.

3.2.5 Speech perception and production

Exemplar Models were first applied to phonology in order to explain the process of speech perception, but efforts have been made to create the link between perception and production, or how the decoding and mental storage of sound structure is transformed into articulation by the speaker.

When the speaker encounters a lexical item, two mechanisms take place: the *similarity matching mechanism* and the *exemplar resonance mechanism* (Johnson 2007). In the first, all exemplars stored in memory are activated, and the auditory distance between them and the input token is calculated. When a match is found, the representation of the matching exemplar is fortified. Input tokens that are similar but not identical to existing exemplars are stored as exemplars themselves, near similar exemplars to constitute clusters (Bybee 2006; Pierrehumbert 2001). Next, the *exemplar resonance mechanism* permits the linking of exemplars to non-phonetic properties such as the identity of the word in which the sound exemplar occurred, the identity of the speaker who pronounced it, information related to the speech event, and so on. Johnson (2007) points out that this mechanism is important because we do not process speech simply bottom-up (building it from exemplars, as the first mechanism would imply), but also top-down: we know that semantic context increases perception (e.g. a topic can activate exemplars related to it), and that listener expectations of the speaker can alter perception (e.g. we expect male and female speakers to have certain types of voices, but when they do not, we have already activated the wrong exemplars, which hinders perception).

Therefore the exemplar-based model assumes no *speaker normalisation*, or automatic normalisation of the acoustic parameters of incoming voices; rather it suggests that listeners perceive speech relative to an internal representation of the person speaking (Johnson 2005). The speech patterns of an individual reflect not only physical vocal tract differences but also social stereotypes, and these clues are used to aid perception. In addition, experiments have proved that words are more likely to be recognised and perceived correctly when they are pronounced by a voice with which the listener has already had previous contact (Goldinger 2000; Johnson 2005). This would imply that specific speaker-related tokens are stored in memory and used when processing speech.

One might doubt the information processing abilities of the human mind and how every single token of experience can be stored. A token that is experienced only once by an adult is likely to only have a minute impact on mental representations compared to all of the already accumulated exemplars. On the other hand, when a child (whose experience with language is much more limited) encounters the same token, it has a much greater impact on mental representations. At the same time tokens that have not been repeated after the first encounter are gradually lost: we have a more vivid memory of things that happened recently, but forget details we encountered a decade ago. Therefore repetition can be seen as fortifying memories, and non-repetition causes loss of memories (Bybee 2006; Pierrehumbert 2001).

Categorisation in an exemplar model is illustrated in Figure 3.2. Every exemplar has a set of auditory properties that are stored in connection to category labels that can be related to linguistic value (sociolinguistic notions, phonological context), speaker identity (name, gender, age), etc.

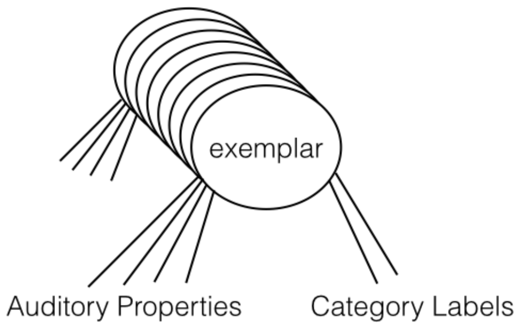


Figure 3.2: Illustration of the exemplar as an association between a set of auditory properties and a set of category labels (after Johnson 1997, p. 148)

However, it can be argued that a more elegant model would account for perception and mental representations without storing each individual exemplar in a separate location in the brain. It seems more reasonable to assume that an incoming token is "mapped" onto an existing parameter space that already contains other encountered exemplars, strengthening the representation of a sufficiently similar exemplar, while weakening a dissimilar exemplar (Pierrehumbert 2001). Johnson (1997) presents a model (based on Kruschke 1992[1]) in which a "covering map" takes the place of exemplars. Figure 3.3 exemplifies this model: in the illustration, there are two auditory categories as part of the input, and two phonological categories two which tokens can be associated. Between them is the covering map in which each location corresponds to a vector of possible auditory

[1]Kruschke, J. K. (1992) ALCOVE: An exemplar-based connectionist model of category learning. *Psychological Review* **99**: 22-44.

properties. Attention weights (the sensitivity of the categorisation process to particular auditory properties) govern the connection of each property to the map, and association weights govern the connection of locations in the map to category nodes. Hence exemplars are encoded in the model as weight modifications of the map locations rather than through explicit storage of individual exemplars.

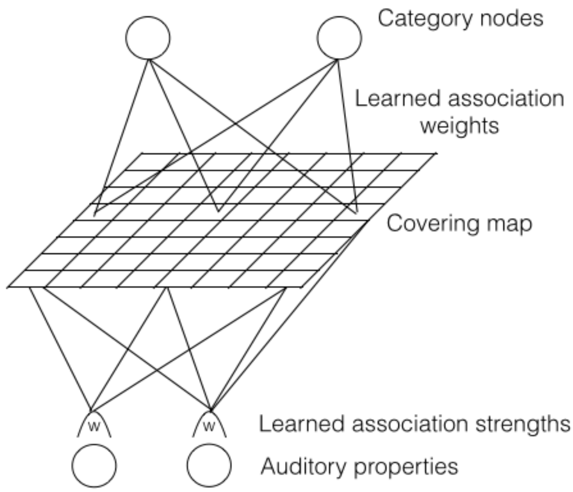


Figure 3.3: A covering map exemplar model of perception (after Johnson 1997, p. 153)

So far we have explained how experienced tokens affect mental representations. The next step is to consider how the exemplar representation is transformed into articulation: if a speaker has various stored exemplars of a lexical item in various phonetic shapes, how does the speaker decide on a certain articulation? Pierrehumbert (2001) sees that the decision to produce a given category comes through the activation of the category label: it is a random selection from an exemplar cloud associated with a label. Production is sensitive to exemplar strength in the same way as perceptual classification is. Phonetic targets are not necessarily achieved completely, and this leads to further reorganisation of a category in the speech community over time.

But when a phonological category is activated, how is it transformed into movements of the vocal tract if the original input has been auditory? Johnson (1997) assumes that the link between perception and production in the exemplar model lies in *ego exemplars* of articulation, that is, in personal articulatory patterns an individual thinks correspond to the auditory stimulus. Pierrehumbert (2002) calls this "phonetic imitation". It is well known that different articulatory strategies can be applied in order to achieve a (sufficiently) similar output: Johnson (1997) gives as examples the speech produced without a tongue (for instance, as a result of a glossectomy, or surgical removal of the tongue), speech produced by a bird that is able to mimic human speech sounds, and the slightly different articulatory strategies between speakers to produce the "same" sounds (which was also discussed by Scobbie & Sebregts 2010, cited in Section 3.2.4). Therefore the gestural knowledge derived or generated while listening to others is based on ego exemplars. *Gestural mirages* (the fact that we hear normal vocal tract actions, and not the possible compensatory articulations) are the norm in the production-perception loop, not the exception (Johnson 1997). This interpretation of the production-perception loop is illustrated in Figure 3.4.

3.3 Laboratory Phonology and Sociophonetics

So far in this chapter, we have discussed language and phonological representations as complex networks that arise from the social interaction between speakers and the subtle probabilistic changes this interaction causes over time. The assumption is, then, that language change is gradual and can manifest itself at different magnitudes and times in different speakers. Therefore, this dissertation is constructed on the notion that experimental data is crucial to understanding the phonological patterns of speakers, and that the data should not be forced into discrete categories. Rather, we assume that gradient phonetic detail is the foundation of phonological representations and sound change. This is why the methodology and objectives of Laboratory Phonology (Pierrehumbert, Beckman & Ladd 2012; Cohn 2011; Pierrehumbert & Clopper 2010) and Sociophonetics (Foulkes, Scobbie & Watt 2011) are adopted in this dissertation.

Laboratory Phonology is not a theory as such, but rather a commu-

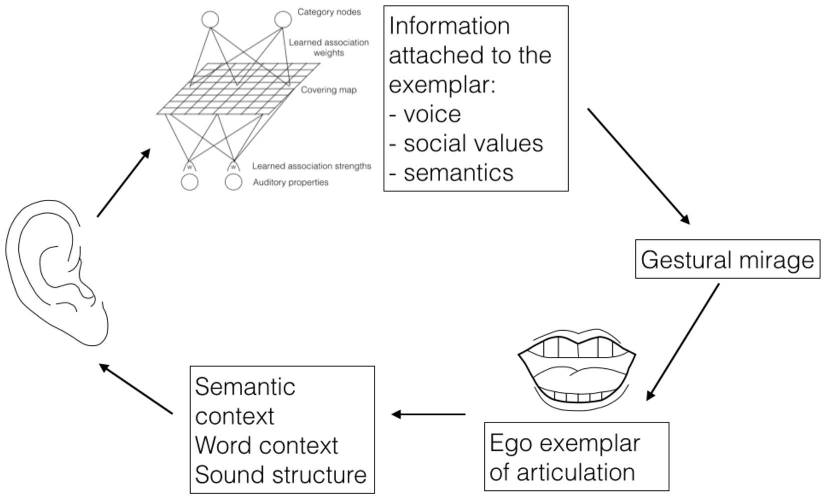


Figure 3.4: The production-perception loop in exemplar-based phonology

nity of researchers interested in understanding sound patterns as part of human cognition, and developing experimental methods to study phonological representations. Language is not seen as a separate module from other cognitive skills, and most importantly, Laboratory Phonology questions the separation of Phonetics and Phonology into two fields. Whereas formalist phonology assumes that variation arises from an abstract level of representation, laboratory phonologists begin with the assumption that variation and change are inherent in any human activity, and from this actual language use we are able to form abstractions. This view is very similar to the bottom-up, non-deterministic view of self-organisation and change in a Complex Adaptive System, as discussed in Section 3.1.

Pierrehumbert et al. (2012, p. 22–23) explain that the Laboratory approach to modelling and understanding phonological variation combines both *discrete* mathematics (logic and formal language theory) and *continuous* mathematics. The early works in the generativist tradition made human language seem like computer languages—the application of discrete algorithms—because they relied exclusively on discrete mathematics. This is why, according to Pierrehumbert et al., the identification of formal linguistics with discrete formalism persists to this day. The assumption behind the Laboratory Phonology approach is that the variation present in human languages cannot be accounted for by using only discrete categories; some types of variation are gradient in nature and need to be described as part of a continuum. According to Scobbie & Sebregts (2010), the study of phonetic detail (by means of acoustics, ultrasound imaging, etc.) may reveal subtle variation and secondary articulations in variants that perceptually seem categorical, and establish an articulatory link between these variants, but on the other hand, experimental techniques may also reveal that variation is indeed categorical. These two possible outcomes point to the fact that variation can either be articulatorily-based (phonetically gradient) or analogical (phonetically discrete).

In addition to Laboratory Phonology, this dissertation draws on sociophonetic methodology. Sociophonetics is a field of phonetics that aims at combining the techniques of phonetic studies with the knowledge on human social interaction that the field of sociolinguistics has produced since the latter half of the 20th century (Foulkes, Scobbie & Watt 2011).

Unfortunately, classic sociolinguistic studies have reduced phonetic variation to discrete categories ("linguistic" or "dependent" variables) whose application is influenced by social factors ("sociolinguistic" or "independent" variables). The contribution of Sociophonetics to the study of the social aspects of language is much the same as it is to phonology: attention to the appropriate recording conditions and techniques for the analysis of variation. Sociophonetics also calls into question the assumption that phonemic categorisation is discrete by showing that phonetic differences can have social value.

Traditionally phonetics has not been particularly concerned with aspects related to the personal history of the speaker or the naturalness and authenticity of input (in perception studies) or output (production studies) speech has not always been a priority. The sociolinguistic aspect to Sociophonetics enables the observation of the speaker as part of a social system. Diverse aspects of that system, such as gender, age, geographical origin, education, ethnicity and speech style, are all intertwined and affect the speech patterns of the individuals that interact within the system. By taking these aspects into consideration in the planning of methodology and data analysis, phonetic variation that may at first seem random may be explained, at least in part, with sociolinguistic factors.

3.4 Conclusions and application

This chapter has been an introduction to the premises and methods of Complex Adaptive Systems, Exemplar-Based Phonology, Laboratory Phonology and Sociophonetics. These frameworks are considered compatible and applicable to the dissertation topic because of their commitment to understanding the gradient and variable nature of language.

Viewing language as a Complex Adaptive System makes it possible to observe sound change as a phenomenon that is influenced not only by immediate phonological factors (adjacent segments, stress, etc.) but also by a myriad of other factors that are also changing inside a larger system called Brazilian Portuguese. These can include but are not limited to general stress patterns of the language, semantics, syntax, sociolinguistic and stylistic tendencies, phonetic gradience, and individual articulatory patterns. Within the phonological system, rhotics (or any other class) interact with and are influenced by changes in other phonological subsystems, such as vowels and the reductive changes they are subject to in unstressed position in BP. Central to a CAS approach is the premise that the language system as a whole emerges from idiolects, and that change takes place interactively and simultaneously in the communal language (system) and idiolects (subsystems). The basic idea of cumulative changes brought about by interaction, exposure and use make it possible to reconcile the CAS approach and the Exemplar Models approach in a dissertation on phonological categorisation and sound change.

The theoretical assumptions of Exemplar-Based Phonology are explored in this dissertation due to the possibility of explaining seemingly irregular phonological variation better than within rule-based models or constraint-based models such as Optimality Theory (Prince & Smolensky 2002). In an Exemplar approach, gradual sound change, as well as the effect of speaker differences and sociolinguistic phenomena can be analysed within a system that is dynamic and moulded by language use itself. In addition, reasons for why a sound change seems to have affected only some lexical items or phonological contexts can be sought in frequency effects of individual lexical items or sound patterns, semantic context, morphological abstractions, *chunking*, or analogy.

The Exemplar approach can also be applied to understanding how perception is possible in a speech community with great phonetic variation—as is the case with the rhotics used by the speakers recorded for this study—in a more dynamic manner. Instead of assuming shared underlying representations, the exemplar-based approach predicts that when exposed to new variants, semantic and pragmatic context allows us to store new and different exemplars of lexical items and use them for on-line perception. Therefore, the phonological interpretation of rhotics as a class will be carried out under the premises of Laboratory Phonology and Exemplar Models: the construction of phonological grammar is assumed to be a bottom-up process involving the same cognitive skills as any other human activity, that is, abstract phonological categories are formed on the basis of phonetic variation.

Sociophonetic methodology is present in this thesis in the choice of participants as well as the speech styles chosen to form the corpus. The participants were controlled for level of education and geographical origin: in order to establish a uniform pool of participants, seven women and men were chosen from a similar education background (university students) and from the same region. The pool of participants is uniform because the aim of this dissertation is not to explain differences in articulation based on social factors, but rather the opposite: how and why variation occurs between individual speakers who are from a similar background, and how this may contribute to to the progress of sound change. Two different speech styles familiar from sociolinguistic tradition were included in the corpus: semi-structured interview and sentence completion. The technical aspects of data collection and analysis in this dissertation were conducted in the tradition of phonetic sciences. Attention was paid to optimal acoustics in the recording situation, and spectrographic analysis was used in order to label the acoustic data objectively.

Chapter 4

Data and Methodology

In this chapter, the compilation of the two corpora of this dissertation will be discussed. Sections 4.1 and 4.2 provide details on the conducted semi-structured interviews and sentence completion task, respectively. The technical aspects of the recording setting are explained in section 4.3, and the choice of speakers in section 4.4. Finally, Section 4.5 provides information on the annotation of the speech data in Praat and the qualitative and quantitative analyses performed on these data.

The material of this dissertation is composed of two corpora: one of them contains the rhotics observed in semi-structured interviews carried out individually with each participant, and the other corpus was collected through a sentence completion task. Both of these data sessions were carried out with 14 participants in August, 2013, in the town of Lavras in the south of Minas Gerais.

The decision to collect data using two different methods in order to obtain both spontaneous speech and laboratory speech is based on the stylistic variation in BP rhotics. A discussion of the advantages and disadvantages of different speech styles can be found in Wagner, Trouvain & Zimmerer (2015). The authors stress that methodology needs to be adapted to the socio-cultural setting of the language, and that an awareness of the differences between methodologies is crucial when interpreting the observed phonetic phenomena: they can either be style-specific or generalisable across all data types. This is why this dissertation relies on two speech styles which complement each other: the task setting is expected to elicit more careful speech patterns which can be considered a baseline for monitored speech, while the interview setting provides connected speech that is expected to involve less self-monitoring, and consequently more lenited and/or sociolinguistically less prestigious forms. The comparison of the data obtained in these two settings can tell to what degree the observed phenomena—e.g. variation in coronal vs. back rhotics, reduction phenomena and the proportion of segments resulting from different lenition mechanisms—are style-specific and what limitations stylistic variation imposes on the phonological analysis of BP rhotics.

4.1 Semi-structured interviews

Perhaps the most common speech elicitation method that balances control over the recording situation and the naturalness of speech is to have the subject converse with an interviewer/experimenter (Warner 2012): the participant's speech may be rather natural, but still have good acoustic conditions. The interviewer can have great influence over the casualness of the situation, keep the participant talking, and steer conversation to topics that will elicit target words. Warner points out that the disadvantage of this method is that the subject does not know the interviewer, which can lead to a more formal speech style than among family or friends. The overlapping of the interviewer's and the participant's speech can be a problem for later analysis; the interviewer can try to avoid this during conversation, but then again overly sequential turn-taking is potentially unnatural depending on the culture. The interview setting is therefore a delicate trade-off between the naturalness of the conversation and the avoidance of overlapping speech.

The interviews carried out with the fourteen participants built on their travel experience in Brazil and foreign countries, the comparison of the personality of *mineiros* (people from the state of Minas Gerais), Brazilians from other regions and foreigners, and moving on to the type of people that occupy political positions in Brazil. This topic was then connected to the mass protests that took place in Brazil during the previous month in response to various political themes and the important sports events hosted by Brazil in the following years, the FIFA World Cup and the Summer Olympics.

The interviews aimed at recording the speaker talking as comfortably as possible about any of the suggested topics. The interviews lasted approximately 15-30 minutes (see Section 4.5.4 for more details on duration and number of labelled tokens) and were placed in the beginning of the recording session in order to avoid giving away the research topic, but also in order to relax the participant and thus maximise the occurrence of reduced speech by giving the impression that the interview was not the most important part of the session (DiPaolo & Yaeger-Dror 2010).

4.2 Sentence completion task

4.2.1 Motivation and procedure

After the interview, participants engaged in the sentence completion task. The task was created for two reasons: in order to guarantee sufficient tokens of the contexts in which rhotics occur in BP, but also in order to observe the possible differences in articulation in the interview and the task. It is assumed that reduction phenomena (deleted syllables, consonant lenition, centralised vowels, incomplete tongue closures, etc.) are more frequent in connected speech than in reading tasks (Warner 2012). The challenge in creating the task was to insert the words containing rhotics into the desired phonological environment (i.e. previous and following segment) without the influence of orthography. The assumption was that the task setting would prompt more citation forms of words that rarely contain a rhotic in connected speech (for instance, infinitive verb forms such as *falar* 'to speak', *fazer* 'to do/make', *sair* 'to leave/go out').

Since pictures may work better than orthographic prompts in recording vernacular speech (Scobbie & Stuart-Smith 2012), the elicitation task was designed to include sentences with missing words that the participants were expected to complete with the aid of a related image placed on top of the sentence. It is also possible that the image distracted the participants from pronunciation and made them concentrate more on the semantics behind the sentence they were expected to complete. Varying carrier sentences were used instead of a single sentence in order to keep the participants focused and avoid fatigue. Some slides included two sentences, an introductory sentence and the actual carrier sentence, because of the abstract nature of the target word which was occasionally difficult to insert into one single sentence. The sentences and related images were put together in slideshow format and showed to the participants in a randomised order.

The participants were instructed to complete the sentences spontaneously with the first word that came into mind and made sense in the sentence. They were told that the experiment concerned vocabulary that speakers from Southern Minas Gerais would use naturally to complete the sentences. This vocabulary could be any kind of words, including nouns, verbs, adjectives and prepositions, and some words were expected to come up several times. If the participant could not think of a way to complete the sentence, they were instructed to jump to the next slide.

Before the actual experiment, the participants could practice the completion task with five slides. Distractor slides were not included in the task for two reasons. Firstly, the number of rhotic contexts to be included in the task was high (57 in total), which already takes the duration of the experiment to 5-10 minutes. Secondly, the type of target words included in the experiment were varied both semantically (they represented several word classes) and in form (the studied segments occurred in various different phonological contexts), which would have made it difficult for the participant to guess the aim of the experiment.

4.2.2 Content of the sentence completion task

Appendix A lists the target words and carrier sentences included in the sentence completion task. Whenever possible, two words were chosen for a phonological context if the context can occur in stressed and unstressed syllables in Portuguese. For instance, the target words for /a/ + coda rhotic + /t/ were *carta* ('letter', stressed syllable) and *cartão* ('card', unstressed syllable). Word-medial coda rhotics were followed in the experiment by both front stops ([t] in *carta* and *cartão*) and back stops ([k] in *barco* 'boat' and *arquitetura* 'architecture') in order to balance possible coarticulatory effects.

In nouns, the vowels surrounding the rhotic in the target word were [a∼ɐ] whenever possible. However, the minimal pair *caro* – *carro* ('expensive' – 'car') with word-final [u∼ʊ] was also included. Word-initial target contexts were preceded by a vowel, whereas word-final contexts in nouns and verbs were followed by a vowel, a consonant and a pause. This is because the phonetic form of word-final rhotics can be expected to vary according to the following segment (see Section 2.4.2). The consonant following word-final coda was a stop or an affricate ([dʒ] in the preposition *de*) in all sentence frames. This was to avoid any assimilation of coda rhotics pronounced as approximants or fricatives to a following fricative. *melhor* ('better; best'), *maior* ('larger; largest'), *qualquer* ('any(one)') and *por* ('by; for') were exceptions because they were only followed by a vowel and a consonant, but not a pause, due to the difficulty and/or impossibility of placing them at the end of a sentence.

Both mono- and polysyllabic target words with a word-final rhotic were included in the task. The reason for this is that there may be more deletion of final rhotics in polysyllabic words than in monosyllabic words. Huback (2006) found that *r*-deletion was less frequent in monosyllabic words such as *cor, mar, por* than in polysyllabic nominals. The motivation for this would be the fact that monosyllabics already have a reduced number of segments, whereas words with a larger number of segments are more prone to reduction since the phonetic difference between the full and reduced forms is small. Based on this result, the monosyllabic nouns *dor* and *mar* and polysyllabic nouns *açúcar, mulher* and *computador* were chosen. In all of these words, except for *açúcar*, the rhotic is located in a stressed syllable; no frequent lexical items ending in stressed *-ar, -ir* or *-ur* that would also be easily inserted into a sentence completion task could be found in the ASPA database (to be discussed in section 4.2.3). In addition to nouns, mono- and polysyllabic verbs were included in the task. *R*-deletion in verbs is more common than in nominals (Oliveira 1983), which makes the comparison of the nouns and verbs in the corpus of this study an interesting task.

The words *besouro* 'beetle' and *guelras* 'gills' were included in the task because there is variation in the rhotic (strong-R or weak-r): in *besouro* possibly due to two different lexical representations, and in *guelras* due to the vocalisation of the preceding lateral. This vocalisation from [ɫ] to [w] has left the rhotic in a position preceded by a diphthong. As weak-r is more productive in this phonological context in Portuguese (e.g. *ou[ɾ]o* 'gold', *Eu[ɾ]opa* 'Europe', *restau[ɾ]ante* 'restaurant'), young speakers have been observed to prefer tap-like articulations over back fricatives in words like *guelra* (Oliveira & Cristófaro-Silva 2002).

4.2.3 Controlling for token frequency

The theoretical framework of this dissertation is that of Complex Adaptive Systems and Exemplar Models, according to which the phonology of a language is an emergent, dynamic structure that is modified constantly as language is being used. The automation of articulation leads to substantive and temporal reduction of articulation. Frequent words and patterns are affected by this neuromotor automation first, whereas analogical change is more common in low-frequency words. Therefore, the underlying assumption when creating the sentence task was that it must consist of relatively frequent words if reduction phenomena are to be found.

All target words were checked for token frequency in the ASPA corpus (*Avaliação Sonora do Português Atual*, available at www.projetoaspa.org). It consists of 199,864 different words annotated for phonological transcription, grammatical category, morphological structure, and frequency of occurrence in a corpus of written Portuguese (Cristófaro-Silva, Almeida & Fraga 2005). A required minimum of 2000 occurrences in the ASPA corpus was established in order to ensure only fairly frequent words in Brazilian Portuguese were used for the task. *besouro* and *guelras* were exceptions because they are low-frequency in the corpus, but included due to the possible variability in the rhotics. Token frequencies of the lexical items included in the sentence completion task can be consulted in Appendix A.

4.3 Technical details

The recording sessions took place in a quiet room at the Federal University of Lavras. Before initiating recording, the room was checked for excessive background noise and echo, and participants were offered a glass of water for maintaining a clear voice during the interview. A Zoom H2n Handy Recorder was set on a tripod stand on a table in front of the participant at a distance of approximately 30 cm, and input level was checked in order to avoid distortion. The recorder was set on XY stereo mode in which its two microphones are positioned at 90-degree angles, optimal for recording sources directly in front of the recorder. Recordings were made in WAV format at a 44.1kHz sampling rate and 16-bit sample size, recommended for acoustic field work (Ladefoged 2003, p. 26; Cieri 2010). Recordings were saved directly onto the memory card of the recorder and subsequently copied onto a computer.

4.4 Speakers

The speakers recorded for this study come from nine different towns at a radius of approximately 150 kilometres from Lavras, where the recordings were made. Seven women and seven men (mean age 21.3 years) who were undergraduate students in English and Portuguese linguistics and literature took part in the study. Table 4.1 provides details on the origin and age of all 14 participants.

Speaker	**Hometown**	**Age**
F1	Nepomuceno	23
F2	São Bento do Sapucaí	20
F3	Santana do Jacaré	21
F4	Lavras	20
F5	Itajubá	19
F6	Lavras	19
F7	Lavras	19
M1	Itajubá	23
M2	Lavras	24
M3	Divinópolis	23
M4	Santo Antônio do Amparo	21
M5	Conceição das Pedras	20
M6	Lavras	23
M7	Carrancas	23

Table 4.1: Recorded speakers (F = female, M = male), hometown and age at the time of recording

The motivation for choosing these speakers was that they not only resided in Lavras, a town situated at a national isogloss concerning coda rhotics, but were also born and raised in towns relatively close to this isogloss. Figure 4.1 illustrates the estimated location of this isogloss for back fricatives and taps/approximants in coda: BP spoken in northeastern and northern Brazil (including states of Pará and Amazonas) are dominated by back fricatives in coda context, whereas varieties to the south are characterised by taps and rhotic approximants (Callou et al. 1996; Callou et al. 2002; Noll 2008; Ribeiro 2011). Because of the scattered population and lack of dialectological references for central and northern Brazil, the exact location of the isogloss beyond Minas Gerais and Goiás cannot be established. Figure 4.1 also indicates the geographical origin of the recorded speakers, as well as the cities of Lavras, Belo Horizonte and São Paulo. Due to the proximity of the isogloss, the speech of the recorded participants is expected to contain influences of both coda patterns, which is interesting from the point of view of phonological representations and diachronical sound changes.

Southwestern Minas Gerais is considered to have one macro-dialect dominated by the use of rhotic approximants in coda. Zágari (1998) calls this the *paulista* dialect because of its similarity with the Portuguese spoken in the state of São Paulo, and explains that its eastern limit passes through the towns of Passa Vinte, Liberdade, Andrelândia, Lavras, Oliveira, Pará de Minas, Divinópolis, Vazante, Bom Despacho, Dores do Indaiá, São Gotardo, Patos de Minas, and São Gonçalo. To the east of this limit, in central (including the state capital Belo Horizonte) and southeastern Minas Gerais, lies what Zágari calls the *mineiro* dialect area. Northern Minas Gerais, on the other hand, belongs to the *baiano* dialect area, which shares characteristics with the Portuguese spoken in the state of Bahia. In the *mineiro* and *baiano* regions, coda rhotics are generally back fricatives (e.g. [ʁ χ ɦ h]).

Figure 4.2 is a map of southeastern Brazil, highlighting the isogloss for coda rhotics (dashed line, based on Zágari 1998) as well as the origin of the recorded speakers (circles) and the recording location, Lavras. This isogloss is based on a dialect atlas, *Esboço de um Atlas Lingüístico de Minas Gerais*, published in the 1970s (Zágari, Ribeiro, Passini & Gaio 1977). Obviously, since then the linguistic situation in Minas Gerais may have changed, but no updated dialect data has been published. The criterion for selecting Lavras as the place of recording is that, according to Zágari et al. (1977) and also more recently Aguilera & Silva (2011), the two coda tendencies coexist in Lavras, which makes it possible to observe the patterns of variation at the level of the communal language and the

Figure 4.1: Map of the coda rhotics isogloss in Brazilian Portuguese, origin of the recorded speakers, and the cities of Lavras, Belo Horizonte and São Paulo

idiolect.

Figure 4.2 also shows that the fourteen speakers come from six towns that are located quite close to the isogloss (this includes Lavras), and three towns that are located more to the southwest. The speakers were chosen based on previous observation of their coda rhotics: speakers who seemed to only use prestige variants (uvular and glottal fricatives) in this context were not chosen because less variation was expected in their output (i.e. the probability of recording the less prestigious rhotic approximants in addition to back fricatives was low). Again, the aim of the present study

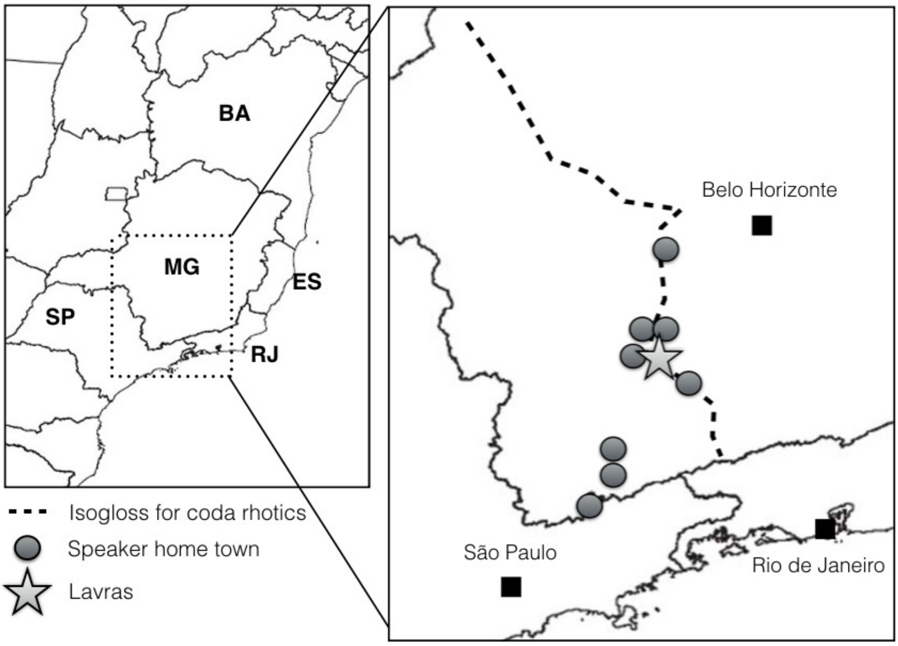


Figure 4.2: Map of the isogloss for coda rhotics in Minas Gerais, origin of recorded speakers, and the recording location, Lavras

was to observe the patterns of rhotic variation and propose a model of production and perception that is able to compass all kinds of variants that coexist in a speech community; this is why a uniform geographical origin was not a criterion in the choice of speakers. All chosen speakers were previously observed using at least approximants, but possibly also back fricatives in syllable codas because they had been living in a town where both coda patterns have been documented.

After completing the interview and sentence completion task, the participants signed a consent form in which they agreed to give permission to the anonymous use of the audio data for scientific purposes. The consent form can be found in Appendix B of this dissertation.

4.5 Data Processing

4.5.1 Annotation

The recordings were analysed and annotated using the spectrogram function in Praat for OSX (Boersma & Weenink 2014) so that the gradient variation of BP rhotics could be captured in the analyses of this dissertation. Impressionistic, auditory analysis is insufficient for the analysis of reduction phenomena: sequences can sound intelligible and normal even if several segments cannot be identified in the spectrogram image (Warner 2012, p. 622).

The data were annotated on three tiers in Praat. On the first tier, rhotics as well as preceding and following segments were annotated with the appropriate IPA symbols and diacritics. The second tier included an interval corresponding to the rhotic on the first tier, marked with a letter combination that identifies the phonological context of the rhotic. Table 4.2 lists the phonological contexts annotated in the corpus. Finally, the third tier specified the lexical item in which the rhotic appeared.

In the annotation of the sentence completion task, the speaker's actual articulation at word boundary was considered: for instance, if a speaker was expected to produce a word-final rhotic followed by a vowel, but paused between the two words, the context was annotated as "followed by pause". Similarly, if a speaker produced a (non-phonological) glottal stop [ʔ] in this kind of context, it was annotated as "followed by consonant". In other contexts than coda, the phonological context was labeled as one would label the expected citation form, even if the surrounding segments creating the phonological context are not present, so that tokens could be listed first based on citation form, and then according to the reduction phenomena that took place. For example, if the vowel following an intervocalic tap (V.ɾV) was deleted in words such as *duro* ('hard') pronounced as [duɹ] or *caras* ('faces'/'guys') pronounced as [kaɾ̥s], the rhotic was labeled as intervocalic in order to facilitate the listing of tokens. Reduction phenomena were then taken into consideration as the next stage of analysis.

One of the most frequent lexical items with a word-final rhotic in the corpus was the preposition *por* ('for; by; per'). Although prepositions are considered to be prosodically unstressed in Portuguese, *por* was labelled as a stressed word-final rhotic context in order to maintain a uniform

Annotated phonological contexts	**Example word(s)**
Stressed word-initial strong-R	*rádio*
Unstressed word-initial strong-R	*rainha*
Stressed intervocalic strong-R	*garrafa*
Unstressed intervocalic strong-R	*carro*
Stressed intervocalic weak-r	*barata*
Unstressed intervocalic weak-r	*cara*
Weak-r in stressed cluster	*tráfico*
Weak-r in unstressed cluster	*trabalho*
Stressed word-medial coda	*carta*
Unstressed word-medial coda	*cartão*
Word-final stressed coda followed by consonant	*mar verde*
Word-final stressed coda followed by vowel	*mar é*
Word-final stressed coda followed by pause	*mar##*
Word-final unstressed coda followed by consonant	*açúcar branco*
Word-final unstressed coda followed by vowel	*açúcar é*
Word-final unstressed coda followed by pause	*açúcar##*

Table 4.2: Phonological contexts for rhotics annotated in the speech corpus

criteria for labeling monosyllabic words (mainly nouns and verbs) ending in a rhotic. In the analyses, nominals, verbs and *por* will be dealt with separately.

As for variation in the stress or syllable number of certain lexical items, the decision was made to label them according to the way they were actually pronounced in the corpus. Variation in stress occurred mostly in the lexical item *ruim* ('bad'). The stress of the rhotic segment was then labeled according to the actual word stress (in this case, stressed when pronounced as [hũj̃], and unstressed when pronounced as [huˈĩ]). Another varying lexical item is the preposition *para* ('to; for'), which consists of two syllables in citation form ([ˈpaɾa]), but often of only one syllable in connected speech ([pɾa]), leaving the rhotic in a consonant cluster. The rhotic was labelled as intervocalic or part of a cluster according to the presence or absence of a stressed syllable before it. When *para* occurred with no rhotic at all (e.g. [pa], or merged with the masculine definite article *para + o* as [pu]) it was labelled a cluster context. In the case of the infinitive verb form *vir* ('to come'), often articulated as [vĩ] in spontaneous speech due to analogy with the finite verb form *vim* ('I came'), the presence of a nasal vowel and no rhotic was labeled as a word-final coda with a deleted rhotic.

The vowels surrounding rhotics were annotated perceptually, i.e. formant values were not taken into consideration when choosing the IPA symbol for a given segment. Occasionally, the BP vowels [a u i] were centralised or lax before a rhotic approximant. Three different phonetic symbols were adopted in the labeling of these segments: [ɐ] for a near-open central vowel, [ʊ] for a rounded near-close back vowel, and [ɪ] for a near-close front vowel. [ə] was used for a neutral vowel that was neither open, closed, back, front or rounded, and could occur as a lenited variant of any vowel in the corpus.

A Praat script was created in order to list and process the data in spreadsheet format.

4.5.2 Rhotic variants in the corpus

This section provides a brief summary of the different rhotic variants observed in the two corpora; more details on annotation criteria and illustrations can be found in the overview sections of the chapters on strong-R (5.1.1), weak-r (6.1.1), and syllable coda (7.1.1.1; 7.2.1.1). Table 4.3 presents the phonetic symbols used for *r*-variants in this study.

4.5.2.1 Tap-like articulations

Tap-like segments were found mostly in consonant clusters and intervocalically, but also word-finally before vowels. Segments labeled as alveolar taps in the corpus have either a complete closure phase that shows up in the spectrogram as a light vertical line (see Figure 6.2) or a clear release burst (Figure 6.3). Full-closure taps can be voiced [ɾ] or voiceless [ɾ̥] (Figure 6.6). However, if formants are present in the closure phase, indicating that the closure is not complete, the segment was labeled an approximant tap [ɾ̞] (Figures 6.4, 6.7), following Leite (2010) and Blecua Falgueras (2001).

Manner	Symbol	Description
Trill	r	Voiced alveolar trill
	r̥	Voiceless alveolar trill
Tap	ɾ	Voiced alveolar tap
	ɾ̥	Voiceless alveolar tap
	ɾ̞	Voiced alveolar approximant tap
Fricative	ɹ̝	Voiced alveolar fricative
	ɹ̝̊	Voiceless alveolar fricative
	ʁ	Voiced uvular fricative
	χ	Voiceless uvular fricative
	ɦ	Voiced glottal fricative
	h	Voiceless glottal fricative
Approximant or vowel	ɹ	Voiced alveolar approximant
	j	Voiced palatal approximant
	ɻ	Voiced retroflex/bunched approximant
	ɚ	R-coloured vowel (or *schwar*)
	w	Voiced labial-velar approximant
	ə	Mid central vowel (or *schwa*)
Aspirated approximant	ɹʰ	Aspirated voiced alveolar approximant
	jʰ	Aspirated voiced palatal approximant
	ɻʰ	Aspirated voiced retroflex/bunched approximant
	ɚʰ	Aspirated r-coloured vowel (or *schwar*)

Table 4.3: *R*-variants in the corpus and their phonetic symbols

4.5.2.2 Fricatives

Glottal fricatives were the most frequent variants for strong-R, but they also appeared in syllable codas. The voiced [ɦ] and voiceless [h] glottal fricatives differ in the spectrogram in the presence or absence of a voicing bar at the bottom of the spectrogram (see Figures 5.2, 5.3, 5.4). Some velar/uvular fricatives were also found in the corpus in the same contexts (see Figures 5.9, 5.10). They will be referred to as voiced [ʁ] and voiceless [χ] uvular fricatives in this dissertation because a spectrogram is not suitable for determining exact places of articulation in the velar/uvular region, as already argued in Section 2.3.3. The alveolar fricative [ɹ̝], with friction noise in the upper end of the spectrogram, was found mostly in tɾ-clusters, and it could be voiced or voiceless (see Figure 6.8). [ɹ̝]∼[ɹ̝̊] are weakened variants of apical full-closure rhotics ([ɾ] and possibly the less frequent [r]), and they do not have a sibilant quality in the same way as [z] and [s], most likely due to the absence of tongue grooving.

4.5.2.3 Approximants and other vowel-like segments

As described in section 2.3.4, approximants are sounds that have a vowel-like continuous formant structure in a spectrogram, and the trajectory of the second and third formants can be used to estimate place of articulation. In this corpus, approximants were attested mostly in syllable codas, but also as weak-r variants in clusters and between vowels. Approximants with a rising F3 were annotated as alveolars [ɹ] (Figure 7.3); rising F2 and falling F3 as retroflex/bunched approximants [ɻ] (Figure 7.5); and rising F2 and F3 as palatal approximants [j] (Figure 7.4), following the acoustic correlates found for rhotic approximants in BP by Leite (2004, 2010) and Ferraz (2005). When the syllable consisted of a centralizing diphthong, the coda segment was labeled as a schwa [ə] (Figure 7.8).

The starting point of a coda approximant was placed in the middle of the vowel-approximant sequence, or if either of these elements was considerably longer than the other, the approximant was estimated to start at the point at which F2 and F3 began shifting. However, if F3 was low and perceptual rhoticity was present during the entire or almost entire duration of the syllable nucleus and coda (and when in fact there was no coda), the segment was labeled as an r-coloured schwa [ɚ] (see Figure 7.6).

4.5.2.4 Aspirated approximants

Some cases of approximants and r-coloured vowels with a fricative release (aspiration) were found in syllable codas ([ɹʰ jʰ ɻʰ]) and as nuclei ([ɚʰ], Figure 7.7). These segments are similar to the approximants described above, but in addition to the continuous formants they show friction noise during or after the approximant/vocalic phase.

4.5.2.5 Deletion

Rhotics were labeled as deleted (Ø) if there were no formant changes indicating the presence of a segment other than the vowel in syllable nucleus (Figures 5.5, 5.6, 6.5, 6.12, 7.9, 7.21).

4.5.2.6 Other variants

Other variants with singleton tokens occurred in the speech of individuals. The alveolar trill, which can be voiced [r] or voiceless [r̥], appears as at least two closure phases in the spectrogram. Some occurrences of the lateral approximant [l], the voiced labial-velar approximant [w], the postalveolar fricatives [ʃ] and [ʒ], and the affricate [ʤ] were also found. These variants do not amount to a significant proportion of tokens in any phonological context in the overall data, but are interesting from the point of view of variation, since they indicate that articulation is extremely dynamic and variable in spontaneous speech. Speech can be perfectly understandable at the word and utterance level, but on closer inspection it can contain segments that are not expected as variants of a phonological category—for instance, the occurrence of sibilants as variants of rhotics is surprising.

4.5.3 Analysis

The data will be analysed in this dissertation both qualitatively and quantitatively. A qualitative approach will be used to observe the proportion (percentage) of different variants in a phonological context in the overall data, in the data obtained from an individual speaker, or in a lexical item. As for quantitative methods, simple logistic regression as well as Fisher's exact test of independence will be used to evaluate the statistical significance of a correlation or distribution in the data. Logistic regression is used to evaluate the relation between a measurement variable (e.g. syllable count of a word) and a nominal variable (e.g. number of non-lenited tokens *versus* number of lenited tokens). Logistic regression renders a likelihood ratio probability, or p-value, which points to a statistically significant relation if below 0.05. Fisher's exact test of independence is used to determine if the proportion of nominal variables (e.g. number of non-lenited tokens *versus* number of lenited tokens) between two data sets (e.g. two different phonological contexts) are significantly different. It is more suited for small data sets, such as the ones analysed in this dissertation, than the chi-square test of independence. Fisher's exact test also renders a p-value that indicates a significant difference in proportions if below 0.05.

The frequencies of occurrence to which the data obtained from the recordings will be compared come mostly from the ASPA corpus (Cristófaro-

Silva, Almeida & Fraga 2005). This corpus will be used for the analysis of *r*-variation in connection with the type and token frequencies of various phonological environments for BP rhotics. As ASPA consists of isolated words and not of word sequences, a text-based corpus called CETEN-Folha (Pinheiro & Aluísio 2003) will be used for determining the token frequencies of alternating environments (consonants and vowels) that follow word-final coda rhotics. CETENFolha is a text corpus available online, consisting of approximately 24 million words worth of text from the Brazilian newspaper *Folha de São Paulo*.

4.5.4 Number of rhotic tokens in the corpus

A total of 7,765 contexts for rhotics (in which a rhotic could be present or absent) were annotated in the corpus: of these, 7,045 are from the interviews, and 720 from the sentence completion task. Table 4.4 lists the number of tokens annotated for strong-R, weak-r, and coda position. It is possible to see that the weak-r contexts, in which a tap-like rhotic is expected, are most numerous in a corpus of connected speech, whereas strong-R contexts are scarce. In the task data, word-final coda is overrepresented because of the choice to include in the task all possible alternating environments (consonant, vowel, and pause) that can follow word-final rhotics in nominals, verbs and prepositions.

Data set	Interviews		Task	
Phonological context	N	%	N	%
Strong-R	478	6.8%	70	9.7%
Weak-r	3,812	54.1%	65	9.0%
Medial coda	934	13.3%	56	7.8%
Final coda	1,821	25.8%	529	73.5%
TOTAL	7,045	100%	720	100%

Table 4.4: Number of annotated contexts in the interview and task corpus

The number of tokens collected from each speaker's semi-structured interview varies greatly. Variation in interview duration and average number of rhotic tokens can be viewed in Table 4.5. We can see that the number of tokens per minute varies from 15 (speaker F7) to 29 (speaker M3). This can be influenced not only by the speech rate of the speaker, but also the amount of time the speaker spent elaborating on a topic (as opposed to the interviewer eliciting responses).

Speaker	Duration of interview (min)	Tokens	Tokens/min
F1	26:20	575	22
F2	20:31	399	19
F3	28:58	500	17
F4	17:39	496	28
F5	16:41	379	23
F6	26:10	542	21
F7	19:26	294	15
M1	27:06	487	18
M2	20:03	373	19
M3	32:36	940	29
M4	16:40	395	24
M5	30:59	560	18
M6	27:02	571	21
M7	25:08	534	21

Table 4.5: Duration of semi-structured interviews and number of rhotic tokens per speaker

Chapter 5

Strong-R

This chapter is the first of three chapters that present analyses of the acoustic data obtained through semi-structured interviews and the sentence completion task. Weak-r will be the topic of Chapter 6, and coda variants will be discussed in Chapter 7.

This chapter begins with the interview data by providing an overview and examples of strong-R variants in the corpus, analysing some of the differences between speakers, and then takes a look at the different lexical items that contained strong-R. The motivation for these points of view in the analysis is that, according to the theoretical framework of this study, sound change takes place in idiolects and in lexical items; that is, changes in individual articulatory patterns give rise to large-scale sound change, and this sound change does not affect all words and structures in the same way. This is why a discussion of the *r*-variants present in the speech of individuals and different types of lexical items is justified. After this discussion, the results of the sentence completion task will be presented, and the chapter concludes with observations on strong-R realisation on a general level.

5.1 Semi-structured interviews

5.1.1 Overview

478 tokens of strong-R, or the rhotic that can occur word-initially and intervocalically, were labelled in the interview corpus. This makes just under 7% of the total of 7,045 annotated rhotic contexts, which suggests that strong-R is not a very frequent segment in spontaneous speech. Figure 5.1 shows the distribution of variants word-initially and intervocalically. It is possible to see that this category is most often produced as a voiced glottal fricative [ɦ]. The voiceless glottal fricative [h] is another main variant, whereas the voiced uvular fricative [ʁ], voiceless uvular fricative [χ], and deletion are minor variants. The variants appear ordered from the uvular fricatives to the glottal fricatives and deletion because we assume that this is the direction of articulatory lenition by or *debuccalisation*, as argued in Section 2.4.1.

Context	**Word-initial**		**Intervocalic**	
Variant	N	%	N	%
ʁ	2	**0.5**	0	**0**
χ	5	**1.4**	2	**1.8**
ɦ	282	**76.6**	90	**81.8**
h	76	**20.7**	13	**11.8**
Ø	3	**0.8**	5	**4.5**
TOTAL	368	**100**	110	**100**

Table 5.1: Strong-R variants in the semi-structured interviews (14 speakers)

Initial observation of the data suggested that strong-R was influenced by the surrounding phonetic context and syllable stress. Figure 5.1 illustrates the observed articulations for strong-R with respect to the preceding segment (in the case of word-initial strong-R), and stress. The token number for each context appears in parentheses. In general, strong-R tends to be voiced if adjacent to voiced segments (vowels or consonants), and it can be voiceless if preceded or followed by a voiceless segment (usually a consonant) or pause. However, voicing of strong-R is frequent even when it is adjacent to voiceless segments or pause, and on the other hand, strong-R's may be voiceless also between vowels. Therefore, the voicing of strong-R is influenced—but not determined—by adjacent segments.

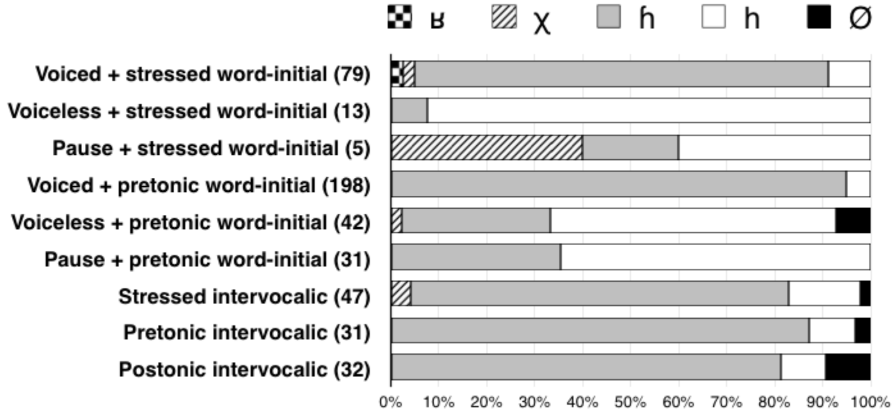


Figure 5.1: Strong-R in the semi-structured interviews according to context

In the following, spectrogram examples of strong-R variants will be presented. The voiced and voiceless glottal fricatives differ in the presence or absence of a voicing bar at the bottom of the spectrogram. Otherwise their composition is very much vowel-like, with little friction. In Figure 5.2, speaker F5 produces the utterance *pelo que eu percebi na r̲ua* ('from what I observed in the street'), with a voiced glottal fricative typical for an intervocalic context.

A token of a voiceless glottal fricative [h] by speaker F7 in the utterance *mais r̲ápido* ('faster') can be observed in Figure 5.3. Voicing stops after the [aj] diphthong in *mais*, and what follows is a sequence of voiceless [sh], after which voicing only resumes in [a].

This kind of [sh] sequence is interesting from the point of view of voicing assimilation. In BP, syllable-final sibilants (alveolar [s]∼[z] in the studied region, postalveolar [ʃ]∼[ʒ] in some other varieties) assimilate voicing to the following segment (e.g. *os̲ patos* [usˈpatʊs] 'the ducks'; *os̲ gatos* [uzˈgatʊs] 'the cats'). In the case of syllable-initial stops, nasals, and sibilants the direction of assimilation is clearly regressive, i.e. from the following segment to the preceding sibilant. Is word-initial strong-R essentially

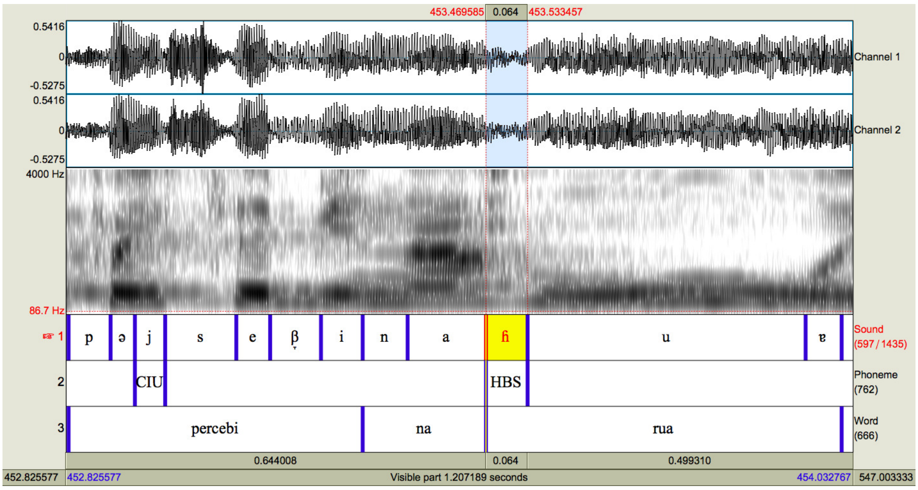


Figure 5.2: Voiced glottal fricative in the word *rua* by speaker F5

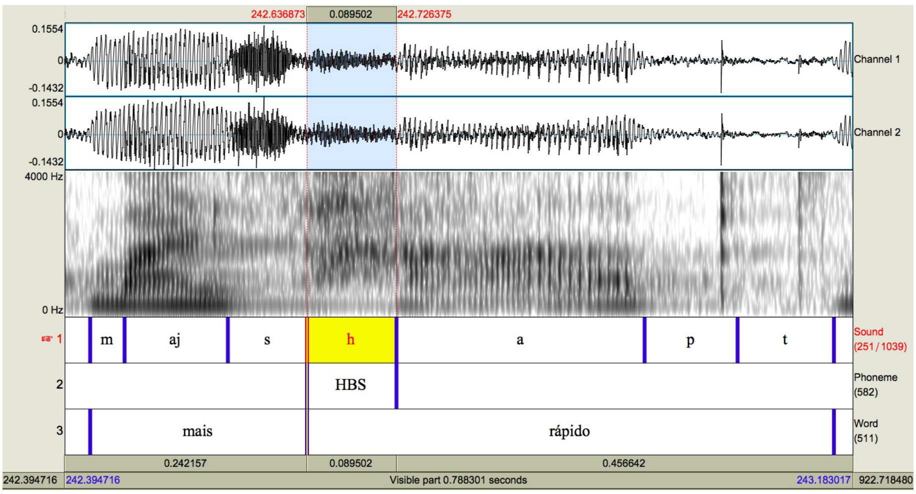


Figure 5.3: Voiceless glottal fricative in the word *rápido* by speaker F7

voiced or voiceless, and does it affect the voicing of the preceding sibilant? Table 5.2 lists the occurrences of strong-R preceded by a sibilant in the interview data. Firstly, in 6 cases strong-R is voiced, in 28 it is voiceless, and in two cases it is deleted. As to the sibilant, it is more often voiced when strong-R is also voiced, and voiceless when strong-R is voiceless or deleted. It should be noted that all six cases of [ɦ] were produced by speaker F1, making voiceless [s] and [h] the main variants in this context for the majority of speakers. It seems that strong-R no longer behaves like other consonants in the sense that it is defined by a voicing feature to which preceding sibilants assimilate; rather, it seems that the voicing of strong-R depends on that of adjacent segments, be they consonants or vowels.

Strong-R variant	[s]	[z]
[ɦ]	2	4
[h]	26	2
[Ø]	2	0

Table 5.2: Word-initial strong-R preceded by a sibilant

Voiceless glottal fricatives can also occur intervocalically, especially if followed by a devoiced vowel. This is frequent utterance-finally when the speaker begins to devoice the unstressed syllable(s) of the last uttered word. Figure 5.4 shows speaker M6 devoicing the last word of the utterance *eu não sei o nome da gue<u>rr</u>a* ('I don't know the name of the war'), leaving post-tonic strong-R as well as the last schwa-like segment voiceless.

Some uvular fricatives occurred in the speech of two individuals, M3 and M7; examples of these variants will be discussed in the next section on individual differences between speakers.

Apart from the back fricatives presented so far, some cases of deletion of strong-R were observed in the corpus. Strong-R was labeled as deleted (Ø) if there were no formant changes or friction noise indicating the presence of a segment other than the vowel in syllable nucleus. Three deletions occurred in unstressed word-initial position preceded by a voiceless segment, one in stressed intervocalic position, one in pretonic intervocalic and three in post-tonic intervocalic position. Figure 5.5 illustrates a word-initial deletion of strong-R by speaker F1 in the utterance *tem gente querendo seiscentos <u>r</u>eais no ingresso* ('there are people asking for six-hundred reais for a ticket'). The utterance *saiu co<u>rr</u>endo para lá* ('he went off running') by M3, with deletion of a stressed intervocalic strong-R, is shown in Figure 5.6. A case of deletion of post-tonic intervocalic strong-R by speaker F4

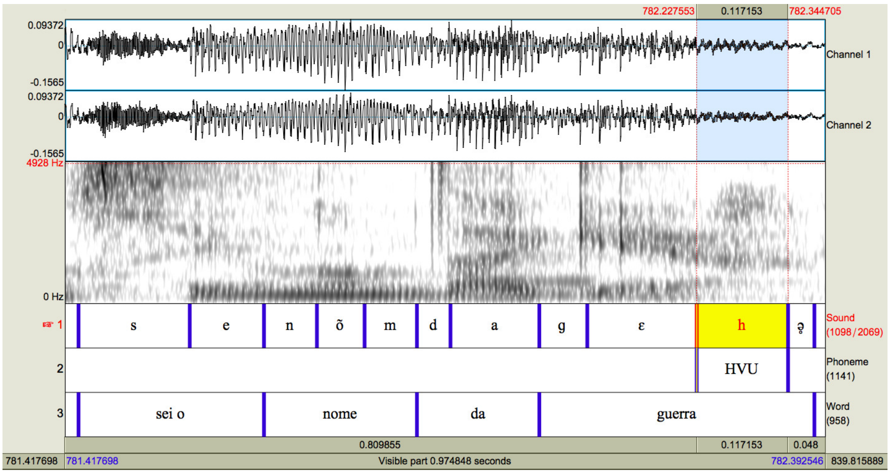


Figure 5.4: Voiceless glottal fricative in the word *guerra* by speaker M6

producing *cachorro quente* ('hot dog') can be observed in Figure 5.7.

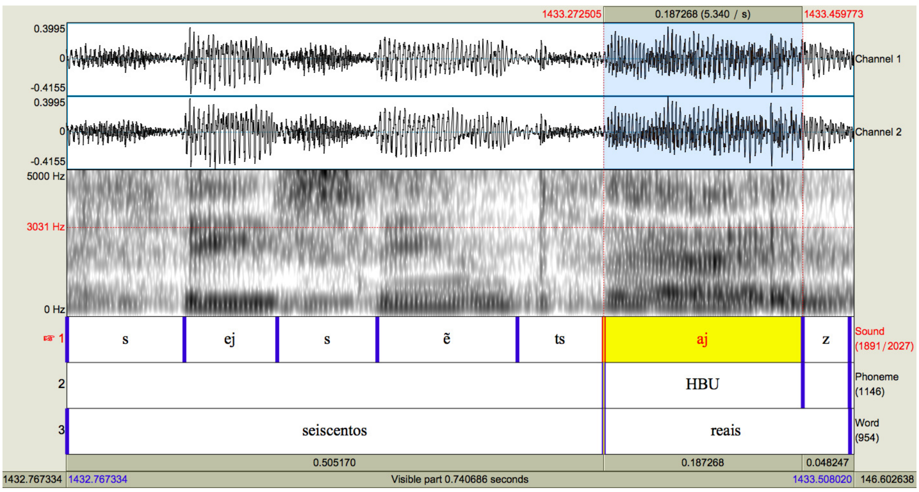


Figure 5.5: Word-initial deletion of strong-R in the word *reais* by speaker F1

This overview of strong-R variants has demonstrated that this category is realised mostly as vowel-like glottal fricatives. Uvular fricatives still exist

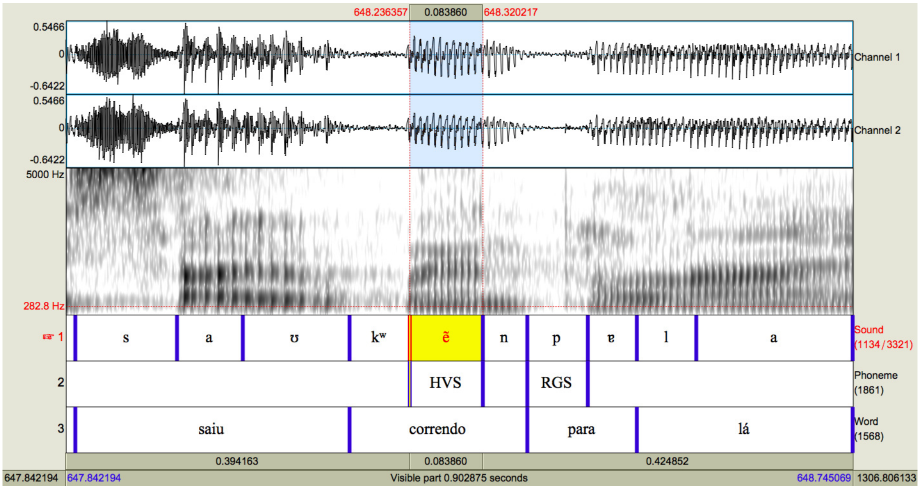


Figure 5.6: Intervocalic deletion of stressed strong-R in the word *correndo* by speaker M3

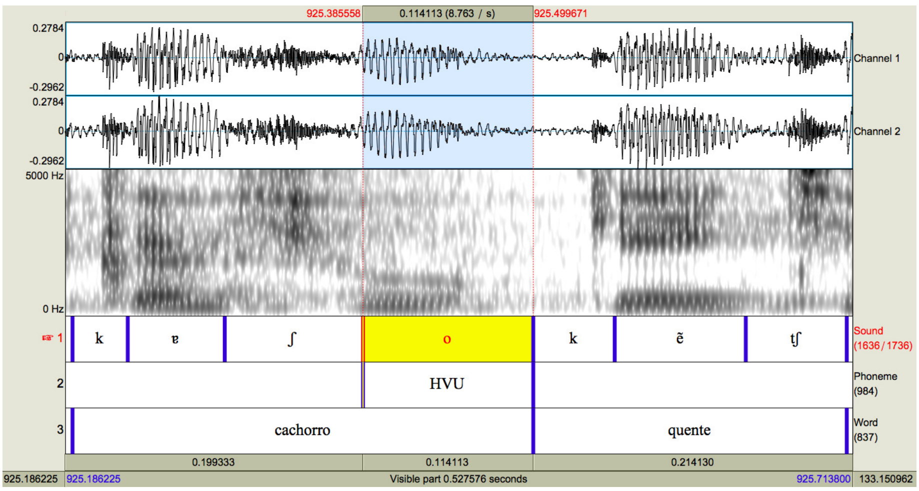


Figure 5.7: Intervocalic deletion of unstressed strong-R in the word *cachorro* by speaker F4

in the studied dialect but they are very rare, which indicates that substantive reduction by debuccalisation has almost completely eliminated the supraglottal constriction in this fricative. Furthermore, the already vowel-like glottal fricatives can lose their friction mostly in unstressed contexts. Thus the strong-R category has a tendency towards Ø through articulatory undershoot. The next section explores how this undershoot manifests itself in the speech of individuals.

5.1.2 Individual speakers

Very little inter-speaker variation could be observed in the data when it comes to word-initial and intervocalic strong-R, indicating that these two contexts are relatively stable in the phonological system of the studied dialect area and speakers. The phonetic realisations of strong-R by individual speakers can be observed in Appendix C. The tendency for glottal fricatives to assimilate to the voicing of the preceding segment does not seem to be consistent in any individual speaker, indicating that it is indeed a tendency and not a categorical phenomenon.

Figure 5.8 presents the individual distribution of strong-R variants in the speech of the 14 participants in all phonological contexts. Again, this category is clearly glottal for most speakers, although M3 and M7 use uvular fricatives as well.

Uvular fricatives seem to occur mostly in contexts of emphasis in the speech of these two participants. Fricatives produced in the velar-uvular region can be considered more prominent than glottals: acoustically, there is more noise in the spectrogram image, and articulatorily, the configuration of the vocal tract requires more coordination. In the former, the tongue dorsum is placed in close contact with the velar-uvular region in order to produce turbulent airflow, whereas in the latter, no supraglottal constriction is required. Since the spectrogram is not a method for determining an exact place of articulation, but rather manner of articulation, fricatives produced in the velar-uvular region are generalised as uvulars in this analysis (see Section 2.3.3 for information on fricative rhotics).

M3 has two tokens of intervocalic strong-R that are articulated as voiceless uvular fricatives, while all other realisations of strong-R are glottal fricatives. The utterances that M3 emphasises are *nossa mas quase mo<u>rr</u>i, nunca mais* ('oh my God, I almost died, never again') and *é ho<u>rr</u>ível o calor, eu não eu não aguento* ('the heat is terrible, I can't I can't take it'). Both emphasised words are also longer than usual. Figure 5.9 presents a

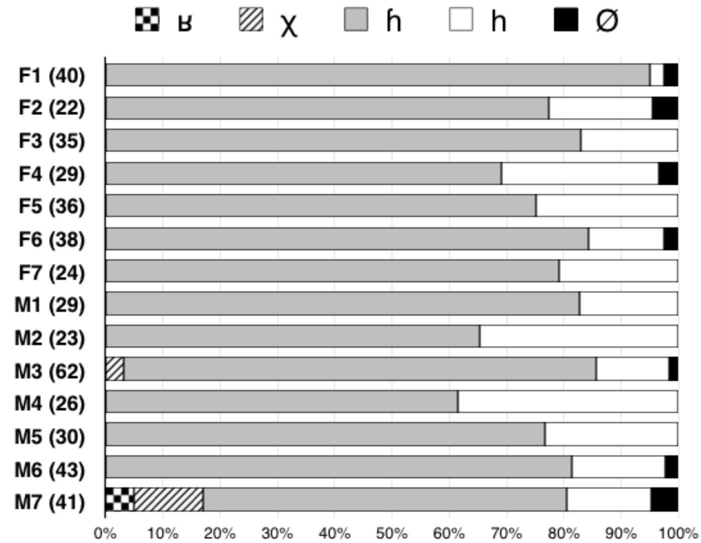


Figure 5.8: Strong-R variants by speaker in the semi-structured interviews

spectrogram image of the first of these utterances.

Speaker M7 produced five voiceless uvular fricatives and two voiced uvular fricatives. Four of these can be considered cases of emphasis, and one of them is a question that focuses the word containing a word-initial rhotic (*mas já, r̲ápido assim?* 'already, that fast?'). Figure 5.10 is a spectrogram image of M7 emphasising *ruim* in the utterance *todo mundo é r̲uim* ('everybody's bad') with a voiced uvular fricative. A voicing bar is present, unlike in Figure 5.9.

The fact that uvular fricatives occur as variants of strong-R in the speech of some individuals, albeit in limited lexical items and expressive settings, shows that dorsal fricatives are still part of the phonological representation of strong-R. However, from the point of view of Exemplar Models, they are peripheral variants in the strong-R category which is dominated by their weakened counterparts, [h]∼[ɦ].

There are speaker-related differences also in the presence of deletion: seven speakers (F1, F2, F4, F6, M3, M6 and M7) have one or two deleted strong-R's in their interview data, while the other seven speakers have none. F1 deleted the unstressed word-initial rhotic of *seiscentos r̲eais* ('six-

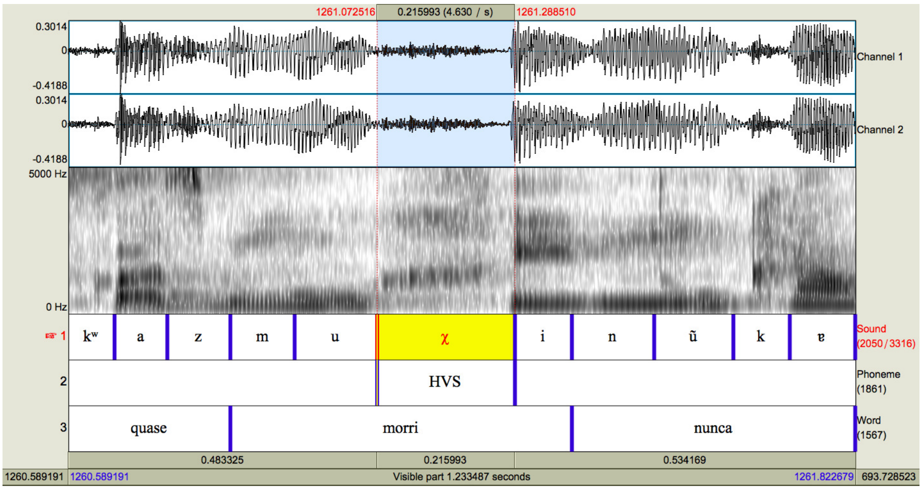


Figure 5.9: Voiceless uvular fricative in the word *morri* by speaker M3

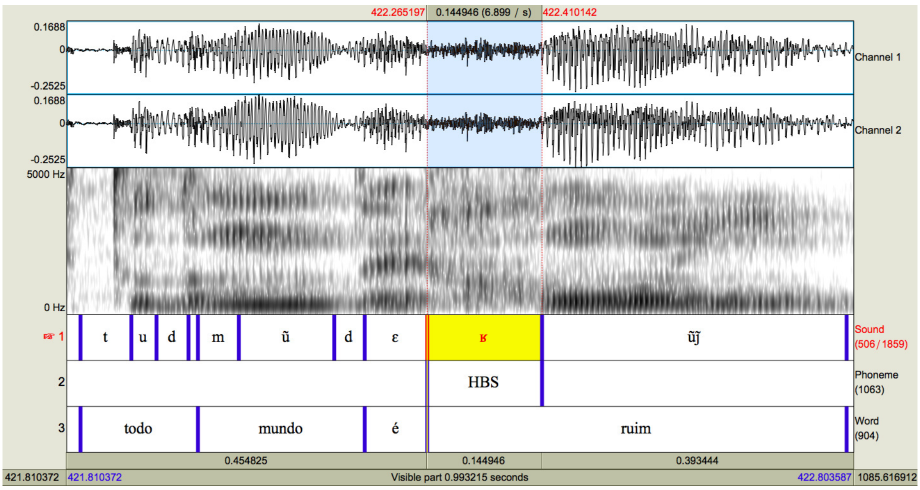


Figure 5.10: Voiced uvular fricative in the word *ruim* by speaker M7

hundred reais'), F2 the pretonic intervocalic rhotic in *corrupção* ('corruption'), F4 the post-tonic intervocalic rhotic in *cachorro quente* ('hot dog'), F6 the pretonic word-initial rhotic in *as reportagens* ('the news reports'), M3 the stressed intervocalic rhotic in *correndo* ('running'), M6 the pretonic word-initial rhotic in *essa região* ('this region') produced as [ɐseʒõ], and M7 the post-tonic intervocalic rhotic in *morro* ('I die') on two different occasions. It is worth noting that in all cases except for M3's *correndo*, the deleted strong-R is in unstressed position, and in addition strong-R is preceded by a voiceless [s] in some of these tokens. Unstressed position weakens all segmental material in BP, including rhotics of all possible types, as will be seen in this dissertation. As for the influence of preceding [s], *r*-deletion can be considered a retiming of the fricative air mechanism and voicing. When the airflow required to produce fricatives ends right after the alveolar gesture of [s], the already vowel-like glottal fricative merges with the gesture and voicing of the following vowel, transforming a [sh]V sequence into [s]V.

We can conclude that there are mild speaker-related differences in the interview data: while strong-R is glottal for most speakers, two speakers still make use of the articulatorily more complex uvular fricatives. In addition, half of the studied speakers delete strong-R, while the other half has no instances of deletion. This could be due to the low token count of strong-R contexts per speaker, but also due to the type of words that occurred in the interview corpus. The next section takes a closer look at word-level variation in strong-R.

5.1.3 Lexical item

This section will present data on the lexical items in which strong-R occurred, separating them according to phonological context (word-initial and intervocalic) and stress. Masculine, feminine, singular and plural forms will appear as separate lexical items: therefore, words such as *professor* '(male) teacher', *professora* '(female) teacher', *professores* '(male/undefined) teachers', *professoras* '(female) teachers' and their token frequencies will be listed separately. According to exemplar-based phonology, affixes are part of lexical representation (see Section 3.2.2). In the following, charts plotting lexical items, their token counts and strong-R output will be presented in order to observe if some words dominate the occurrences of a particular phonological context and if any word-specific patterns of variation can be detected.

Figure 5.11 plots on the vertical axis the lexical items with a stressed word-initial strong-R in the interview corpus. The most frequent word

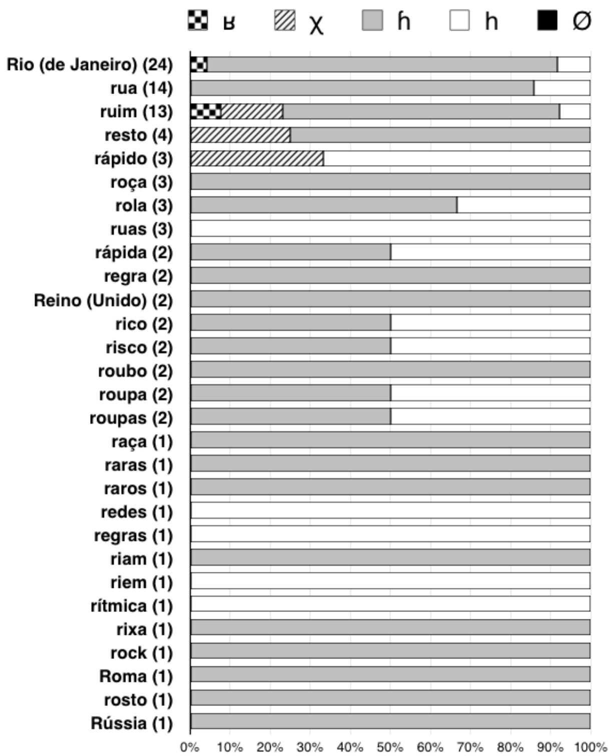


Figure 5.11: Lexical items with word-initial stressed strong-R

with a stressed word-initial strong-R in this corpus was *Rio (de Janeiro)*, undoubtedly due to the fact that the interview began with questions about where the participants had travelled. Next in order of frequency were *rua* 'street', *ruim* 'bad', *resto* '(the) rest', *rápido* 'fast', *roça* 'farm; countryside', *rola* 'happens, goes on' (lit. 'rolls'), and *ruas* 'streets', after which separate lexical items have only one or two tokens. Uvular fricatives seem to occur in some of the most frequent lexical items with this phonological context. As already discussed above, the uvular fricatives in this corpus were produced by only two speakers out of fourteen and mostly in contexts of emphasis, making it difficult to attribute these variants to any frequency effect. The token count of all words is also very low for the analysis of any frequency effects. Therefore what seems to explain (but not predict) most accurately the phonetic realisation of stressed word-initial strong-R is the voicing of the preceding segment.

Figure 5.12 lists the token count for words with pretonic word-initial strong-R. A person name with 9 tokens appears as NAME in this chart in order to protect the participants' privacy. The words with most tokens were *realmente* 'really; sure enough', *região* 'region', *relação* 'relationship', *reais* 'reais (currency)', *regiões* 'regions', *receptividade* 'receptivity', *rural* 'rural', *rapaz* 'boy', *recebidos* 'received (pl.)', *responder* 'to answer', and *receber* 'to receive', after which token count stays at four or less tokens. Again, uvular fricatives and deletions are exceptions to the general pattern of glottal fricatives whose voicing depends greatly on that of the preceding segment.

Figure 5.13 lists intervocalic stressed strong-R by token count. Only 27 different words make up this category; with at least three tokens we only have *errado* 'wrong', *horrível* 'horrible', *correndo* 'running', *Carrancas* (town), and *garrafa* 'bottle'. The few detected exceptions to the pattern of glottal fricatives are due to individual speakers and single repetitions.

Intervocalic unstressed strong-R is shown in Figures 5.14 (pretonic) and 5.15 (post-tonic). Words with pretonic strong-R and two or more tokens were *corrupção* 'corruption', *correria* 'rush, hurry', *arrumar* 'to arrange, organise', *arrogantes* 'arrogant (pl.)', and *corretamente* 'correctly'. The two tokens of strong-R preceded by a nasal vowel (*enraizada* 'rooted (fem.)' and *enrolado* 'complicated' (lit. 'rolled') are also included in this intervocalic category since they are phonetically in fact intervocalic (the prefix *en-* being [ẽ]∼[ĩ] in the studied dialect) as opposed to traditional phonological analysis that assigns a nasal archiphoneme (/eN/) to the position before strong-R. Apart from one deletion in *corrupção*, all words were produced with glottal fricatives.

In post-tonic context (Figure 5.15), the words with two or more tokens are *morro* 'I die', *erre* 'the letter r', *morro* 'hill, slope', *Inglaterra* 'England', *guerra* 'war', and *cachorro* 'dog'. We can see that deletions occur in tokens of *morro* (verb) and *cachorro*.

The two different types of *morro* are homophones (['moɦu]), but appear separated in this chart due to their significantly diverging meanings, and in order to observe if the lexical context in which they appear affects their phonetic outcomes. Out of the four tokens of *morro* (noun), three are

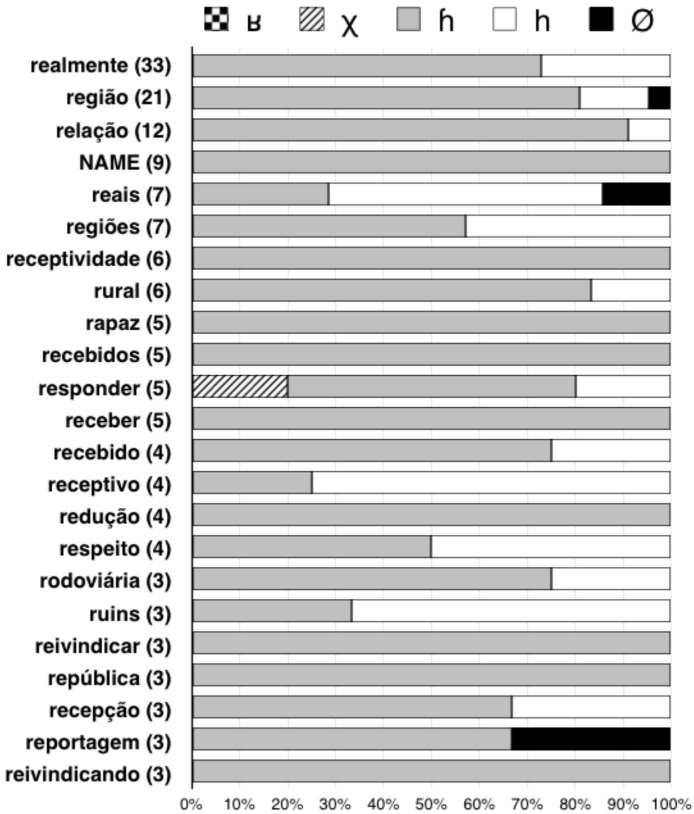


Figure 5.12: Lexical items with word-initial pretonic strong-R (3 or more tokens)

followed by a pause (speakers M1, M2 and M3), and one is followed by a nasal vowel in *então* 'then; so' (M3). As a verb, *morro* is followed by the preposition *de* 'of; from' (mostly [dʒi]∼[ʒi]∼[tʃi] in the corpus) in all five cases. The fixed expressions in which it occurs are *morro de vontade* 'I really want to' (lit. 'I die from wanting') by M5 (1 token with [ɦ]) and M7 (1 token with [ɦ] and two deletions), and *morro de enxaqueca* 'it gives me a terrible headache' (lit. 'I die from a migraine') (1 token by M7 with [ɦ]). We can see that *morro* (verb) occurs only in these fixed expressions in the corpus, and *morro de* may be considered a **chunk** with

Figure 5.13: Lexical items with intervocalic stressed strong-R

the meaning 'to be overwhelmed by a sensation' to which a sensation is added (*morro de vontade* ∼ *enxaqueca* ∼ *medo* 'fear', etc.). Deletions occur in this corpus when *morro* is a verb chunked together with a preposition, but not when it is a noun followed by a pause or a vowel. Chunking increases the likelihood of phonetic reduction as the words in a chunk begin to form a single processing unit. As an example, the two tokens of *morro de* with deletion by M7 were phonetically [ˈmodʒə] and [ˈmoʒ], showing significant reduction from the full citation form [ˈmoɦu dʒi].

The word *cachorro* provides a third token of deleted post-tonic strong-R. This word only occurs in *cachorro quente* 'hot dog' in this corpus; it was

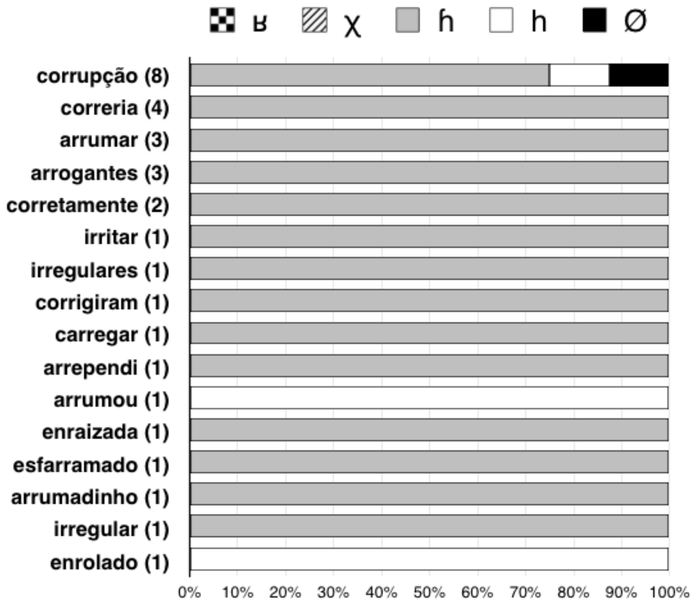


Figure 5.14: Lexical items with pretonic intervocalic strong-R

produced as [kaˈʃohʊ ˈkẽj̃tʃə] by M3 and [kɐʃoˈkẽtʃ] by F4 (see Figure 5.7). F4's token is certainly more chunked than that of M3 since it only seems to have one stressed syllable, and the whole post-tonic syllable containing strong-R and a vowel has been deleted.

It can also be pointed out that the three deletions in post-tonic context occur when strong-R is followed by the back high vowel [u∼ʊ]. Not all words of this type suffered deletion: *morro* (noun), *carro* 'car', *corro* 'I run', and *erro* 'mistake' all contained only glottal fricatives. Post-tonic weak-r also undergoes devoicing and deleting lenition in this context (see Section 6.1.3). All this indicates that post-tonic position and the adjacency to high unstressed vowels may be the driving forces behind a post-tonic lenition trajectory in BP.

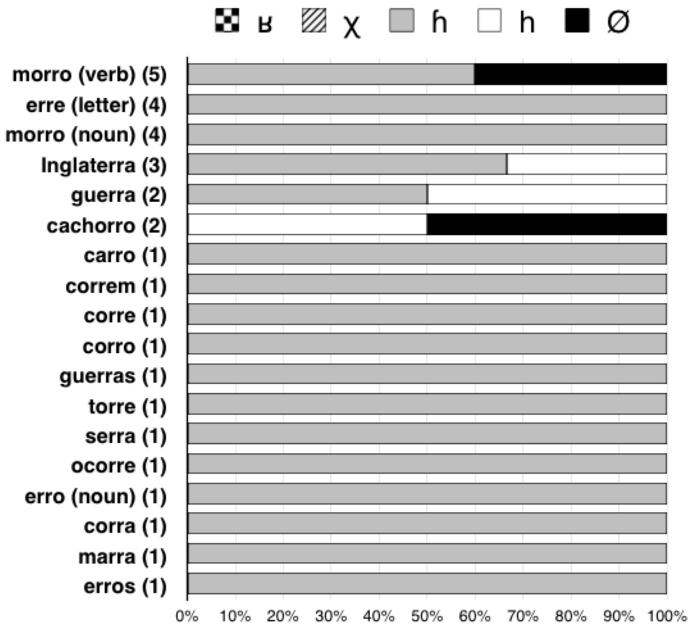


Figure 5.15: Lexical items with post-tonic intervocalic strong-R

5.2 Sentence completion task

This section discusses strong-R variants in the sentence completion task. Figure 5.16 lists the variants for the words *rádio* 'radio' (stressed word-initial), *rainha* 'queen' (pretonic word-initial), *garrafa* 'bottle' (stressed intervocalic), *barra* 'bar' (post-tonic intervocalic) and *carro* 'car' (post-tonic intervocalic) elicited in the sentence completion task. The task yielded a total of 70 tokens of strong-R.

The sentence completion task was designed so that all contexts for strong-R occurred, in principle, between vowels: word-initial strong-R in *rádio* and *rainha* was preceded by a vowel in the carrier sentences (*ouço rádio* 'I listen to the radio' and *a rainha* 'the queen'). However, the last vowel in *ouço* was devoiced by two speakers (M2, M3), and deleted by one speaker (M6), which left the word-initial strong-R preceded by voiceless [s]. Speaker F1 paused before the target word *rádio*. In the case of *rainha*,

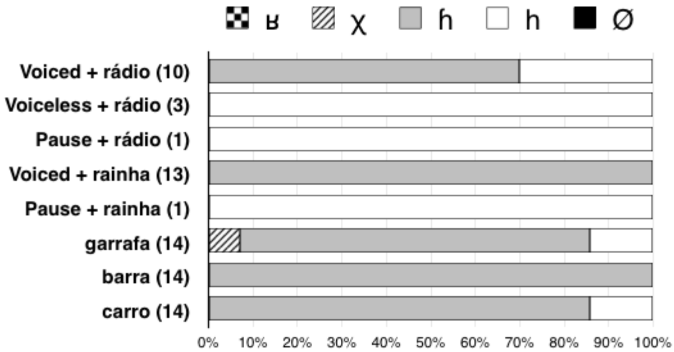


Figure 5.16: Strong-R variants in the sentence completion task (14 speakers)

speaker M6 omitted the article *a* before the target word, leaving it in an utterance-initial position.

The task data show less variation than the interview corpus: no deletions are to be found, and only one voiceless uvular fricative was produced intervocalically by speaker F1. All other realisations are voiced or voiceless glottal fricatives. Similarly to the interview data, word-initial strong-R was mostly voiced when preceded by a voiced segment, and voiceless when preceded by a voiceless segment or pause. In intervocalic context, no adjacent vowels were devoiced, yet 5 tokens of voiceless strong-R were attested in this context. Three of these voiceless tokens occurred in stressed position (*garrafa*), and two in post-tonic position (*carro*). The absence of deletion and the fact that only one token of a uvular fricative occurred in the task data suggest that the least marked variants for strong-R are glottal fricatives, whose voicing is unstable.

5.3 Observations on strong-R

Very little variation is to be found in the production of strong-R by the speakers in this corpus. Most tokens are glottal fricatives whose voicing depends on the voicing of the preceding segment (progressive assimilation). However, voiceless glottal fricatives may also occur intervocalically, and sometimes this can be attributed to regressive assimilation to the following segment (e.g. a devoiced vowel, such as that in Figure 5.4). The predominance of glottal fricatives indicates that BP strong-R is no longer an obstruent, nor does it behave like one at word boundary since it does not voice preceding sibilants. Rather, a preceding sibilant seems to devoice strong-R, which has become a category unspecified for voicing.

A uvular or velar articulation may serve as a marker of emphasis (frustration, exaggeration, etc.), and the virtual absence of these variants and deletion in the task setting suggests that they belong to a less monitored speech register. In addition to register, chunking is another factor found to possibly cause variation in strong-R: in the case of *morro* (verb), chunking with the preposition *de* could explain why post-tonic deletions occurred in this word but not in *morro* (noun). Some variation can also be found between speakers: only two out of fourteen speakers use uvular fricatives, and half of all speakers delete strong-R in some tokens while the other half does not.

The articulation of strong-R in BP is a dynamic process with at least three articulatory parameters: place of articulation (glottal *versus* uvular), degree of constriction (realisation *versus* deletion), and voicing. In terms of a Complex Adaptive System, the variation in the synchronic speech data collected for this study indicate a lenition trajectory from uvular fricatives to glottal fricatives and ultimately to deletion, with articulatory undershoot as its mechanism. This kind of lenition through debuccalisation is a recurring cross-linguistic trajectory (Bybee & Beckner 2015). Figure 5.1 and Table 5.2 illustrated that post-tonic position and adjacency to voiceless [s] may be leading the leniting change towards deletion, and as such may be considered *attractors* in the lenition trajectory of BP strong-R. Articulatory reduction takes place in both of these contexts: post-tonic segmental material is undergoing both substantive and temporal reduction in the studied dialect, and the change from [sh]V to [s]ØV can be considered temporal reduction by retiming as the fricative airflow ceases before the articulatory configuration of the following vowel.

Chapter 6

Weak-r

In this chapter, we will take a look at the variants of weak-r, or the tap-like segment that can occur intervocalically and as the second member of a consonant cluster. Taps may also occur in word-final codas when followed by a vowel; however, this context will be dealt with in Chapter 7, dedicated to rhotics in syllable codas.

This chapter starts with the analysis of rhotics in the interview data. The data will be first explained in general terms, then from the point of view of individual speakers, and lastly by taking into consideration the lexical item in which weak-r occurs and the frequency effects weak-r production may be subject to. After this, attention is turned to the weak-r variants elicited in the sentence completion task in general and by different speakers. This chapter ends with conclusions on weak-r and the intervocalic contrast of rhotics in the studied variety of BP.

6.1 Semi-structured interviews

6.1.1 Overview

In total, 3,812 tokens of weak-r were labeled in the interview corpus. This amount constitutes 54.1% of the total 7,045 rhotic tokens in the corpus, indicating that tap-like segments are the most frequent rhotic variants in informal BP. They can occur intervocalically and as the second member of a consonant cluster (namely pɾ, bɾ, tɾ, dɾ, fɾ, vɾ, kɾ, gɾ)[1], and in stressed and unstressed position. In the following, weak-r in intervocalic position (Section 6.1.1.1) and in clusters (Section 6.1.1.2) will be analysed separately.

6.1.1.1 Intervocalic context

Table 6.1 lists the token numbers for different weak-r variants according to syllable stress: stressed, pretonic and post-tonic. Three isolated occurrences of the voiced postalveolar affricate [dʒ], voiced postalveolar fricative [ʒ], and alveolar lateral approximant [l] were found as weak-r variants; these are excluded from the chart.

Context	**Stressed**		**Pretonic**		**Post-tonic**	
Variant	N	%	N	%	N	%
ɾ	231	**37.7**	107	**43**	298	**32.3**
ɾ̞	372	**60.7**	133	**53.4**	549	**59.4**
ɾ̥	3	**0.5**	1	**0.4**	57	**6.2**
ɹ̝ ɹ̝̊	3	**0.5**	2	**0.8**	10	**1.1**
ɹ	0	**0**	1	**0.4**	2	**0.2**
Ø	4	**0.7**	5	**2**	8	**0.9**
TOTAL	613	**100**	249	**100**	924	**100**

Table 6.1: Intervocalic weak-r variants in the semi-structured interviews

In all contexts, voiced alveolar taps [ɾ] and voiced alveolar approximant taps [ɾ̞] constitute the majority of tokens. However, voiceless alveolar taps [ɾ̥] occur especially in post-tonic context, and a small number of alveolar fricatives [ɹ̝]∼[ɹ̝̊], alveolar approximants [ɹ] and deletions occur in all three contexts. We are not aware of other studies on BP weak-r that distinguish these five types of articulations ranging from full-closure taps to approximant taps, fricatives and approximants. The level of phonetic

[1]The use of forward strokes (//) will be avoided due to their traditional association with underlying phonological representations. The Exemplar framework adopted in this dissertation assumes that phonological representations are probabilistic and multiple. IPA symbols without forward strokes will refer to possible phonetic targets, and IPA symbols within square brackets ([ ]) will refer to realisations attested in the recordings.

detail observed in this study can therefore be considered novel and a significant contribution to the analysis of lenition trajectories in this BP sound category.

Figure 6.1 presents the data in Table 6.1 in a bar chart with the stress contexts plotted on the Y-axis. Since the phonetic realisation of the post-tonic vowel following weak-r was found to be significant for weak-r variation in post-tonic position, the realisation of this vowel is also taken into consideration: it can be voiced (third bar), devoiced (fourth bar), or deleted, in which case the rhotic can be followed by a voiced consonant (fifth bar), a voiceless consonant (sixth bar), or a pause (seventh bar). The token number for each context appears in parentheses. In the following, the acoustic correlates and spectrogram examples are given for the main weak-r variants in each context.

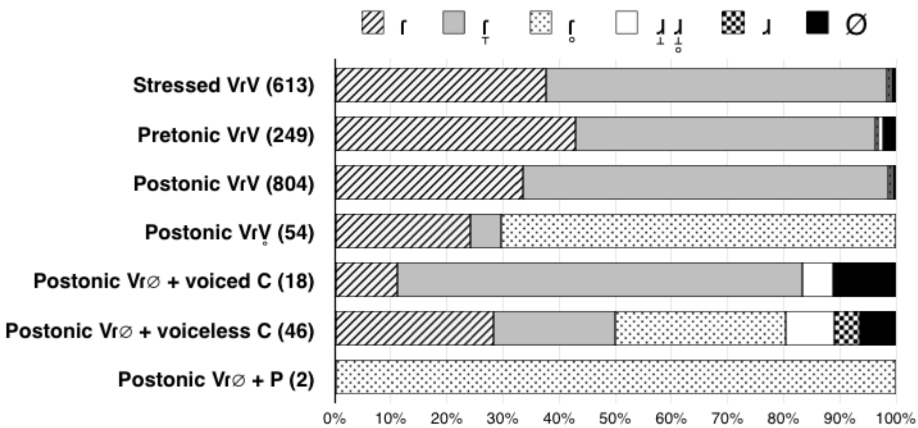


Figure 6.1: Intervocalic weak-r in the semi-structured interviews according to context

In stressed position, voiced alveolar taps make up 37.7% of all tokens. Two criteria were adopted for a segment to be labeled as a voiced alveolar tap: the segment has to either involve a complete closure (light vertical bar in the spectrogram) or a small burst bar indicating the release of a closure, not unlike the burst bars present in plosives. A segment can, of course, have both a full closure and a burst. Figure 6.2 shows a spectrogram image of speaker F3 producing a voiced alveolar tap with a full closure and a visible burst in the utterance *da gente querer lutar pelos nossos direitos* 'that we want to fight for our rights'. A voicing bar is also present during the articulation of the tap. In Figure 6.3, speaker M3 produces a voiced alveolar tap in the utterance *seria como é* '(it) would be what it's like' with formants visible throughout the articulation of the tap, but with a small burst bar before the following [i].

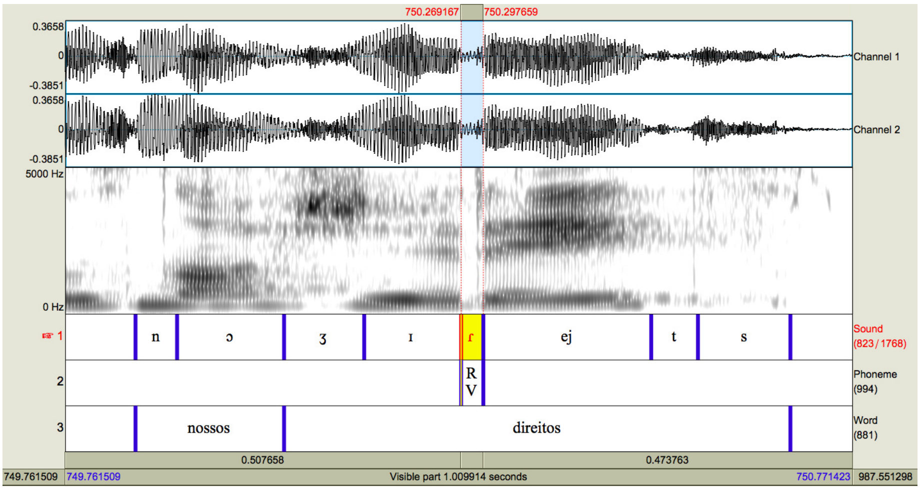


Figure 6.2: Voiced alveolar tap in the word *direitos* by speaker F3

However, the most common variant of stressed intervocalic weak-r with 60.7% of all tokens is the voiced alveolar approximant tap [ɾ̞]. This segment is perceptually very similar to the voiced alveolar tap, but differs in the spectrogram: the formant structure of an approximant tap is continuous and the burst bar is absent. Therefore what most likely takes place in this articulation is the same ballistic movement required to produce a full-closure tap, but the gesture is weakened and full contact of the tongue tip with the alveolar ridge is not achieved, leaving the tap with the formant structure of an approximant. Nevertheless the approximant tap is different from the voiced alveolar approximant [ɹ] in its duration and perceptual quality (a spectrogram example can be found in Figure 7.3). Approximant taps are much shorter than alveolar approximants, and they are auditorily almost indistinguishable from full-closure taps—most likely due to the

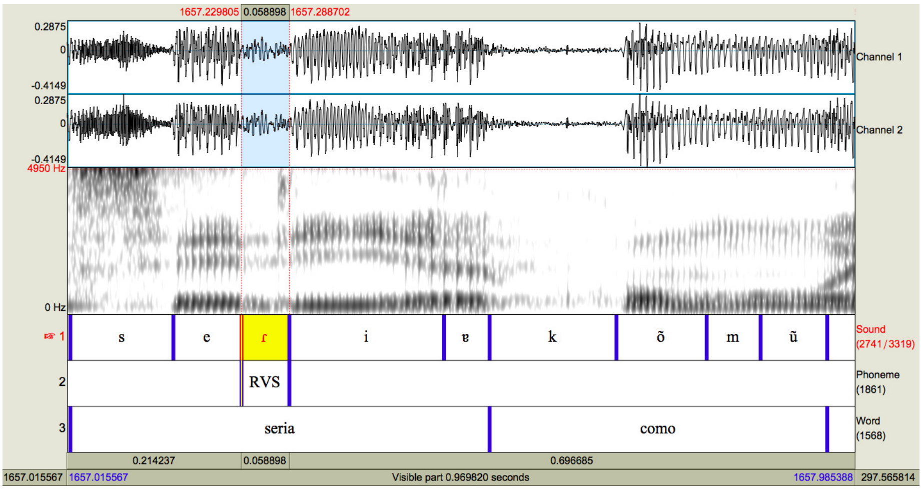


Figure 6.3: Voiced alveolar tap in the word *seria* by speaker M3

similarity of the articulatory gesture. Alveolar approximants, on the other hand, are perceptually much more reminiscent of retroflex approximants. Diacronically speaking, the approximant tap may well be the intermediate phase between the alveolar tap and the alveolar approximant proper.

Figure 6.4 shows speaker M5 articulating an approximant tap in the utterance *eu não consigo pensar direito que será que vai acontecer* 'I can't really think what will happen'. When compared to F3's articulation of *direitos* in Figure 6.2, we can see that formants are present in M5's approximant tap, and they are lower in intensity than the adjacent vowels. In addition, no burst can be observed.

Moving on to intervocalic weak-r in unstressed position, the second and third bars in Figure 6.1 show its articulation in the corpus in pretonic and post-tonic position if the adjacent vowels have not been devoiced or deleted. Voiced alveolar taps constitute 43% of pretonic and 34% of post-tonic tokens, and approximant taps 53% and 65% of tokens, respectively. Weak-r was deleted in 5 tokens (2%) of pretonic weak-r; an example is shown in Figure 6.5. Here speaker F6 says the utterance *geralmente é filho* 'it's usually the children' without any trace of a tap. The articulatory gesture may be still be present, but it is so weak that it leaves no trace in the spectrogram.

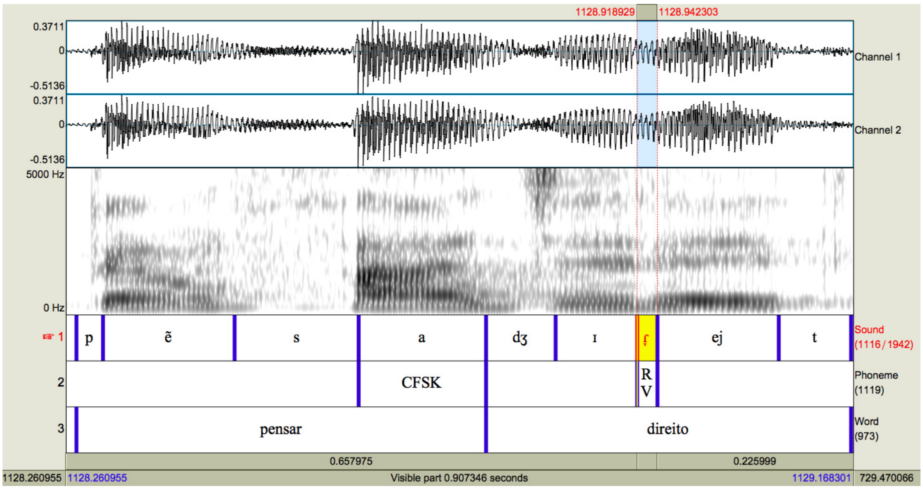


Figure 6.4: Voiced alveolar approximant tap in the word *direito* by speaker M5

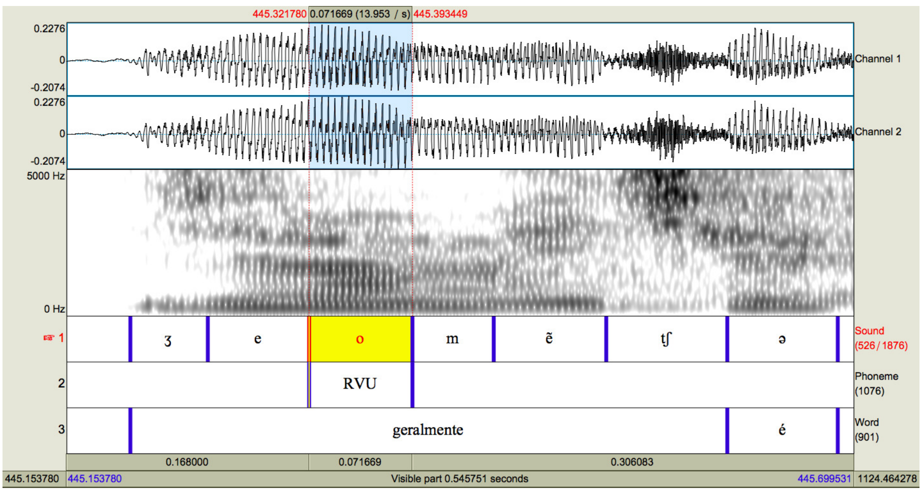


Figure 6.5: Deletion of intervocalic weak-r in the word *geralmente* by speaker F6

The answer as to why weak-r seems to be undergoing lenition in post-tonic position may lie in the type of lenition taking place in the other surrounding post-tonic segments. The articulation of post-tonic weak-r is strongly dependent on the presence or absence and voicing of the following segment—that is, in post-tonic position the intervocalic weak-r may not always be intervocalic. In 13% of all 924 tokens of post-tonic intervocalic weak-r, the following vowel was devoiced (fourth bar in Figure 6.1) or deleted (fifth–seventh bar). If the vowel was deleted, the rhotic could then be followed by a voiced consonant, a voiceless consonant, or a pause. We can observe that when the following vowel is devoiced, 30% of weak-r tokens are voiced, while 70% consist of voiceless alveolar taps [ɾ̥]. Figure 6.6 shows speaker M6 asking the question *eu fui claro?* 'was I clear?' and devoicing both the tap and the following vowel towards the end of the utterance. There is no voicing bar in the low end of the segment, but the vertical burst bar is very clear. The friction-like noise extends over the following vowel, which is also voiceless. What most likely happens in articulation is that at the time of release, the lips are already rounded for the following [ʊ], making it possible to perceive the quality of the vowel in the burst noise.

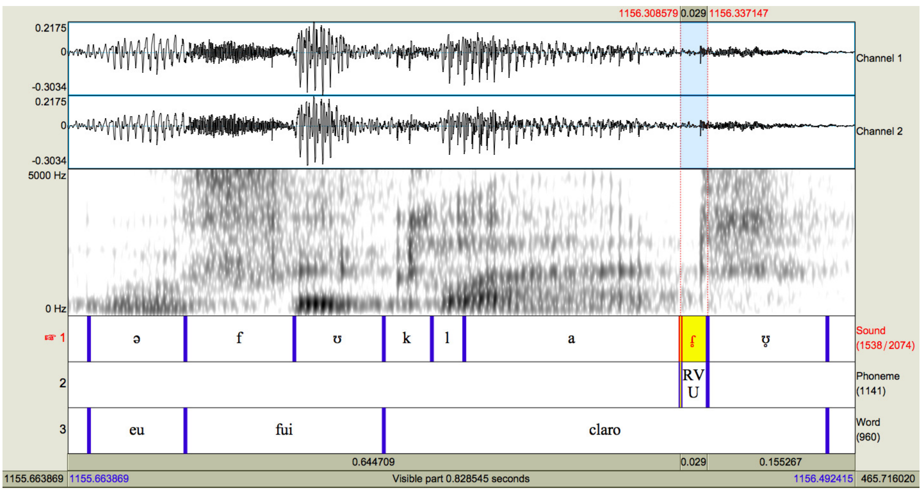


Figure 6.6: Intervocalic voiceless alveolar tap in the word *claro* by speaker M6

When the vowel following post-tonic weak-r is deleted and followed by a voiced consonant (fifth bar in Figure 6.1), we observe that the rhotic can be a voiced alveolar tap, a voiced alveolar fricative or it can also be deleted. However, in this context the most frequent realisation was a voiced alveolar approximant tap (72%). Figure 6.7 is a spectrogram image of this type of articulation: speaker M1 produces a voiced alveolar approximant tap in *assim eu não sei o brasileiro mas o mineiro* 'well I don't know about Brazilians but *mineiros*', with the rhotic immediately before the initial [m] in *mas*.

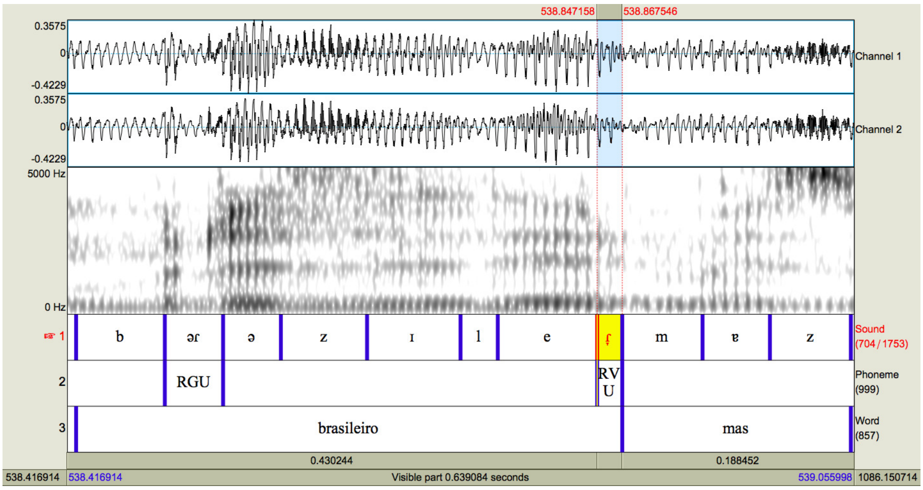


Figure 6.7: Voiced alveolar approximant tap in the word *brasileiro* by speaker M1

Voiced and voiceless alveolar fricatives (9%) can also be found when the word-final unstressed vowel is deleted and weak-r is then followed by a voiceless consonant (sixth bar in Figure 6.1). In Figure 6.8, speaker M3 deletes the word-final vowel before [t] and produces a voiced alveolar fricative in *(o) banheiro está igual uma sauna* 'the bathroom is like a sauna'. A voicing bar is present at the low end, and friction noise is visible at the higher frequencies. Nevertheless, in this context the three tap-like segments are the most frequent realisations ([ɾ] 28%, [ɾ̞] 22%, [ɾ̥] 30%). Less frequent variants in this context were alveolar approximants (4%) and deletions (7%). The comparison of bars five and six of Figure 6.1 reveals that the voicing of intervocalic weak-r that ceases to be intervocalic due to the deletion of the following vowel is influenced by the following consonant: when it is voiced, weak-r is also mostly voiced (89%), but when the consonant is voiceless, the proportion of voiceless r-variants increases (33% as opposed to 0% in the previous case).

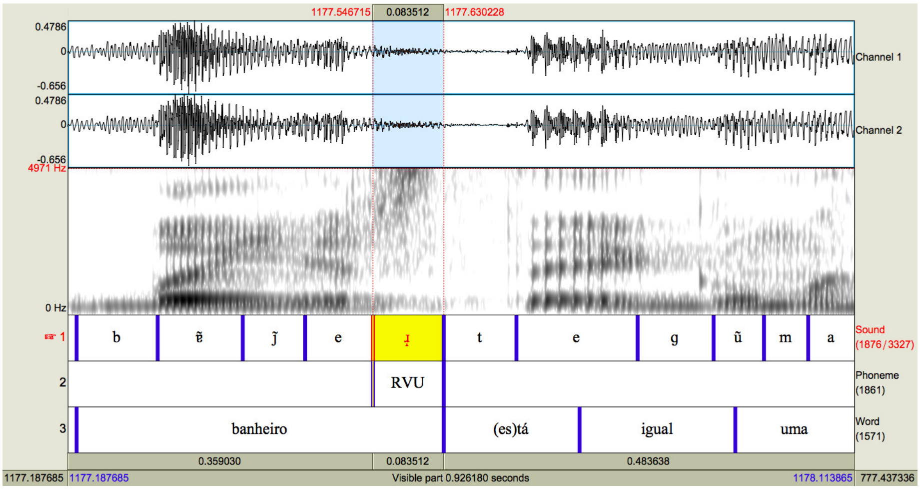


Figure 6.8: Voiced alveolar fricative in the word *banheiro* by speaker M3

Finally, the last bar in Figure 6.1 features the two tokens in which post-tonic intervocalic weak-r was left in utterance-final position due to the deletion of the word-final vowel. These were both voiceless alveolar taps.

To conclude this overview on intervocalic weak-r, the two main variants of this category in stressed and pretonic position are [ɾ] and [ɾ̞]. In post-tonic position, 13% of tokens show devoicing or deletion of the following word-final vowel, which affects weak-r. [ɾ̥] is frequent before a voiceless vowel or consonant or pause. When the following vowel is deleted (i.e. intervocalic post-tonic position becomes stressed coda position; ˈV$ɾV → ˈVɾ#), the proportion of fricative variants and deletions increases. This points to a tendency for the emergence of new oxytone words from paroxytones through vowel deletion in BP; this discussion will be elaborated in the conclusions of this chapter (Section 6.3).

6.1.1.2 Cluster context

As mentioned in the beginning of this section, weak-r also occurs as the second member of consonant clusters. Table 6.2 lists the main variants and their distribution in stressed, pretonic and post-tonic clusters. One isolated case of a voiced alveolar trill (stressed pɾ) and one voiceless alveolar trill (post-tonic tɾ) were found; these will mostly be excluded from the analyses. Another rare articulation was [ʃ] in post-tonic bɾ, which will also be excluded.

Context	**Stressed**		**Pretonic**		**Post-tonic**	
Variant	N	%	N	%	N	%
r r̥	1	**0.1**	0	**0**	1	**0.2**
ɾ Vɾ	302	**38.3**	302	**37.4**	152	**35.6**
ɾ̞ Vɾ̞	297	**37.7**	354	**43.9**	89	**20.8**
ɾ̥ Vɾ̥	56	**7.1**	56	**6.9**	72	**16.9**
ɹ̝ Vɹ̝	14	**1.8**	26	**3.2**	18	**4.2**
ɹ̝̊	12	**1.5**	16	**2**	6	**1.4**
ɹ	9	**1.1**	11	**1.4**	2	**0.5**
Ø	97	**12.3**	42	**5.2**	87	**20.4**
TOTAL	788	**100**	807	**100**	427	**100**

Table 6.2: Weak-r variants in clusters in the semi-structured interviews

Weak-r variants in clusters can be approached from two points of view: degree of constriction and presence/absence of a vocalic segment between the consonant-rhotic sequence. In Section 2.3.2 we mentioned that a vocalic segment is common in BP Cɾ-clusters, and in fact this type of articulation is the most frequent among the recorded speakers: 59% of clusters contain a vocalic segment. In this type of cluster, weak-r can be a tap, approximant tap, or fricative (V[ɾ], V[ɾ̥], V[ɾ̞], V[ɹ̝]) in the corpus of this study. These tokens appear grouped together with the corresponding weak-r variants without the vocalic segment in Table 6.2 and in the analyses of this chapter. As for degree of constriction, we can see that the voiced [ɾ] and voiceless [ɾ̥] alveolar taps, with or without a preceding vocalic element, are the only full-closure variants. The remaining variants are (in decreasing order of constriction) fricatives, approximant taps, and approximants, and when combined, these variants with weakened constriction make up 73% of all cluster tokens. Ultimately, the rhotic can also be deleted completely from the cluster.

A first look at the cluster data in Table 6.2 shows that voiced alveolar taps [ɾ] and voiced alveolar approximant taps [ɾ̞] are the most frequent variants in all stress positions. In addition, more voiceless and fricative variants as well as deletions occur in post-tonic context compared to stressed and pretonic context. This could indicate that post-tonic lenition is taking place in Cɾ-clusters in a way similar to the lenition already observed in intervocalic weak-r. In order to analyse the different clusters in more detail, Figure 6.9 lists all 2,020 tokens of Cɾ clusters according to C and stress (stressed, pretonic and post-tonic), with token number in parentheses. The data are presented in this way in order to observe the effect of the preceding consonant and stress. No tokens of pretonic or stressed vɾ occur in the corpus. The context with the highest token number, 494, is stressed pɾ, mostly because of the high-frequency preposition *para* 'to; for' that is responsible for 409 of these tokens (see Section 6.1.3 below for further discussion). It was already explained in Section 4.5 that in full citation form, this preposition contains a post-tonic intervocalic weak-r ([ˈpaɾa]), but as the reduced form *pra* is much more common in spontaneous speech, all tokens of *para* with a cluster were annotated as containing a cluster context. It should be noted that although weak-r is listed as being part of a cluster with a certain consonant, the phonetic form of this consonant may be altered: for instance, the plosive in a bɾ-cluster could actually be an approximant [β̞], or a citation-form kɾ-cluster could contain [g]. Since the focus of this study is on the realisation of rhotics, the exact articulation of cluster-initial consonants will not be discussed further.

After stressed pɾ, the most frequent of all contexts are pretonic pɾ (due to high-frequency words such as *pr̲incipalmente* 'mainly', *pr̲imeiro/pr̲imeira* 'first', *pr̲efiro* 'I prefer', *apr̲ender* 'to learn', *pr̲oblema* 'problem', *pr̲ecisa* 'is necessary'), pretonic bɾ (mostly *Br̲asil*, *br̲asileiro(s)* 'Brazilian(s)'), and tɾ in all stress positions (e.g. *entr̲ar* 'to enter', *tr̲ês* 'three', *tr̲anquilo* 'calm', *tr̲abalhar* 'to work', *outr̲o* '(an)other'). In the remainder of this section, spectrogram examples of weak-r variants in clusters will be provided.

Almost all observed variants can be found in pɾ-clusters. Figure 6.10

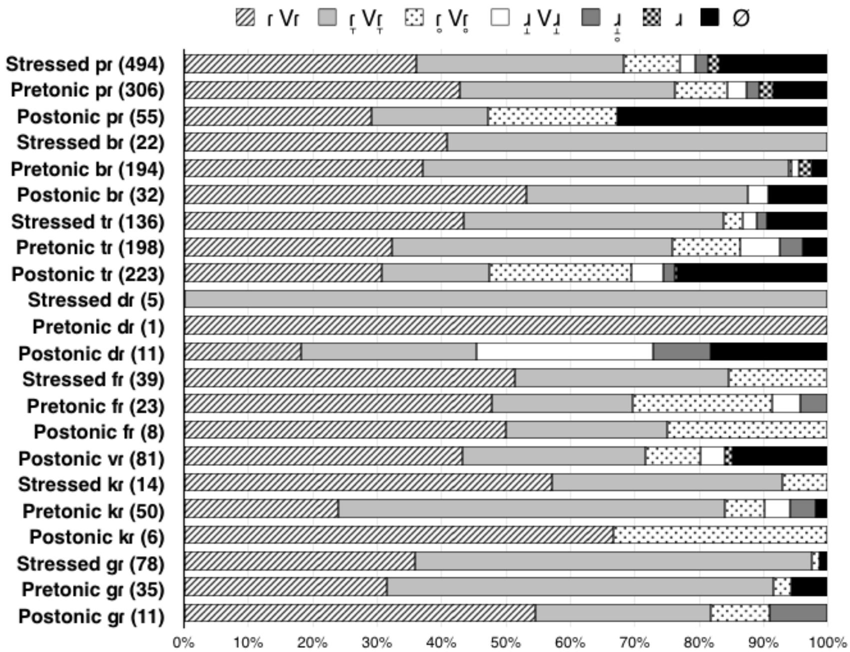


Figure 6.9: Weak-r in clusters in the semi-structured interviews according to context

features speaker F5 producing an alveolar tap without a preceding vocalic segment in *só pa<u>r</u>a falar que fez alguma coisa diferente* 'just to say you did something different'. The release burst of preceding [p] is weak, and the next burst is that of [ɾ].

In comparison, Figure 6.11 features a spectrogram image of speaker F3 articulating clusters with vocalic segments before voiced alveolar taps in the utterance *gastar sei lá o dob<u>r</u>o ou t<u>r</u>iplo do dinheiro que gastaram* 'spend I don't know double or triple the money they spent'. After [b] and [t], there is a darker vertical bar corresponding to a short vocalic segment, followed by a light vertical bar corresponding to the closure phase of the tap, and finally, there is a burst bar corresponding to the release of the tap before a vowel.

In tɾ-clusters, we also find virtually all possible cluster variants of weak-

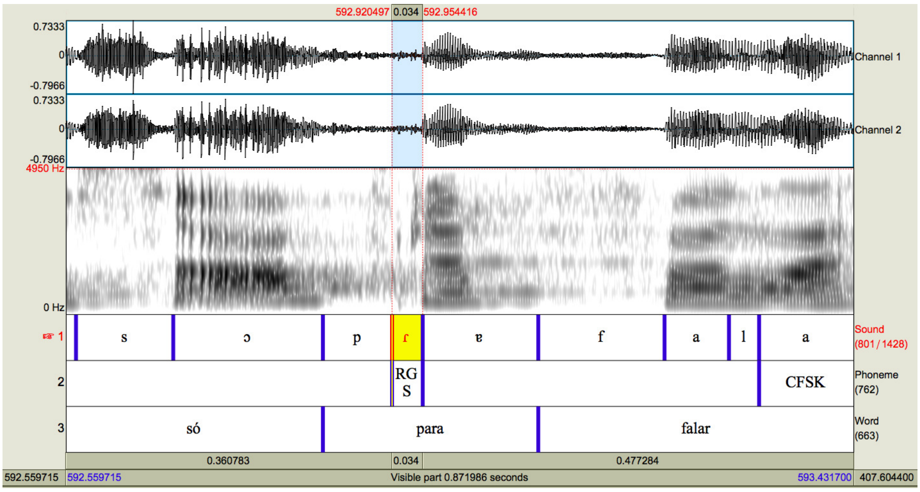


Figure 6.10: Voiced alveolar tap in the word *para* by speaker F5

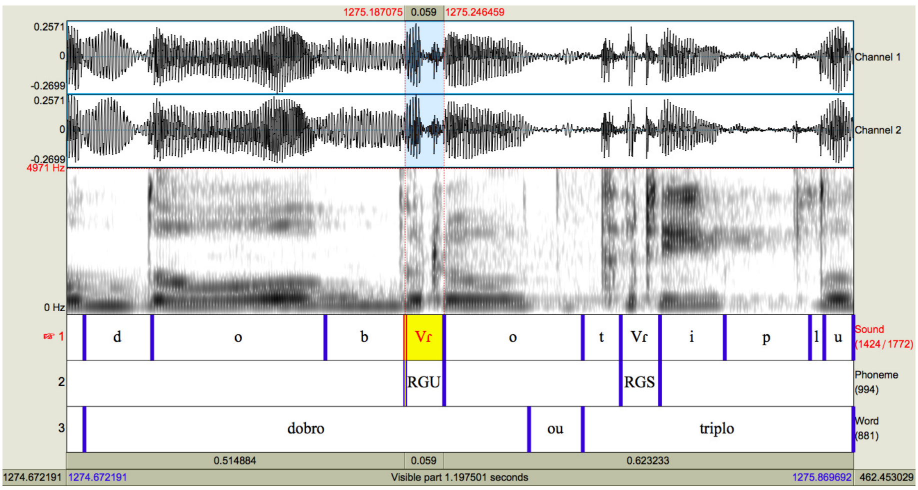


Figure 6.11: Voiced alveolar tap preceded by vocalic segment in the words *dobro* and *triplo* by speaker F3

r; three spectrogram examples can be found in Figure 6.12. These are all instances of feminine and/or plural forms of the high-frequency word *outro* from the utterances *conheço outras pessoas que foram em outras épocas e*

‘I know other people who have gone on other occasions and’ by F2, *alguns com tanto outros com nada* ‘some have so much others have nothing’ by M4, and *vou ter que ir para outra cidade* ‘I’ll have to go to another town’ by F6.

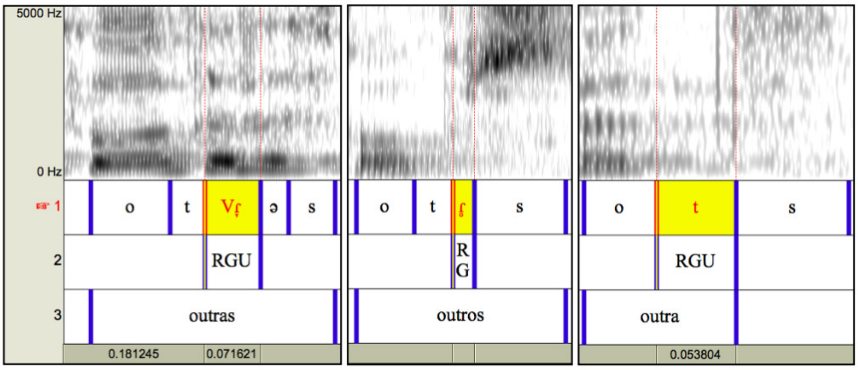


Figure 6.12: Three different realisations of a tɾ-cluster by speakers F2, M4 and F6

We can see that in *outras*, the alveolar approximant tap [ɾ̞] is preceded by a vocalic segment that is similar in intensity and duration to the schwa-like vowel following the approximant tap. The approximant tap itself has vowel-like formant structure, and is only slightly less intense than the surrounding vowels. In *outros*, following the burst bar of [t] there is another burst bar for the voiceless alveolar tap [ɾ̥], followed by the high-frequency friction noise of [s]. The unstressed vowel between the cluster and word-final [s] has therefore been deleted, creating a one-syllable word with a word-final [tɾ̥s] cluster. It should be noted that this type of cluster does not occur in BP according to traditional phonotactics: the only permitted tautosyllabic clusters are Cl (e.g. *atleta* [aˈtlɛtɐ] ‘athlete’) and Cɾ, and any other tautosyllabic or heterosyllabic clusters are separated by an epenthetic [i]~[ɪ] (e.g. *pneu* ‘tyre’ [piˈnew]~[pɪˈnew], *étnico* [ˈɛtʃɪnikʊ] ‘ethnic’, *captar* [kapɪˈtah] ‘to capture’).

Therefore, much in the same way that post-tonic intervocalic weak-r may not actually always be intervocalic due to the deletion of the following vowel, the same phenomenon takes place in post-tonic Cɾ-clusters. In addition to altering the stress pattern of the lexical item—and possibly of the language—from paroxytone to oxytone, vowel deletion is creating new consonant clusters. Both tendencies have already been attested in BP (e.g. Cantoni 2013). Stress shift and new coda consonants emerge also if both the rhotic and the following vowel are deleted, as in the word *outra* in Figure 6.12: here speaker F6 produces *outra cidade* (citation form [ˈowtɾɐ siˈdadʒɪ]) as [ˈotsˈdadʒ], deleting not only weak-r and word-final [ɐ], but also pretonic [i] and post-tonic [ɪ] from *cidade*, which gives rise not only to adjacent [tsd], but also word-final [dʒ]. Other examples of this kind of deletion of post-tonic vowels that gives rise to new coda consonants in BP have already been given in Figures 6.2 (*direitos* as [ʒɪˈɾejts]), 6.4 (*direito* as [dʒɪˈɾ̥ejt]), 6.7 (*brasileiro* as [bəɾəzɪˈleɾ̥]), and 6.8 (*banheiro* as [bɐ̃ˈj̃eɹ̥]).

Another observation that can be made on weak-r variants in clusters based on Table 6.2 and Figure 6.9 is that voiceless taps and voiced and voiceless fricatives as well as deletion seem to have a somewhat higher percentage of occurrence in post-tonic clusters than in other stress positions. Out of all tokens of stressed pɾ, 12% are voiceless taps and various types of fricatives, 13% in pretonic position, and 20% in post-tonic position. For the other clusters the respective percentages are bɾ 0-3-6%, tɾ 6-22-34%, dɾ 0-0-36%, fɾ 16-30-25%, kɾ 7-14-34%, and gɾ 1-3-18%. vɾ-clusters only occurred in post-tonic position in the corpus, and in 13% of them weak-r was produced as voiceless taps and fricatives.

As for deletion, it occurs in 17% of stressed pɾ-clusters, 8% in pretonic position and 33% in post-tonic position. For the other clusters with deletion, the respective percentages are bɾ 0-3-9%, tɾ 10-4-23%, dɾ 0-0-18%, kɾ 0-2-0%, and gɾ 1-6-0%. No deletions were found in fɾ-clusters, and vɾ-clusters only occurred in post-tonic position in the corpus; of these clusters, 15% had a deleted weak-r.

Based on the data presented on the realisation of weak-r intervocalically and in clusters, it can be argued that the articulation of weak-r in these contexts is strongly dependent on word stress. Whereas the articulation of weak-r as a full-closure tap or an approximant tap seems not to be influenced by the stress of the segment in question—rather, it is more likely that speech rate and idiolect determine if taps are produced with full closure (see Section 6.1.2 below)—the devoicing and/or fricativisation of alveolar taps as well as their deletion increase in post-tonic position. This lenition pattern in rhotics seems to be part of a larger lenition phenomenon in which all post-tonic material—consonants and vowels—is devoiced, reduced or deleted, and which is creating new phonetic tokens with word-final stress and emergent word-final consonant clusters. This pattern will be discussed further in Section 6.3.

6.1.2 Individual speakers

This section takes a closer look at the speakers and the possible differences between them that contribute to the variation and change in the weak-r category. Detailed charts on the articulation of weak-r between vowels and in clusters by the fourteen speakers in the corpus are included in Appendices D and E. The data show two interesting variation phenomena that will be discussed in this section. The first of these is the predominance of either [ɾ] or [ɾ̞] as the main variant of intervocalic weak-r. The second phenomenon pertains to post-tonic lenition, already discussed in the previous section, and the level and manner at which this lenition takes place in the speech of different individuals.

None of the recorded speakers are absolutely consistent in the articulation of weak-r: for every phonological context, there are at least two possible variants. Qualitatively, Figure 6.13 demonstrates that [ɾ] and [ɾ̞] are complementary realisations for an intervocalic tap target. F3 and M3 are the only speakers who produce more taps than approximant taps. For the remaining speakers, as the percentage of [ɾ] falls, the proportion of [ɾ̞] increases. The speakers can therefore be said to have individual articulatory patterns concerning intervocalic weak-r: both variants are present in the speech of all recorded speakers, but some speakers are more likely than others to produce their taps with a full closure. In terms of lenition, the speakers who use more [ɾ̞] can be considered innovators in the sound change leading to lenited articulations.

Most speakers show at least some post-tonic lenition both intervocalically and in clusters. The post-tonic variants used by individual speakers can be viewed in Figures 6.14 and 6.15. In intervocalic context, the only speaker with no post-tonic lenition of vowels or the preceding rhotic is M2. Speakers who stand out with a higher proportion of voiceless taps [ɾ̥] are F7, M1, M4 and M6. M3 also uses fricativisation as a lenition strategy, and five speakers have some deletions of weak-r in this context (F3, F4, F7, M3 and M7). The articulatory gesture of alveolar taps can therefore be weak-

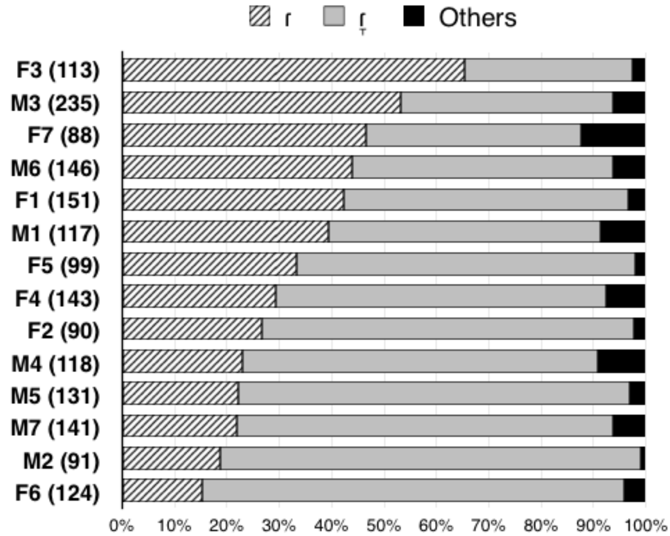


Figure 6.13: Intervocalic [ɾ] and [ɾ̞] by individual speakers

ened by both fricativisation and approximantisation, leading ultimately to deletion. These lenited variants can be followed by either a devoiced or deleted vowel; in the latter case, the word changes from paroxytone to oxytone. As an example of this phenomenon in intervocalic context, M7 produced *(com) dinheiro cê (vai para qualquer lugar)* ‘if you have money you can go anywhere’ as [dʒẽsə].

In post-tonic clusters (Figure 6.15), three main lenition strategies can be found. Eight speakers (F1, F4, F5, F6, M2, M4, M6, M7) show lenition that manifests itself as [ɾ̥]∼[ɹ̝]∼[ɹ̝̊]∼Ø. Other combinations of lenition strategies are the use of [ɾ̥]∼[ɹ̝] (F3), [ɾ̥]∼Ø (F7, M1, M3, M5), and only Ø (F2).

There does not seem to be a direct link between lenition in stressed and pretonic intervocalic position and post-tonic weak-r in the speech of an individual. For instance, M2 is among the speakers who mostly use [ɾ̞] intervocalically; yet he has no tokens of post-tonic lenition of either weak-r or the following vowel, but on the other hand he has a fair amount of lenition in post-tonic clusters in the form of devoicing, fricatives, alveolar

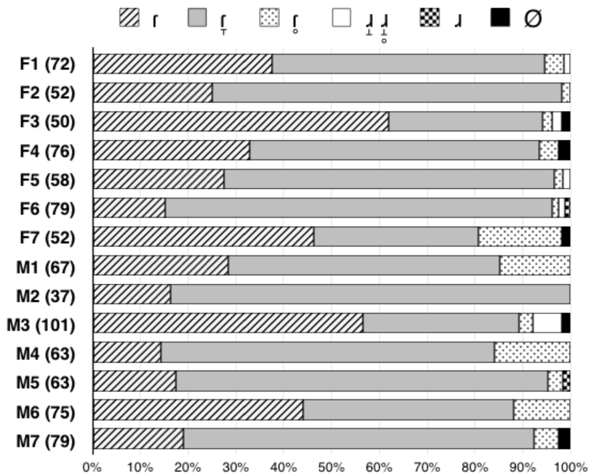


Figure 6.14: Post-tonic intervocalic weak-r by individual speakers

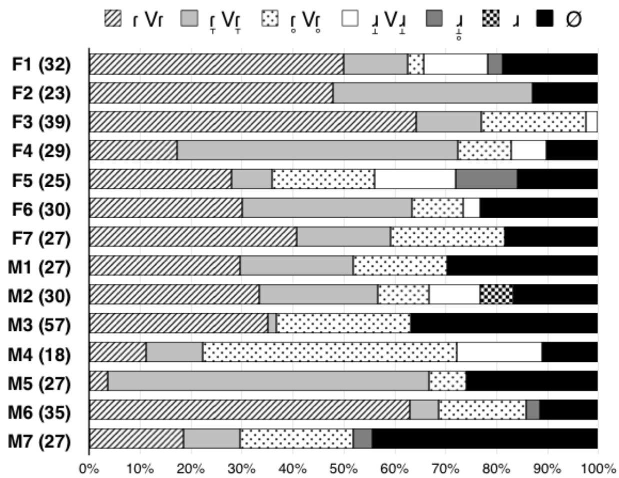


Figure 6.15: Post-tonic weak-r in clusters by individual speakers

approximants [ɹ], and deletion. Similarly, F2 is also among the speakers who mostly use the lenited tap variant [ɾ̞] intervocalically, but she shows less diversified lenition in post-tonic ɾV and Cɾ than most of the other speakers. However, we can also point out that speakers M4 and M7 show advanced lenition in all of these contexts. Based on the interview data we can conclude that the articulation of weak-r in different contexts is highly dependent on the articulatory patterns of the individual, and that lenition of weak-r in one context does not imply its lenition in another context by the same speaker; rather, it seems that word stress and the location of weak-r either between vowels or in a cluster interact in complex ways. It is important to point out that the lenition of weak-r is present to some extent in the speech of all fourteen speakers, but it manifests itself in different proportions and outcomes. In terms of Complex Adaptive Systems, post-tonic context and cluster context seem to be attractors for weak-r lenition, which operates through substantive reduction of the full-closure tap gesture.

6.1.3 Lexical item and frequency effects

6.1.3.1 Intervocalic context

As in the previous chapter, we will present charts plotting lexical items, their token counts and weak-r output in order to observe if some words dominate the occurrences of a particular phonological context and if any word-specific patterns of variation can be detected. The phonetic realisation of the most frequent lexical items in stressed intervocalic context can be observed in Figure 6.16. The ten most frequent words in the interview corpus are *diferente* 'different' with 37 tokens, followed by *parece* 'looks like; seems' (34), *seria* 'would be' (22), *querendo* 'wanting (gerund)' (20), *querer* 'to want' (19), *diferença* 'difference' (17), *período* 'period; semester' (14), *queria* 'wanted' (14), *melhorar* 'to get better' (14), and *maioria* 'majority' (13). It is interesting to note that lexical items of two groups, *diferente–diferença–diferentes* (58 tokens) and *querendo–querer–queria–queriam* 'they wanted' (55 tokens) make up 9,5% and 9% of the 614 stressed intervocalic tokens of the corpus. The words with a stressed intervocalic weak-r can be proparoxytones (e.g. *período*), paroxytones (e.g. *diferente, seria*), and oxytones (e.g. *querer, natural*).

No voiceless taps or alveolar approximants were found as variants in these most frequent words. We can see that there are some deletions and fricatives among the lexical items with most tokens. The three deletions

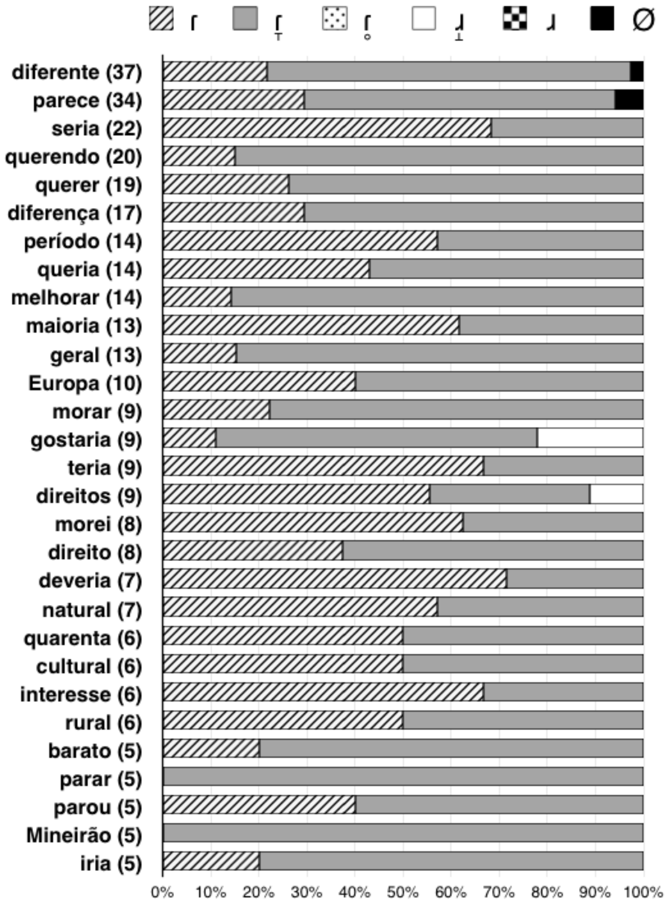


Figure 6.16: Lexical items with stressed intervocalic weak-r (5 or more tokens)

can be found, perhaps not coincidentally, in the two most frequent lexical items of the corpus. The deletion in *diferente* is by M7 in the utterance *tem um tanto de modalidade diferente (es)tá mais interessante (vo)cê assistir* 'there are many different sports it's more interesting for you to watch', producing *modalidade diferente (es)tá* as [modərɪˈdaˈtʃfẽˈta]. As for *parece*, the two deletions are by F4 (*os políticos que entram parece que (es)tá cada vez pior* 'the politicians that enter seem to be getting worse' as [paˈesˈkə]) and M5 (*parece que só quer pegar o lado negro* 'it seems they only want to focus on the dark side' as [ˈpɐskˈsɔ]). In all three examples, the speakers are not deleting just the rhotic but also vowels and other consonants, resulting in the transformation of paroxytones into oxytones.

Moving on to pretonic intervocalic weak-r, the most frequent lexical items can be seen in Figure 6.17. The nine most frequent words with this context in the corpus are *interessante* 'interesting' (44), *(Belo) Horizonte* (the state capital, 19 tokens), *geralmente* 'usually' (11), *interior* 'interior; countryside' (11), *(Copa das) Confederações* 'Confederations (Cup)' (8), *exterior* 'exterior; abroad' (8), *parecer* 'to look like; seem' (6), *americano* 'American' (6), and *maravilhoso* 'wonderful' (6). In all of these words, weak-r is situated in the syllable preceding word stress. *interessante*, which makes up 18% of all 249 pretonic tokens, curiously does not include any fricative tokens or deletion, but its plural form *interessantes* (5 tokens) was produced once with a voiced alveolar fricative. Some lenited rhotics were present in *Belo Horizonte* and *geralmente*. Weak-r was deleted in *Belo Horizonte* by M3 ([ˈβ̞ələˈzõtʃ]), and produced as an alveolar approximant by M2 ([ˈbelɹəˈzõtʃ]). As for *geralmente*, a spectrogram example of the r-deletion by F6 has already been shown in Figure 6.5. There are few tokens of pretonic intervocalic weak-r in the corpus, which makes the evaluation of frequency effects unviable.

Figure 6.18 presents the most frequent lexical items with intervocalic weak-r in post-tonic position. The number of post-tonic tokens in the corpus, 924, is much higher than that of stressed (614) and pretonic (249) tokens. With over 15 tokens there is *agora* 'now' (88), *era* 'was' (59), *brasileiro* 'Brazilian (masc.)' (41), *quero* 'I want' (28), *dinheiro* 'money' (24), *cultura* 'culture' (23), *foram* 'they were/went' (21), *hora* 'hour; time' (20), *caro* 'expensive' (18), *lugares* 'places' (18), *espero* 'I hope' (17), *fora* 'out; outside' (17), and *área* 'area' (15).

The lexical items with a post-tonic intervocalic weak-r can be roughly divided into 14 types:

1. *-ro* (217 tokens), consists mostly of words ending in *-eiro* (e.g. *brasileiro*), 1S verb forms (e.g. *quero, moro*), and nominals such as *claro, número* (the latter being proparoxytone, as opposed to the other paroxytones in this category);

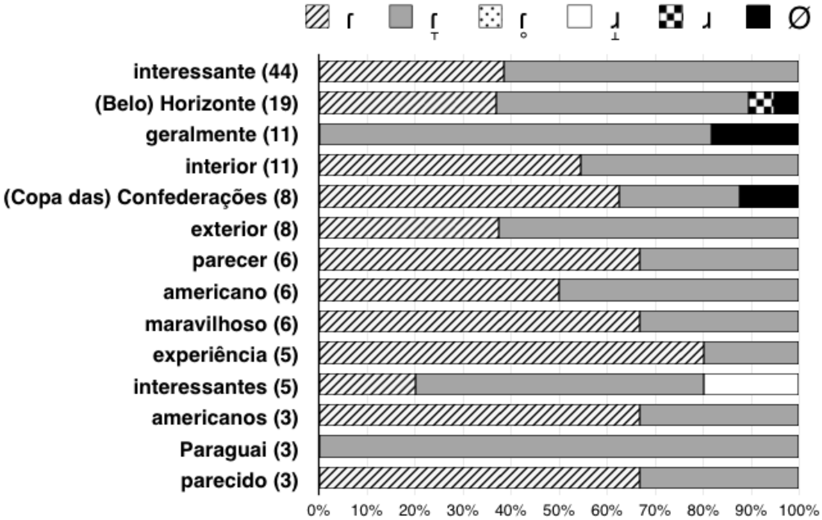


Figure 6.17: Lexical items with pretonic intervocalic weak-r (3 or more tokens)

2. *-ros* (19 tokens), consists mostly of *-eiro* plurals (e.g. *brasileiros*), and nominals such as *raros, temperos*;

3. *-ra* (364 tokens), consists mostly of words ending in *-eira* (e.g. *primeira*), the feminine *-dora, -ora* endings (e.g. *professora, conservadora*), 3S verb forms (e.g. *melhora*), the present subjunctive form *queira*, the past tense form *era*, and others (e.g. *agora, cultura, hora, fora, para, embora, estrutura*);

4. *-ras* (20 tokens), consists of plural forms of the *-ra* word type (e.g. *horas, grosseiras, culturas, emissoras*);

5. *-res* (55 tokens), mostly plurals of words ending in *-ar, -or, -er* (e.g. *lugares, professores, maiores, melhores, mulheres, poderes*);

6. *-ram* ([ɾɐ̃w̃], 134 tokens), consists of 3P past tense forms (e.g. *foram*), 3P present tense forms (e.g. *moram*), and the 3P present subjunctive form *queiram*;

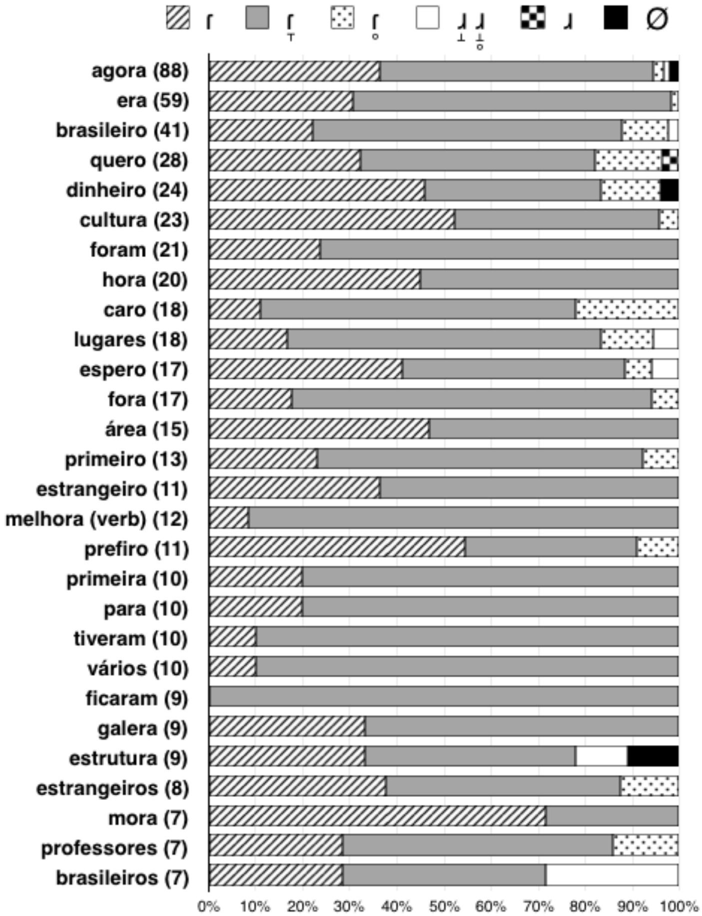


Figure 6.18: Lexical items with post-tonic intervocalic weak-r (7 or more tokens)

7. *-rem* ([ɾẽȷ̃], 22 tokens), consists of 3P present forms (*querem, ingerem*), 3P future subjunctive form *estiverem*, inflected infinitives (e.g. *falarem*), and the 3P present subjunctive *segurem*;

8. *-rio* (21 tokens), consists of masculine nominals (*e.g. contrário, vocabulário*);

9. *-rios* (12 tokens), consists of plural masculine nominals (*vários, funcionários, universitários*);

10. *-ria/-rea* (33 tokens), consists of feminine nominals (e.g. *séria, história, área*)

11. *-rias/-reas* (19 tokens), consists of plural feminine nominals (e.g. *várias, matérias, áreas*);

12. *-rico*, with one token of *histórico*;

13. *-rica* (5 tokens), with nominals such as *histórica, América*, and one token of the plural *-ricas* in *homéricas*;

14. *árvore* (1 token) and its plural *árvores* (1 token). This lexical item differs from the *-res* category in its stress pattern: *árvore(s)* is a proparoxytone, whereas the *-res* category comprises paroxytones.

The most frequent categories *-ro*, *-ra* and *-ram* make for 23%, 39% and 14.5% of all intervocalic post-tonic tokens in the corpus, respectively. When we observe the 40 most frequent words in the corpus (5 or more occurrences, Figure 6.18), 33 of them fall into these three categories; the remaining seven are *área, história, lugares, maiores, professores, vários, várias.*

Weak-r was articulated as a fricative in tokens of *agora, brasileiro, lugares, espero, estrutura, brasileiros,* and *número*, as an alveolar approximant in *quero, claro*, and it was deleted in *agora, dinheiro*, and *estrutura.* It seems difficult to link these lenited tokens to the token count of the lexical item in the speech corpus, or the type frequency of the word ending; after all, there are very few lenited tokens, and we have seen in the previous section that the post-tonic lenition strategies of different speakers vary greatly and can therefore be responsible for any of these individual tokens.

Nevertheless, Table 6.3 shows that the percentage of tokens realised with a voiceless rhotic ([ɾ̥], [ɹ̥̝]) and in which weak-r was deleted is higher in words ending in *-ro*, *-ros*, and *-res*, as opposed to *-ra*, *-ras* and *-ram.* It was already concluded in Section 6.1.1 that voiceless tokens of post-tonic weak-r are most common when the following vowel is also devoiced, or when the following vowel is deleted and the rhotic is followed by a voiceless consonant (either that of the word itself—e.g. in *lugares*—or the first segment of the following word). It is perhaps no coincidence that word-final devoicing and deletion is most frequent in these endings that include the high vowels of BP (*-ro* [ɾu]∼[ɾʊ], *-ros* [ɾus]∼[ɾʊs], *-res* [ɾis]∼[ɾɪs]). The high vowels of BP are shorter in duration than mid and low vowels (Rauber 2008), making them more prone to lenition. In fact, gradient lenition of unstressed mid and high vowels in the Belo Horizonte dialect and other varieties of BP has been reported by e.g. Napoleão de Souza (2012), Meneses (2012), Dias & Seara (2013), and Cruz (2013). Thus vowel reduction is taking place in both pretonic and post-tonic high vowels in BP. Another factor adding to the frequency of devoiced weak-r is the plural marker *-s*, which is also voiceless before other voiceless segments.

Post-tonic word-final ɾV(S)	Voiceless weak-r	Ø	ASPA type frequency
-ro (217)	27 (12.4%)	3 (1.3%)	927
-ros (19)	2 (10.5%)	0	585
-res (55)	7 (12.7%)	1 (1.8%)	1,236
-ra (364)	10 (2.7%)	4 (1%)	2,604
-ras (20)	1 (5%)	0	946
-ram (134)	3 (2.2%)	0	2,351
Logistic regression $p = 4.176 \times 10^{-7}$			

Table 6.3: Post-tonic word-final ɾV(S), devoicing and ASPA frequencies

There may also be a frequency factor involved. According to Bybee (2001), lexical items with a high token frequency are more likely to undergo phonetic reduction, whereas a low token frequency makes them subject to analogical sound changes. Type frequency, on the other hand, is connected to productivity: a higher type frequency means that the pattern applies to more words and therefore has a stronger mental representation and is less prone to sound change. The logistic regression p-value calculated for the correlation of type frequency and level of lenition as devoicing and deletion in Table 6.3 suggests that the high type frequency of especially *-ra* and *-ram* may also be protecting these word endings from lenition. It is interesting to note that while the diphthong in word-final [ɾɐ̃w̃] is being reduced (Cristófaro-Silva, Fonseca & Cantoni 2012) and occurs often as a monophthong in the *-ram* verb endings in this corpus ([ɾɐ̃w̃]∼[ɾũ]∼[ɾu]) comparable to the *-ro* ending, the level of weak-r lenition in the *-ram* endings is lower. In sum, the higher number of lenited word-final *-ro, -ros, -res* seems to be an interplay of stress, vowel quality, the voicing of the following consonant, but possibly frequency effects as well.

6.1.3.2 Cluster context

In order to discuss frequency effects in cluster tokens, we may start by checking if indeed the token counts of different clusters in this corpus match their token frequencies in a larger corpus. Unfortunately, ASPA (Cristófaro-Silva, Almeida & Fraga 2005) only allows searches that list the frequencies of sound sequences either in all stress positions or only post-tonic position. Table 6.4 relates the frequencies of Cɾ clusters in all possible ASPA searches to their token count in the present study in descending order of pretonic and stressed token frequency. We can observe that in pretonic and stressed position, the order is similar in ASPA and the speech corpus. However, in post-tonic context we find that vɾ seems to be overrepresented in the recorded corpus (undoubtedly due to the name of the place of recording, *Lavras*), and dɾ and bɾ seem to be underrepresented. Nevertheless in both corpora tɾ clusters are most frequent in post-tonic position, followed by bɾ and pɾ.

	ASPA frequency				**Tokens in speech corpus**	
Cluster	**Pretonic & Stressed**		**Post-tonic**		**Pretonic & Stressed**	**Post-tonic**
	Token	Type	Token	Type	Token	Token
pɾ	6,449,983	5,252	162,302	29	800	55
tɾ	4,298,623	6,538	1,639,263	292	334	223
bɾ	1,788,933	2,222	779,650	152	216	33
gɾ	1,498,224	2,262	77,715	62	113	11
kɾ	1,475,905	2,265	44,750	34	64	6
fɾ	708,653	1,255	40,585	25	62	8
dɾ	368,775	876	157,661	90	6	11
vɾ	73,469	86	125,506	6	0	81

Table 6.4: Token and type frequency of Cɾ clusters

This section will present an analysis of weak-r-variation in the most frequent lexical items, starting with stressed clusters, and moving on to pretonic and post-tonic clusters. In the interview corpus (Figure 6.9), pɾ is by far the most frequent in stressed position (494 tokens, mostly due to *para*), followed by tɾ (136) and gɾ (78). The percentage of voiceless taps, fricatives, alveolar approximants and deletions in these clusters seems to accompany their frequency in the corpus (31%, 16% and 2%, respectively). However, stressed fɾ (39 tokens, 16% voiceless taps) and kɾ (14 tokens, 7% voiceless taps) also show devoicing of weak-r, but no fricatives, approximants or deletion. Stressed bɾ, on the other hand, was not lenited at all. This could indicate that lenition in stressed clusters is linked with the voicing of the preceding consonant: devoicing of weak-r is more likely if preceded by [p t f k] than [b d g].

The most frequent lexical items with a stressed Cɾ-cluster can be observed in Figure 6.19. The token numbers vary greatly, as *para* makes for 52% of all 787 stressed cluster tokens. We can see that tokens of *para* with almost all the possible lenited weak-r variants in clusters were found in the corpus: 10% of *para* tokens had a voiceless tap, 5% were fricatives, 1% was alveolar approximants, and 20% were articulated with no rhotic segment at all as [pa]∼[pɐ]∼[pə]∼[p].

Figures 6.20–6.22 illustrate weak-r-variation in lexical items in the most numerous stressed clusters (pɾ, tɾ and gɾ). In pɾ-clusters, *para* is the most frequent and also has the highest percentage of lenited weak-r tokens. The high frequency of this preposition is also confirmed in the ASPA database: while *para* has a token frequency of 2,545,607, the next lexical item with pɾ in any stress position is *presidente* 'president' (330,581 tokens). Therefore it is possible that the high level of lenition in *para* (36.4% voiceless taps, fricatives, approximants and deletion) compared to the rest of stressed pɾ (9.4%) is due to the extreme high frequency of this preposition. Moving down in token count, the proportion of lenited variants decreases. This sort of variation is less visible in tɾ (Figure 6.21) and gɾ-clusters (Figure 6.21).

The most frequent lexical items with pretonic clusters are included in Figure 6.23. In this context, the most frequent cluster types in the corpus are pɾ (306 tokens), tɾ (198) and bɾ (194). The percentage of voiceless taps, fricatives, alveolar approximants and deletions in these clusters is 23%, 26% and 8%, respectively. However, in other pretonic clusters with less tokens there is also considerable lenition (fɾ 30%, dɾ 0%, kɾ 16%, gɾ 9%).

Figures 6.24–6.26 show the lexical items with the three most numerous pretonic clusters (pɾ, tɾ and bɾ). In the case of pɾ, no individual word dom-

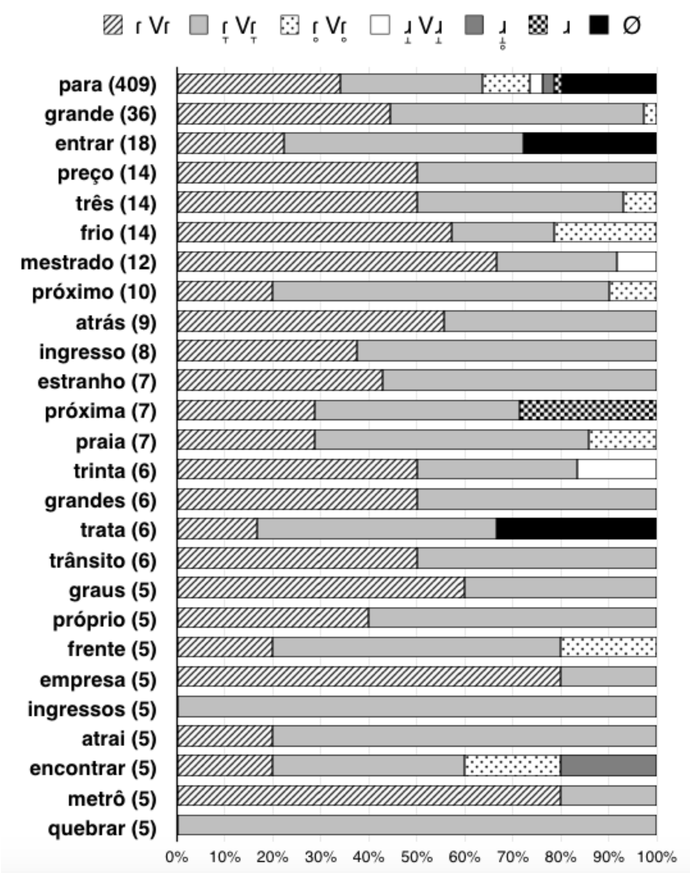


Figure 6.19: Lexical items with weak-r in stressed clusters (5 or more tokens)

inates the high-frequency end in the corpus. There is more lenition in the words *principalmente* 'mainly', *prefiro* 'I prefer', *aprender* 'to learn', *problema* 'problem', *precisa* 'needs (3S); is needed' *professores* 'teachers', *professor* 'teacher (masc.)', *princípio* 'principle', *professora* 'teacher (fem.)', *presidente* 'president', *aproveitar* 'to take advantage of; enjoy', *procurar* 'to look for', *provável* 'probable', and *precisava* 'needed (3S); was needed'. In eight of these thirteen words, the cluster is situated further to the left

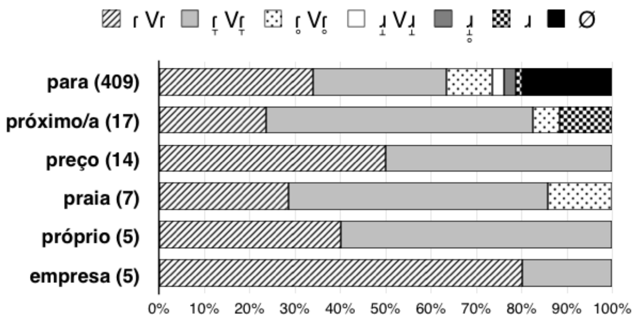


Figure 6.20: Lexical items with stressed pɾ (5 or more tokens)

Context	*para*		**Others**	
Variant	N	%	N	%
r	1	**0.2**	0	**0**
ɾ Vɾ	139	**34**	39	**45.9**
ɾ̝ Vɾ̝	120	**29.3**	38	**44.7**
ɾ̥ Vɾ̥	41	**10**	3	**3.5**
ɹ̞ Vɹ̞	11	**12.7**	0	**0**
ɹ̞̥	10	**2.4**	0	**0**
ɹ	6	**1.5**	3	**3.5**
Ø	81	**19.8**	2	**2.4**
TOTAL	409	**100**	85	**100**

Table 6.5: Weak-r variants in *para* and other lexical items with stressed pɾ

than one syllable before main word stress. This may indicate that in pretonic position, lenition is more likely as distance from stress increases, and in adverbs (such as *principalmente*). Of the remaining six words, *princípio*, *aprender* and *provável* had lenited tokens only in the form of weak-r deletions, whereas lenition was gradient in *prefiro*, *problema* and *precisa*. The pɾ clusters in these three lexical items are known to be highly lenited in the Portuguese of Minas Gerais, even creating emerging clusters such as [pf] and [ps] (*prefiro* [ˈpfiɾu], *problema* [poˈblemɐ]∼[poˈbɾemɐ], *precisa* [ˈpsizɐ]).

In pretonic tɾ-clusters (Figure 6.25), almost all words (the exceptions

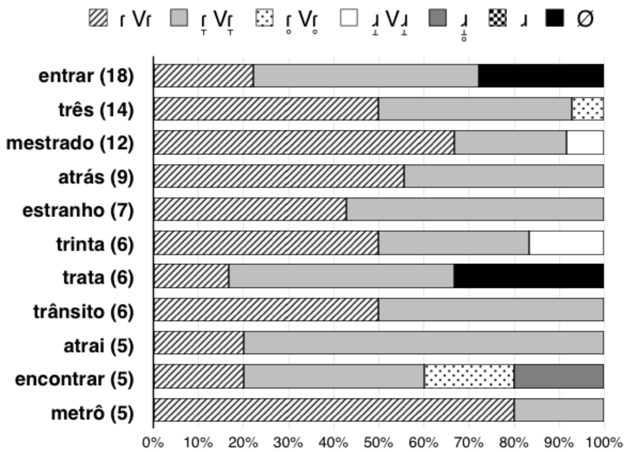


Figure 6.21: Lexical items with stressed tɾ (5 or more tokens)

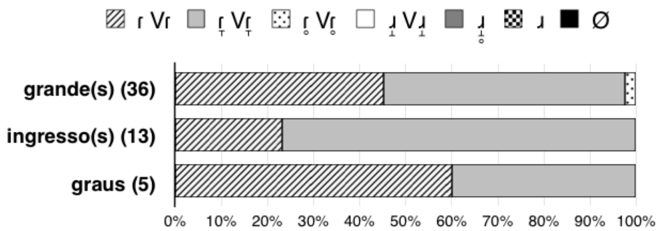


Figure 6.22: Lexical items with stressed gɾ (5 or more tokens)

being *transporte*, *controlar*, *tropeiro* and *através*) show some level of lenition in the form of voiceless taps, frication or deletion, and this does not seem to depend on stress pattern, lexical item, or if the cluster is preceded by [s]. It could be noted that the two words with the highest percentage of lenited tokens—*infraestrutura* with 4 out of 5 tokens deleted, and *tradicional* with one voiceless tap and three fricatives—differ in a sense from the others. *infraestrutura* is arguably a low-frequency word (token frequency 132 in the ASPA corpus) in which the tɾ-cluster is preceded by another similar cluster, fɾ, and it is a paroxytone word with four pre-stress syllables. These factors may make it a lexical item with a weak mental

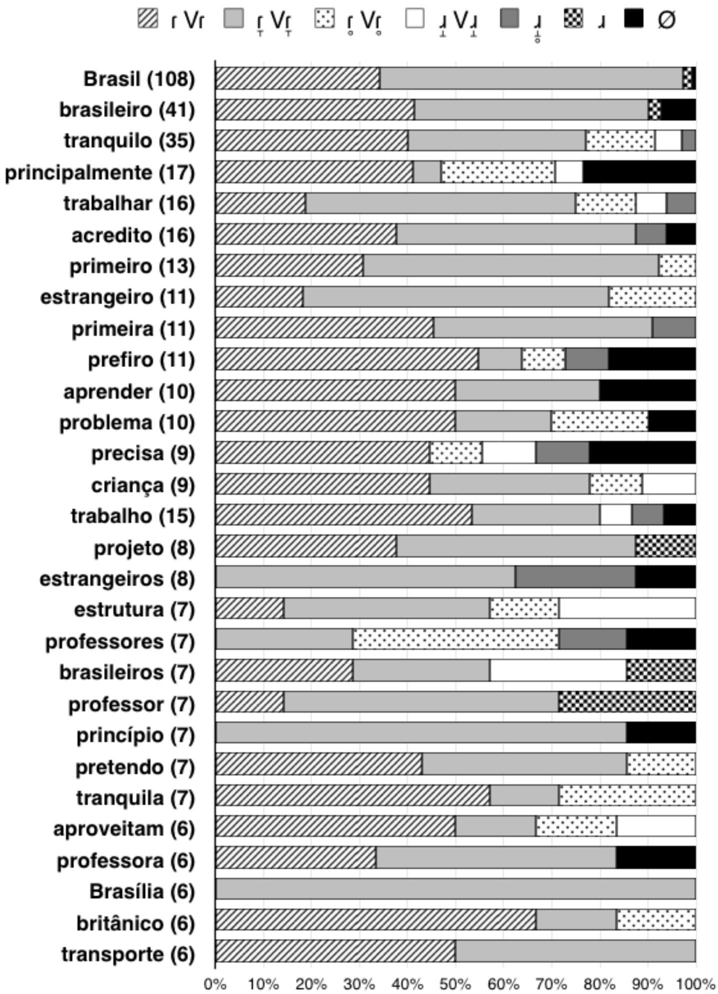


Figure 6.23: Lexical items with weak-r in pretonic clusters (6 or more tokens)

representation that is prone to lenition due to its extension and the coincidence of two clusters. *tradicional* is arguably of higher frequency (13,662 in ASPA), but in this oxytone word the cluster is situated three syllables before stress, making it another prime candidate for pretonic cluster

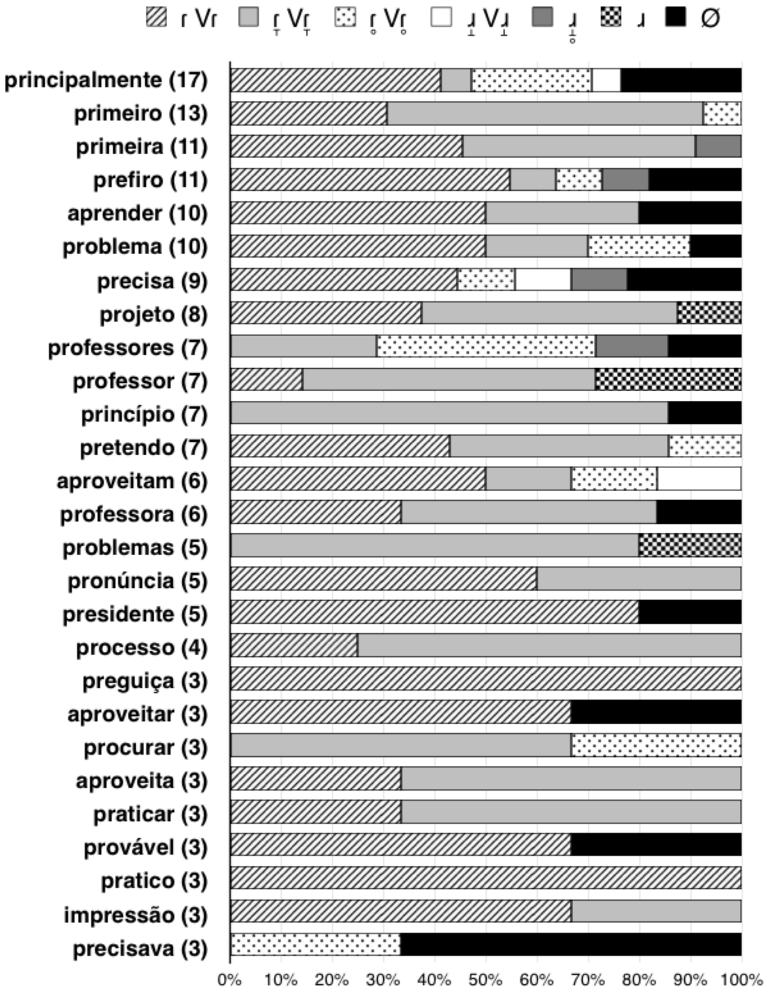


Figure 6.24: Lexical items with pretonic pɾ (3 or more tokens)

reduction.

In Figure 6.26, we can see that *Brasil*, *Brasília*, and *britânico*, the words in which the cluster is in the syllable immediately before word stress, have virtually no deletions. There is also no weakening in *brincadeira*, a word with few tokens in the speech corpus. Within *brasileiro/brasileiros/brasileira*,

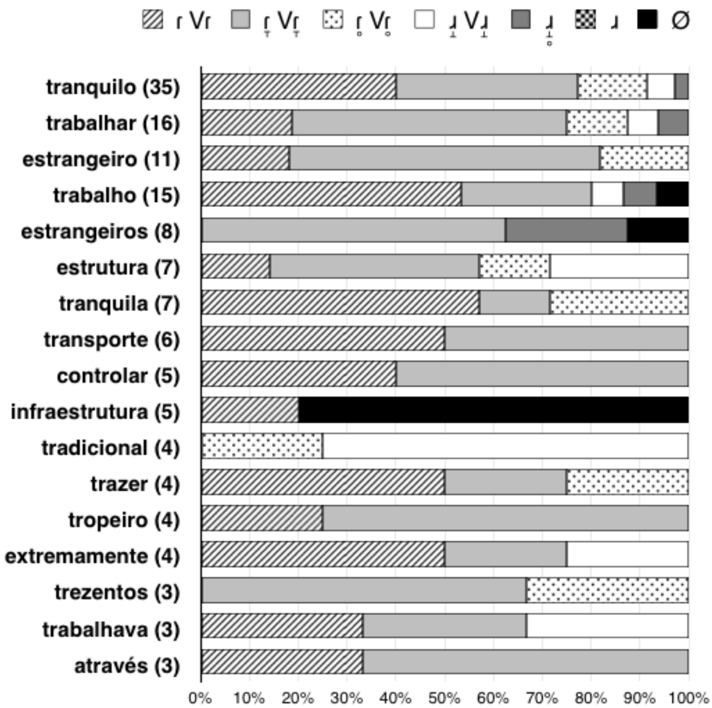


Figure 6.25: Lexical items with pretonic tɾ (3 or more tokens)

words in which the cluster is situated two syllables before stress, there are deletions, alveolar approximants, fricatives and voiceless taps. Therefore, in the case of pretonic bɾ, the stress pattern may influence lenition.

Figures 6.27–6.30 present the lexical items with the most frequent post-tonic clusters: tɾ (223 tokens in total), vɾ (81), pɾ (55) and bɾ (33). The word family *outro/ outra/ outros/ outras* 'other (masc. sing./fem. sing./masc. pl./fem. pl.)' makes for 52% of all post-tonic tɾ-clusters (Figure 6.27). In these words, the amount of lenition by devoicing, frication and deletion can be related to their token frequency in the ASPA corpus: *outros* (153,195 tokens in ASPA) has 89% lenited tokens, *outro* (124,867) 61%, *outra* (89,126) 34%, and *outras* (86,457) 40% (in *outra*, the percentage of deletion is 1 percentage point higher and that of voiceless taps, 4 percentage points lower than in *outras*). As for the remainder of the words

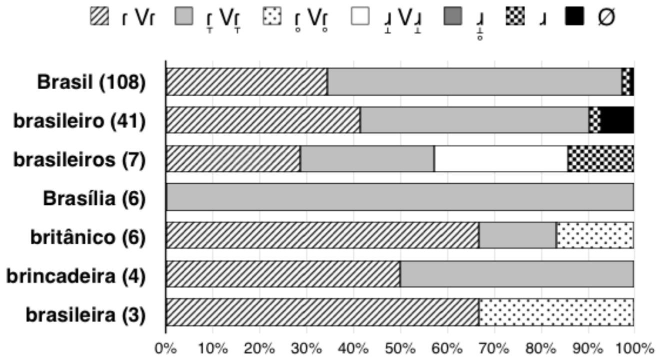


Figure 6.26: Lexical items with pretonic bɾ (3 or more tokens)

Post-tonic tɾV(s)	Token count	Lenited weak-r
tɾu	66	42 (64%)
tɾus	23	19 (83%)
tɾa	61	20 (33%)
tɾas	56	26 (46%)
tɾi	3	3 (100%)

Table 6.6: Lenition in post-tonic tɾV(s) clusters

with post-tonic tɾ, stress pattern or surrounding phonological context do not seem to explain the different types of lenition present in the data. In words with over five tokens, two lexical items stand out with a high percentage of deletions: *dentro* (67%) and *quatro* (60%). In both lexical items, [tɾu] is being reduced in one way or another—as it is also in *outro(s)*. *dentro* occurs in the data as [ˈdẽtu]∼[ˈdẽt] or in the chunk *dentro do/da* 'inside of the (masc./fem.)', which is undergoing phonetic reduction into [ˈdẽdu], [ˈdẽdɐ]. Much in the same way, *quatro* occurs as [ˈkwatu]∼[ˈkwat].

It seems that much like post-tonic *-ro* and *-ros*, post-tonic *-tro* and *-tros* are leading the leniting change. As can be seen in Table 6.6, lenition is most advanced in [tɾu], [tɾus] and [tɾi], which is to be expected because unstressed high vowels are prone to reduction, and the adjacency to voiceless [s] also promotes devoicing lenition.

The second most frequent post-tonic cluster, vɾ, only occurs in two

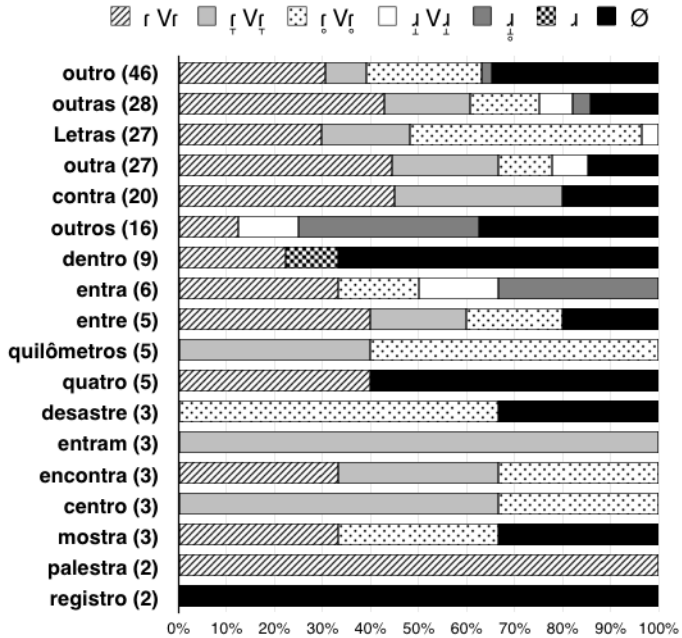


Figure 6.27: Lexical items with post-tonic tɾ (2 or more tokens)

words: *Lavras* (the town were the speakers were studying at the moment, lit. 'farming (pl.)'), and *palavra* 'word' (Figure 6.28). These words are different in structure as the former is a plural form with [s]∼[z] following the unstressed vowel, and the latter is a singular form. The weak-r in *Lavras* was deleted in 18% of all tokens, produced as a voiceless tap in 6%, as a voiced alveolar fricative in 4%, and as an alveolar approximant in 1% of tokens. It is plausible that *Lavras* is a high-frequency words for the speakers, which could also explain its high level of lenition. Once again, lenition does not affect only weak-r, but the whole CɾV sequence, as *Lavras* was pronounced as, for instance, [ˈlavəs]∼[ˈlavəz], [las]∼[laz] (depending on the voicing of the following segment), [lavz], and [lavɾ̥s]. It is possible that the presence of word-final [s]∼[z] contributes to the weakening of the preceding CɾV sequence since the same amount of lenition is not present in *palavra*. With only two different lexical items, it is difficult to deem this a lexical frequency effect.

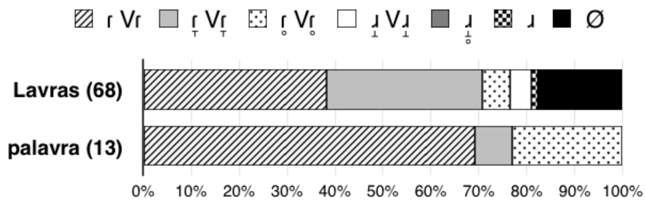


Figure 6.28: Lexical items with post-tonic vɾ

The words with post-tonic pɾ appear in Figure 6.29. Of these, *sempre* is the most frequent and also the one with lenition in the form of both voiceless taps (27%) and deletion (34%). *próprio* and *própria* ([ˈpɾɔpɾiu]∼[ˈpɾɔpɾju], [ˈpɾɔpɾiɐ]∼[ˈpɾɔpɾjɐ]) may have high rates of post-tonic deletion due to the fact that the words already contain another pɾ cluster in stressed position, and because the diphthongisation of [iu], [iɐ] creates an inconvenient [ɾj] sequence. In this sequence, the tongue tip needs to make a ballistic movement towards the alveolar ridge while the whole front of the tongue is beginning to make an approximant gesture towards the palate.

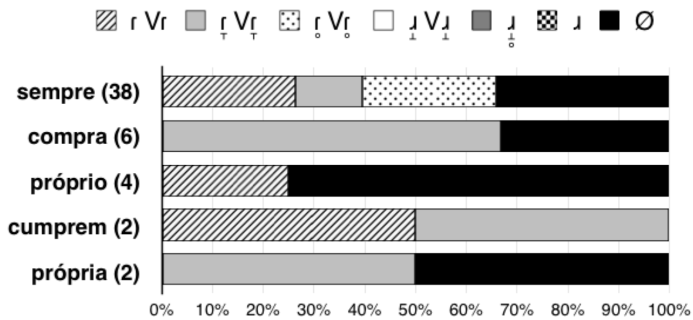


Figure 6.29: Lexical items with post-tonic pɾ (2 or more tokens)

The words with post-tonic bɾ and two or more tokens appear in Figure 6.30. The token number of the words is quite low, but we can see that *sobre* (‘on top of; about’) occurs five times more (15 tokens) than the next words with three tokens. Weak-r and the following unstressed vowel in *sobre* were deleted in two tokens by M4 ([soβ̝]) and M6 ([sob̚]). This may be due to high token frequency—in the ASPA corpus, *sobre* is by far the most frequent lexical item with word-final post-tonic bɾV, with 404,931 tokens as opposed to the second most frequent item, *obra*, with 59,790 tokens—but also due to analogy. Portuguese has two prepositions, *sobre* [ˈsobɾi] 'on top of; about' and *sob* [ˈsobi] 'under', that are antonyms but also phonetically very similar. According to (Bybee 2001), a frequency-motivated change is likely to be gradient whereas an analogical change is more likely to be abrupt. Therefore the weak-r-lenition in *sobre* could be due to high token frequency, or analogy, or both of these effects together. At any rate, no gradient variation seems to be present in the speech corpus as the weak-r in *sobre* was either a full-closure tap or an approximant tap, if not deleted, which could point to an analogical change rather than one of articulatory reduction.

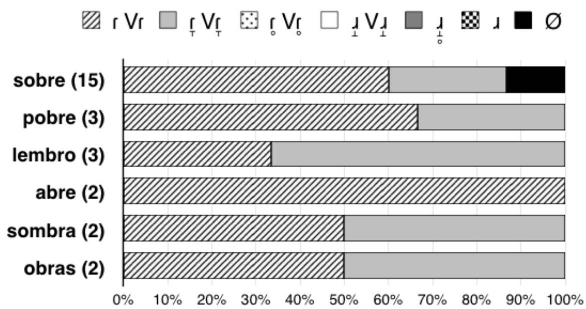


Figure 6.30: Lexical items with post-tonic bɾ (2 or more tokens)

So far we have not addressed the voicing of the first consonant in these clusters from a quantitative point of view. Table 6.7 sums all cluster tokens according to the voicing of the consonant preceding weak-r and the type of lenition. The percentage of both types of lenition is higher when preceded by voiceless consonants than voiced consonants. Fisher's exact test, applied to non-lenited forms *versus* [ɾ̥ ɹ̞ ɹ̞̊ ɹ] and to non-lenited forms *versus* deletion in both groups, renders the *p*-values given under each lenition type. They are below the significance threshold, meaning that there is a statistically significant difference in the distribution of lenited variants between the two voicing alternatives. In other words, a voiceless C is more likely to be followed by a lenited weak-r than a voiced C.

To end this section on lexical and frequency effects on weak-r in clus-

C voicing	ɾ̥ ɹ̝ ɹ̝̊ ɹ	Ø
p t k f (1552)	271 (17.5%)	201 (13%)
b d g v (471)	27 (5.7%)	25 (5.3%)
p-value (Fisher)	9.275×10^{-14}	7.804×10^{-9}

Table 6.7: Voicing of C in Cɾ-clusters and lenition

ters, Tables 6.8–6.10 summarise the lenited variants observed in all clusters in stressed, pretonic and post-tonic position. Voiceless, fricative and approximant variants appear in one column, deleted tokens in the next, and the "Total lenition" column combines the tokens in these columns. A qualitative look at these tables will tell that lenition is not taking place in all stress positions in the same way: while in stressed and pretonic position devoicing, fricativisation and approximantisation are more frequent than deletion in most clusters types, the percentage of deletions and total lenition in post-tonic position is much higher. Therefore lenition is more advanced in post-tonic position (which has already been defined as an attractor in CAS terms), and is also affected by other factors, such as the voicing of the preceding consonant, height or deletion of the following vowel, and adjacent [s].

Cluster	**Tokens**	ɾ̥ ɹ̝ ɹ̝̊ ɹ	Ø	**Total lenition**
pɾ	494	74 (15%)	83 (16.8%)	157 (31.8%)
tɾ	136	9 (6.6%)	13 (9.6%)	22 (16.2%)
gɾ	78	1 (1.3%)	1 (1.3%)	2 (2.6%)
fɾ	39	6 (15.4%)	0	6 (15.4%)
bɾ	22	0	0	0
kɾ	14	1 (7.1%)	0	1 (7.1%)
dɾ	5	0	0	0
TOTAL	**788**	**91 (11.5%)**	**97 (12.3%)**	**188 (23.9%)**

Table 6.8: Lenition in stressed clusters

Cluster	Tokens	ɾ̥ ɹ̝ ɹ̝̊ ɹ	Ø	Total lenition
pɾ	306	47 (15.4%)	26 (8.5%)	73 (23.9%)
tɾ	198	40 (20.2%)	8 (4%)	48 (24.2%)
bɾ	194	7 (3.6%)	5 (2.6%)	12 (6.2%)
kɾ	50	7 (14%)	1 (2%)	8 (16%)
gɾ	35	1 (2.9%)	2 (5.7%)	3 (8.6%)
fɾ	23	7 (30.4%)	0	7 (30.4%)
dɾ	1	0	0	0
TOTAL	**807**	**109 (13.5%)**	**42 (5.2%)**	**151 (18.7%)**

Table 6.9: Lenition in pretonic clusters

Cluster	Token count	ɾ̥ ɹ̝ ɹ̝̊ ɹ	Ø	Total lenition
tɾ	223	65 (29.1%)	52 (23.3%)	117 (52.5%)
vɾ	81	11 (13.6%)	12 (14.8%)	23 (28.4%)
pɾ	55	11 (20%)	18 (32.7%)	29 (52.7%)
bɾ	32	1 (3%)	3 (9.1%)	4 (12.1%)
dɾ	11	4 (36.4%)	2 (18.2%)	6 (54.5%)
gɾ	11	2 (18.2%)	0	2 (18.2%)
fɾ	8	2 (25%)	0	2 (25%)
kɾ	6	2 (33.3%)	0	2 (33.3%)
TOTAL	**428**	**98 (22.9%)**	**87 (20.3%)**	**185 (43.2%)**

Table 6.10: Lenition in post-tonic clusters

6.2 Sentence completion task

6.2.1 Overview

This section will provide details on the realisation of weak-r in the sentence completion task. In particular, it is relevant to observe if laboratory speech entails less lenition than the spontaneous speech already analysed. The words included in the task for the observation of weak-r are *barata* 'cockroach' (stressed intervocalic), *cara* 'face; [on a coin] heads' (post-tonic intervocalic), *caro* 'expensive (masc.)' (post-tonic intervocalic), *tráfico* 'traffic; trafficking' (stressed cluster), and *trabalho* 'work' (pretonic cluster). In total, these words provided 65 tokens of weak-r. The realisation of these five lexical items is detailed in Figure 6.31. The range of variants is much more limited than in the interview data (see Figures 6.1 and 6.9): the only observed variants were voiced alveolar taps [ɾ], voiced alveolar approximant taps [ɾ̞], and voiceless alveolar taps [ɾ̥]. In clusters, they could occur with or without an epenthetic vowel. No tokens of fricatives, lateral approximants, alveolar approximants or deletions were found in the sentence completion task.

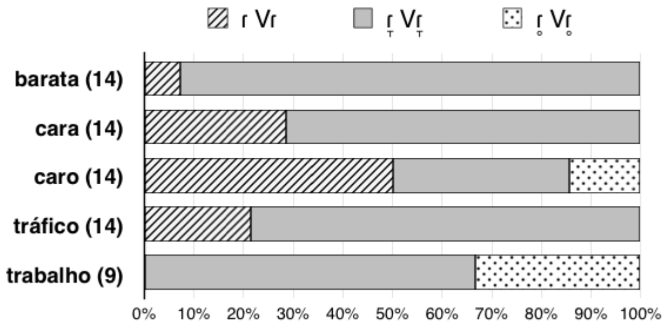


Figure 6.31: Weak-r variants in the sentence completion task

Much like in the interview data, approximant taps seem to be more common in intervocalic position (66% of intervocalic tokens) than voiced or voiceless full-closure taps. Voiceless taps are to be found in *caro* and *trabalho*. In both words weak-r is situated in an unstressed syllable, and it has become clear in the sections above that post-tonic word-final [ɾu] and pretonic [tɾ] are among the contexts where weak-r was most often lenited. Although there is lenition in stressed tɾ in the interview data (16% of all tokens), no such tokens of *tráfico* occur in the sentence data. The predominance of [ɾ]∼[ɾ̞] and the absence of lenition in any other form than devoicing in the sentence data suggest that, in the case of weak-r, devoicing, fricativisation, alveolar approximants and deletion are indeed characteristic of a less monitored register and can therefore be classified as lenited variants of weak-r. This is also evidence for an exemplar organisation of speech patterns: similar phonological contexts were found to have a range of articulatory variation, which implies that phonological representations are multiple and detailed, and that speakers have stylistic information attached to variants and articulatory patterns. Overall, the sentence completion task can be considered successful in demonstrating that laboratory speech induces more careful and complete articulations of weak-r than connected speech.

6.2.2 Individual speakers

Only one speaker, F3, produced all three intervocalic contexts in the task as [ɾ]; she was also the only speaker that produced more than half of all intervocalic weak-r's as full-closure [ɾ] in the interview data (see Section 6.1.2). This would imply that in terms of weak-r lenition, she is conservative. There does not seem to be an inter-speaker pattern of variants comparable to that of the interview data because lenited variants are hardly present in the task data.

Voiceless taps [ɾ̥] occurred in the recordings of five female speakers: F5 and F7 in *caro*, and F1, F5 and F6 in *trabalho*. In post-tonic intervocalic context (as in *caro*), F5 showed very little lenition in the interview data, whereas F7 had several devoiced tokens of this context. In pretonic tɾ (as in *trabalho*), the interview data also showed devoicing lenition for F1 and F5; however, F6 produced voiced and voiceless alveolar fricatives in this context. Most other speakers who showed lenition in these and other contexts in the interview data seem to have a more careful pronunciation in the task setting. This indicates that there may not always be a correspondence between the lenition patterns present in laboratory speech and spontaneous speech.

Speech patterns, variants and the stylistic information attached to their mental representations exist primarily on an idiolectal level, and they can begin to change at the level of a speech community as individuals use language in interaction with others. This is understood in an exemplar-based approach as articulatory patterns being created, updated and changed through repetition in a production-perception loop with other language users. Those language users are *agents* in terms of Complex Adaptive Systems (Beckner et al. 2009) whose language use both on an individual and communal level shapes and changes language.

6.3 Observations on weak-r

This chapter has described the variants of weak-r observed in the interview and task data. From a synchronic point of view, it was established that the average weak-r in any position is a voiced alveolar tap [ɾ] or voiced alveolar approximant tap [ɾ̞]. In clusters, of course, these two segment types may or may not be preceded by a vocalic segment that eases the articulation of a Cɾ-sequence. [ɾ] and [ɾ̞] are stable variants since they were mostly used in the task setting. Fricative and approximant variants as well as deletion, all considered lenited from a synchronic point of view, belong to an informal register. Fricatives and approximants are weak-r variants emerging from a reduction in the magnitude of the tap gesture, and this reduction ultimately leads to deletion. This chapter has demonstrated that these lenited variants can arise from the interaction of various factors, as predicted by the Complex Adaptive Systems approach.

The first of these factors is word stress. In general, post-tonic weak-r is more often lenited than stressed and pretonic weak-r, and within the pretonic context, increasing distance to the left of the main stress can also leave weak-r more prone to lenition. Related to word stress is the tendency towards oxytone words that seems to be operating in the studied dialect: final unstressed vowels can be deleted after weak-r, transforming the originally intervocalic rhotic into a word-final rhotic in a stressed syllable. Thus weak-r realisation is part of a bigger picture involving word stress and the reduction of all unstressed segments in BP (Napoleão de Souza 2012; Meneses 2012; Dias & Seara 2013; Cruz 2013; Cantoni 2013).

We have also seen that weak-r articulation is influenced by the surrounding phonetic context. When it precedes the high vowels [u]∼[ʊ] and [i]∼[ɪ], weak-r is more often devoiced (a voiceless alveolar tap or voiceless alveolar fricative) or deleted than before other vowels because the high vowels of BP themselves are also prone to reduction in the form of devoicing and deletion. When a following high vowel is deleted, the devoicing lenition of weak-r can be further promoted by the plural [s]-ending.

The voicing of the preceding consonant in Cɾ-clusters can also determine the realisation of weak-r: lenition is somewhat more frequent after voiceless consonants. The voicing of weak-r seems to be a dynamic process in the same way as for strong-R: the occurrence of a voiced or voiceless variant depends on but is not determined by the voicing of adjacent segments. Rather, the beginning of voicing in a rhotic may be delayed after a voiceless segment, or its voicing may end prematurely in anticipation of a voiceless segment or syllable. Weak-r can vary in constriction degree and voicing as long as contrast is preserved with other alveolar segments ([t d l n s z]). Perceptually and articulatorily, [l] resembles [ɾ], and in fact these two segments are closely linked because they are the only segments that can occur as second members of a cluster according to traditional phonotactics. Diachronically, many Latin laterals in clusters have evolved into taps in Portuguese (e.g. PLACERE → *prazer* 'pleasure'), but some have remained especially in erudite words reintroduced from Latin after rhotacism had begun in clusters (e.g. PLENU- → *pleno* 'full, complete') (Teyssier 1984). [ɾ] and [l] have therefore coexisted in the same type of clusters for centuries, and this is why there are no minimal pairs in cluster context, which could open the possibility of [l] occurring as a variant of weak-r. However, as [l] → [ɾ] is far more common in popular BP (e.g. *planta* → [ˈpɾɐ̃tɐ] 'plant'), this is not likely, and indeed it was not attested in the interview corpus.

Frequency effects were also discussed in this chapter. The preposition *para* is the clearest case for a lexical frequency effect on lenition in this corpus. In the word family *outro/ outra/ outros/ outras* 'other (masc. sing./fem. sing./masc. pl./fem. pl.)', which makes for 52% of all post-tonic tɾ tokens, differences in lenition were also linked to token frequency. Higher type frequency was found to possibly hinder devoicing lenition of weak-r in *-ra* and *-ram* words. Analogy may also be deleting weak-r: categorical deletions with no apparent intermediary phases were attested in the preposition *sobre*, which seems to be merging with *sob*.

In sum, the interview data has demonstrated that there is gradient variation in the articulation of weak-r, and that the phonetic form this category is given by different speakers in different phonological contexts is unpredictable. The results of the sentence completion task also indicate that even in a more monitored register, there are three different weak-r variants; one of them with complete closure, one with incomplete closure, and one that is devoiced. Therefore the articulation of weak-r is dynamic, and takes place within at least two articulatory parametres: stricture and voicing.

6.4 Intervocalic contrast of strong-R and weak-r

Chapters 5 and 6 have dealt with the varying forms that the rhotics of BP take in all phonological contexts except syllable coda (which is the topic of the next chapter). It was argued in Section 2.4.2 that a data-oriented phonological approach to analyzing the contrast of strong-R and weak-r in Brazilian Portuguese must assume that this contrast is incomplete since the two rhotics are neutralised in other contexts than intervocalically. At this point we have already presented the data from the semi-structured interviews and the sentence completion task regarding intervocalic rhotics. Figure 6.32 summarises these findings and adds the rhotic tokens from two specific lexical items in the sentence completion task: *besouro* 'beetle' and *guelras* 'gills'.

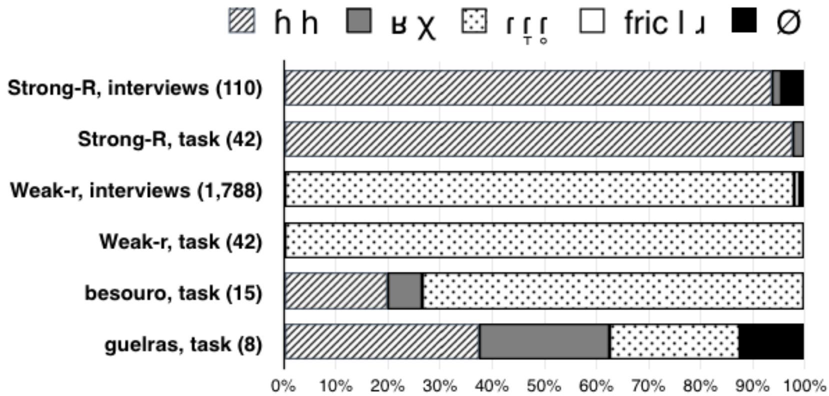


Figure 6.32: Intervocalic contrast of rhotics in the interview and sentence task data

We explained in Section 4.2.2 that these two words were included because of the possible variation in the rhotic (strong-R or weak-r). For *besouro* there may be two possible lexical representations ([biˈzowɾu] ∼ [biˈzoɦu]). *guelras*, on the other hand, represents a handful of words with a heterosyllabic lateral-rhotic sequence; others include *palra/palrar* 'gab, jabber'/ 'to gab, to jabber' and *melro* 'blackbird'. This type of word is so rare in BP that the ASPA corpus has only 295 tokens of lateral-rhotic sequences in 13 different words. In BP, coda laterals have been vocalised ([ɫ] → [w]), which has left the rhotic preceded by a diphthong (Oliveira & Cristófaro-Silva 2002). Preceded by [w], weak-r is the only rhotic that occurs in Portuguese (e.g. *ouro* [ˈowɾu] 'gold', *Europa* [ewˈɾɔpɐ] 'Europe', *restaurante* [hestawˈɾẽtʃi] 'restaurant'). Thus Vl.R words seem to be merging with Vw.ɾ words because the former are extremely rare, and the latter quite common: ASPA returns 280,115 tokens in 578 different lexical items with Vw.ɾ.

Figure 6.32 demonstrates that, indeed, the intervocalic contrast between strong-R and weak-r is clear-cut in the overall interview and task data. Strong-R was produced as glottal and uvular fricatives, and in some cases deleted; weak-r was articulated as a tap-like alveolar segment, and in a very limited number of cases, as an alveolar or postalveolar fricative, [l], [ɹ], or deleted. Therefore, in the studied variety of BP, it is evident that what used to be an alveolar trill [r] has evolved into a back fricative, while the alveolar tap has remained anterior. If weak-r suffers weakening through fricativisation, it still remains in the alveolar and postalveolar region, and does not merge with the back fricatives.

However, the pattern changes when we turn to *besouro* and *guelras.* For *besouro* there are fifteen tokens—one more than the number of speakers—because speaker F1 pronounced this word twice on the recording: the first time with [ɾ], and then a second time with [h], stating that that is what people actually say and thus indicating that she was correcting herself by producing the tap. Tap-like segments are in fact more common in the results (11 tokens) as opposed to back fricatives (4 tokens). There is no apparent reason for *besouro* to occur with a varying intervocalic rhotic. The motive for variation may be dialectal: the lexical representation is different from one area to another, or from one speaker to another. At any rate, this indicates that phonetic form and mental representations are word-specific, as suggested by Exemplar Models.

For *guelras*, there are only 8 tokens due to its unfamiliarity: most speakers either skipped the slide or replaced the target word with another word of the wrong semantic content. Only four of the fourteen speakers produced the correct target word: F1 ([h]), F4 (Ø), F5 ([ɦ]) and M7, who was in doubt about the correct pronunciation. He produced *guelras* five times with the following rhotic variants: [χ], [ɾ], [ɦ], [χ], and finally settled on [ɾ]. The deletion by F4 is most likely a deletion of the glottal fricative [h]∼[ɦ] because there are no clues in the audio to a weakened alveolar articulation. Therefore the initial output of all four speakers was a back fricative, and the only one to express doubt was M7, who eventually opted for the alveolar tap.

The sentence completion task can be considered successful in demonstrating that there are indeed some lexical items with intervocalic variation in the studied variety of BP. However, this variation is word-specific since strong-R and weak-r have clearly diverging variants in the overall interview and sentence completion data. Strong-R is fricative and articulated in the uvular and glottal region, and weak-r is generally a tap-like alveolar segment.

Chapter 7

Coda

The topic of this chapter is syllable coda, or syllable-final position. In Portuguese, rhotics may appear in word-medial coda and word-final coda. In both contexts, the syllable can be stressed or unstressed. This chapter begins with an account of word-medial coda rhotics in the semi-structured interviews and the sentence completion task first from a general point of view, and then by taking into consideration differences between speakers, the lexical items in which the rhotics occur, as well as frequency effects. The second part of this chapter focuses on word-final coda, separating not only the same aspects mentioned for word-medial coda, but also grammatical class: word-final coda may take on different phonetic forms in verb forms, nominals and the preposition *por* 'by; for; per', and this variation is further conditioned by the alternating phonological environment at word boundary.

7.1 Word-medial coda

7.1.1 Semi-structured interviews

7.1.1.1 Overview

In word-medial codas, rhotics can occur in stressed syllables (e.g. *curso* 'course') or pretonic syllables (e.g. *universidade* 'university'). Post-tonic coda rhotics that are not word-final do not occur in Portuguese, that is, a word such as *ˈCV.CVR.CV is not phonotactically possible. This section provides a general account of the coda variants in the interview data along with spectrogram examples of these variants.

934 tokens of word-medial coda rhotics were analysed in the interview data; 451 of these are in stressed syllables, and 483 in pretonic syllables. Word-medial coda contexts comprise 13.3% of the total of 7,045 rhotic contexts in the interview corpus. Word-medial coda variants appear listed in Table 7.1 according to syllable stress. The *p*-values obtained by Fisher's exact test of independence appear marked with an asterisk (*) if the difference in the distribution between contexts is statistically significant.

Context	**Stressed**		**Pretonic**		***p*-value (Fisher)**
Variant	N	%	N	%	
ɾ	0	**0**	1	**0.2**	1
ɹ̝	0	**0**	2	**0.4**	0.5
ɹ	33	**7.3**	45	**9.3**	0.288
j	23	**5.1**	17	**3.5**	0.2597
w	0	**0**	1	**0.2**	1
ɻ	118	**26.2**	76	**15.7**	0.0001 *
ɚ	79	**17.5**	187	**38.7**	4.733×10^{-13} *
ɹ^h	3	**0.7**	11	**2.3**	0.0575
j^h	1	**0.2**	0	**0**	0.4829
ɻ^h	5	**1.1**	7	**1.4**	0.7746
ɚ^h	18	**4**	12	**2.5**	0.1999
χ	5	**1.1**	1	**0.2**	0.1122
h	19	**4.2**	6	**1.2**	0.0071 *
ɦ	20	**4.4**	30	**6.2**	0.247
ə	5	**1.1**	1	**0.2**	0.1122
Ø	122	**27.1**	86	**17.8**	0.0007 *
TOTAL	451	**100**	483	**100**	

Table 7.1: Word-medial coda variants in the semi-structured interviews

A first look at Table 7.1 tells that there is much more variability in coda than in the strong-R and weak-r contexts explored in the previous chapters. In addition, we can see that some strong-R and weak-r variants can also be found in coda: uvular and glottal fricatives, but also alveolar taps, fricatives and approximants were found in coda context. In both stress positions, most tokens contained some sort of approximant (alveolar [ɹ], palatal [j], retroflex/bunched [ɻ]) or a schwar [ɚ]. The schwar, also referred to as an r-coloured vowel, is a syllabic variant perceptually very similar to the retroflex approximant. The proportion of schwar is higher (38.7% vs. 17.5%) and that of retroflex approximants lower (15.7% vs. 26.2%) in pretonic context than in stressed context. Aspirated approximants and schwar ([ɹʰ], [jʰ], [ɻʰ], [ɚʰ]) constitute 6% of all tokens in stressed codas, and 6.2% in pretonic codas. Back fricatives ([χ], [ɦ], [h]) make for 9.7% in stressed context, and 7.6% in pretonic context. Schwa-like neutral vowels [ə] occurred in a limited number of cases. Coda-*r* was also deleted in a significant portion of both contexts.

Other minor variants include the voiced alveolar tap [ɾ], voiced alveolar fricative [ɹ̝], and voiced labial-velar approximant [w]. These variants are excluded from Figure 7.1, which presents the data from Table 7.1 as a bar chart. Variants are ordered according to manner of articulation, with approximants on the left, followed by the combined tokens of aspirated approximants, and the two back fricatives. The vocalic coda schwa and deletion constitute their own categories. Within the approximant and fricative variants, front variants appear on the left.

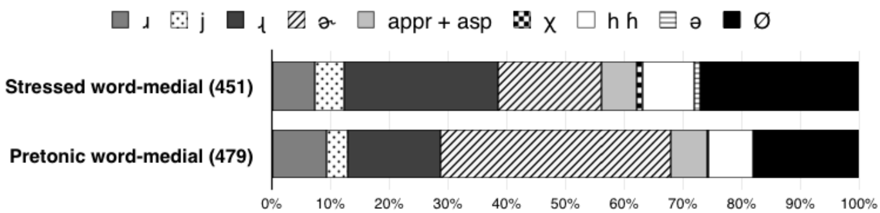


Figure 7.1: Word-medial coda in the semi-structured interviews

The *p*-values in Table 7.1 suggest that the differences in percentage are significant for [h], [ɻ], [ɚ] and deletion. The volatile voicing of glottal fricatives has already been discussed in Chapter 5, and therefore this distribution difference is not qualitatively relevant. In fact, when tokens of [h] and [ɦ] are combined (39 in stressed and 36 in pretonic syllables), the *p*-value rises to 0.5476, indicating that glottal fricatives occur evenly in these contexts.

As for the distribution of [ɻ], [ɚ] and deletion, it must be noted that out of the 451 stressed word-medial codas, 171 tokens (38%) are of the conjunction *porque* 'because'. This conjunction actually consists of the preposition *por* 'by; for' and the interrogative or relative pronoun *que* 'what, which; that', but was considered a chunk in the data annotation. When used as an explanatory conjunction, *porque* has variable stress, but was categorised as having a stressed coda-*r* for the sake of simplifying data processing. Since *porque* is so frequent in the stressed category, a more balanced comparison between stressed and unstressed position is achieved by removing the 171 tokens of this word from the analysis. The resulting bar chart can be seen in Figure 7.2. When compared to Figure 7.1, the stressed coda context excluding *porque* has a higher percentage of retroflex approximants than when *porque* is included (40% vs. 26%), and the percentage of r-coloured vowels and aspirated approximants is lower (12% vs. 18% and 2% vs. 6%). The proportion of deletions is also slightly lower (22% vs. 27%) when *porque* is excluded.

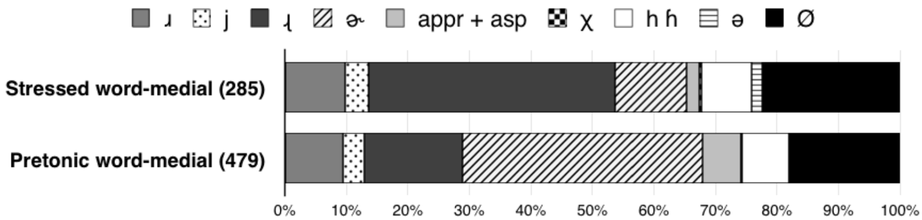


Figure 7.2: Word-medial coda in the semi-structured interviews excluding the conjunction *porque*

With *porque* excluded from stressed coda contexts, the *p*-values for differences in distribution can be recalculated. The difference in [ɹ], one of the main variants, continues to be insignificant (0.8), and the differences in [ɻ] (1.486×10^{-13}) and [ɚ] (8.667×10^{-17}) are still statistically significant. However, the difference in deletion (0.132) is no longer statistically significant. The coda rhotic in the high-frequency conjunction *porque* can therefore be considered more lenited than the average stressed coda rhotic in the corpus since its exclusion eliminated the statistically significant difference in the distribution of deletions. Therefore, we conclude that the type of lenition that preserves the vowel quality in syllable nucleus (as in

V[ɹ] and V[ɻ]) is preferred in stressed position, whereas lenition by merging the nucleus vowel and rhoticity (as in [ɚ]) is more frequent in pretonic syllables. The variants that occurred in *porque* will be further discussed in Section 7.1.1.3.

When *porque* is excluded, r-coloured vowels are more than three times more common in pretonic syllables (39%) than in stressed syllables (12%). On the other hand, retroflex approximants are more frequent in stressed syllables (40%) than pretonic syllables (16%). These two variants are acoustically and perceptually very similar, and their distribution according to syllable stress may be linked to this similarity. BP can be described either as stress-timed or syllable-timed depending on dialect and speech rate (Meireles et al. 2010). In Chapter 6 we demonstrated that unstressed vowels are reduced by devoicing and deletion (with consequences for adjacent weak-r as well), indicating that there are characteristics of a stress-time language in the studied dialect. The fact that a rhotic articulation with a lowered third formant—which alters vowel quality—can occupy a syllable nucleus more often in unstressed syllables than in stressed syllables seems to be in accordance with stress-timing.

In the following, examples of different coda variants will be provided. Spectrogram examples of uvular and glottal fricatives were already provided in Section 5.1.1 in the case of strong-R. The same labelling criteria were adopted in the case of coda fricatives. Fricatives were labelled as uvular if strong friction was present in the spectrogram and the variants were perceptually confirmed as articulated in the velar-uvular region (see Figures 5.9 and 5.10). Fricatives were labelled as glottal based on their perceptual quality and if their spectrogram image resembled more that of a vowel with weak friction noise (see Figures 5.2, 5.3, and 5.4).

The three approximant variants ([ɹ], [j], [ɻ]) were identified in the spectrogram according to the parameters referred in Section 2.3.4. The alveolar approximant [ɹ] has a rising third formant, whereas the acoustic correlate of the retroflex approximant [ɻ] is a lowering of the third formant that may conflate with the second formant. Low F3 is most likely the feature that makes [ɻ] perceptually more rhotic than [ɹ]. In the palatal approximant [j], both the second and third formant are elevated, and the auditory impression is that of a non-rhotic diphthong.

Figure 7.3 shows a spectrogram image of speaker F6 producing an alveolar approximant in the utterance *tem uma certa distância um do outro* ‘there is a certain distance between them’. The rise in the third formant is very subtle, but since there is an initial lowering of the second formant and the approximant segment has a rhotic perceptual quality, this token was classified as an alveolar and not a palatal token.

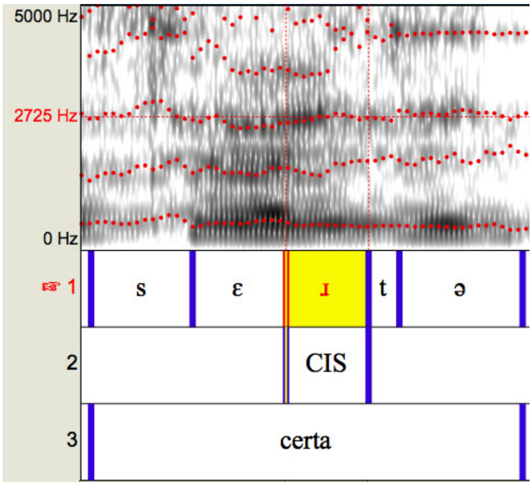


Figure 7.3: Voiced alveolar approximant in the word *certa* by speaker F6

In Figure 7.4, speaker F2 produces a palatal approximant in the utterance *para fazer o curso de Letras* ‘in order to get a degree in Linguistics and Literature’. The formant trajectories in alveolar and palatal approximants are very similar, and sometimes they are also auditorily difficult to distinguish; this may imply that there are both articulatory and acoustic factors that make it possible for both of these variants to occur in coda position. However, it is possible to see that in the palatal approximant, the elevation of the second formant is more clearly visible than in the alveolar approximant.

Figure 7.5 shows speaker M2 producing a type of approximant labelled as retroflex in the utterance *eu já fui para o norte* ‘I already went to the north’. Unlike in the alveolar and palatal approximants, the third formant of the retroflex approximant descends in comparison with the preceding vowel. This falling third formant can be produced using various strategies (see Section 2.3.4), including but not limited to tongue retroflexion,

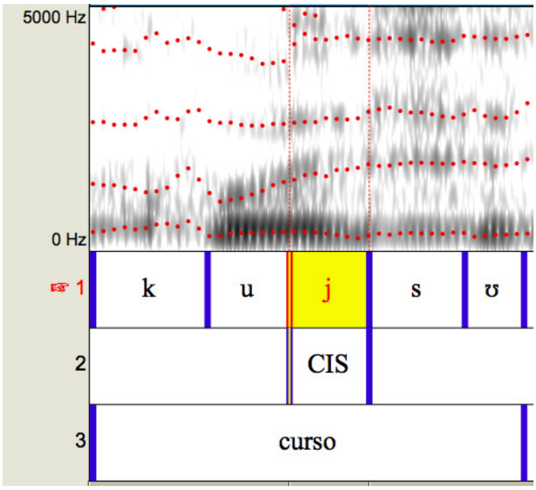


Figure 7.4: Voiced palatal approximant in the word *curso* by speaker F2

bunching, and lip rounding. Acoustics-only data does not permit the distinction of these strategies, which is why an approximant with a falling third formant is labelled as a retroflex approximant [ɻ] in this study.

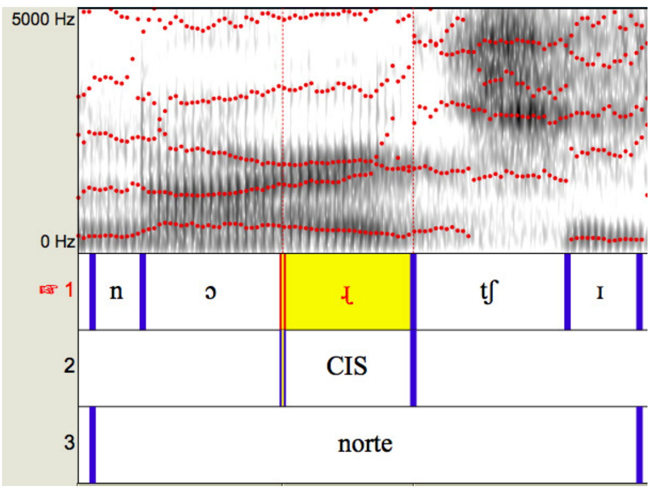


Figure 7.5: Voiced retroflex approximant in the word *norte* by speaker M2

The r-coloured vowel (or schwar) is very similar to the retroflex approximant both perceptually and in its formant structure. In Figure 7.6, speaker M1 produces a schwar in a stressed syllable in the utterance *eu achei que a gente ia passar um aperto* ‘I thought it would be difficult for us’. Much like in Figure 7.5, the third formant is low and close to the second formant, but the difference is that this conflation begins immediately after the preceding [p]. This is the criterion for differentiating the schwar from the retroflex approximant in this study: if there is a low third formant present, and no differing formant structure before the rhotic segment that would imply the presence of a non-rhotic vowel configuration before the rhotic approximant, the entire syllable nucleus is considered an r-coloured central vowel [ɚ]. Therefore, the retroflex approximant (as well as the alveolar and palatal approximants) are consonantal coda segments, whereas the r-coloured vowel is a syllabic segment. It is possible that there are differences in the quality of r-coloured vowels; however, the focus of this dissertation is on rhotics and not vowel quality, and for this reason the possible differences between r-coloured vowels arising from different VR rhymes will not be discussed here.

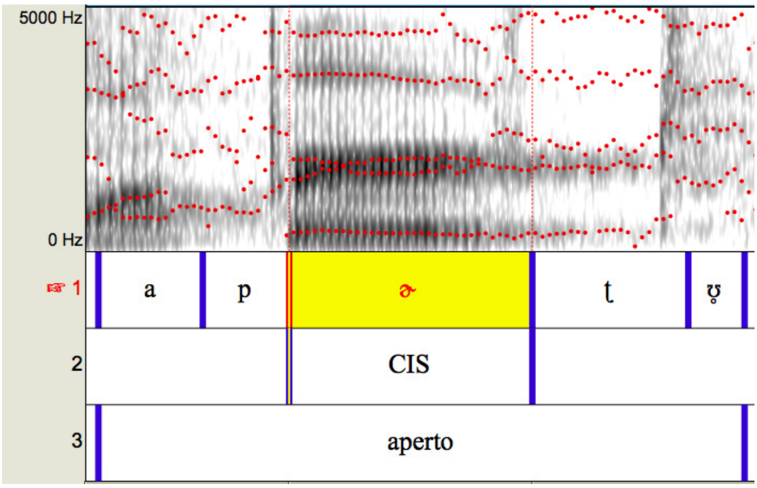


Figure 7.6: R-coloured vowel in the word *aperto* by speaker M1

The aspirated approximants ([ɹʰ], [jʰ], [ɻʰ]) and aspirated schwar ([ɚʰ]) were used by only a few speakers. The aspirated portion could be either voiced or voiceless; the voicing of the aspiration was not taken into account in the annotation and classification of these tokens. In Figure 7.7, speaker F3 produces an aspirated r-coloured vowel in the utterance *as pessoas tavam muito di-dispersas sabe não tinham um motivo em comum* ‘people were sca-scattered you know they didn’t have a common motivation’. The conflation of the second and third formants is very similar to that observed in Figure 7.6, but there is a voiced glottal fricative with friction noise in frequencies lower than the high-frequency friction of the following [s].

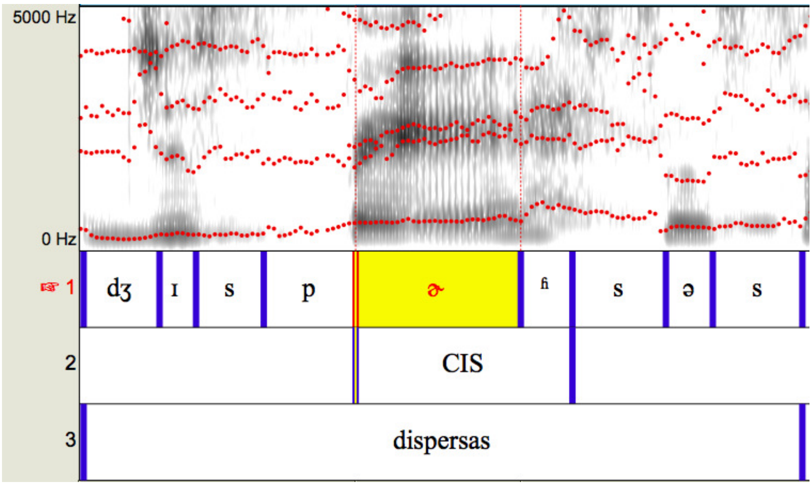


Figure 7.7: Aspirated r-coloured vowel in the word *dispersas* by speaker F3

It was discussed in Section 2.3.5 that vowel-retroflex sequences have a diphthong-like nature, and that the presence of a coda rhotic can be cued either by diphthong-like formant transitions or rhoticity itself. This type of V[ə] diphthongs were used by some of the recorded speakers as a way of cueing a word-internal coda rhotic. In Figure 7.8, speaker M3 produces a coda schwa in the utterance *aí ele puxando a sorte que não sei que lá tem muita polícia tem muitas* ‘so he was pushing his luck I don’t know because there are many police officers there are many’. There is a striking similarity between the formant trajectories of Figures 7.8 and 7.5. These two words (*norte* ‘north’ and *sorte* ‘luck’) form a minimal pair, and it is possible to see that in both tokens, the second formant rises and the third formant descends. However, the impressionistic perceptual quality of *norte* is clearly rhotic, whereas in *sorte* it is diphthong-like. Unlike the r-coloured vowel (or schwar) [ɚ] that occurs as a syllabic segment in this corpus, the schwa [ə] occurs as the second element of a diphthong-like realisation of a VR sequence, and therefore it is not syllabic.

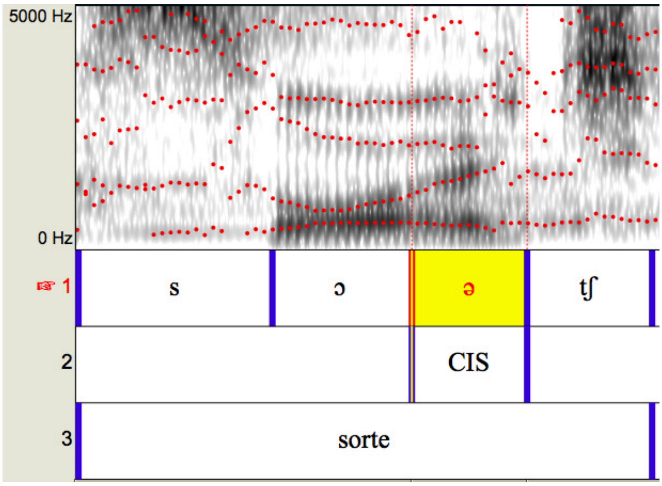


Figure 7.8: Schwa in the word *sorte* by speaker M3

The rhotic could also be deleted both in stressed and unstressed syllables. In Figure 7.9, speaker M3 deletes a coda rhotic in the utterance *isso facilita muito ter uma área ve<u>r</u>de para um fim de semana por exemplo um zoológico* 'it is a lot easier having a green space for a weekend for example a zoo'. There are no significant formant transitions in the [e] vowel, nor is there any rhotic or diphthong-like perceptual quality in this token.

When the rhotic is deleted, the quality of the preceding vowel can also be altered; there seems to be a continuum of realisations from a full retroflex approximant to deletion. Possible outputs of a word such as *verde* in the corpus are, among others, the following: [ˈveɻdʒi] ∼ [ˈveədʒi] ∼ [ˈvəɻdʒi] ∼ [ˈvɚdʒi] ∼ [ˈvədʒi] ∼ [ˈvedʒi]. Therefore, almost every possible combination of a non-altered nucleus vowel or a neutral central vowel paired with either the presence or absence of rhoticity can be found in the corpus. Since the focus of this study is on the realisation of rhotics, tokens of the [ˈvədʒi]∼[ˈvedʒi] type were both categorised as containing a

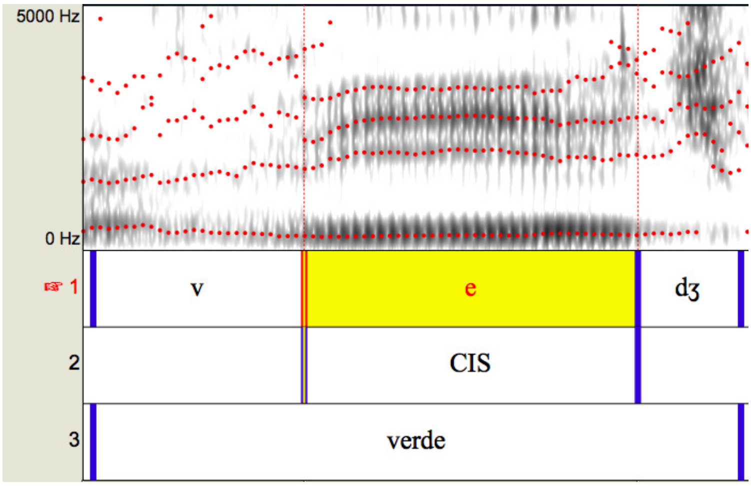


Figure 7.9: Deletion of a word-internal coda rhotic in the word *verde* by speaker M3

deleted rhotic, although it can be argued that a centralised vowel in syllable nucleus is a cue for rhoticity; we leave this speculation for future studies. The nucleus vowel may of course also be prolonged to cue the missing coda rhotic: for instance, the vowel [e] in Figure 7.9 is quite long when compared to the average length of nucleus vowels in previous examples. The possible effects of rhotic deletion on vowel length will not be discussed in this dissertation.

This overview of word-medial coda variants demonstrates that there are two separate coda tendencies, one of approximantisation and one of fricativisation, and both of them can ultimately lead to deletion. Deletion is already quite advanced in this context: 208 out of 934 word-internal coda tokens, or 22%, were *r*-less. Whereas strong-R and weak-r were found to be more or less stable categories in terms of place of articulation, and post-tonic position was found to increase lenition, word-medial coda is articulatorily much more diverse and shows an advanced level of lenition in both stressed and pretonic context. The next section will discuss how *r*-lenition is taking place in the speech of individuals.

7.1.1.2 Individual speakers

Charts on the realisation of stressed and pretonic word-internal coda rhotics by the fourteen recorded speakers can be consulted in Appendix F. These charts exclude the conjunction *porque*, whose phonetic realisation will be discussed in more detail in Section 7.1.1.3. Figure 7.10 below combines all word-medial coda variants (stressed and pretonic) by speaker.

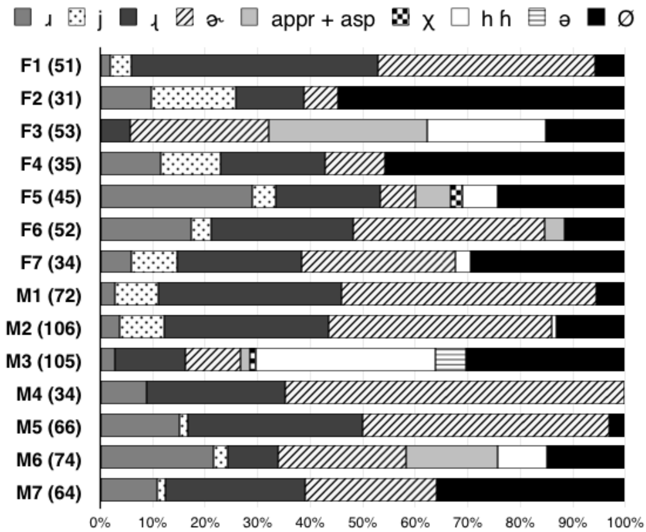


Figure 7.10: Word-medial coda variants by speaker (excluding the conjunction *porque*)

Figure 7.10 demonstrates that the speakers make use of three major variant combinations in word-medial coda. The most common strategy is to use approximants ([ɹ], [j], [ɻ]), r-coloured vowels and deletion. 6 out of 14 speakers use this strategy (F1, F2, F4, M1, M5, M7). Speaker M4 uses approximants and r-coloured vowels, but unlike any other speaker in the corpus, has no tokens of coda deletion. Finally, 7 speakers (F3, F5, F6, F7, M2, M3, M6) use aspirated approximants and/or back fricatives in addition to approximants and deletion. F3, F5 and M6 use aspirated approximants and back fricatives; F5 uses aspirated approximants, and uvular and glottal fricatives; F6 uses aspirated approximants; F7 and M2 have some tokens of glottal fricatives. M3 is the speaker with the most diversified coda output: in addition to approximants, schwar and deletion, his speech also contains aspirated approximants, uvular and glottal fricatives, and schwas [ə].

The rhotic approximants [ɹ] and [ɻ] as well as the r-coloured vowel [ɚ] occur in word-medial codas in the speech of all speakers. The palatal approximant [j] was not used by three speakers (F3, M3, M4). Voiceless uvular fricatives were found in the speech of speakers F5 and M3 only (and in the conjunction *porque* by F7, see Section below). Aspirated approximants/schwar's were used by five speakers only: F3, F5, F6, M3 and M6. Therefore the approximants, schwar and deletion can be considered the standard rhotic variants among the recorded speakers, while the use of aspirated approximants and back fricatives can be attributed to speaker-specific patterns situated outside the general pattern of lenition by approximantisation.

The aspirated approximant/schwar may be seen as an intermediate variant between approximants and a glottal fricative: four of the five speakers that use them are also the speakers that use glottal fricatives. The only exception is speaker F6 who has two tokens of pretonic [ɚʰ] and no tokens of any kind of back fricatives. This tendency could imply that speakers who vary between approximant/schwar and back fricatives overlap the articulatory gestures of these two variants. This means that an additional aspiration is superposed on the diphthong-like gesture of a VR rhyme that has been reinforced since childhood. The reason for such an overlapping aspiration can be either the influence of varying tendencies in the speech community and/or the adoption of a more prestigious pronunciation; Section 2.4.3 already discussed that in the context of Minas Gerais, back fricatives are more desirable coda variants than rhotic approximants.

The different coda strategies do not seem to directly reflect the areas where the speakers were born and raised (see Section 4.4). Figure 7.11 places the speakers' home towns on a map and groups their word-medial coda variants into four categories. Of these, "Others" comprises mostly deletions, but some tokens of tap-like segments as well. Speakers from the three towns to the southwest of the isogloss (F2, F5, M1, M5) would be expected to possibly have a more uniform coda pattern, and the speakers from towns close to the isogloss another pattern. However, there is one speaker (F5) from the southwest who uses back fricatives, and several speakers closer to the isogloss who do not use them. It can be pointed out that a large proportion of back fricatives is to be found in M3 and F3; this could be due to the geographical proximity to the state capital, Belo Horizonte, where coda rhotics are mostly back fricatives.

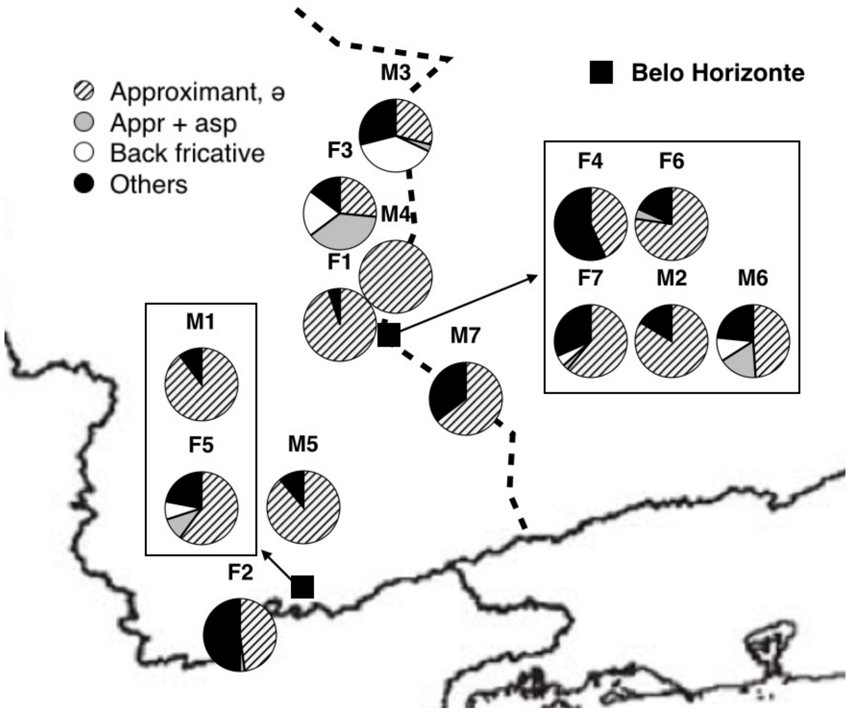


Figure 7.11: Word-medial coda variants (including *porque*) and the coda isogloss

Instead of being fixed in childhood, individual articulatory patterns are known to be influenced by changes in the surrounding speech community (e.g. Sankoff & Blondeau 2007). This makes it reasonable to assume that the studied speakers have shifted their pronunciation towards that of Lavras and the university environment, and away from whichever patterns they had acquired in their hometowns. From a phonological point of view, this suggests that language use does affect phonological representations and articulatory patterns. Idiolects are therefore ever-changing subsystems in a larger Complex Adaptive System: the communal language.

Six out of the fourteen recorded speakers (F1, F4, M1, M2, M4, M7) are leniting word-medial coda rhotics by approximantisation and/or deletion. However, the remaining eight speakers seem to vary between two lenition strategies—one involving approximants and the other, back fricatives—and even merge the two by using aspirated approximant variants. Ultimately, it can be argued that both trajectories lead to deletion. However, word-medial deletion is taking place at very different paces: while M4 deleted no rhotics whatsoever, the highest deletion rate was 57% (F4 in Figure 7.11). Thus there are two lenition trajectories present in the data—both of which can be considered phonetically gradient—and the rate at which these lenition trajectories have advanced in the speech of individuals varies greatly. Articulatory reduction towards deletion is therefore taking place in two different trajectories: one of them operates through approximantisation, and the other through debuccalisation. From both an intra-speaker and inter-speaker point of view, word-medial coda is highly variable, and it is this individual variation that ultimately contributes to general sound change in a Complex Adaptive System. These trajectories may affect lexical items in different ways and be subject to frequency effects, which is the topic of the next section.

7.1.1.3 Lexical item and frequency effects

This section will take a closer look at the lexical items in which word-medial coda rhotics occur and discuss frequency effects. The section begins with a consideration of what constitutes synchronic lenition in the corpus. After this, the lexical and frequency factors affecting word-medial coda rhotics will be analysed, starting with stressed context (including the high-frequency conjunction *porque*) and moving onto pretonic context. This separation into stress contexts is made so that the effect of syllable stress on coda rhotics can be observed. As discussed in the beginning of this chapter, the differences in the distribution of retroflex approximants and r-coloured vowels are statistically significant between stressed and pretonic syllables.

For the analysis of frequency effects on lenition, we should first establish what constitutes synchronic lenition in the output of the studied speakers. With such a large variety of gradient coda variants, it is challenging to establish which variants may be considered "full" or lenited. From a diachronic point of view, the voiced alveolar tap is the original full-closure variant that occurs in word-medial codas in other varieties of BP (e.g. São Paulo and the Southern states), and it still occurs in word-final codas in this corpus (see Section 7.2). Therefore, any variant that is not an alveolar tap is lenited diachronically speaking. From a synchronic point of view, however, it can be argued that a variant that virtually never occurs in a given phonological context cannot have a mental representation and established articulatory patterns among speakers.

Thus the synchronic non-lenited coda variants in the studied variety of BP would be the different approximants, the aspirated approximants and aspirated schwar, and the back fricatives. It can be argued that the alveolar approximant has its origin in the alveolar tap through gestural weakening, and that the palatal approximant and retroflex approximant are further developments of an alveolar approximant. However, all three variants contribute to diphthong-like formant transitions cueing the presence of a coda rhotic. In fact, the retroflex approximant—which has most likely developed from the alveolar approximant—can be argued to convey stronger rhoticity by the lowering of the third formant than the alveolar approximant. However, if this lowering of the third formant becomes syllabic and centralises the nucleus vowel, giving rise to what is labelled an r-coloured vowel [ɚ] in this study, this variant must be considered lenited since the formant transitions characteristic of a VR rhyme are no longer present. But if aspiration is superposed on the syllabic schwar, as in [ɚʰ], the resulting articulation contains elements from two different lenition trajectories and can hardly be considered synchronically lenited.

The back fricatives [χ], [h], [ɦ] are also problematic in terms of defining coda lenition. Again, from a diachronic point of view, we suggest that BP uvular fricatives have their origin in trills (first alveolar, then uvular; see Section 2.4.1.2), and were lenited further into glottal fricatives. But if in the case of strong-R, synchronically glottal fricatives are the norm and uvular fricatives the exception used mostly for emphasis (see Chapter 5), it is difficult to consider glottal fricatives synchronically lenited in coda context. If a segment occurs in a language in both syllable-initial position and syllable-final position—for instance, in the word *horror* [oˈɦoɦ], and remembering that the voicing of glottal fricatives is influenced but not determined by the surrounding segments (preceding or following)—it would be contradictory to consider the same segment non-lenited in onset but lenited in coda. This is why back fricatives are considered synchronically non-lenited in word-medial coda for the analysis of lexical and frequency effects.

Thus so far the syllabic schwar has been defined as a synchronically lenited variant. The coda schwa, present only in the speech of M3, may also be considered a lenited form of the coda approximants. Although it contributes to diphthong-like formant transitions (see Figure 7.8) in the same way as the approximants, it lacks the slightly more consonant-like perceptual quality and articulatory gesture.

Finally, deletion must be considered synchronic lenition in the case of coda rhotics. However, as exemplified by the different realisations of *verde* above, a coda rhotic may be deleted, but the vowel may be prolonged or centralised in order to cue the presence of a missing segment. An unaltered nucleus vowel would then perhaps represent a higher degree of lenition than a nucleus vowel with traces of the deleted rhotic; thus deletion is also gradient. Since this dissertation does not encompass vowel quality, and no formant or duration measurements will be provided for these nucleus vowels, the realisation of these vowels will not be discussed, and all types of deletion will be analysed as a single phenomenon.

Moving on to lexical items with stressed word-medial coda rhotics, the conjunction *porque* 'because' is by far the most frequent lexical item in this category (171 tokens). It is also the second most frequent lexical item among all words including a neutralised mid back vowel followed by a coda rhotic in the ASPA database (see Table 7.2). This ASPA category contains words in which [o] is neutralised with [ɔ]∼[u] in unstressed syllables, and words in which [o] and [ɔ] mark either a semantic or grammatical function (e.g. verb *versus* noun). Figure 7.12 plots the variants used in *porque* by each of the fourteen speakers, as well as the total of all speakers. The most common variants for the coda rhotic in this lexical item are deletion (37%), schwar (27%), and aspirated approximant (9%). When compared to the average of stressed word-medial coda in other lexical items (Figure 7.2), with 40% retroflex approximants, 22% deletion and 12% schwar, *porque* has a higher percentage of deletions and syllabic rhotic variants. This implies that weakening is in fact more advanced in this high-frequency conjunction than in the overall data, both by the rhoticisation of the nucleus vowel and by deletion of the rhotic or the entire VR rhyme.

Lexical item	**Meaning**	**VR stress**	**ASPA token frequency**
reportagem	‘news report’	Pretonic	187,071
porque	‘because’	Ambiguous	158,203
acordo	‘agreement’; ‘I wake up’	Stressed	113,535
forma	‘form’	Stressed	91,307
informações	‘information (pl.)’	Pretonic	58,354
importante	‘important’	Pretonic	49,792
jornal	‘newspaper’	Pretonic	45,108
força	‘force’; ‘(s)he forces’	Stressed	39,388
porto	‘port’; ‘I carry’	Stressed	34,894
torneio	‘tournament’	Pretonic	32,588

Table 7.2: ASPA token frequencies for the 10 most frequent lexical items with neutralised [o] followed by a coda rhotic

The variants of *porque* in the corpus therefore include (but are not limited to) [ˈpuɹki] ∼ [ˈpʊɹki] ∼ [ˈpujki] ∼ [ˈpʊjki] ∼ [ˈpuɻki] ∼ [ˈpʊɻki] ∼ [ˈpɚki] ∼ [ˈpɚʰki] ∼ [ˈpuhki] ∼ [ˈpʊhki] ∼ [ˈpuki] ∼ [ˈpʊki] ∼ [ˈpəki] ∼ [ˈpəkə] ∼ [pki] ∼ [pk]. The nucleus vowel may be an unaltered [u], a lax [ʊ], a schwa [ə], or the whole syllable rhyme may be deleted. Once again it becomes evident that the lenition of rhotics is closely linked to reduction in the surrounding vowels, and that this lenition is highly gradient.

Figure 7.12 shows that almost all speakers who produced more than one token of *porque* use several different *r*-variants. Speaker M4, with nine tokens of r-coloured vowels, is the only one with a consistent pattern in *porque*; he is also the speaker with no word-medial deletions, which may indicate that he is more conservative when it comes to coda lenition. M2 only produced one token of *porque*, and M7 had no tokens of *porque*. The other 11 speakers use approximants, schwar, aspirated approximants, back fricatives and deletion in combinations of at least two.

In addition to *porque*, lenition is present in other lexical items as well. Figure 7.13 lists the tokens of lexical items with a stressed word-medial coda and three or more tokens. The ten most frequent lexical items are *porque* ‘because’, *curso* ‘course; degree’, *parte* ‘part’, *forma*

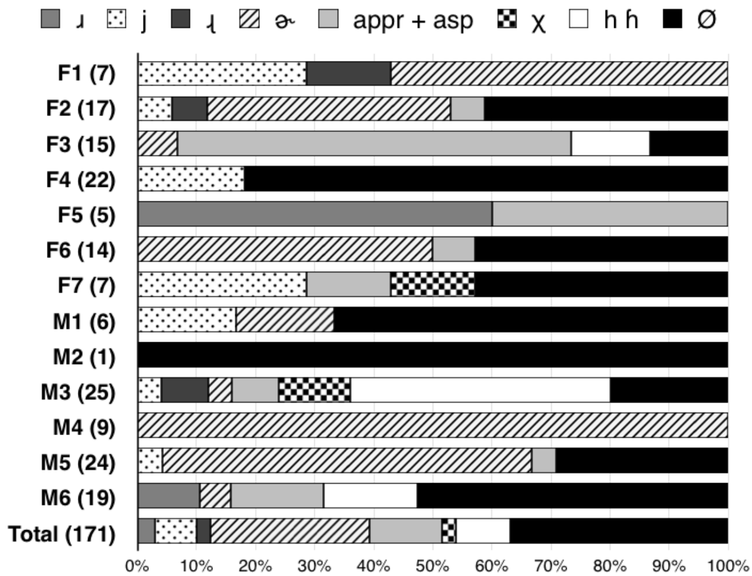


Figure 7.12: Coda variants in the conjunction *porque* in the semi-structured interviews

'form, shape', *esporte* 'sport', *governo* 'government', *certo* 'certain; correct (masc.)', *carne* 'meat', *perto* 'close(by)', and *transporte* 'transport'. The distribution of variants is different from that seen for strong-R and weak-r in that there does not seem to be a clear pattern of variation—coda variants seem almost random. The low token count for most words means that they most likely represent individual articulatory patterns (which, as argued in the previous section, are quite divergent).

The picture is no different in pretonic codas (Figure 7.14). Among the ten most frequent words are *português* 'Portuguese', *verdade* 'truth', *certeza* 'certainty' (used mostly in the expression *com certeza* 'sure, definitely'), *universidade* 'university', *importante* 'important', *oportunidade* 'opportunity', *Argentina*, *Portugal*, *participei* 'I participated', and *internet*. Again, the coda variants seem dispersed, and most words consist of only a handful of tokens.

The place or manner of articulation of the following consonant was not found to influence the preceding coda rhotic, and the low token count

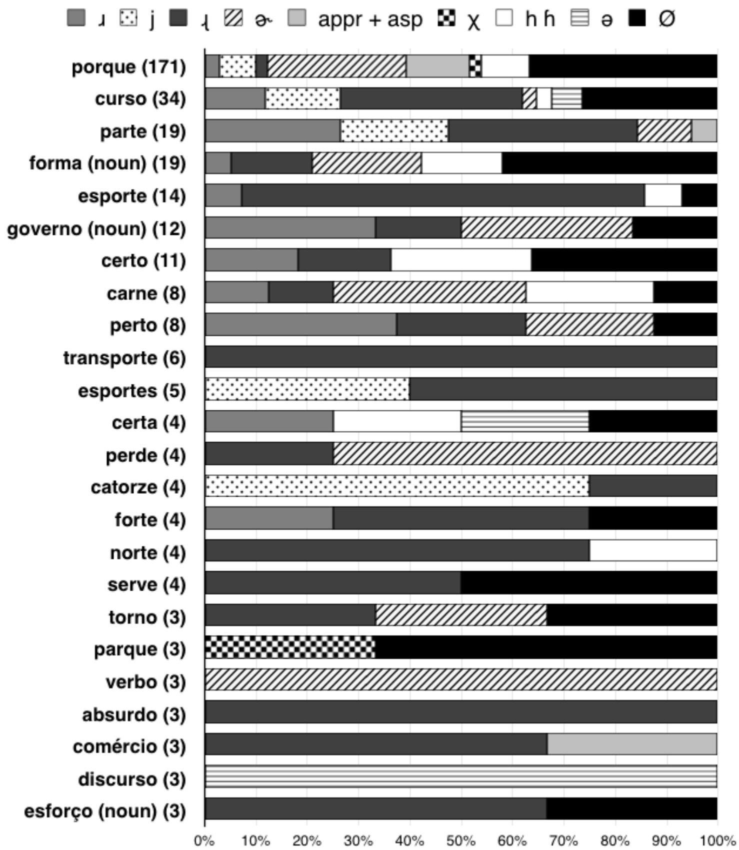


Figure 7.13: Lexical items with stressed word-medial coda rhotics in the semi-structured interviews (3 or more tokens)

of individual words makes it unviable to perform an analysis of lexical frequency effect. A partial explanation for the distribution of *r*-variants may be found in the type of vowel that precedes coda rhotics. Figures 7.15 and 7.16 plot the rhotic variants according to they nucleus vowel in a VR rhyme in stressed and pretonic codas. No tokens of stressed iR.C or pretonic ɔR.C occurred. The proportion of [ɚ] may be linked to vowel frontness in both cases: the proportion of this syllabic variant increases with vowel frontness. In stressed context, there are 16% r-coloured vowels

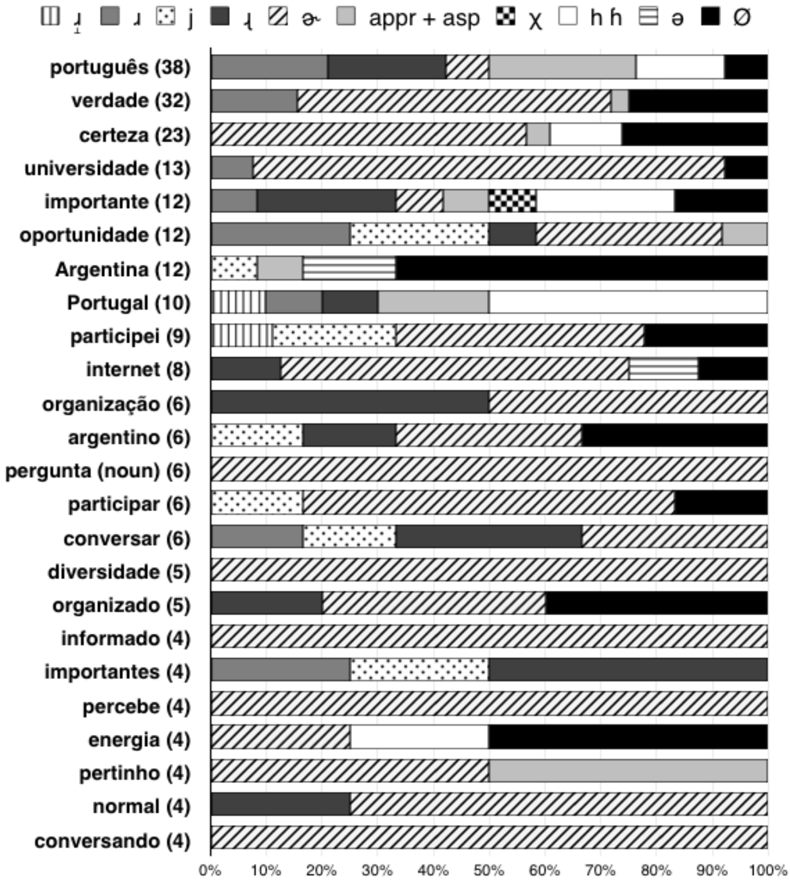


Figure 7.14: Lexical items with pretonic word-medial coda rhotics in the semi-structured interviews (4 or more tokens)

for phonological eR, 24% for ɛR, 23% for aR, 4% for ɔR, 5% for oR, and 4% for uR (excluding *porque*). As the proportion of [ɚ] decreases, that of coda approximants and back fricatives increases. The effect of a retroflex or bunched approximant on the preceding vowel was discussed in Section 2.3.4: the tongue body must be retracted for the production of the rhotic, which is why in the case of a preceding front vowel there is reduction in the degree of frontness and/or in the degree of rhoticity. This centralisation of front vowels and merger with the rhotic gesture that produces a low third formant may in fact be what lies behind the varying proportion of [ɚ]. This is confirmed by the Fisher p-value reported in Table 7.3. Here, for clarity of presentation, nucleus vowels are divided into front and back vowels, and the difference in the percentage of [ɚ] (22.1% in syllables with a front nucleus, 4.3% in syllables with a back nucleus) is statistically significant.

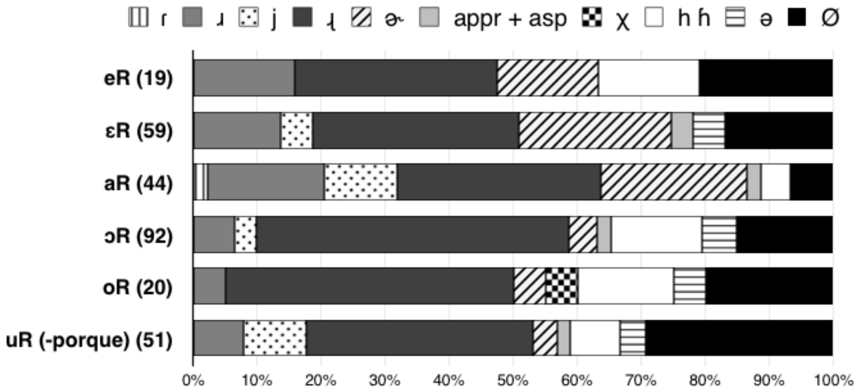


Figure 7.15: Lenition in stressed word-medial VR rhymes in the semi-structured interviews

Nucleus vowel / Variant	**ɚ**	**Others**	**TOTAL**
Front (e ɛ a)	27 (22.1%)	95 (77.9%)	122
Back (ɔ o u)	7 (4.3%)	156 (95.7%)	163
Fisher's exact test $p = 0.00000487$			

Table 7.3: [ɚ] distribution in stressed word-medial codas

The distribution of [ɚ] according to the preceding vowel is even more accentuated in pretonic context (Figure 7.16). Schwar [ɚ] constitutes 57% of iR tokens, 56% of eR tokens, 50% of ɛR tokens, 50% of aR tokens, 20% of oR tokens, and 11% of uR tokens. The tendency of increasing proportion of schwar when preceded by a phonologically front vowel therefore seems to be present also in pretonic VR rhymes, indicating that front vowels could be less compatible with the articulatory gesture producing a low third formant than central or back vowels. Table 7.4 presents the number of tokens for [ɚ] and other variants in pretonic codas, and again the Fisher p-value confirms that by contrasting front and back vowels, the difference in [ɚ] distribution is significant.

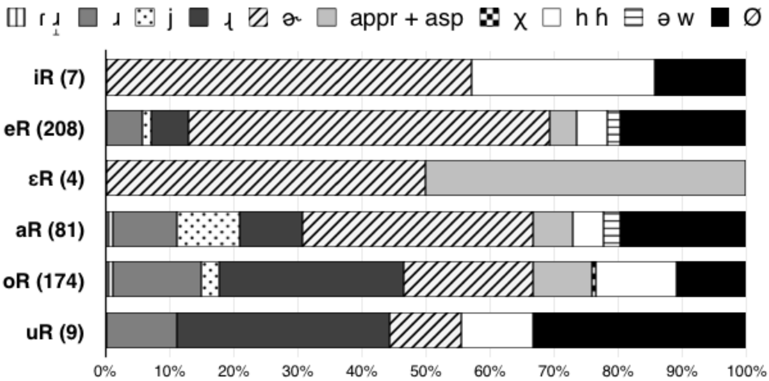


Figure 7.16: Lenition in pretonic word-medial VR rhymes in the semi-structured interviews

Nucleus vowel / Variant	**ɚ**	**Others**	**TOTAL**
Front (i e ɛ a)	152 (50.7%)	148 (49.3%)	300
Back (o u)	36 (19.7%)	147 (80.3%)	183
Fisher's exact test $p = 5.263 \times 10^{-12}$			

Table 7.4: [ɚ] distribution in pretonic word-medial codas

We can conclude that there is evidence for the influence of vowel frontness on VR merger in BP. This could suggest that the articulatory gesture for coda approximants is bunched (and not retroflex) for at least some of the speakers, as Lawson, Scobbie & Stuart-Smith (2013) found bunching to promote vowel neutralisation and merger with the rhotic more clearly than a retroflex configuration. However, this cannot be confirmed with the acoustic-only data used in this study. We have also demonstrated that the coda rhotics in the conjunction *porque* are considerably more lenited than the average for word-medial codas, indicating that this high-frequency construction has indeed undergone lenition at a faster rate due to its frequency of use. The next section takes a look at word-medial coda variants in the sentence completion task and compares the variants used by individual speakers between the interview and task settings.

7.1.2 Sentence completion task

7.1.2.1 Overview

The sentence completion task yielded a total of 56 tokens of word-medial coda. They were obtained through the elicitation of the words *carta* 'letter', *barco* 'boat', *cartão* 'card' and *arquitetura* 'architecture'. The first two contain a stressed coda rhotic, and the latter two a pretonic coda rhotic. Thus there are two word pairs (stressed and pretonic) containing the sequences aR.t (anterior plosive) and aR.k (posterior plosive).

The labelled variants can be observed in Figure 7.17. The range of variants is more limited than in the interview data: no tokens of aspirated palatal approximants [j^{h}], uvular fricatives [χ] or coda schwas were found. It should also be noted that the level of deletion is very low in the sentence task data: only two deletions were found, by speaker F5 in *carta* and by speaker M6 in *barco*. The most frequent variants are the alveolar approximant [ɹ], retroflex approximant [ɻ], r-coloured vowel [ɚ] and glottal fricative [ɦ]∼[h]. Variants of only a few tokens include the palatal approximant [j], and aspirated approximants and schwar ([ɹ^{h}], [ɻ^{h}], [ɚ^{h}]).

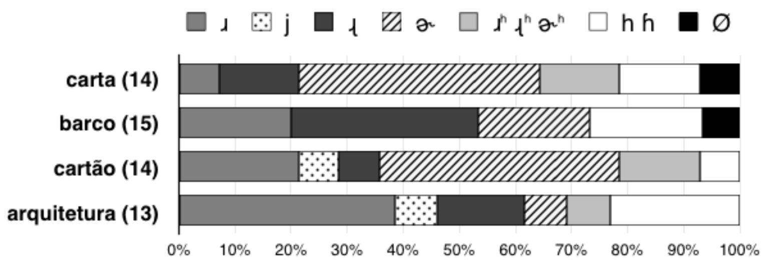


Figure 7.17: Word-medial coda variants in the sentence completion task

The difference in schwar distribution is not statistically significant (Fisher $p = 0.771$) between stressed and pretonic syllables. This finding is the opposite of schwar distribution in the interview data, in which [ɚ] was more common in pretonic than stressed position (p $= 8.667 \times 10^{-17}$ when *porque* is excluded). It is interesting to notice that both stressed and pretonic aR.t seem to have a larger proportion of r-coloured vowels (42% in both cases) compared to aR.k (20% and 8%, respectively), and the Fisher *p*-value of 0.037 shows that this difference is weakly significant. This tendency was not observed in the interview data. In addition, there are two tokens of deletion in stressed context and none in pretonic context; this difference is not significant ($p = 0.492$).

The proportion of glottal fricatives is also quite different in the sentence task data: when in the interviews there were 8% of glottal fricatives in word-medial codas (75 out of 934 tokens), in the sentence task data they form 16% (9 out of 56 tokens) of word-medial coda tokens. This doubling of glottal fricatives in percentage points is statistically significant, although close to the significance threshold (Fisher $p = 0.046$), and it is most likely the result of monitored speech: the social prestige associated with glottal fricatives in coda position makes some speakers use these variants in a reading situation. This change takes place at the idiolectal level, which is why the speakers who added glottal fricatives or increased their proportion in the task setting will be discussed in the next section.

7.1.2.2 Individual speakers

A comparison of the variants used by the fourteen recorded speakers can be found in Table 7.5. Eight speakers deleted coda rhotics in the interviews but only produced approximants and r-coloured vowels and/or aspirated approximants and r-coloured vowels in the task (F1, F2, F4, F6, M1, M2, M5, and M7). In the interview, speaker F3 produced variants from all categories in Table 7.5, but in the task used only glottal fricatives. Speaker F5 also produced tokens from all categories in the interview, but no longer used approximants and schwar in the task. F7 produced approximant, schwar, fricative and deleted tokens in the interview, but did not delete rhotics in the task. Both M3 and M6 produced tokens from all categories in their interviews, but in the task, M3 only produced approximants and M6 aspirated approximants/r-coloured vowels and one deletion. The only speaker consistent in the production of coda rhotics is M4, who only produced approximants and r-coloured vowels in both corpora.

Speaker	Corpus	Appr. & schwar	Appr. + asp.	Back fricative	Deletion
F1	I	X			X
	S	X			
F2	I	X			X
	S	X			
F3	I	X	X	X	X
	S			X	
F4	I	X			X
	S	X			
F5	I	X	X	X	X
	S		X	X	X
F6	I	X	X		X
	S	X			
F7	I	X		X	X
	S	X		X	
M1	I	X			X
	S	X			
M2	I	X			X
	S	X			
M3	I	X	X	X	X
	S	X			
M4	I	X			
	S	X			
M5	I	X			X
	S	X			
M6	I	X	X	X	X
	S		X		X
M7	I	X			X
	S	X	X		

Table 7.5: Word-medial coda variants by speaker in the semi-structured interviews (I) and sentence completion task (S)

The low level of deletion shows that, in general, the speakers seem to monitor their articulation in a task setting and produce more complete forms of the target words. In addition, speakers F3, F5, M6 and M7 seem to either avoid approximants/schwar or add aspiration or glottal fricatives to their speech in order to shift towards a more prestigious pronunciation. This is further evidence for an exemplar organisation of sound patterns: speakers make use of a gradient, continuous range of variants and apply them flexibly in speech situations that call for variants with certain sociolinguistic information attached to them. Of course, we have also demonstrated that not all speakers respond to these sociolinguistic expectations in the same manner: for instance, speaker M4 produced the same type of word-medial coda segments in both settings. Speech patterns, and consequently language change, therefore exist essentially on an idiolectal level.

This section has also shown that from a diachronical point of view, two different coda trajectories—one of approximantisation, and one of debuccalisation to [ɦ]∼[h]—can coexist not only in the overall data, but also in the speech of an individual. Therefore sound change in coda rhotics does not seem to follow one deterministic articulatory strategy; rather, various lenition trajectories can coexist in an idiolect. The same trajectories are present also in word-final codas, which is the topic of the remainder of this chapter.

7.2 Word-final coda

This section concerns the variation of rhotics in word-final codas. Previous studies have shown that the level of deletion in BP word-final rhotics may be dependent on lexical item, syllable count, following segment, and grammatical class (Oliveira 1983; Huback 2006; Oliveira 1997). These aspects will be taken into consideration in the interview and sentence task data.

7.2.1 Semi-structured interviews

In total, 1,821 word-final contexts for rhotics were annotated in the semi-structured interviews. They amount to 25.8% of the total of rhotic contexts (7,045) in the interview corpus. 210 of these tokens are nominals (such as *lugar* 'place' or *melhor* 'better; best'), 1,424 are verb forms (infinitives such as *falar* 'to speak', future subjunctive forms such as *fizer* '(if I/he/she) do/does (1/3S)', and the present indicative form *quer* 'wants (3S)'), and 147 are tokens of the preposition *por* 'by; for; per'. In addition to these three major categories, there were 40 other tokens. They come from the prepositional phrase *apesar de* 'in spite of' (20 tokens), the pronoun *qual-*

quer 'any (one)' (14), and 6 tokens of paroxytone words (the prefix *super* 'super', *caráter* 'character', and *açúcar* 'sugar'). Apart from these three paroxytones, all other word-final coda contexts were stressed. This distribution of word types indicated that, in the studied variety, word-final rhotics are most often stressed, and they occur most often in verb forms. Therefore it is likely that any frequency-based sound change will be more advanced in verbs.

7.2.1.1 Overview

This section will present the overall distribution of variants in nominals, verbs, *por*, and the remaining lexical items with a different grammatical function or stress pattern. The results will be presented in relation to the type of context that could follow word-final rhotics in the interview corpus: consonant, vowel, or pause. There were some instances of word-final rhotic contexts followed by glottal stops [ʔ], which do not carry meaning nor do they contrast phonologically with other sounds in BP. They are considered consonantal contexts in this study since they require obstruction of the airflow. The rhotic variants observed in word-final codas are mostly the same as those in word-medial context: approximants ([ɹ j ɻ]), schwar [ɚ], aspirated approximants and schwar ([ɹʰ jʰ ɻʰ ɚʰ]), glottal fricatives [ɦ h], and deletion. No uvular fricatives were observed word-finally. Unlike in word-medial codas where only a handful of tap-like tokens were observed and mostly excluded from the analyses, [ɾ ɾ̥ ɾ̞] occur in word-final codas, especially before vowels.

Starting with the nominals, Table 7.6 lists variants according to following segment (consonant, vowel, or pause), and the same data can be observed as a bar chart in Figure 7.18. These nominals are mostly nouns and adjectives ending in *-(d)or* and *-ar*; a more detailed description will be provided in Section 7.2.1.3 below. A single token of a coda schwa [ə], found in the speech of M3 in the word *maior* 'bigger' has been excluded from Figure 7.18 for clarity of presentation.

Alveolar tap-like articulations are abundant when the rhotic is followed by a vowel: altogether, these segments form 53.5% of all tokens followed by a vowel. There was also one single token of [ɾ̞] before a consonant. The retroflex approximant is the most common variant when followed by a consonant (39%) and pause (59.2%); also when followed by a vowel, 16.3%

Context	+C		+V		+P	
Variant	N	%	N	%	N	%
ɾ	0	**0**	10	**23.3**	0	**0**
ɾ̥	0	**0**	1	**2.3**	0	**0**
ɾ̞	1	**0.8**	12	**27.9**	0	**0**
ɹ	5	**4.2**	0	**0**	0	**0**
j	2	**1.7**	0	**0**	0	**0**
ɻ	46	**39**	7	**16.3**	29	**59.2**
ɚ	9	**7.6**	1	**2.3**	2	**4.1**
ɻʰ	1	**0.8**	0	**0**	2	**4.1**
ɚʰ	1	**0.8**	0	**0**	1	**2.0**
h	3	**2.5**	1	**2.3**	2	**4.1**
ɦ	9	**7.6**	0	**0**	3	**6.1**
ə	1	**0.8**	0	**0**	0	**0**
Ø	40	**33.9**	11	**25.6**	10	**20.4**
TOTAL	118	**100**	43	**100**	49	**100**

Table 7.6: Word-final coda variants in nominals in the semi-structured interviews

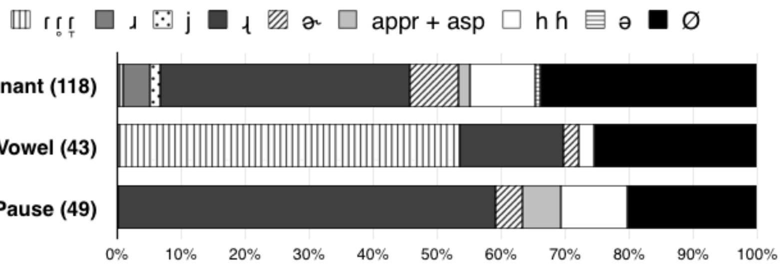


Figure 7.18: Stressed word-final rhotics in nominals in the semi-structured interviews according to following segment

of tokens are retroflex approximants. Alveolar and palatal approximants only occur before consonants (6%). There are lower percentages of the schwar [ɚ], aspirated approximants/schwar, and glottal fricatives in all three contexts. Deletion is most advanced before consonants (33.9%), then vowels (25.6%), and least advanced before pause (20.4%).

In sum, some kind of rhotic is most often present word-finally in nominals; however, before a consonant or pause, it is most frequently a retroflex approximant, and before a vowel, a tap-like alveolar segment. As an example of [ɻ] in a nominal, Figure 7.19 shows a spectrogram image of speaker M4 producing the verb *ver* 'to see' that is functionally a noun in the phrase *a meu ver* ('in my opinion') before a pause. The lowering of the third formant that is characteristic of retroflex/bunched approximants is present.

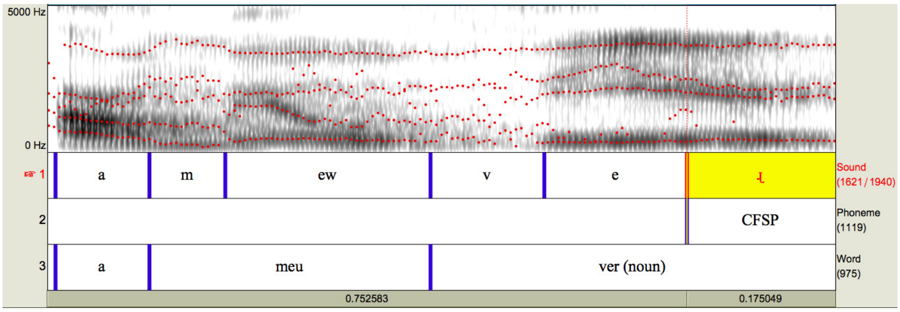


Figure 7.19: Word-final retroflex approximant [ɻ] in the word *ver* (noun) by speaker M4

As already mentioned, infinitive verb forms are the word type with word-final rhotics with the highest number of tokens. Infinitive verb forms can end in -[a]*r*, -[e]*r*, and -[i]*r*. Other similar verb forms include future subjunctive forms such as *quis*[ɛ]*r* '(if I/he/she) want(s) (1/3S)' or *f*[o]*r* '(if I/he/she) am/is/go(es) (1/3S)', and *qu*[ɛ]*r* 'wants (3S)'. The variants used in verb forms are detailed in Table 7.7, and plotted onto a bar chart in Figure 7.20, which separates the data into infinitives and non-infinitives. Compared to nominals, it is possible to see that deletion is much more advanced in verb forms irrespective of the following segment. Before consonants, verbs were produced with a handful of tokens of retroflex approximants, palatal approximants, voiced glottal fricatives, and schwas; however, deletions make for 98.3% of all tokens. Before vowels, there were 11 tokens of tap-like articulations and one voiced glottal fricative, but in this context deletion was most common. Before a pause, verbs were articulated with a slightly higher percentage of glottal fricatives. This may be explained by the release of airflow towards the end of an utterance. Single tokens of [ɻ], [ɚ], and [ə] were also found before pause.

Context	+C		+V		+P	
Variant	N	%	N	%	N	%
ɾ	0	**0**	2	**0.5**	0	**0**
ɾ̞	0	**0**	9	**2**	0	**0**
j	1	**0.2**	0	**0**	0	**0**
ɻ	5	**0.7**	0	**0**	1	**0.4**
ɚ	0	**0**	1	**0.2**	1	**0.4**
h	0	**0**	0	**0**	16	**5.9**
ɦ	3	**0.4**	1	**0.2**	5	**1.7**
ə	3	**0.4**	0	**0**	1	**0.4**
Ø	696	**98.3**	431	**97.1**	248	**91.2**
TOTAL	708	**100**	444	**100**	272	**100**

Table 7.7: Word-final coda variants in verbs in the semi-structured interviews

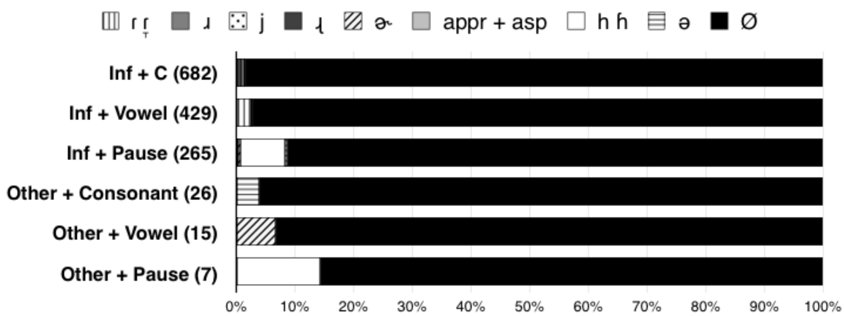


Figure 7.20: Stressed word-final rhotics in verbs in the semi-structured interviews according to following segment

The finite verb forms with word-final rhotics are far fewer in number (bottom bars in Figure 7.20) than infinitives, and the seemingly higher percentages of segments other than deletion are due to a single diverging token in each context. Speaker M5 produced *for* as [foə] before a consonant, F4 *tiver* as [tʃiˈvɚ] before a vowel, and M3 *quer* as [kɛɦ] before a pause.

A spectrogram example of a deleted rhotic in an infinitive verb can be seen in Figure 7.21. Here M4, the same speaker as in Figure 7.19, produces *ver* in the utterance *as formas que a gente tem de ver isso* ‘the ways we have of looking at it’. In this example, *ver* clearly has a verbal function, which means that the presence of a rhotic is much less likely. In careful pronunciation a tap-like segment would be needed word-finally before a vowel, but the analysis of this corpus has shown that deletion, as exemplified in Figure 7.21, is the norm in informal speech.

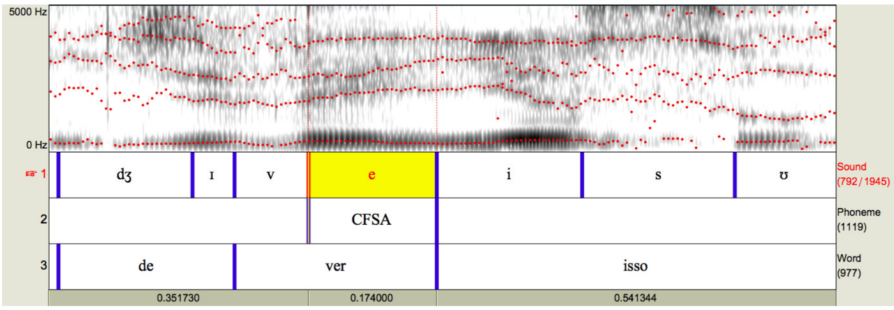


Figure 7.21: Word-final deletion in the word *ver* (verb) by speaker M4

The realisation of word-final rhotics in the preposition *por* can be observed in Table 7.8 and Figure 7.22. The first interesting aspect is that deletions are only found before consonants (36.4%). Approximants and schwar are among other frequent variants. Before vowels, *por* is a tap-like alveolar segment in 100% of tokens. Three tokens of *por* also occurred before pause: these are tokens in which the speaker has paused in order to collect his or her thoughts. One of these pre-pausal tokens has a retroflex approximant, and the other two, a schwar. Generally prepositions do not occur utterance-finally in Portuguese, which is why the number of pre-pausal tokens is so low. It is interesting to note that there are no back fricatives as variants of *por* apart from the few tokens of aspirated retroflex approximant or schwar.

The remaining contexts for word-final rhotics and their variants can be observed in Figure 7.23. *apesar* only occurs in the corpus as part of the prepositional phrase *apesar de* ‘in spite of’, which is why it is always

Context	+C		+V		+P	
Variant	N	%	N	%	N	%
ɾ	0	**0**	51	**57.3**	0	**0**
ɾ̞	0	**0**	38	**42.7**	0	**0**
ɹ	2	**3.6**	0	**0**	0	**0**
j	6	**10.9**	0	**0**	0	**0**
ɻ	8	**14.5**	0	**0**	1	**33.3**
ɚ	16	**29.1**	0	**0**	2	**66.7**
ɻ^{h}	2	**3.6**	0	**0**	0	**0**
ɚ^{h}	1	**1.8**	0	**0**	0	**0**
Ø	20	**36.4**	0	**0**	0	**0**
TOTAL	55	**100**	89	**100**	3	**100**

Table 7.8: Word-final coda variants in the preposition *por* in the semi-structured interviews

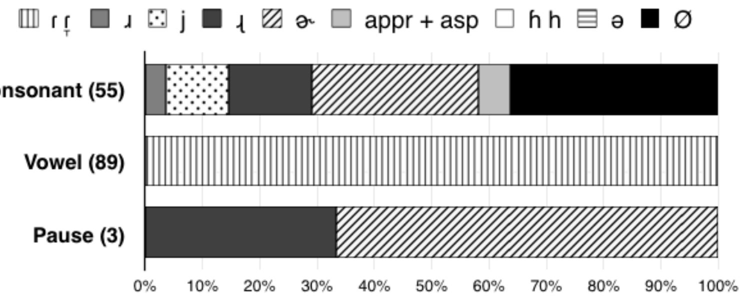


Figure 7.22: Word-final rhotics in the preposition *por* in the semi-structured interviews according to following segment

followed by a consonant—usually the initial segment of *de* is an affricate [dʒ]. Various approximants make for 60% of all tokens of *apesar*, voiced glottal fricatives 20%, and deletions 20%. The pronoun *qualquer* 'any(one)' can precede either a consonant or a vowel in the corpus, and in both cases the rhotic was mostly deleted. Before a consonant, there was one token of [ɚ], and before a vowel, one approximant tap [ɾ̞]. The remaining three words (*super-, caráter, açúcar*) are paroxytones, which means that the word-final rhotic is exceptionally unstressed. Very few tokens of these words were found in the corpus, and the rhotic was either a syllabic [ɚ] or deleted.

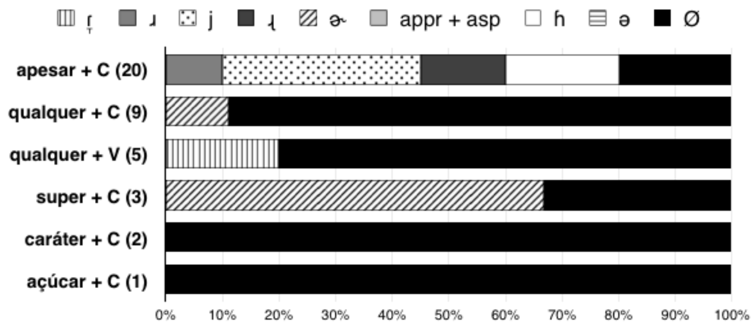


Figure 7.23: Word-final rhotics in *apesar*, *qualquer*, *super-*, *caráter* and *açúcar* in the semi-structured interviews according to following segment

It is clear that in codas, deletion seems to be more advanced word-finally than word-medially. The range of variants is almost identical, with the exception that uvular fricatives were not found word-finally, and there is also a significant increase in tap-like segments before vowels. The next sections discuss how lenition takes place on the idiolectal level, and what lexical and frequency effects may be causing varying lenition trajectories in nominals, verbs and *por*.

7.2.1.2 Individual speakers

The categories with most tokens in this corpus—nominals, infinitive verb forms, and the preposition *por*—and their realisation by the 14 speakers can be consulted in Appendix G. The first striking aspect is that all speakers only produce tap-like alveolar segments ([ɾ], [ɾ̞]) in *por* when followed by a vowel. The situation changes in nominals: only two speakers (F1 and M6) use tap-like segments in all nominals followed by a vowel. Four speakers (F2, F5, M3, and M7) use either tap-like segments or deletion in this context; F3 uses tap-like segments and back fricatives; F4 and M4 use tap-like segments and approximants; F6 uses approximants and deletion; and M2 and M5 use only approximants. F7 and M1 produced no tokens of nominals followed by a vowel. In verbs, deletion is predominant in any context; however, five speakers produced some tap-like segments (F2, F3, F5, M3, and M4). M6 is the only speaker to produce a differing segment: he has one token of a voiced glottal fricative in the verb *estar* 'to be' followed by a vowel. The other eight speakers delete all rhotics in infinitives before vowels.

In nominals and *por* before consonants, the speakers also used different strategies. In addition to deletion, most speakers used only approximants and/or schwar (F1, F2, F5, F6, F7, M2, M4, M5, M7). M3 used approximants and glottal fricatives, F4 and M1 approximants and aspirated approximants, and M6 only glottal fricatives. F3 is the only speaker to use all three strategies. Speakers M4 and M5 stand out due to the complete lack of deletion of word-final rhotics in nominals.

Compared to the data on word-medial codas, the speakers' word-final rhotic output is more limited but corresponds roughly to the variants each speaker used word-medially. Word-finally, F4 and M1 added aspiration to their approximants, while F5, F6 and F7 excluded aspiration and/or glottal fricatives. M6, on the other hand, produced no approximants whatsoever word-finally, even though he uses them word-medially. Speaker M4 is consistent in having no tokens of coda deletion in word-medial coda or in word-final coda in nominals. Again, there does not seem to be a direct correlation between coda variants and the origin of the speakers (see Section 7.1.1.2). The speakers who stand out from the others (who mostly use retroflex approximants and schwar in nominals) are F3, M3, and M6 due to an elevated percentage of glottal fricatives. F3 and M6 come from the Lavras region, and M3 from Divinópolis. Glottal fricatives are absent from the speech of three out of four participants from cities more to the southwest (F2, M1, and M5); however, F5 is also from this region but produced some tokens of word-final [ɦ h]. On the other hand, [ɦ h] were absent from the speech of several participants from the Lavras region, reinforcing the conclusion that distance from the isogloss does not seem to be relevant in determining possible coda variants.

The level of lenition in stressed word-final rhotics varies among speakers. Table 7.9 lists the levels of lenition in different contexts for each speaker. Presenting the data this way allows us to assess the level of lenition at the idiolectal level. R-coloured vowels [ɚ], coda schwa [ə], and deletion (Ø) were considered synchronically lenited forms in word-medial coda, and this criterion will be used for word-final coda as well. If any of these variants, alone or combined, make for at least 50% of all tokens in a given context, the variant(s) will appear in the table with the variant with a higher percentage first. Contexts of which there is only one token (that is lenited) for a speaker have been excluded from this list. The contexts appear listed in order of least to most overall deletion in the corpus (see Figures 7.18, 7.20, and 7.22).

	Nom+P	**Nom+V**	**Nom+C**	***por*+C**	**Inf+P**	**Inf+V**	**Inf+C**
F1					Ø	Ø	Ø
F2		Ø		Ø	Ø	Ø	Ø
F3	Ø			ɚ	Ø	Ø	Ø
F4	Ø		ɚ		Ø	Ø	Ø
F5		Ø			Ø	Ø	Ø
F6				Ø, ɚ	Ø	Ø	Ø
F7			Ø		Ø	Ø	Ø
M1				Ø, ɚ	Ø	Ø	Ø
M2					Ø	Ø	Ø
M3	Ø		Ø, ə		Ø	Ø	Ø
M4			ɚ	ɚ, Ø	Ø	Ø	Ø
M5				ɚ, Ø	Ø, ə	Ø	Ø, ə
M6			Ø		Ø	Ø	Ø
M7				Ø, ɚ	Ø	Ø	Ø

Table 7.9: Lenition of stressed word-final rhotics in nominals, infinitive verb forms and the preposition *por* by 14 speakers

Table 7.9 shows that for all speakers, infinitives are practically *r*-less in spontaneous speech, even before vowels. However, lenition has advanced in other contexts at a rather uneven pace for these speakers. In *por* followed by a consonant, we can see that half of the speakers pronounce this preposition mostly as [pu] ∼ [pu̥] ∼ [pʊ] ∼ [pə] or [pɚ]. In nominals followed by a consonant, five speakers use these lenition strategies in at least half of all tokens; before vowels, two speakers; and before pause, three speakers. Speakers F1 and M2 stand out due to the low level of lenition in contexts other than infinitive verb forms. The progress of lenition seems to skip stages within an individual speaker in this particular corpus; this may be due to the low token number of some contexts for some speakers. Nevertheless, it is an indication that the leniting sound change takes place on an idiolectal level in a non-deterministic pattern, as individual speakers can be seen to weaken word-final rhotics at different paces in different contexts. In CAS terms, the word-final leniting change is self-organizing, with infinitive verb forms and pre-consonantal context most likely acting as *attractors* for this change.

The differences in lenition rate may be dependent on other factors in addition to the following segment or speaker-related articulatory patterns. The next section will examine the effects of the lexical items in which final coda rhotics occur and of alternating environments and their frequency.

7.2.1.3 Lexical item and frequency effects

Why are the types of rhotics and the levels of deletion so different between nominals, verbs, and *por*? Word-final coda variation can be analysed in terms of **alternating environments** (Bybee 2000; Bybee 2001, p. 143; Bybee 2002). This term has been adopted from Timberlake (1978), and it is used for observing sound change at word boundaries or morphological boundaries. Such is the case of, for instance, French *liaison* and the weakening of coda sibilants in Spanish: these, too, are sound changes affected by the adjacent phonological context that varies depending on the consonant, vowel, and possibly lexical item that follows. Bybee (2000; 2001; 2002) explains that if a sound change begins in word-medial coda, it can spread to word-final coda, but the rate at which it takes place in this last context can be slowed down by the alternating environment: that is, unlike word-medial coda, word-final coda is not always pre-consonantal.

We can begin to consider frequency effects by having a look at the overall frequency of word-final rhotics being followed by either consonants, vowels, or a pause. Table 7.10 lists the token frequencies of these contexts in the CETENFolha corpus (Pinheiro & Aluísio 2003) and their token count in the semi-structured interviews (see Tables 7.6, 7.7, 7.8, and Figure 7.23), along with the number and percentage of deletions found for these contexts in the interview corpus. A CETENFolha search of word-final rhotics followed by all possible word-initial orthographic vowels and consonants renders the token numbers in the second column of Table 7.10. In addition, this table includes a Fisher p-value for the consonant/vowel distributions in the two corpora, as well as a likelihood ratio p-value for the correlation between the token numbers of each context in the interview corpus and the percentage of deletions in each context.

Following segment	**CETENFolha**	**Interview corpus (1,821 tokens)**	**Deletions (% of tokens)**
Consonant	624,725	916	772 (84%)
Vowel	451,234	581	446 (77%)
Pause	n/a	324	258 (80%)
p-value (Fisher) for consonant/vowel distribution between corpora: 0.0148			
p-value (likelihood ratio) for deletion		0.004284	

Table 7.10: Distribution of alternating environments for word-final rhotics in the CETENFolha corpus and the interview corpus

Pre-consonantal contexts are more frequent than pre-vocalic contexts in both corpora, but the Fisher p-value indicates that there is a slight distribution difference between the data sets. Indeed, CETENFolha includes 1.38 pre-consonantal contexts for every pre-vocalic context, while the same ratio in the interview corpus is 1.58. Since a pre-pausal search based on punctuation in a text corpus such as CETENFolha is not exactly suitable for analysing correlation to a speech corpus, a likelihood ratio p-value for the CETENFolha frequencies is not viable. However, when logistic regression is performed with the token counts of the interview corpus itself (third column in Table 7.10), the p-value is below 0.05. In other words, the increasing token count of an alternating environment implies increasing deletion in word-final *r*-contexts.

The fact that word-final rhotics are most often followed by consonants in Brazilian Portuguese means that most often word-final rhotics appear in an environment similar to that of word-medial codas. It is indeed this environment that has the highest overall percentage of deletions in the interview corpus (84%). However, as we have seen, the lenition rates in nominals, verbs, and *por* are quite different. The remainder of this section will consider the factors causing lenition in these categories.

Nominals

In word-medial coda, rhotics were found to involve more lenition in the high-frequency conjunction *porque*, and [ɚ] was more common when the nucleus consisted of a front vowel. Word-final coda brings an additional level of complexity to the analysis of frequency and coarticulatory effects because of the diverging tendencies in nominals and verbs. Table 7.11 takes a closer look at stressed word-final VR rhymes by listing their token and type frequencies in the ASPA database. Clearly, eR, aR and oR are the most frequent stressed word-final VR rhymes, while iR, ɛR, ɔR and uR are far less frequent. However, when we look at how many words the pattern applies to in nominals and in verbs, we see that the tendencies are opposite. oR is by far the most productive VR ending in nominals, while aR applies to more than 3,000 verb forms. This indicates that *-ar* is the most productive infinitive, and therefore responsible for a significant part of the overall aR tokens in the database. On the other hand, oR tokens correspond mostly to nominals. Unfortunately, ASPA does not allow searches that separate token frequencies for grammatical classes, so the exact token frequencies for each word class cannot be analysed.

VR rhyme	**ASPA token freq (all word types)**	**ASPA type freq (nominals)**	**ASPA type freq (verbs)**	**ASPA type freq (others)**
iR	861,373	175	354	0
eR	1,906,065	25	335	1
ɛR	339,008	32	29	1
aR	3,756,613	458	3,346	3
ɔR	376,176	20	0	1
oR	1,544,981	1,402	46	0
uR	16,260	44	0	0

Table 7.11: Token and type frequency of stressed word-final VR rhymes in nominals and verbs

The nominals category, with 210 tokens, consists of words with low token numbers in the corpus; the ten most frequent words are *lugar* ‘place’ (35 tokens), *melhor* ‘better; best’ (29), *maior* ‘larger; largest’ (22), *poder* ‘power’ (12), *interior* ‘interior; countryside’ (11), *calor* ‘heat’ (9), *exterior* ‘exterior; abroad’ (8), *menor* ‘smaller; smallest’ (8), *professor* ‘teacher (masc.)’ (8), and *mulher* ‘woman’ (7). No nominals ending in [i]R were found in the interview data, and only one token of [u]R occurred in the word *tour*. The low token count of these lexical items does not allow an analysis of lexical frequency effects.

It seems that the uneven distribution of *r*-variants and high level of tap-retention (see Table 7.6) compared to word-internal coda is caused by an alternating environment. Word-finally, rhotics are most often followed by consonants not only in a larger corpus (see Table 7.10) but also in the interview corpus of this study, and it is in this context that lenition through approximantisation and deletion is most advanced in nominals. However, tap-like segments are still used in 53.5% of prevocalic tokens, which means that the leniting sound change is slowed down by the alternating environment, as predicted by Bybee (2002).

Figures 7.24, 7.25 and 7.26 offer a qualitative look at stressed word-final VR rhymes in nominals according to following segment. Deletion before consonants (Figure 7.24) is most advanced in oR and ɔR (35% and 46%, respectively). In pre-vocalic context (Figure 7.25) there is variation in the aR, ɔR and oR categories: in addition to tap-like segments, we find retroflex approximants, schwar, and glottal fricatives. This does not happen in ɛR, where we only find tap-like segments and deletion prevocalically. Pre-pausally (Figure 7.26) there are no tap-like segments, but otherwise the selection of variants in this position consists of approximants, back fricatives and deletion much in the same manner as in pre-consonantal position. It seems, then, that the historical lenition process is most advanced in nominals ending in aR, ɔR and oR. Word-final aR and oR rhymes are the most productive in nominals (see Table 7.11), while the ɔR nominals consists mostly of few high-frequency words (such as *melhor*, *maior*, *menor*, and *pior* 'worse; worst'). As the token counts for word-final rhotics in nominals are limited, the effects of token or type frequency cannot be analysed further. At any rate, the sound change from full-closure taps to approximants and fricatives word-finally in nominals was first favoured by the pre-consonantal context, and now it is spreading to pre-vocalic context.

The number of syllables in the nominal may have an effect on *r*-articulation: according to Huback (2006), *r*-deletion is less frequent in monosyllabic nominals than in polysyllabic nominals in the Portuguese spoken in Belo Horizonte. Figures 7.27, 7.28, and 7.29 relate the syllable count of nominals to the rhotic variants observed before consonants, vowels, and pause. Unfortunately, the token number for the different contexts is quite disproportionate in the interview data, which is why the percentages are not directly comparable. Especially one-syllable nominals

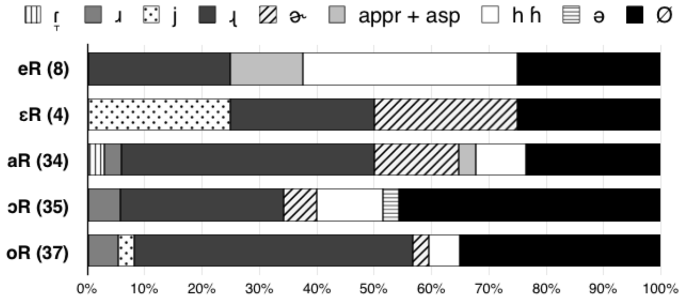


Figure 7.24: Word-final rhotics in nominals followed by consonants in the semi-structured interviews

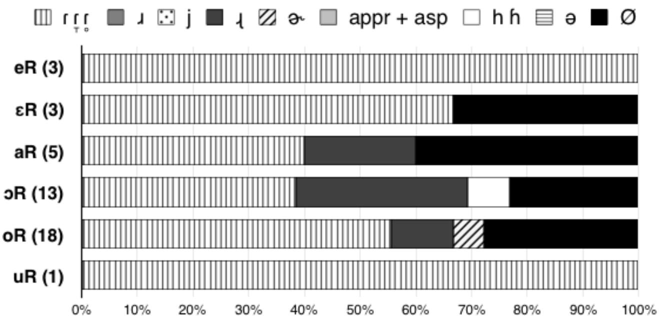


Figure 7.25: Word-final rhotics in nominals followed by vowels in the semi-structured interviews

are difficult to examine since there were only six tokens in total.

One qualitative observation can be made based on these charts: the word-final rhotic in one-syllable nominals was not deleted in any of the three possible contexts. Before a consonant, M3 produced *ar* as [aɻ]; F3 produced *tour* as [tuɾ] before a vowel; and before pause M3 produced *ar* as [aɻ], M5 *ver* twice as [veɻ], and M4 *mar* as [mɚ]. Before vowels (Figure 7.28), the proportion of tap-like segments decreases and the proportion of deletions increases as the syllable count also increases. This could be an indication of the relevance of syllable count for the realisation of word-final rhotics. However, the likelihood ratio *p*-value obtained by logistic regres-

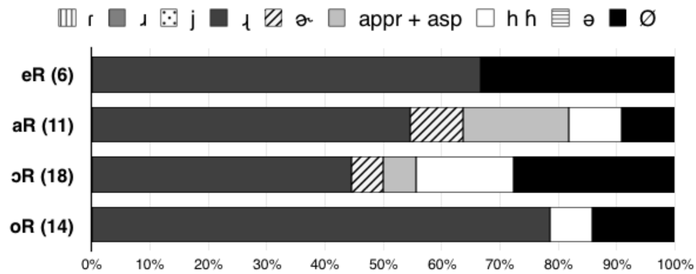


Figure 7.26: Word-final rhotics in nominals followed by pause in the semi-structured interviews

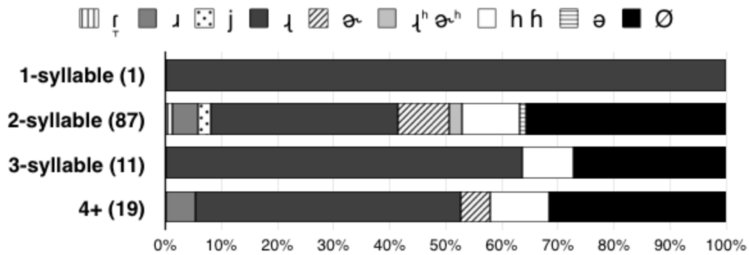


Figure 7.27: Syllable count in nominals before consonants

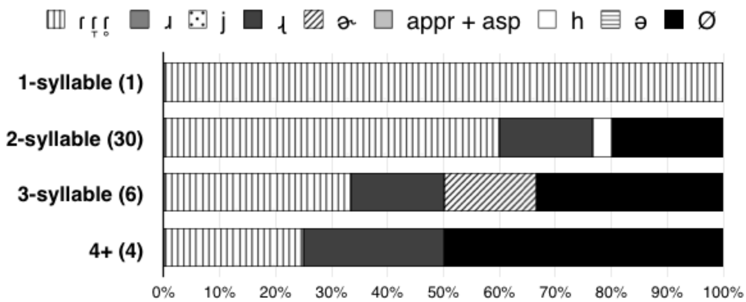


Figure 7.28: Syllable count in nominals before vowels

sion on syllable count does not point to a statistically significant correlation in the data obtained for this study (see Table 7.12). Therefore the quali-

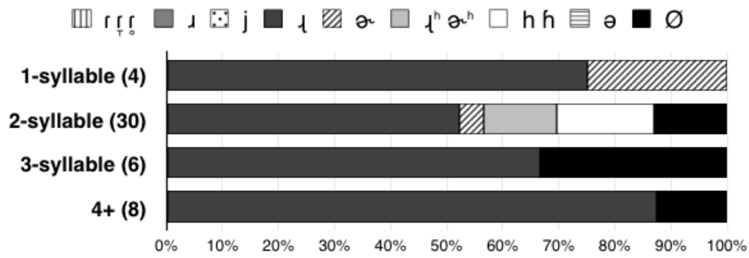


Figure 7.29: Syllable count in nominals before pause

tative tendencies observed in Figures 7.27–7.29, tentatively confirming the findings by Huback (2006), cannot be verified quantitatively.

Syllable count	**Tokens**	**ɚ**	**ə**	**Ø**
1	6	1 (16.7%)	0	0
2	147	9 (6%)	1 (0.7%)	40 (27.2%)
3	23	1 (4.3%)	0	7 (30.4%)
4	30	1 (3.3%)	0	8 (26.7%)
5	1	0	0	1 (100%)
Syllable count and Ø: Logistic regression $p = 0.3897$				
Syllable count and lenition total: Logistic regression $p = 0.8024$				

Table 7.12: Syllable count in nominals containing stressed word-final *r*

Infinitive verb forms

In verb forms, Table 7.7 and Figure 7.20 have already shown that the final rhotic is mostly deleted; that is, the presence of a rhotic is exceptional in a lexical item with a verbal function. This is why a comparison of realisations in different lexical items, VR rhymes (*-ir*, *-er* and *-ar* for infinitives) or verbs of different syllable counts will not shed light on why rhotics sometimes occur in verb forms. The verbs that had a tap-like segment before a vowel were *expor* 'to expose', *dizer* 'to say', *fazer* 'to do', *ser* 'to be' (3 tokens), *amenizar* 'to soften; to ease', *desvencilhar* 'to shake off', *trazer* 'to bring', and *ter* 'to have' (2 tokens). In addition, M6 produced one token of *estar* 'to be' with [ɦ] pre-vocalically. This does not mean that these were the only tokens of these verbs: dozens of other infinitive tokens—especially of the high-frequency verbs *ser*, *ter*, *fazer*, and *estar*—were produced without a rhotic in any of the possible environments. This is to say that *r*-retention in verbs is not lexically motivated.

Much like nominals, verb forms were also mostly followed by a consonant (682 tokens, or 50%), then by vowels (429 tokens, 31%), and then by a pause (265 tokens, 19%). This would imply that just like in the case of nominals, pre-consonantal context is leading the leniting (i.e. deleting) change due to the coarticulatory pressure of a following consonant, but also due to its higher rate of occurrence. 98% of rhotics were deleted pre-consonantally, 97% pre-vocalically, and 91% pre-pausally (in addition to voiceless glottal fricatives totaling 6% of pre-pausal tokens.) This leaves us with the interesting question of why deletion is more advanced in verbs than in nominals if they are more or less similar in their phonological structure and followed by consonants, vowels, and pauses more or less in the same proportion.

According to Bybee (2000, p. 257; 2001, p. 138–143), the fact that a phonological phenomenon occurs in an alternating environment causes the words with this particular phenomenon to have a range of variation. That is, in terms of Exemplar Models, each word has numerous mental representations based on the phonetic forms that occur in speech, and the strength of those representations is affected by the frequency at which they occur in the language. The variants of a word form a cluster, and more frequent variants may shift the center of this cluster and replace more marginal variants. In other words, for the speakers in this corpus, a verb such as *cantar* 'to sing' may have several representations, including but not limited to [kɐ̃ˈtaɾ] ∼ [kɐ̃ˈtaɻ] ∼ [kɐ̃ˈtaj] ∼ [kɐ̃ˈtɚ] ∼ [kɐ̃ˈtah] ∼ [kɐ̃ˈta]. Of these, [kɐ̃ˈta] has by far the strongest mental representation because infinitive verb forms most often have their rhotics deleted. Consequently, [kɐ̃ˈta] has almost completely replaced other variants such as [kɐ̃ˈtaɾ].

Why has [kɐ̃ˈta] taken over [kɐ̃ˈtaɾ] in verbs almost completely, but tokens such as [luˈga] for *lugar* 'place' have not taken over tokens such as [luˈgaɾ] with tap-like segments before vowels (25.6% and 53.5% respectively in Table 7.6)? The answer may lie in the frequency of use of nominal and verbal morphology. Nominals ending in rhotics still form plurals by [is]∼[ɪs]: for instance, a word such as *lugar* may have several variants in singular ([luˈgaɻ] ∼ [luˈgɚ] ∼ [luˈgah] ∼ [luˈga], etc.) but its plural is still formed with the [luˈgaɾ] variant ([luˈgaɾɪs]). This means that variants with a tap-like segment form a considerable part of the representation of most nominals.

Of course, the verbal morphology of Portuguese also requires the tap variants. For instance, the 3P preterite as well as future and conditional tenses of a verb such as *cantar* ([kɐ̃ˈtaɻ] ∼ [kɐ̃ˈtaj] ∼ [kɐ̃ˈtɚ] ∼ [kɐ̃ˈtah] ∼ [kɐ̃ˈta], etc.) are all formed with the [kɐ̃ˈtaɾ] variant: *cantaram* [kɐ̃ˈtaɾɐ̃w̃] 'they sang', *cantarei* [kɐ̃taˈɾej] 'I will sing', *cantará* [kɐ̃taˈɾa] '(s)he/it will sing', *cantaria* [kɐ̃taˈɾiɐ] 'I/(s)he/it would sing', and so on. However, the synthetic future and conditional forms that contain a [ɾ]-initial stressed syllable are becoming increasingly uncommon in spoken BP, and are being replaced by analytic constructions. The future tense is most often expressed with the construction *ir*(PRES) 'to go' + INF, meaning literally 'to go do' something. This means that the meanings conveyed by *cantarei* and *cantará* will most often be expressed with *vou cantar* 'I am going to sing' and *vai cantar* '(s)he/it is going to sing'. Similarly, the synthetic conditional tense is being replaced by *ir*(IMPERF) + INF: *cantaria* will most likely be expressed with the construction *ia cantar* (lit. 'I/(s)he/it went to sing') in spoken informal BP. As for the preterite *cantaram* [kɐ̃ˈtaɾɐ̃w̃], it differs from the future and conditional tenses in containing a tap-like segment in a post-tonic syllable. It is worth noting that this structure is also undergoing reduction from diphthong to monophthong ([ɾɐ̃w̃]∼[ɾũ]∼[ɾu]), and this reduction is bringing it closer to nominals ending in *-ro* ([ɾu]∼[ɾʊ]) which seem to be undergoing a devoicing lenition in the studied dialect (see Section 6.1.3).

Therefore the decreasing frequency with which the verb variants containing tap-like final segments are being used in speech may be contributing to the generalised tendency to deletion of word-final rhotics in verbs. As the tap variants of verbs decrease in frequency, and as consonants follow verbs more often than vowels in BP, whichever change taking place before consonants gains more ground to work on. In nominals, the pluralisation by [is]∼[ɪs] is still productive (although the deletion of plural markers is common; see Section 8.2 for further discussion), which means that nominal variants with tap-like final segments have a stronger representation than in verbs. In addition to this, there is the simple fact that verbs ending in a rhotic are more frequent (1,424 tokens in this corpus; 4,208,080 in the CETENFolha corpus) than nominals ending in a rhotic (210 in this corpus; 423,359 nouns and adjectives in the CETENFolha corpus). Therefore any change affecting word-final rhotics and the morphophonological representations of the words in which they occur has more ground to work on verb forms than on nominals.

The preposition *por*

We are left with the curious case of the preposition *por* (see Table 7.8 and Figure 7.22), which was produced with approximants, r-coloured vowels and deletion before consonants and pause, but with a tap-like segment in 100% of pre-vocalic tokens. Inflectional morphology surely cannot protect word-final rhotics in a preposition, so why are there no cases of deletion (or even approximantisation) before vowels—*por* has, after all, a word-final context for rhotics in an alternating environment just like nominals and verbs?

The answer may lie in **chunking**, or the merging of words into a single phonological unit. When words occur frequently together, they begin to behave as one processing unit that can consequently behave phonologically as one word. Bybee (2000, p. 258) explains that this is the reason why word-final sibilants may occur as [s] pre-vocalically in some dialects of Spanish although they have mostly been weakened to [h] or deleted both word-medially and word-finally: as the author puts it, the [s] is "in a sense word-internal in these cases", and therefore not subject to the same alternating environment as other word-final [s] tokens. Similarly, *por* forms high-frequency chunks with certain words, and many of these words begin with a vowel. Table 7.13 lists the ten most frequent words that follow *por* in the CETENFolha corpus. The masculine indefinite article *um* accounts for 8.3% of all tokens, followed by *exemplo* with 5.9%. After these frequent words with an initial vowel, the percentage of different words following *por* decreases rapidly.

In other words, in a large text corpus such as the CETENFolha, the two most frequent words following *por* begin with a vowel and make for 14.2% of all tokens, demonstrating that this preposition occurs often before vowels (unlike nouns and verbs with word-final rhotics). In the semi-structured interviews, pre-vocalic context was also more frequent: of the total 147

	Word	Translation	Tokens	% of total tokens
1.	*um*	'for/by a/one (masc.)'	12,562	8.3%
2.	*exemplo*	'for example'	8,802	5.9%
3.	*seu*	'for/by his/her (masc.)'	4,419	2.9%
4.	*causa*	'because of'	3,779	2.5%
5.	*isso*	'because of that'	2,583	1.7%
6.	*que*	'for what/which'	2,191	1.5%
7.	*dia*	'per day'	1,831	1.2%
8.	*ter*	'for having'	1,630	1.1%
9.	*outro*	'for/by another'	1,586	1.1%
10.	*ano*	'per year'	1,502	1.0%

Table 7.13: The 10 most frequent words following *por* in the CETENFolha corpus and their percentage of the total 150,455 tokens

tokens of *por*, 55 were pre-consonantal (37%), 89 pre-vocalic (61%), and 3 pre-pausal (2%).

Table 7.14 lists the words that follow *por* in pre-vocalic context in the semi-structured interviews. The selection of words is quite different from that of Table 7.13: the expression *por exemplo* is responsible for 50.5% of all pre-vocalic tokens of *por*. Most of the chunks that occurred in the interview corpus consist of *por* followed by an indefinite article (*um*, *uma*), personal pronoun (*elas*), demonstrative pronoun (*esse*, *esses*, *isso*, *aqueles*), or adverb (*aqui*, *aí*, *enquanto*). The distribution of alveolar taps [ɾ] and approximant alveolar taps [ɾ̞] does not seem to be linked with the token count of the chunk: that is, the tap is not more lenited in more frequent chunks of the interview corpus. This is another indication that intervocalic [ɾ]∼[ɾ̞] variation is related to individual patterns in the completion of the articulatory gesture (as discussed in Section 6.1.2).

It is likely that the frequent occurrence, or chunking, of *por* in fixed expressions (such as *por exemplo*) and followed by high-frequency grammatical morphemes has left the word-final rhotic intervocalic, which is why its phonetic output is much more similar to that of intervocalic weak-r (see Table 6.1 and Figure 6.1) than other word-final contexts. When *por* occurs before consonants, its phonological behaviour follows the same pathways of approximantisation and deletion as any pre-consonantal coda context.

Word	Translation	Tokens	[ɾ]	[ɾ̞]
exemplo	'for example'	45	31 (69%)	14 (31%)
isso	'because of that'	11	4 (36%)	7 (64%)
um	'for/by a/one (masc.)'	7	3 (43%)	4 (53%)
aí	'around there; around that'	6	3 (50%)	3 (50%)
enquanto	'for now'	4	3 (75%)	1 (25%)
esse	'for/by that'	4	2 (50%)	2 (50%)
aqui	'around here'	4	0	4 (100%)
ir	'for the sake of going'	2	1 (50%)	1 (50%)
abuso	'for abusing'	1	1 (100%)	0
esses	'for/by those'	1	1 (100%)	0
elas	'for/by them (fem.)'	1	1 (100%)	0
aqueles	'for/by them'	1	0	1 (100%)
e-mail	'by e-mail'	1	1 (100%)	0
uma	'for/by a/one (fem.)'	1	0	1 (100%)

Table 7.14: Words following pre-vocalic *por* in the semi-structured interviews and the distribution of rhotic variants

This section on lexical and frequency effects on word-final rhotics has demonstrated that all coda contexts do not undergo lenition in the same way. The word-final rhotics of nominals, verbs and *por* are influenced by the following segment in different ways. Verbs and the pre-consonantal context are acting as attractors, pulling nominals and pre-pausal as well as pre-vocalic contexts into the leniting change. Lenition does not affect all coda contexts equally, but the general path of lenition through approximantisation and debuccalisation can already be attested in all contexts except for pre-vocalic *por*. The next section provides details on word-final lenition in the task data on a general and idiolectal level.

7.2.2 Sentence completion task

7.2.2.1 Overview

The sentence completion task yielded 529 tokens of word-final rhotic contexts. The task covered word-final rhotics in nouns (*mar* 'sea', *dor* 'pain', *mulher* 'woman', *computador* 'computer', *açúcar* 'sugar'), two comparative/superlative adjectives (*maior* 'larger; largest', *melhor* 'better; best'), infinitive verb forms (*dar* 'to give', *ser* 'to be', *ir* 'to go', *falar* 'to speak', *fazer* 'to do', *sair* 'to leave; to go out'), and the preposition *por*. The nouns include two one-syllable and three polysyllable words; of these, *açúcar* is paroxytone while all others are oxytones. The infinitive verb forms include three monosyllabic and three two-syllable verbs, and in both cases they represent the three different conjugations (*-ar*, *-er*, *-ir*). In the following, the *r*-variants in these words will be discussed before consonants, vowels and pause.

Word-final rhotic variants in pre-consonantal position can be observed in Table 7.15 and Figure 7.30. In comparison with the interview corpus, the levels of deletion are much lower. In spontaneous speech, deletion is at 33.9% in nominals, 98.3% in infinitive verb forms, and 36.4% in *por*; in the sentence task, deletion in oxytone nominals is at 10.2%, in verbs at 29.5%, and the rhotic in *por* is deleted in 23.1% of tokens. Therefore, as can be seen in Figure 7.30, nominals and verbs appear similar in the speakers' task output, whereas in the interview data verbs are practically *r*-less. *R*-fulness in verbs can therefore be considered monitored speech in the studied dialect. There are some tokens of pre-consonantal tap-like segments in nominals and verbs, which were almost nonexistent in the interview data (one token of [ɾ̞] in 188 pre-consonantal nominal tokens). This may be the consequence of monitored speech during the task.

Before vowels, Table 7.16 and Figure 7.31 show that tap preservation is at an extremely high level compared to the interview data. Deletions are to be found only in *açúcar*, *dar*, *falar* and *sair*, and they are at most 17%. Speech monitoring affects therefore even verbs in pre-vocalic position. However, some tokens of approximants and r-coloured vowels can be found in this context, which means that the historical lenition process from taps to approximants can manifest itself even in a task situation.

The rhotic variants in pre-pausal contexts in the sentence completion task can be observed in Table 7.17 and Figure 7.32. Again, there is much less deletion than in the interview data, but almost all individual words show some deletion (except for the monosyllables *mar* and *dor*). In general, verbs have higher deletion percentages than nouns; nevertheless the level of *r*-retention is much higher in the task than pre-pausally in the interview data. Yet another difference in relation to the interview data

Context	**Nominals (S)**		**Nominals (U)**		**Verbs**		*por*	
Variant	N	%	N	%	N	%	N	%
ɾ	2	**2.3**			2	**2.3**		
ɾ̥			2	**14.3**				
ɹ	7	**8**			11	**12.5**	2	**15.4**
j	5	**5.7**						
ɻ	38	**43.2**			26	**29.5**		
ɚ	12	**13.6**	6	**42.9**	6	**6.8**	4	**30.8**
ɹʰ	2	**2.3**						
ɻʰ	1	**1.1**			1	**1.1**		
ɚʰ	1	**1.1**					1	**7.7**
χ							1	7.7
h	5	**5.7**	1	**7.1**	5	**5.7**	2	**15.4**
ɦ	6	**6.8**			11	**12.5**		
Ø	9	**10.2**	5	**35.7**	26	**29.5**	3	**23.1**
TOTAL	88	**100**	14	**100**	88	**100**	13	**100**

Table 7.15: Word-final rhotics before consonants in the sentence completion task. S = stressed, U = unstressed.

Context	**Nominals (S)**		**Nominals (U)**		**Verbs**		*por*	
Variant	N	%	N	%	N	%	N	%
ɾ	31	**45.6**	4	**30.8**	38	**50**	10	**71.4**
ɾ̥	32	**47.1**	6	**46.2**	26	**34.2**	3	**21.4**
ɹ					1	**1.3**		
ɻ	5	**7.4**			5	**6.6**		
ɚ			1	**7.7**				
ɻʰ							1	**7.1**
ɦ					1	**1.3**		
Ø			2	**15.4**	5	**6.6**		
TOTAL	68	**100**	13	**100**	76	**100**	14	**100**

Table 7.16: Word-final rhotics before vowels in the sentence completion task. S = stressed, U = unstressed.

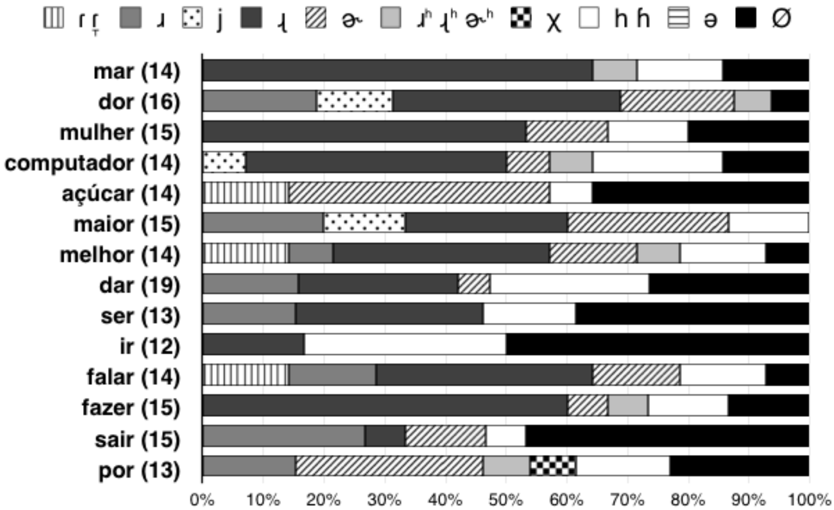


Figure 7.30: Word-final rhotics in lexical items before consonants in the sentence completion task

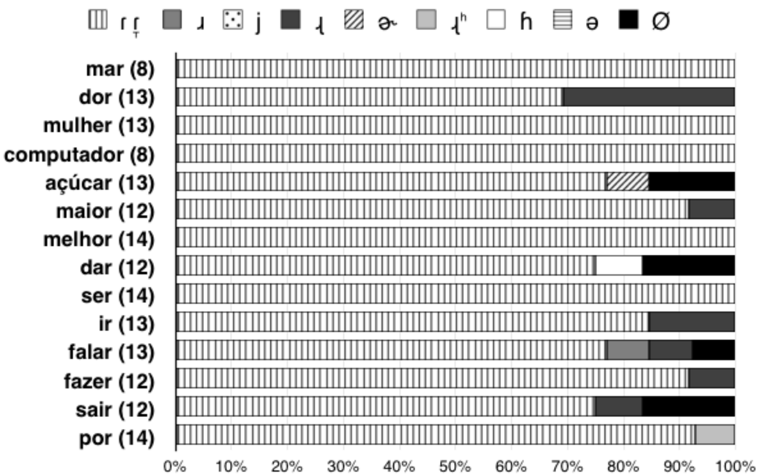


Figure 7.31: Word-final rhotics in lexical items before vowels in the sentence completion task

is the use of voiceless uvular fricatives [χ] word-finally: this variant did not occur in connected speech, but in the task setting, it was used before consonants and pause.

Context	**Nominals (S)**		**Nominals (U)**		**Verbs**	
Variant	N	%	N	%	N	%
ɾ					1	**1.2**
ɹ	3	**5.1**			5	**6.2**
ɻ	27	**45.8**			29	**35.8**
ɚ	6	**10.2**	7	**46.7**	5	**6.2**
ɹʰ	1	**1.7**			2	**2.5**
ɻʰ	8	**13.6**			8	**9.9**
ɚʰ					1	**1.2**
χ	3	**5.1**	1	**6.7**		
h	6	**10.2**			12	**14.8**
ɦ	1	**1.7**			3	**3.7**
Ø	4	**6.8**	7	**46.7**	15	**18.5**
TOTAL	59	**100**	15	**100**	81	**100**

Table 7.17: Word-final rhotics before pause in the sentence completion task. S = stressed, U = unstressed.

The number of syllables in a noun or verb does not seem to correlate with levels of deletion in the task data. Table 7.18 lists the occurrence of [ɚ] and deletion in monosyllabic and polysyllabic nominals and infinitives in the task data, and provides Fisher p-values for differences in the distribution of these lenited variants (no tokens of [ə] occurred in the task data). The amount of deletion or deletion paired with [ɚ] is not statistically different between monosyllabic and polysyllabic words of the same grammatical class, confirming the result obtained in the interview data (see Table 7.12).

7.2.2.2 Individual speakers

Table 7.5 already established that the recorded speakers alter their articulatory patterns in word-medial coda in a task setting compared to the interview setting. The following tables carry out a similar comparison re-

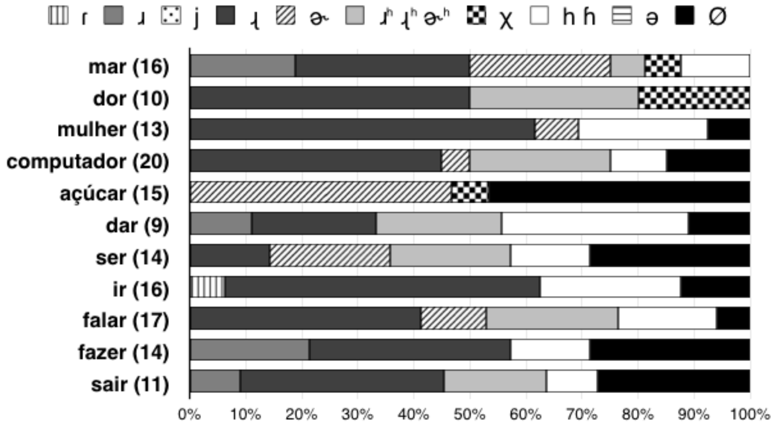


Figure 7.32: Word-final rhotics in lexical items before pause in the sentence completion task

Syllable count (nominals)	**Tokens**	**ɚ**	**Ø**
1	77	7 (9.1%)	3 (3.9%)
2+	138	11 (8%)	10 (7.2%)
Difference in Ø: Fisher $p = 0.3867$			
Difference in lenition total: Fisher $p = 0.6917$			
Syllable count (infinitives)	**Tokens**	**ɚ**	**Ø**
1	122	4 (3.3%)	25 (20.5%)
2	123	7 (5.7%)	21 (17.1%)
Difference in Ø: Fisher $p = 0.5168$			
Difference in lenition total: Fisher $p = 0.8807$			

Table 7.18: Syllable count and lenition in the sentence completion task

garding all stressed word-final rhotics before consonants and pause (Table 7.19) and vowels (Table 7.20). These tables exclude five tokens of coda [ə] that occurred in the interview data, and the *açúcar* tokens from the sentence task since it is a paroxytone word.

It has already been established that the overall deletion rate in any grammatical category, lexical item or alternating environment is lower in the task data than in the interview data. Similarly, compared to the *r*-

realisations in nominals and verbs before vowels in the interview data, there is a significant dominance of tap-like segments pre-vocalically in the task data. Therefore, even if a speaker deleted rhotics in both data sets, the deletion rate was much lower in the task data; and if a speaker used taps in both data sets, their proportion of all tokens is much higher in the task data.

Before consonants and pause (Table 7.19), the speakers who used the same rhotic variants in the interview and task setting are F2, F5, F6, M4, M5, and M7. Five other speakers can be considered to have shifted their articulation towards more prestigious and/or less lenited variants in the task. F3 produced only aspirated approximants and back fricatives in the task, but had no tokens of approximants or deletions like in the interview data. F4 produced back fricatives instead of aspirated approximants in the task. M1 and M2 had the exact same variants and changes between the two corpora: they had tokens of deletions, aspirated approximants and approximants in the interview data, but no deletions in the sentence data, as well as some rare tokens of tap-like segments. Similarly, M3 also added coda taps and aspirated approximants to his inventory in the task, and no longer produced back fricatives or deletions like in the interview.

The remaining two speakers cannot be said to have shifted their articulation in the same way: F1 produced some back fricatives in the interview alongside approximants and deletions, but in the task data, this speaker had aspirated approximants but no tokens of fricatives. M6 had quite a minimalistic set of variants in the interview, consisting of only back fricatives and deletions, but in addition to these he produced approximants and aspirated approximants in the sentence completion task.

Thus there is a tendency to monitor the output of final coda rhotics also on an individual level as speakers can be found to eliminate deletion as a strategy and add aspiration, back fricatives, and even taps to their pre-consonantal and pre-pausal articulation of rhotics. As non-pre-vocalic coda taps are highly uncharacteristic for these speakers in the interview corpus, their occurrence in a task setting in the speech of three individuals indicates that the speakers are most likely aware of the prestige of this variant in some other varieties of BP, and of the fact that in monitored speech, it still is the main variant in pre-vocalic context.

A comparison of individual speakers' word-final variants in pre-vocalic

Speaker	Corpus	Tap	Appr. & schwar	Appr.+asp.	Back fricative	Deletion
F1	I		X		X	X
	S		X	X		X
F2	I		X			X
	S		X			X
F3	I		X	X	X	X
	S			X	X	
F4	I		X	X		X
	S		X		X	X
F5	I		X		X	X
	S		X		X	X
F6	I		X			X
	S		X			X
F7	I		X		X	X
	S		X	X	X	X
M1	I		X	X		X
	S	X	X	X		
M2	I		X	X		X
	S	X	X	X		
M3	I		X		X	X
	S	X	X	X		
M4	I		X			X
	S		X			X
M5	I		X			X
	S		X			X
M6	I				X	X
	S		X	X	X	X
M7	I		X	X	X	X
	S		X	X	X	X

Table 7.19: Word-final coda variants before consonants and pause by speaker in the semi-structured interviews (I) and sentence completion task (S)

context can be seen in Table 7.20. Most female speakers (F1-5, F7) and M5 reduced their output to only tap-like segments in the task setting. F6, M1 and M3 produced taps in both settings but deletions only in the interviews and approximants only in the task. The remaining four speakers (M2, M4, M6 and M7) all have differing coda strategies: while M2 and M4 reduced their inventory of variants in the task, M6 and M7 added new variants (including approximants and aspirated approximants, which are less desirable variants than those they used in the interviews).

Speaker	Corpus	Tap	Appr. & schwar	Appr.+asp.	Back fricative	Deletion
F1	I	X				X
	S	X				
F2	I	X				X
	S	X				
F3	I	X			X	X
	S	X				
F4	I	X	X			X
	S	X				
F5	I	X				X
	S	X				
F6	I	X				X
	S	X	X			
F7	I	X				X
	S	X				
M1	I	X				X
	S	X	X			
M2	I	X	X			X
	S	X	X			
M3	I	X				X
	S	X	X			
M4	I	X	X			X
	S	X				X
M5	I	X	X			X
	S	X				
M6	I	X			X	X
	S	X	X			X
M7	I	X				X
	S	X	X	X	X	

Table 7.20: Word-final coda variants before vowels by speaker in the semi-structured interviews (I) and sentence completion task (S)

The tendency to a more reduced set of coda variants in a task setting is thus also present in pre-vocalic context. However, it does not manifest itself evenly: female speakers were in general more conservative in their pre-vocalic task variants than the male speakers, who also had tokens of approximants and other unconventional variants for this context. This finding points to the importance of sociophonetic methodology: a pool of both female and male speakers, in the sociolinguistic tradition, makes it possible to observe gender-related differences in speech patterns.

7.3 Observations on coda rhotics

This chapter has focused on coda rhotics through the observation of the overall distribution of variants, the differences in the use of these variants by the speakers, and the various factors that may influence the sound change that is taking place in coda rhotics. The rhotic variants range from alveolar taps and approximant taps to various approximants of different tongue configurations, uvular and glottal fricatives, and deletion (following which the nucleus vowel may remain intact or be centralised). The articulatory gesture(s) responsible for the lowering of the third formant in retroflex approximants may overlap the configuration of the preceding vowel, resulting in a syllabic schwar-like vowel. Another alternative is for the diphthong-like VR to lose rhoticity and become a centralizing V[ə] diphthong.

Most of the recorded speakers come from towns close to a nationwide isogloss regarding coda rhotics (see Figure 4.2): to the east, they are mostly uvular and glottal fricatives, and to the west, approximants. This means that the speakers most likely have had contact with both articulatory patterns since childhood through everyday communication with other speakers, but also the media and popular culture. Perhaps unsurprisingly, some speakers use both of these coda strategies, and even seem to overlap the two by producing VR rhymes (V[ɹ] ∼ V[j] ∼ V[ɻ] ∼ [ɚ]) with additional aspiration.

Coda variation is therefore extremely gradient in the corpus. Alveolar taps can be of complete or incomplete closure (approximant tap), and diachronically, it is plausible that the latter has weakened into an alveolar approximant. The alveolar approximant has a perceptual link to palatal and retroflex/bunched approximants, and by the overlapping of the vowel and retroflex/bunched gestures, a syllabic r-coloured vowel emerges. Back fricatives may also be either uvular or glottal, and may vary in voicing according to the adjacent segments. Finally, deletion is also gradient since it may or may not affect the quality and length of the preceding vowel. From this data-oriented point of view, any phonological analysis that simplifies BP coda rhotics into categories labelled "tap", "retroflex", "fricative" or "deletion" ignores the fact that all these categories encompass subvariants, and that there are gradient articulatory connections between the subvariants of different categories that provide vital information on how they came into being. For instance, it is common to refer to coda approximants with a clearly rhotic perceptual quality as "retroflex" in Brazilian linguistics (see Section 2.3.4), but the results of this dissertation have shown that there are at least three possible approximant variants with perceptual rhoticity (alveolar [ɹ], retroflex/bunched [ɻ], and r-coloured vowel [ɚ]). Once it has been established that an alveolar approximant is a contemporary variant, the link to alveolar approximant taps becomes obvious, thus demystifying the origin of the various approximant variants.

This chapter has also demonstrated that the factors causing lenition are different in word-medial and word-final codas. Structural factors that were found to cause increased lenition in word-medial codas are frontness of the preceding vowel and unstressed position in general. In word-final position, a qualitative analysis found rhotics to undergo less deletion in one-syllable nominals (although this could not be confirmed statistically). The alternating environment at word boundary most likely combined with ongoing morphophonetic changes in BP verb tenses and pluralisation determine the course of word-final lenition in nominals, verbs and the preposition *por*. While tap-like rhotics hardly ever occur in word-medial codas in the data, they still occur word-finally. This implies that the leniting sound change taking place in word-medial and word-final codas is operating through the same pathways, though at a different pace: word-finally, it is slowed down by the alternating environment (Bybee 2002).

Out of all word-final *r*-contexts, verbs outnumber any other word type, and due to the decrease in the use of analytic verb forms, the leniting change that began in pre-consonantal position has spread to other contexts. Nominals hold second place in overall lenition because pluralisation still maintains a pattern of root forms that contain a rhotic. Nevertheless, nominals are also losing their plural markers, which may be another driving force behind word-final lenition. Whereas for verbs and nominals pre-consonantal contexts are more numerous, the preposition *por* is most often followed by a vowel-initial word, which means that the nature of the alternating environment is different for this preposition as opposed to verbs and nominals. In fact, almost all pre-vocalic tokens of *por* (except for one token of [ɻ̊ʰ] in the task data) are tap-like segments. The higher token frequency of pre-vocalic contexts and the resyllabification caused by a word-final tap (e.g. *por isso* 'that is why' [pu.ˈɾi.sʊ]) have transformed these pre-vocalic word-final contexts into intervocalic contexts.

The sociolinguistic aspect of coda rhotics, already discussed in Section 2.4.3, must not be ignored. We have seen that several speakers altered their coda rhotics in the task setting to include or increase the proportion of alveolar taps and aspiration, both considered more desirable variants in monitored speech than the various approximants. This could indicate that, in the case of the back fricatives [χ] ∼ [ɦ] ∼ [h], a direct articulatory link establishing lenition from the approximants to back fricatives through debuccalisation is not plausible since in general lenition was *decreased*, not *increased* in the task setting. Back fricatives and approximants are more likely to form two separate, but co-existing coda strategies in the studied variety of BP. Their origin lies in different "lineages" of lenition (see Chapter 8), and their use is controlled and activated by the sociolinguistic values associated with them by each speaker.

BP coda rhotics are an intriguing phenomenon for Complex Adaptive Systems since they behave exactly as language and its subsystems have been described in this approach. The coda context is complex both from the point of view of its variants (which encompass several manners and places of articulation), the unpredictable ways in which these variants occur in speech, and the complex interactions of coarticulation, stress and frequency effects that seem to direct the leniting change. However, coda position is clearly also adaptive since one single unifying tendency can be observed: in one way or another, the coda rhotics in this study are being weakened towards complete deletion. The precursors of this change in word-final position are the verbs, followed by nominals and then by *por*. However, there is no single articulatory strategy leading towards deletion in the overall data or in the speech of individuals: two different paths of lenition, one of approximantisation and another of debuccalisation, are present. As predicted in the CAS approach, change is non-deterministic, and this is also the case in BP codas as two different diachronic pathways are merging into one outcome, deletion, with verbs and pre-consonantal context as attractors.

Chapter 8

Discussion and Conclusions

This chapter is dedicated to the discussion of the analyses presented in previous chapters. Section 8.1 takes a look at the different variants observed in the corpus and the implications they might have for theories of sound change. Section 8.2 considers the factors promoting sound change in the rhotics of BP, and how this sound change may be formalised. Section 8.3 recapitulates the sound changes that have taken and are taking place in the rhotics of BP, the motivations behind them, and how these changes link rhotic variants to each other. Section 8.4 discusses why classhood in the rhotics of BP is best defined as *language-specific family relationships*. Section 8.5 picks up the discussion on the phonological status of BP rhotics in light of the data presented in this study. Finally, the concluding remarks of this dissertation will be presented in Section 8.6.

8.1 Overview of phonetic variation

Table 8.1 lists all variants observed in the interview and task data with respect to phonological context, representative example words from the corpus, and the speakers who stand out from the rest by producing a high proportion of lenited forms (these speakers will be further discussed in Section 8.2.5). Variants with even one token in the corpus have been included for the observation of the articulatory range within which rhotics may be produced in each context. In clusters, the vocalic segment between the rhotic and the preceding consonant is not contemplated here. The table also excludes the two words with a varying intervocalic rhotic, *besouro* 'beetle' and *guelras* 'gills', which were part of the sentence completion task.

Starting with strong-R, we have seen that it is most often a glottal fricative whose voicing is dependent on but not determined by the surrounding segments. Some instances of uvular fricatives and deletion occur, but they are very rare. This is why the speakers included as having lenited strong-R are the ones who had one or two deletions; generalizing them as speakers with consistent lenition of strong-R is an overstatement. Strong-R can therefore be considered a fairly stable phonological category in the studied dialect.

While strong-R is a posterior fricative, we can see that weak-r variants are all anterior, or more precisely, alveolar or alveo-palatal. They range from rare tokens of voiced or voiceless trills to voiced or voiceless taps, approximant taps and alveolar approximants, voiced or voiceless fricatives, and ultimately deletion. This phonological category seems to consist of speech sounds that are mostly alveolar, and are not nasals, stops, or sibilants (although some fricative tokens overlap sibilants). This sort of definition of rhotics as an "elsewhere category" has already been suggested by Scobbie (2006). It is interesting to note that unlike in syllable codas, where we find alveolar, palatal and retroflex/bunched approximants, only alveolar approximants are to be found in weak-r contexts. There seems to be a continuum from full-closure taps to approximant taps, fricatives, and approximants proper, indicating that the various rhotic approximants have their origin in full-closure taps. This approximantisation has then gone through further changes in coda.

In syllable coda, variants similar to those in strong-R and weak-r contexts can occur, as well as palatal and retroflex/bunched approximants, schwas, and any kind of approximants paired with aspiration. In addition, rhotics may merge with the preceding vowels and form syllabic r-coloured vowels (which in turn can also be aspirated). There is also a significant amount of deletion.

The gradience observed in the data has major theoretical implications for the analysis of sound change. As for manner of articulation, rhotics can be trills, taps, approximant taps, fricatives, approximants, or deleted. The place of articulation for strong-R can be either uvular or glottal, for

Context	Example	Trill	Tap	Approximant	Vocalic	Fricative	Deletion	Speakers with increased level of lenition
Strong-R								
Word-initial stressed	*rio*					h ɦ ʁ χ		
Word-initial unstressed	*realmente*					h ɦ χ	Ø	F1, F6, M6
Intervocalic stressed	*errado*					h ɦ χ	Ø	M3
Intervocalic pretonic	*corrupção*					h ɦ	Ø	F2
Intervocalic post-tonic	*morro*					h ɦ χ	Ø	F4, M7
Weak-r								
Intervocalic stressed	*diferente*		ɾ ɾ̞ ɾ̥			ɹ̝ ʒ	Ø	
Intervocalic pretonic	*interessante*		ɾ ɾ̞ ɾ̥	ɹ		ɹ̝	Ø	
Intervocalic post-tonic	*agora*		ɾ ɾ̞ ɾ̥	ɹ l		ɹ̝ ɹ̝̊ dʒ	Ø	F7 M3 M4 M6 M7
Cluster stressed	*p(a)ra*	r	ɾ ɾ̞ ɾ̥	ɹ		ɹ̝ ɹ̝̊	Ø	
Cluster pretonic	*Brasil*		ɾ ɾ̞ ɾ̥	ɹ		ɹ̝ ɹ̝̊	Ø	
Cluster post-tonic	*outro*	r̥	ɾ ɾ̞ ɾ̥	ɹ		ɹ̝ ɹ̝̊ ʃ	Ø	M7
Medial coda								
Stressed	*curso*			ɹ j ɻ ɹʰ jʰ ɻʰ	ɚə ɚʰ	h ɦ χ	Ø	F2 F5 M4
Pretonic	*português*		ɾ	ɹ j ɻ w ɹʰ jʰ ɻʰ	ɚə ɚʰ	ɹ̝ h ɦ χ	Ø	F1 F2 F3 F4 F6 F7 M1 M2 M4 M5 M7
Final coda								
Pre-consonantal	*lugar*		ɾ ɾ̞	ɹ j ɻ ɹʰ ɻʰ	ɚə ɚʰ	h ɦ χ	Ø	M4
Pre-vocalic			ɾ ɾ̞ ɾ̥	ɹ ɻ ɻʰ	ɚ	h ɦ	Ø	F2 F5
Pre-pausal			ɾ	ɹ ɻ ɹʰ ɻʰ	ɚə ɚʰ	h ɦ χ	Ø	F3 F4 M3

Table 8.1: List of all variants in the interview and task data with respect to phonological context

weak-r it can be alveolar or alveo-palatal, and for coda rhotics it can be alveolar, palatal, retroflex/bunched, uvular, or glottal. In coda, even deletion is gradient: the rhotic may be deleted, but the remaining vowel can be lengthened or centralised. Therefore—assuming that the origin of BP rhotics lies in the alveolar trills of Latin—sound change is best explained in terms of gradient phonetic variation and alteration (e.g. gestural retiming or reduction, secondary articulations), and not the formal addition or removal of an articulatory feature.

Scobbie & Sebregts (2010, p. 258) point out that *any* kind of transcription data and the analyses of phonological allophony and contrast based on those data are essentially abstract. What is problematic is that there is no scientifically agreed level of fineness of phonetic transcription that constitutes the basis of phonological analysis. Most often the data for phonological analysis come from broad transcription, and articulatory labels are assigned to phonetic variants according to convention. Scobbie and Sebregts explain further that fine-grained experimental data are crucial to any phonological analysis (p. 258):

> [I]t is no wonder so many phenomena can appear segmental and categorical, and hence phonological, if the data is prepared at the appropriate level of granularity. Using fine-grained phonetic data might change our conception of the phenomenon, revealing it to be more subtle, variable, and less phonological [...], but it might also reinforce its phonological status from a firmer empirical base.

The phonetic data collected for this study can be considered a photograph, as it were, of the subtle, gradient changes that have already occurred in the rhotics of the studied speakers (diachronic change) and that are occurring at the moment (synchronic variation). This "photograph" shows chains of phonetic variants that allow us to trace connections between variants that are seemingly unrelated in terms of classic feature theory, very much in the spirit of Lindau (1985) and her original idea of a network of rhotics linked to each other by *family resemblances*. For instance, we are able to establish a chain of events from the alveolar trill to the r-coloured vowel ([r] → [ɾ] → [ɾ̞] → [ɹ] → [ɻ] → [ɚ]), or from the alveolar trill to the glottal fricative ([r] → [ʀ] → [ʁ] ∼ [χ] → [ɦ] ∼ [h]).

The observed variation in most rhotic contexts is highly irregular in terms of place and manner of articulation, which would imply that it is impossible to define a deterministic articulatory strategy for BP rhotics. In other words, a rule-based approach to *explaining* or *predicting* the articulation of a BP rhotic synchronically or its development in terms of sound change is likely to run into problems, although one may be used to *describe* the observed phenomena (Scobbie & Sebregts 2010, p. 276).

The phonetic data of this dissertation are an abstraction just like any other transcription data; however, an effort has been made in order to establish categories of variants based on the phonetic data, instead of fitting the variants into broad-transcription categories recycled from previous studies. The latter approach has often simplified the vast network of variants that form the rhotics of BP. This dissertation has striven to provide details on manner of articulation and voicing especially in terms of strong-R and weak-r, and the diverging formant trajectories characteristic of coda approximants. These contributions will be detailed in the remainder of this section.

Strong-R is often described as a velar fricative in Brazilian linguistics, but authors such as Abaurre & Sandalo (2003) have already argued that in most Brazilian dialects it is indeed a glottal fricative. This view is supported by the phonetic data in this dissertation; however, fricatives articulated in the velar-uvular region were also found, meaning that any categorical definition of the place of articulation of strong-R is most likely too drastic. The data also shed light on the variability of weak-r by establishing that it has weakened fricative and approximant variants, and that it can also have voiceless variants. In Brazilian linguistics, weak-r has mostly been described in terms of the presence or absence of a vocalic segment before or after it in clusters or pre-consonantal codas (see Section 2.3.2), but little attention has been paid to manner of articulation; we are only aware of Leite's (2010) study which distinguished taps proper ([ɾ]) and approximant taps ([ɾ̞]). Knowing that the alveolar tap is weakened to fricatives and approximants in the data makes it possible to establish new connections between it and the coda approximants.

Perhaps most importantly, this dissertation has provided details on coda rhotics and their inherent unpredictability in terms of manner and place of articulation, and in terms of the phonological context in which they occur. First, it has been established that word-final pre-vocalic rhotics most often are *not* alveolar taps, contrary to the intuitions that many formalist approaches use to argue in favour of an underlying coda tap (see Section 2.4.2.1). Second, it has been shown that coda approximants are much more than what has traditionally been fit under the simplistic term “retroflex *r*” in Brazilian linguistics (see Section 2.3.4): they can be alveolar, palatal, and most importantly, we still do not know if they are in fact *retroflex*, or if the conflation of the second and third formants can be produced with a bunched tongue configuration as well. Therefore, any analysis regarding the origin of rhotic approximants in BP codas must take into consideration that there is a continuum of variants, and that the use of any articulatory label for explaining the origin of a rhotic approximant must be based on experimental data. The problems this kind of gradient allophony creates for a feature-based analysis of sound change in rhotics will be further discussed in Section 8.3.

8.2 Factors causing sound change in BP rhotics

This study has striven to demonstrate that rhotics, just like any other sound class, are subject to the influence of numerous factors beyond those traditionally contemplated in phonological analysis. Most importantly, sound change takes place in rhotics because phonological change takes place at the syllable level (by reducing and deleting both nucleus vowels and adjacent rhotics) and at the word level (by slowly altering the main stress pattern of BP from paroxytone to oxytone, and by affecting frequent lexical items first). In addition to this, sound change in rhotics takes place at a different pace in the speech of individuals and in different speech registers: careful articulation brings about less lenited variants than an informal context, but speakers are affected by these expectations in varying degrees. This section will analyse BP rhotics as a Complex Adaptive System that encompasses changes in the structure of the language, in articulatory patterns, and changes influenced by frequency of use, idiolect, and speech style.

8.2.1 Language as a Complex Adaptive System

The factors that cause sound change in BP rhotics, and the fact that they represent structural, articulatory, social, stylistic and individual domains of sound change, indicate that BP rhotics are a good example of speech sounds that undergo change in a Complex Adaptive System (introduced in Section 3.1). Central to this approach to language change is that there are no deterministic mechanisms aiming towards a result, and the lenition trajectories of rhotics in BP and other languages are a good example of this kind of non-determinism. The rhotics of BP, as far as descriptions of spoken Latin can be relied on (e.g. Sturtevant 1920), have their origin in alveolar trills, as do many other European languages (Barry 1997). The rhotics of Romance languages such as Italian, Spanish and Catalan have remained mostly apical, while in French they are mostly uvular; among the Germanic languages, most varieties of English have approximant rhotics, and German mostly uvulars, while Dutch speakers make use of various places and manners of articulation. Similarly, Portuguese stands out as a language that has developed not only an intervocalic place and manner contrast for rhotics, but also a host of coda variants that are subject to variation according to dialect, speaker, lexical item, and alternating environments. Therefore not all languages make use of all of the lenition mechanisms that give rise to the potentially abundant "elsewhere category" that is rhotics: any language-specific factor, such as phonological contrast or phonotactics, may hinder these changes.

The mechanisms that lead to lenition in rhotics and in any other type of speech sound can be considered universal: they include gestural reduction through automation and, specifically in coda position compared to onset, a less synchronous alignment of articulatory gestures (which, of course, also leads to reduction) (Bybee 2001, p. 206). Section 8.3 will demonstrate that both of these mechanisms operate in the rhotics of BP in the change from apical trills to fricatives, approximants, and deletions, and especially in syllable codas. While the articulatory mechanisms for these phonetic changes are universal, similarly vast rhotic inventories are not found in many languages, making the point that paths of sound change are bound by the language in question even if the mechanisms behind them are, in theory, possible in any human language.

The next sections provide a summary of the different factors that were found to cause lenition in BP rhotics. Lenition is taking place in various linguistic subsystems of Brazilian Portuguese: the syllable, the word, stress patterns, chunks, degree of constriction, sociolinguistic values, and individual articulatory patterns. These subsystems are constantly self-organizing as language is being used and converging towards lenition (and ultimately, deletion) in most *r*-contexts. As idiolects change, though at different paces, the communal language also changes.

8.2.2 Structural factors

The structural factors found to cause lenition include post-tonic position, adjacency to a high vowel (of weak-r) or front vowel (in VR mergers to [ɚ]), adjacency to the plural marker [s] after the deletion of high vowels (e.g. [i]∼[ɪ] in *mares* → *marØs*, or [u]∼[ʊ] in *outros* → *outrØs*), syllable count, and pretonic distance from word stress. In the case of post-tonic position, the important insight of this study was the contradictory discovery that phonologically post-tonic rhotics are often not phonetically post-tonic in the studied dialect. In other words, the unstressed vowel following a post-tonic intervocalic strong-R (as in *cachorro*), weak-r (*brasileiro*) or cluster (*outro*) can be devoiced or deleted, leaving the rhotic also devoiced or lenited in some other way, or in coda position, or deleted. This tendency is, of course, further linked to the adjacency of the high vowels of BP [i ɪ u ʊ], which previous studies have found to be shorter in duration than mid and low vowels, and therefore prone to devoicing and reducing change in unstressed position (Rauber 2008; Napoleão de Souza 2012; Meneses 2012; Dias & Seara 2013; Cruz 2013). In addition, post-tonic weak-r can be devoiced, fricated or deleted by an adjacent plural [s] as a consequence of vowel deletion (e.g. *brasileirØs*, *outrØs*). All this contributes to a tendency towards an oxytone stress pattern at least in this variety of Brazilian Portuguese.

In VR rhymes, the proportion of [ɚ]-variants was found to be higher when the nucleus vowel was a front vowel. This could be a consequence of the incompatibility of the tongue configuration needed in the production of a front vowel and a retroflex or bunched approximant—however, data on the specific articulatory patterns is necessary to verify this claim. As for pretonic clusters, it was found that distance from word stress may play a part in increasing lenition.

Syllable count is another structural factor that permits the lenition of word-final coda rhotics: one-syllable nominals in the interview data suffered less lenition than nominals with two or more syllables, tentatively confirming Huback's (2006) findings, although the small sample size found in the interview corpus made it impossible to verify this statistically. However, this same phenomenon was not attested in the sentence completion task that elicited, in general, a more careful pronunciation.

Coda lenition, in the form of approximantisation, debuccalisation and deletion, reflects a general tendency of BP to reduce segmental material in syllable codas: this has already taken place in laterals ([ɫ] → [w] → Ø) and nasals (*Vn ∼ *Vm → Ṽ), but less so in coda sibilants. Lenition seems to affect sibilants in the Portuguese of Minas Gerais only in a very limited set of words, such as *mesmo* ('same; really, very; for real') [ˈmezmu] ∼ [ˈmeɦmu] ∼ [ˈmemu] and *mais* ('more; anymore') [ˈmajs] ∼ [ˈmajh] ∼ [ˈmaj]. Of course the deletion of the plural marker -*s* in nominals is a widespread phenomenon in any variety of BP, but it is generally considered to be of morphological nature rather than phonetic or phonological: the singular form is used instead of the plural form (and not a plural form from which -*s* has been deleted), which is evident in nominals with irregular plural forms. For example, the singular form of 'bread' is *pão* [pɐ̃w̃], and the irregular plural form is *pães* [pɐ̃j̃s]; however, 'two loaves of bread' with a deleted plural marker in informal BP is not **dois pãe* [dojs pɐ̃j̃], but *dois pão* [dojs pɐ̃w̃].

The data in this thesis show that at the same time as laterals, nasals and rhotics are being lenited in syllable codas, and considering that BP has (at least in the past had) a tendency to insert epenthetic vowels after coda stops (e.g. *admirar* 'to admire' [adʒimiˈɾah], *captar* 'to capture' [kapiˈtah], *étnico* 'ethnic' [ˈɛtʃiniku]), coda stops and affricates as well as tap-like rhotics are emerging as coda segments due to the deletion of post-tonic vowels. Examples include *outra cidade* as [ˈotsˈdadʒ], *direitos* [ʒɪˈɾejts], *direito* [dʒɪˈɾ̞ejt], *brasileiro* [bəɾəzɪˈleɾ̞]), and *banheiro* [bɐ̃ˈj̃eɹ̝]. As the stress pattern of BP is being reorganised, so is the inventory of possible coda segments.

8.2.3 Articulatory reduction

In addition to structural factors, the gradient allophony found for rhotics in all phonological contexts indicates that gradual articulatory reduction is one of the key factors that cause sound change in rhotics. Both substantive reduction (decrease in the magnitude of an articulatory gesture) and temporal reduction (overlapping and/or shortening of gestures) (Browman & Goldstein 1992; Mowrey & Pagliuca 1995; Bybee 2001) can be used to explain the emergence of most of the rhotic variants found in this study. Substantive reduction has taken place in the change from trills/taps to fricatives, approximants, vocalic variants, and ultimately deletion; in terms of Exemplar-Based Phonology, the articulatory gesture for the full-closure rhotic has been weakened due to automated articulatory patterns over time. As for temporal reduction, an overlapping of the vocalic and the rhotic coda gesture seems to take place in the r-coloured vowel: first the vowel is centralised in anticipation of the rhotic, and the rhotic gesture of either bunching or retroflexion begins earlier than in a non-merged VR rhyme, creating a neutral vowel with a low third formant.

8.2.4 Frequency effects

The influence of the core concepts of Exemplar-Based Phonology, token and type frequency, was also tested insofar as the recordings and online corpora of phonological patterns permitted. Frequency effects were not found to play a part in the articulation of strong-R in the speech corpus, since it is a fairly uniform category of glottal fricatives. As for weak-r, some high-frequency lexical items were found to include more lenited forms. The high-frequency preposition *para* [ˈpaɾa] ∼ [pɾa] was found to be especially reduced—in addition, the fact that the first vowel has mostly been deleted, leaving weak-r in a cluster in BP is in itself a reducing sound change. Low type frequency was found to possibly promote devoicing in ɾV(S) endings. In word-medial codas, the high-frequency conjunction *porque* was found to be more lenited than the average for stressed word-medial codas.

The strongest case for frequency effects can be found in word-final position. The varying level of lenition in word-final coda rhotics is linked to alternating environments. The fact that infinitive verb forms outnumber any other *r*-final word type in token frequency means that any leniting change has more ground to work on in verbs than in nominals or the preposition *por*. The increasingly analytic verbal constructions for the future and conditional tenses further decrease the frequency of verb roots containing a rhotic. Although verbs are practically r-less in the data, nominals still contain 53.5% tap-like segments before vowels, indicating that the alternating environment is hindering lenition in word-final codas compared with word-medial codas (where taps have already been lenited to approximants).

The preposition *por*, on the other hand, was found to be weakened at more or less the same rate as nominals and verbs pre-consonantally, but to contain only tap-like segments pre-vocalically. Pre-vocalic contexts outnumber pre-consonantal contexts following *por*, which means that the frequencies of alternating environments for this preposition are different than for nominals and verbs. This explains why *chunking*, or the processing of this preposition as part of a larger phonological unit that includes the following word, is hindering lenition in pre-vocalic *por*. The vowel-initial words that follow *por* in a larger text corpus and in the speech corpus are mostly grammatical morphemes (articles, pronouns and adverbs), and the word-final rhotic in *por* becomes intervocalic by the chunking of the two words into one phonological and semantic unit.

8.2.5 Speaker

This dissertation demonstrated that lenition manifests itself in different forms and at different rates in the speakers. Therefore, the overall proportions of different variants in the data tell of general lenition tendencies, but they may not be evident in the speech of an individual. The last column of Table 8.1 listed speakers that stand out in having a high rate of weakened r-variants in each context. We already commented that in the case of strong-R, these speakers are the ones with only one or two deletions, as opposed to those speakers with no deletions at all. In post-tonic clusters, all speakers produced highly lenited variants, but M7 stands out because of a higher deletion rate. Stressed and pretonic weak-r contexts are not considered in the table because no evident differences were found between speakers. Word-final coda lenition refers mostly to nominals, since verbs are practically r-less in the data.

Excluding the contexts for strong-R, most speakers are among the most leniting speakers in one or two phonological contexts. Speakers F2 (medial and final coda), M4 (post-tonic intervocalic weak-r, medial and final coda) and M7 (post-tonic intervocalic weak-r and clusters, medial and final coda) stand out in more than two contexts. Speaker M7 can be considered as having the highest overall level of lenition. Another interesting observation is that F7 is the only female speaker with advanced lenition in a weak-r context (post-tonic intervocalic) and a coda context (pretonic word-medial), whereas several female speakers show advanced lenition only in different coda contexts. All this shows that lenition in one context by a speaker does not imply lenition in another context: individuals differ in both the pace and type of lenition that takes place in their speech patterns. From a sociophonetic point of view, this study has showed that speakers are not equally affected by sound changes that take place in the speech community nor the notions attached to those changes. The root of all sound change is the individual, who updates speech patterns and mental representations through repetition and interaction with other speakers.

8.2.6 Speech style

In addition to speaker differences, speech style was found to impact the level of lenition. This was an expected result, as reduction phenomena have been found to occur more frequently in connected speech than in a task setting that involves reading (Warner 2012). In this sense, the sentence completion task provided a reference for the more complete rhotic variants. In general, the task setting implied less deletions in all contexts: no deletions were found for strong-R or weak-r, and in codas the rate of deletion was drastically reduced. In strong-R contexts, no uvular fricatives were found in the task data, which is interesting from a diachronic point of view: the glottal fricatives have their origin in the more "consonantal" uvular fricatives, yet uvulars only occurred in the more informal interview data. The interpretation offered for this phenomenon is that the uvular fricatives were used mostly in contexts of emphasis by two speakers only, and this sort of emphasis is less likely in a task setting. As for weak-r, approximant and fricative variants were absent from the task data. In codas, the proportion of back fricatives, considered more prestigious in the speech community, were more frequent in the task than in the interviews; in addition, the proportion of word-final pre-vocalic taps was higher.

Sociolinguistic conditioning is therefore also present as a factor that directs sound change in coda rhotics. The seemingly straightforward sound change from alveolar taps to approximants is intertwined with other coda variants, the back fricatives, which have a different origin both from a geographical and phonological point of view (see Section 8.3 for discussion). These two coda patterns therefore coexist in the speech of the recorded participants, and even merge into aspirated rhotic approximants.

8.3 Modelling the rhotics of Brazilian Portuguese

This section is dedicated to the modelling of a "family tree" for the rhotics of BP in the spirit of Lindau (1985), Magnuson (2007) and Sebregts (2014). In other words, by combining the historical accounts of sound change in the rhotics of Portuguese (see Section 2.4) and the information gathered in this dissertation on the relationship between different rhotic variants, this section contemplates the articulatory and perceptual factors that may lie behind the sound change that has already taken place and the variation that exists today.

The data collected for this dissertation give insight into both diachronic and synchronic lenition. By this distinction we mean that different rhotic variants coexist in the corpus, and depending on the point of view—diachronic or synchronic—a variant can be considered lenited from an original full-contact variant (e.g. the glottal fricatives as lenited developments of the trill), or lenited due to more recent reductive changes (e.g. realisation *versus* deletion). This is where the importance of the sentence completion task is underlined: it defined a baseline articulation in a fairly formal speech register against which the interview data could be compared. For example, the retroflex/bunched approximant [ɻ] was not considered lenited from a synchronic point of view because it was one of the most frequent coda variants in the task data. However, from a diachronic point of view, it is undoubtedly a lenited variant of the alveolar trill and tap. Similarly, the approximant tap [ɾ̞] is a lenited variant of the alveolar tap and is most likely the articulatory link between the alveolar tap and the various approximants, but since it seemed to be the product of individual articulatory patterns rather than a systematic lenition strategy in the data, it was not considered lenition from a synchronic point of view.

The historical and synchronic variants for rhotics appear in Figure 8.1 organised according to manner (y-axis) and place (x-axis) of articulation. This way of organizing rhotics is inspired by Magnuson (2007) and Sebregts (2014), and it is especially useful in the case of BP rhotics that can be of various places and manners of articulation. All stages necessary for the derivation of new weakened variants, except for the uvular trill (hence the dashed circle), were present in the speech data. There are reliable historical references as well as synchronic variation data from Portugal (Rennicke & Martins 2013) to indicate that the uvular trill can be an intermediate step between the alveolar trill and uvular and glottal fricatives.

The first observation on Figure 8.1 is that there is a common starting point in the upper left corner (the alveolar trill), and two pathways that take different directions from the alveolar trill but come to merge at the bottom half of the figure. We will first contemplate each of these pathways, and then analyse their merger.

The alveolar trill is said to be the "original" rhotic in Romance languages: Sturtevant (1920, p. 81–82) cites Roman grammarians who describe the Latin *r* as "dry", produced with "rapid blows", by "vibrating the tip of the tongue", and that "the tongue puts the breath into tremulous motion". These are most likely descriptions of an alveolar trill. Moving downwards along the left side of the model, we suggest that the next stage of lenition from the alveolar trill is the alveolar tap. Some authors have argued that the link between the trill and the tap is perceptual, and not directly articulatory (see Catford 1977, p. 130; Barry 1997), because the trill is produced with a prolongable gesture involving tensing of the tongue body, whereas the tap is produced with a momentary ballistic movement. Therefore the trill would not turn into a tap by reducing tension (substantive reduction) or duration (temporal reduction); rather, the tap seems to be an articulatory reinterpretation of the trill. However, as noted in Section 2.3.2, Blecua Falgueras (2001) finds that one-tap trills can occur as variants of a trill target in Spanish. This could mean that over time this type of lenited trill form can evolve into a tap not only due to perceptual similarity, but also through minimal articulatory modification. This is why there are two arrows from trills to taps, indicating that the relationship originates in both articulatory reduction (trill failure causes the trill to shorten to a one-tap trill) and reinterpretation (the gesture of the

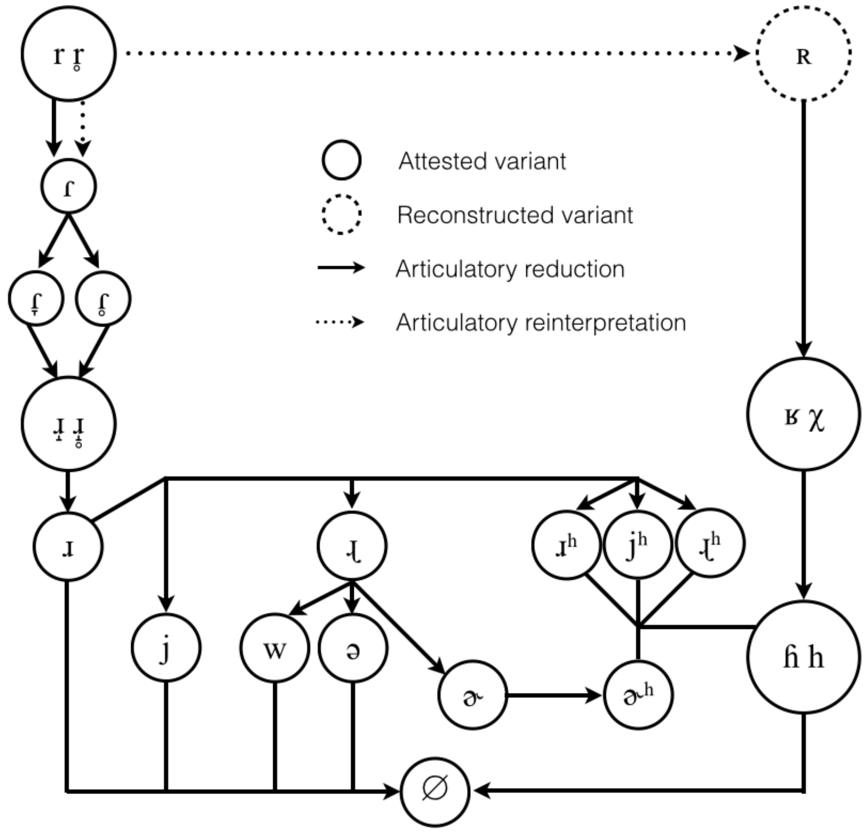


Figure 8.1: Rhotic relations in BP according to manner (y-axis) and place (x-axis) of articulation

one-tap trill becomes ballistic). In the corpus of this study, only two trill tokens were found: one voiced in a stressed cluster in the preposition *para* by speaker F4, and one voiceless in a post-tonic cluster in the verb *entram* ('they enter') by speaker F3. In both contexts, the alveolar tap is the most frequent variant, but the occurrence of trills in these contexts tells of a close perceptual link between the trill and the tap.

This perceptual link led to the change from a duration contrast ([rː] : [r]) to a manner contrast ([r] : [ɾ]) between the intervocalic rhotics of

Portuguese. In the speech data, both trills and taps can be voiced or voiceless. Voiceless taps were considered weakened variants of weak-r in Chapter 6 (together with fricatives, approximants and deletion) because the basic variants for this context were the tap and the approximant tap. Especially in post-tonic position, weak-r can be devoiced together with other post-tonic segments. On the other hand, the approximant tap is also a lenited variant of the tap, but through a different mechanism: the spectrogram images of approximant taps indicate that the articulatory target is the same as that of a tap, but the target is not fully achieved. The approximant tap is therefore perceptually very similar to the tap, but has an approximant-like formant structure. Both the voiceless tap and the voiced approximant tap are still produced with the momentary ballistic movement characteristic for taps.

The next step from these tap variants in Figure 8.1 are the voiced and voiceless alveolar fricatives. They occurred as variants of weak-r, but also in two tokens of pretonic codas (*participei* 'I participated' by speaker F4, and *Portugal* by M6) in the interview data. The leniting change from a tap to a fricative most likely involves the reduction of the magnitude of a full-closure ballistic movement to a fricative gesture in which airflow passes through a narrow stricture between the tongue tip and the alveolar ridge. Here lies the contradiction in the lenition process and its result: the process here is one of reducing the magnitude of the gesture, but the resulting segment is arguably "stronger" from both an articulatory and acoustic point of view. The voicing of the resulting fricative depends strongly on the voicing of adjacent segments, which is why the voiced and voiceless alveolar fricative appear in the same circle in Figure 8.1. When the fricative gesture is further reduced in magnitude, the segment turns into an alveolar approximant [ɹ]. This approximant was a possible variant for weak-r in almost all positions, but it was more common in coda.

Up to the alveolar approximant, Figure 8.1 has concerned variants that occur in the phonological contexts for weak-r and syllable coda. The next developments reflect variants only found in coda position. Articulatory gestures in coda position are less synchronous and completed with less magnitude than those in onset position, which leads to more variation of the "same" speech sounds in codas (Browman & Goldstein 1992; Bybee 2001, p. 86–88, 195–196). We suggest that two further approximant variants have their origin in syllable-final [ɹ]: the palatal approximant [j], and the retroflex/bunched approximant [ɻ]. As was already discussed in Section 7.1.1.1, the formant trajectories of alveolar and palatal approximants and their perceptual quality are strikingly similar. In addition, [j] already occurs in Portuguese in various oral diphthongs ([ej ɛj aj ɔj oj uj]) identical to the VR rhymes in which rhotics can occur (in addition, iR is possible, whereas *[ij] is not). These two aspects make [j] a prime candidate for occurring in the same coda environments as alveolar approximants by an alteration of the approximant gesture.

In the case of Dutch, Sebregts (2014) found that a distributional link was missing between the alveolar [ɹ] and retroflex/bunched approximant [ɻ]: the former only occurs in onsets, and the latter in codas. In other words, the lack of an articulatory continuum between the two variants in the same phonological context posed a challenge for considering [ɻ] a lenition from [ɹ]. However, in the BP data, both variants can be found in coda, which establishes an articulatory link between the two. Since there is no data on the exact articulation of [ɻ] in BP, we assume that whichever configurations are used in its production by BP speakers, this kind of approximant can be considered a slightly more vocalic, and therefore lenited, coda approximant. The spectrogram images provided in this dissertation have shown that this variant is characterised by a sharp lowering of the third formant, resulting in a diphthong-like rhyme. The resulting segment is perceptually more rhotic than the alveolar approximant (or the palatal approximant), undoubtedly because of the lowering of the third formant. Here we find a second contradiction in the lenition trajectory of rhotics: sometimes a leniting change can actually increase perceivable rhoticity, as is the case in [ɹ] → [ɻ].

Some authors have tried to link BP [ɻ] to the velarisation of coda /l/ → [ɫ], arguing that the merger of the already velarised laterals to rhotics (*rhotacism*) in popular BP is behind the backing of coda rhotics (Head 1987; Cohen 2006). These explanations depart from two apparent assumptions: 1) that there is only one categorical type of "retroflex (r)" whose origin must be accounted for; and 2) that coda rhotacism is a purely phonetic, and not phonological, process.

As for the first assumption, this dissertation has shown that most likely the coda approximants of BP form an articulatory continuum involving alveolar, palatal and retroflex/bunched tongue configurations. Therefore, we are able to establish a gradient origin for [ɹ̢]: nearly all of the speakers recorded for this study use alveolar, palatal and retroflex/bunched coda approximants. This indicates that [ɹ̢] can be derived articulatorily from alveolar rhotics, without suggesting a merger with another phoneme. The second assumption implies that if there is a merger of coda laterals and rhotics, the resulting rhotic is phonetically similar to the lateral [ɫ] in terms of place and manner of articulation. However, we have already argued in Rennicke (2011, p. 154) that rhotacism seems to be a more phonological phenomenon, and that the resulting rhotic reflects the regional tendencies for coda rhotics. By examining the dialectological atlases of various Brazilian states, it is possible to observe that rhotic approximants are common surface forms of rhotacism in Paraná, Mato Grosso do Sul and southern Minas Gerais. On the contrary, in northern and northeastern Brazil, coda rhotacism most often manifests itself as taps and back fricatives. These two arguments favour the view that [ɹ̢] originated in the alveolar approximant, and that an analogy to the changes in coda laterals is not necessary.

Sebregts (2014, p. 284–285) sees trouble in drawing a lenition pathway from alveolar rhotics to [ɹ̢] in Dutch because the latter is a categorical variant for the observed speakers: [ɹ̢] occurs only in coda and not in onset, and [ɹ] *vice versa*. Nevertheless he states that cross-linguistic patterning suggests [ɹ̢] should be classified as a lenited form of alveolar rhotics and not uvular rhotics. He adds that its status as a high-prestige coda variant in Dutch may be behind its generalisation among speakers without any other kind of rhotic approximants in their speech. The results of the present study have shown that in the case of BP, alveolar, palatal and retroflex/bunched approximants are indeed in a coda continuum, and therefore an articulatory link to alveolar rhotics can be established. Of the fourteen speakers, ten individuals used all four coda approximants ([ɹ j ɹ̢ ɚ]). The remaining four speakers have two different combinations of approximant variants: F3 and M2 use only [ɹ̢ ɚ], and M3 and M4 [ɹ ɹ̢ ɚ]. Therefore the continuum is present at an idiolectal level even in a small number of speakers such as the one examined in this dissertation.

In Figure 8.1, three further variants depart from [ɹ̢]: the r-coloured vowel or schwar [ɚ], the schwa [ə], and the voiced labial-velar approximant [w]. The differences and similarities of [ɹ̢] and [ɚ] were discussed in Chapter 7: the former is a consonantal coda variant, while the latter is a syllabic merger of a VR rhyme. They are, nevertheless, perceptually very similar due to a low third formant. Therefore the continuum of coda approximants extends to [ɚ] as well: in the passage from a coda [ɻ] to a syllabic [ɚ], whichever articulatory gesture is responsible for the lowering of the third formant (lip rounding, tongue retroflexion/bunching, pharyngeal constriction, etc.) begins to overlap the gesture of the preceding vowel. This kind of temporal reduction, or gestural retiming, was found to be more common in front vowels than back vowels in word-medial coda (see Section 7.1.1.3), which can be explained by the fact that the retracted tongue body required in the production of the rhotic is less "compatible" with front vowels than back vowels. This is why either the vowel is centralised, as in the case of [ɚ], or the degree of rhoticity is reduced. Perceptually, [ɚ] can have an even higher degree of rhoticity than [ɻ] due to its syllabicity; it is yet another instance of articulatory lenition that actually increases perceptual rhoticity rather than decreases it.

The remaining two coda variants, [ə] and [w], were not very frequent in the data, but they can be taken as evidence that the presence of a coda rhotic can be cued either by diphthong-like formant transitions or rhoticity itself (see Section 2.3.5.2). Section 7.1.1.1 presented the strikingly similar spectrogram images of the words *no*[ɻ]*te* and *so*[ə]*te* that demonstrate these two ways of cueing a coda rhotic. As for [w], there was only one token of this variant in pretonic word-medial coda by speaker M7 in the word *perguntou* '(s)he asked'. This may be due to assimilation: the following velar stop (although phonetically an approximant [ɰ] in this token) may have caused the speaker to assimilate the coda approximant to this place of articulation, and in anticipation of the following [ũ], the speaker also rounded his lips. In addition, just like in the case of [j], [w] forms oral diphthongs in BP ([iw ew ɛw aw ɔw ow uw]) similar to the possible VR rhymes, which further promotes the possibility of cueing a coda rhotic with an oral non-rhotic diphthong. Therefore, [j], [ə], and [w] are three lenited non-rhotic coda variants in which perceptual rhoticity has also been decreased.

We now move on to the right-hand side of Figure 8.1. This side of the flowchart concerns variants that are developments of the alveolar trill by means of posteriorisation, or backing in the vocal tract, and debuccalisation. Section 2.2.3 discussed how the shift from alveolar to uvular trills is most likely perceptually motivated, since a direct articulatory link between [r] and [ʀ] could not be established based on the existing literature. The substitution of uvular trills for alveolar trills is frequent already during acquisition in many languages, and the prestige of this variant in Western Europe since the 17th century may have also promoted its generalisation in Portugal since the 19th century, documented first by Gonçalves Viana (1903, p. 19; 1973, p. 102). Because of the perceptual nature of the connection between [r] and [ʀ], the arrow leading from the alveolar trill to the uvular trill is dotted, in the same way it is between [r] and [ɾ]. The circle surrounding the uvular trill is dashed because no tokens of this variant were found in the speech corpus; however, strong historical evidence was presented in Section 2.4.1.2 to demonstrate that the uvular trill is an intermediate stage between the alveolar trill and the uvular fricatives in both European and Brazilian Portuguese.

When the tongue configuration required for the trilling of the uvula against the tongue dorsum is relaxed, trilling fails and, as a result, a constriction that causes friction arises. Uvular fricatives [ʁ χ] occurred as variants of strong-R (word-initially and intervocalically) as well as in coda; they were most often voiceless, as voiced uvular fricatives occurred only in stressed word-initial position. No uvular approximants as rhotic variants were found in the data as the next step in lenition; rather, uvular fricatives seem to weaken directly into glottal fricatives [ɦ h] in BP. This change can also be explained as a substantive reduction by debuccalisation: the uvular constriction needed to produce the uvular fricative is eliminated, leaving an increased friction-like airflow in the glottis. This similarity with vocalic variants is why the glottal fricatives appear at the same level as [j], [w] and [ə] in Figure 8.1. The voicing of glottal fricatives examined in this corpus was found to be highly dependent on the voicing of the surrounding segments—most often the preceding segment. Like the uvular fricatives, the glottal fricatives are also variants of strong-R and coda rhotics, and they can be voiced or voiceless in any position.

In the bottom right corner of Figure 8.1, there are still four variants whose origin has not been discussed. These variants have been called "aspirated approximants" in this dissertation due to a [h]-like fricative that overlaps the approximant. [ɹʰ jʰ ɻʰ ɚʰ] occur in word-medial and word-final coda in the corpus, and they can be considered a merger of the two coda pathways: the approximant derives from apical rhotics, while the glottal fricative derives from uvular rhotics. The fact that these two tendencies can overlap tells that the VR rhymes involving approximants are indeed diphthong-like sequences; that is, articulatorily they do not consist of a vowel and a consonant. Rather, they can be considered one articulatory vowel-like unit onto which glottal friction can be superposed. In other words, the articulation of the VR sequence has been automated to such an extent that, in a sense, there is no rhotic anymore, and that is why another rhotic segment can be added. Sections 7.1.2.2 and 7.2.2.2 demonstrated how some of the speakers add aspiration or increase its proportion with respect to other variants in a task setting, indicating that glottal fricatives seem to carry more prestige in coda context. We suggest that glottal friction is therefore superposed onto the original VR rhyme (which has been lenited to a diphthong-like rhyme or an r-coloured vowel) as the speaker attempts to achieve a socially more acceptable pronunciation.

Section 4.4 explained that the place of recording, Lavras, is situated at an isogloss concerning coda rhotics: to the east, mostly glottal fricatives occur in coda, whereas to the west, approximants are more common. This isogloss was established in the *Esboço de um Atlas Lingüístico de Minas Gerais* (Zágari et al. 1977). Not all of the speakers recorded for this dissertation were born and raised in Lavras, but the tendency to coda variation between these two macrocategories was observed in the corpus. This tendency in Lavras was also confirmed by data collected for the Brazilian Linguistic Atlas project (ALiB) in 2010. Aguilera & Silva (2011) report that four speakers were recorded in Lavras for this atlas: two females and two males in groups of 18–30 and 50–65 years of age. In 46% of coda tokens, the rhotic was "retroflex" (term used for rhotic approximants) and in 54% of tokens, it was "glottal" (i.e. a glottal fricative). In relation to speaker age, it was found that approximants are more frequent among the two young speakers than the two older speakers: the former used glottal fricatives in 45% and approximants in 55% of tokens, whereas the latter used these variants in 62% and 38% of tokens, respectively. When compared to the distribution in the present study (Table 8.2), back fricatives seem overrepresented in Aguilera & Silva (2011), while approximants and deletions appear to be underrepresented. This discrepancy can be due to various factors. Firstly, all four speakers in the ALiB corpus were born and raised in Lavras, which was not the case in the present study. Second, speech style may have influenced the speakers' output since the ALiB data consist of the elicitation of individual words. Third, the number of speakers and tokens in the ALiB data is low, which also leaves the distribution more likely to represent word-specific and speaker-specific patterns.

Data set	**N**	**Tap**	**Approximant**	**Appr. + asp.**	**Back fricative**	**Deletion**	**Others**
A & S (2011): medial	60		48%		52%		
A & S (2011): final (nominals)	n/a		25%		50%	25%	
A & S (2011): final (verbs)	36		n/a		n/a	75%	
Interview: medial	930		62%	6%	9%	22%	1%
Task: medial	56		71%	9%	16%	4%	
Interview: final (nominals, stressed+C)	118	1%	53%	2%	10%	34%	
Task: final (nominals, stressed+C)	88	2%	70%	5%	13%	10%	
Interview: final (verbs+C)	708		1%		0.5%	98%	0.5%
Task: final (verbs+C)	88	2%	49%	1%	18%	30%	

Table 8.2: Distribution of coda variants in Aguilera & Silva (2011) and the speech corpus

At any rate, both corpora demonstrate that taps, approximants, and back fricatives along with other variants are all possible coda realisations in the Portuguese of the studied region. We have argued above that the glottal fricatives are not weakened variants of the rhotic approximants; rather, we have proposed that these two categories come from different lenition lineages that can coexist in a speech community and in an idiolect. Table 8.3 illustrates that in addition to tap-like variants and deletion, both approximants and back fricatives (and their merger, the aspirated approximants) are present in the speech of eight speakers, whereas three speakers use approximants and aspirated approximants, and three others only approximants. We concluded in Chapter 7 that this distribution cannot be directly explained by the geographical origin of the speakers. The four speakers who come from towns 100–180 kilometres to the southwest of Lavras—and therefore stand out from the rest of the speakers who come from towns closer to the isogloss—include F2 (only approximants), F5 (all three categories), M1 (approximants and aspirated approximants), and M5 (only approximants). However, there is one other speaker who used only approximants (M4) and three who used approximants and aspirated approximants (F6, M1, M2), and they are all from towns close to the isogloss.

Therefore the coda variants in the corpus do not have a geographical explanation, and it must be assumed that they coexist in the isogloss region and specifically in Lavras.

Speaker	**Approximant**	**Appr. + asp.**	**Back fricative**
F1	X	X	X
F2	X		
F3	X	X	X
F4	X	X	X
F5	X	X	X
F6	X	X	
F7	X	X	X
M1	X	X	
M2	X	X	
M3	X	X	X
M4	X		
M5	X		
M6	X	X	X
M7	X	X	X

Table 8.3: The use of coda approximants, aspirated approximants and back fricatives by 14 speakers in the interview and task data (in addition to taps and deletion)

In sum, from the point of view of modelling the rhotics of BP, we propose that the coda variants have the same historical origin, i.e. the alveolar trill, but that they have followed different trajectories: an anterior and a posterior trajectory. In coda context, the posterior trajectory seems to pertain to a more careful speech register for the recorded speakers since its proportion of total tokens was higher in the task setting than in the interview setting; this increased proportion is also why it was not considered a synchronically lenited form in the analyses. The variants used by a contemporary speaker who interacts in a speech community at a nationwide isogloss for coda rhotics do not need to be consistent from the point of view of historical developments or phonological representations. Sebregts (2014, p. 234) points out that individual speakers are not a storage space for cross-linguistic patterning and diachronic changes. In the case of BP, it could be added that an individual does not have to account for the *cross-dialectal* patterns present in their speech: some intermediate stages may be absent, and variants of different trajectories may be used by one single individual. An Exemplar model of phonology allows the speaker to have multiple phonetic representations of lexical items, and phonological categories are formed probabilistically across these representations.

One major variant in Figure 8.1 concerning the changes in BP rhotics still requires an articulatory explanation. At the bottom of the figure lies one of the most frequent coda variants: deletion. Deletions occurred in all *r*-contexts except in stressed word-initial context. Thus deletion can arise as the result of a decrease in articulatory magnitude in any type of rhotic: a glottal fricative, an apical weak-r variant, or the coda approximants. The inclusion of deletion as a possible stage of lenition sets the current study apart from previous accounts of *r*-classhood (Lindau 1985; Magnuson 2007; Sebregts 2014). A significant part of coda contexts for rhotics were found to be *r*-less in the speech corpus, and as phonetic form is considered part of lexical representation under the exemplar-based approach, deletion must be considered part of the network of rhotic variants. The inclusion of deletion as an *r*-variant also underlines the connectionist view adopted in the description of rhotics in this study: instead of concentrating merely on articulatory similarities or variants that are inherently rhotic, this dissertation has sought to establish complete lenition pathways that also include non-rhotic variants and ultimately deletion.

Table 8.4 summarises the sound changes in BP rhotics, the origin of the change (perception or gestural automation), and the type of articulatory reduction (substantive or temporal) if any. The change [r] → [ɾ] is deemed to involve both perception and gestural reduction, and [r] → [ʀ] is considered a perceptual rather than articulation-based sound change. In addition, two changes ([r] → [ɾ] and [ɹ̞] → [ɚ]) have undergone a temporal rather than substantive type of articulatory reduction.

Section 2.2.1 of this dissertation discussed the problems of defining lenition in rhotics as an increase in openness, sonority, or |V|-prominence (see Lass 1984; Anderson & Ewen 1987; Clements 1990; Bonet & Mascaró 1997). In the lenition trajectories proposed by these authors, the sonority of rhotics is considered in relation to other consonants, but the lenition mechanisms and relationships *between* different rhotics are seldom elabo-

Sound change	Motivation		Reduction	
	Perception	Gestural automation	Substantive	Temporal
r → ɾ	X	X		X
ɾ → ɾ̝~ɾ̥		X	X	
ɾ̝~ɾ̥ → ɹ̞~ɹ̞̥		X	X	
ɹ̞~ɹ̞̥ → ɹ		X	X	
ɹ → j		X	X	
ɹ → ɻ		X	X	
ɻ → ə~w		X	X	
ɻ → ɚ		X		X
r → ʀ	X			
ʀ → ʁ~χ		X	X	
ʁ~χ → ɦ~h		X	X	
any variant → Ø		X	X	

Table 8.4: Sound changes in BP rhotics, origin and type of reduction

rated on. Therefore, it seems, rhotics are seen as an invariable category in a language, or if there are two rhotic categories in a language (as proposed by Bonet & Mascaró 1997), these two belong to distant positions on a sonority scale in order to justify their contrast. The present study has shown that the rhotics of a language can be anything but invariable, and that the variants of rhotic categories can overlap. The continuum from full-closure rhotics to fricatives, approximants and deletion can be considered to imply an increase in articulatory openness, but not always in sonority. Lenition in the rhotics of BP is driven by articulatory undershoot, i.e. the incomplete articulation of speech segments. However, the opening of the constriction does not always increase the permeability of the vocal tract to airflow (contradicting Lass 1984): for instance, the change from trills and taps to fricatives certainly decreases the permeability to airflow, and consequently, sonority.

8.4 Classhood in BP rhotics

The rhotics of BP, as a class, are best modelled as a Complex Adaptive System of exemplar clusters, as well as *family relationships* as proposed by Sebregts (2014) for the rhotics of Dutch, which are also highly variable in both place and manner of articulation. The rhotic variants found for BP are more numerous than in Dutch, and they present an additional level of complexity due to the distribution into contexts for strong-R variants, weak-r variants and coda variants and due to the intervocalic contrast between strong-R and weak-r. Other differences compared to the Dutch rhotics include the optional voicing of some BP rhotics (taps and fricatives), the occurrence of the syllabic r-coloured vowel [ɚ] and the non-rhotic glottal fricatives [ɦ h], as well as the aspirated approximants that merge two different coda trajectories.

Exemplar-Based Phonology accommodates the gradient continuum of rhotics without the need to specify features (in the SPE tradition) and underlying forms for rhotics in different contexts from which standard and non-standard surface forms are derived by rules. Instead, BP rhotics can be considered to have more central variants depending on the phonological context ([ɦ]~[h] for strong-R, [ɾ]~[ɾ̞] for weak-r, and [ɾ]~[ɻ]~[ɚ]~Ø in codas for the speakers in this study), but less central variants also have mental representations and are therefore part of the speakers' perceptual repertoire and the class of rhotics. More importantly, Exemplar-Based Phonology allows us to examine rhotics as part of the words and constructions in which they occur, and not only individual segments defined by articulatory labels: this dissertation has discussed the interference of stress patterns, frequency effects, and inflectional morphology not only in the lenition trajectories of rhotics, but also in the syllables in which they are adjacent to other segments that also undergo lenition.

As for Sebregts' (2014) insight in modelling rhotics in terms of *family relationships* (and not *resemblance*), this combination of synchronic and diachronic evidence has proven vital in understanding the rhotics of BP as a network of phonetically diverse variants. The original idea of resemblance by Lindau (1985)—that every rhotic bears a similarity to at least one other rhotic in a language—is still present in this concept, but it is complemented by the idea of relationships, or diachronic connections that are not always tangible to the contemporary speaker but which lie behind the seemingly unrelated rhotic variants present in the language. The main variants found in the corpus for the three different phonological contexts for rhotics in BP ([ɦ]~[h] for strong-R, [ɾ]~[ɾ̞] for weak-r, and [ɾ]~[ɻ]~[ɚ]~Ø in codas) are very diverse from a synchronic point of view. In terms of distinctive features (see Table 8.5), these segments can only be described as non-labial, non-high, non-back, voiced, continuant, and non-strident. This is quite close to Scobbie's (2006) definition of rhotics as oral lingual sonorant consonants that are *not* specifically palatal, lateral, or labial; the contradiction to this definition is that BP [ɦ]∼[h], one of the main variants for strong-R but also in coda, is not a sonorant.

Feature	[ɦ]	[ɾ]	[ɻ]	[ɚ]
Vocalic	-	-	+	+
Consonantal	-	+	+	+
Syllabic	-	-	-	+
Sonorant	-	+	+	+
Coronal	-	+	+	+
Anterior	-	+	-	-
Labial	-	-	-	-
High	-	-	-	-
Back	-	-	-	-
Voiced	+	+	+	+
Continuant	+	+	+	+
Strident	-	-	-	-

Table 8.5: Some distinctive features of main BP rhotic variants (after Chomsky & Halle 1968; Katamba 1989)

If we take into account the gradient variation observed in BP rhotics in this dissertation, the definition of rhotics in terms of features becomes even more difficult because not all variants fit into the definition given above. Palatal [j] (which is [+high]) was found to be a frequent coda variant; uvular fricatives that can occur as variants of strong-R and coda rhotics are [+back]; trills, taps and fricative rhotics can be [-voiced]; apart from [ɦ]∼[h], all other fricative variants are [+strident]; and all fricative variants are [-sonorant]. Therefore, in terms of feature specification, the rhotics of BP can only be described as [+continuant], [-labial], [-nasal], which cannot be considered specific enough to form a feature-based phonological class in mental representation: rhotics are not uniform even in major class features ([vocalic], [consonantal], [syllabic], [sonorant]). In addition, the rhotics of BP can hardly be classified as simply "liquids" and distinguished from laterals only as [-lateral].

This is why Sebregts' notion of defining the classhood of rhotics as *family relationships* is relevant from the point of view of the synchronic speaker. The definition of this class cannot be based on the phonetic properties of variants used by an individual speaker because the articulatory link between positional variants has become obscure. Rather, classhood must be based not only on phonetic resemblance to other variants, but also on the historical articulatory changes in rhotics. These changes cannot be expected to be obvious and present in the output of a contemporary speaker, which is why the connection between different rhotic variants is not always one of resemblance, but one best described as a loose relationship.

One of the main findings of this dissertation has been that these family relationships are always *language-specific*, that is, rhotics can occupy any articulatory range permitted by the language in question. Thus it becomes questionable if some segments can be considered inherently rhotic (such as those in Table 2.1), and others non-rhotic. In BP, variants include the non-rhotic approximants [j] and [w], schwa [ə], as well as the uvular fricatives [ʁ χ] and the glottal fricatives [ɦ h]. Rhotics have been able to occupy such a large articulatory range in BP—trills, taps, fricatives, and approximants in alveolar, palatal, uvular and glottal places of articulation—because the phonological system of contrasts and the positions in which rhotics occur have permitted such changes. In the alveolar-postalveolar place of articulation, any consonantal segment other than [t d l n s z ʃ ʒ tʃ dʒ] can be a rhotic; any segment in the velar-uvular region apart from [k ɡ] can be a rhotic; and any glottal segment can be a rhotic. The virtually infinite range of articulatory possibilities for rhotics cross-linguistically once again underlines the non-descriptive nature of the term *rhotics*: rhotics are not always "rhotics". There is no articulatory or phonetic property necessarily shared by all rhotic variants in a language, which is why the class of rhotics across languages is featurally, articulatorily, and phonetically unspecified, and most importantly, what can be labelled a rhotic is always language-specific. Sound change taking place inside lexical items and in different phonological contexts creates the network of rhotic variants that exists in a given language. That network constitutes a Complex Adaptive System that accommodates changes taking place in other phonological phenomena and adjusts itself accordingly.

8.5 Phonological representation of BP rhotics

In Section 2.4.2 we presented the main proposals of featural representation for the rhotics of BP. The incomplete contrast between strong-R and weak-r, which manifests itself only intervocalically, forces a formalist approach to assume either the alveolar trill [r] or the alveolar tap [ɾ] as the underlying rhotic. From this underlying rhotic, variants are derived by rules and/or positions on the sonority scale. Although coda is highly variable, some authors claim that all variants in this position derive from an underlying tap because the tap still emerges pre-vocalically (*ma*[ɾ] *azul* 'blue sea') and in derivative morphology (*ma*[ɾ]*es* 'seas'; *ma*[ɾ]*ítimo* 'maritime').

This dissertation has demonstrated that the speakers do not use any type of trill as a common *r*-variant in any position: only two tokens were observed, meaning that trills represent 0.03% of all 7,045 tokens. This implies that the alveolar trill cannot be judged to have a strong mental representation in the studied dialect. What is interesting is that the trill tokens occurred in cluster context, which should be predominantly a context for weak-r, or the alveolar tap. The data suggests, then, that the contrast between strong-R and weak-r can no longer be defined as one of manner or duration (multiple closures *versus* one closure): it must be defined as one of place (dorsal/glottal *versus* coronal). In the coronal place, subtle gradience ranges from trills to taps, fricatives and approximants.

The coda variation of BP rhotics is especially tricky for a formalist approach. We have shown that 46% of word-final pre-vocalic *r*'s in nominals are not taps in spontaneous speech; in addition, 97% of pre-vocalic infinitives do not have taps. The only context to corroborate the assumption of an underlying tap in coda is the preposition *por*, with 100% pre-vocalic tap-like segments in the interview data. This phenomenon was explained as *chunking*, or the processing of two or more words as one phonological unit, by which the word-final rhotic has actually become intervocalic. This study has shown that not only can the same variants that occur in strong-R position also occur in coda (dorsal and glottal fricatives), but also weak-r-variants (coronal articulations), as well as three other possibilities: approximants, schwa, and aspirated approximants. Therefore taps are far from being common in coda in the studied dialect, nor do they occur pre-vocalically in most word-final contexts, as *r* has been mostly deleted from pre-vocalic infinitive verb forms (which make for 78% of all pre-vocalic contexts).

Thus there is a tendency for weakening and deletion in BP coda rhotics, but the specific pathways for lenition can hardly be considered predictable or consistent. Abaurre & Sandalo (2003) argue that BP codas tend towards segments that are [-consonantal], as has been the case for laterals and nasals, and the data seem to support this view. Coda rhotics are becoming more vocalic in one way or another, either by debuccalisation (Bybee & Beckner 2015, p. 187), i.e. the loss of supraglottal constriction (as in [χ]∼[ʁ] → [h]∼[ɦ]), or approximantisation ([ɾ] → [ɾ̞] → [ɹ] → [j]∼[ɻ]∼[ɚ]). However, the gradience in these changes and the existence of two different strategies indicate that this tendency is not deterministic or the result of one articulatory mechanism. Rather than a change in featural representation, coda variation most likely finds its explanation in the universal tendency for syllable-final segments to be articulated in a less synchronous fashion and with less magnitude than syllable-initial segments (Browman & Goldstein 1992; Mowrey & Pagliuca 1995; Bybee 2001, p. 206). This leads to substantive and temporal reduction, and eventual loss of coda consonants, which is the origin of the observed preference for open syllables in most languages.

Meanwhile, vowel deletion elsewhere creates new consonant clusters and coda consonants (Bybee & Beckner 2015, p. 187–188) at the same time as other clusters and codas are undergoing lenition. While coda rhotics are being weakened to approximants, glottal fricatives and being deleted in BP, the weakening of unstressed segmental material is bringing about new coda contexts for rhotics (as in *brasilei*[ɾʊ] 'Brazilian' → [bəɾəzɪˈleɾ̞] in Figure 6.7, and *banhei*[ɾʊ] 'bathroom' → [bɐ̃ˈȷ̃eɹ̞] in Figure 6.8) and other consonants (such as the emerging word-final clusters [ts tz ds dz ks], as suggested by Cristófaro-Silva & Leite in press).

To paraphrase Mattoso Câmara Jr. (1977, p. 79), phonemics cannot distance itself from phonetic reality. Inspired by this line of reasoning, we propose that the highly variable and gradient group of rhotics in BP is best modelled as a phonetic-semantic network under the Exemplar Models approach (Johnson 1997, 2005, 2007; Bybee 2001, 2006; Pierrehumbert

2001, 2002), and that this network can be considered a Complex Adaptive System. This network is based on memory traces of lexical items that are connected to each other by their phonetic and semantic properties. Section 3.2.2 discussed the storage of linguistic elements, and we argued that these elements are most likely entire words. Phonological patterns and generalisations emerge probabilistically as language is being used: articulatory patterns become more automatic through repetition, segments undergo reduction, and over time this reduction changes the mental representation of words. Instead of defining an underlying representation, this approach assumes that for each phonological context (i.e. generalisation over lexical items) there are several possible variants, but some variants may be more central, and others more peripheral. This probabilistic makeup of a phonological category is created and updated constantly as the individual uses language.

Figure 8.2 presents a simplified phonetic-morpho-semantic network of rhotic variants that a speaker of BP may have. The first aspect to notice in this figure is the existence of three variant clusters with different central variants: [ɻ], [ɾ] and [ɦ]. The [ɻ]-cluster includes coda variants, the [ɾ]-cluster represents the coronal category of weak-r variants, and the [ɦ]-cluster relates to the dorsal and glottal strong-R variants. Depending on the speaker and dialect, the central and peripheral variants of these categories will be different. Three types of connections appear marked in the figure: *schema* indicates morpho-semantic generalisations over phonetic elements; *phonetic overlap* connects similar variants across categories; and *stylistic information* points to information on sociolinguistic and pragmatic aspects attached to a variant.

The coda category is a selection of the most frequent variants in the corpus of this dissertation, and they are part of the lexical representation of words such as *curso* ‘course’, *por mim* ‘by me; as far as I am concerned’, and *jogador* ‘player (masc.)’. This category overlaps the weak-r category by sharing some variants, e.g. the alveolar tap [ɾ] and alveolar approximant [ɹ] included in this figure. The weak-r category is part of the lexical representation of words such as *jogadora* ‘player (fem.)’, *jogadores* ‘players (masc. pl.)’, *por exemplo* ‘for example’, and *outro* ‘(an)other’, that is, intervocalic and cluster contexts. A schema can emerge through a generalisation of the word type *jogador*, *jogadora* and *jogadores* (and also *jogadoras*

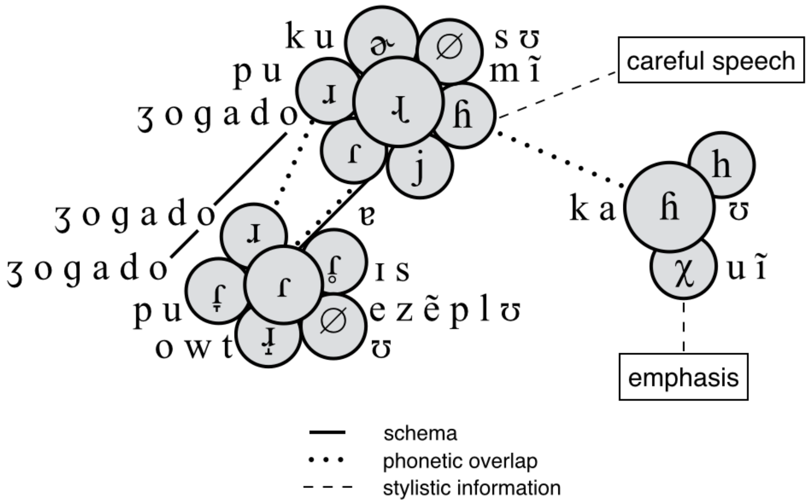


Figure 8.2: Simplified phonetic-morpho-semantic network of main BP *r*-variants

'players [fem. pl.]'): in *-or* nominals—a derivational morpheme indicating an agent (similar to *-er* in English)—the word-final rhotic in masculine singular can have several phonetic outputs, but the feminine and plural forms are produced mostly with coronal variants.

The analysis of the preposition *por* (see Section 7.2.1.3) demonstrated that stored representations can also be chunks, or combinations of two or more words that are processed as one unit. The word-final rhotic in *por* was found to be processed as intervocalic in chunks such as *por exemplo* because 100% of all pre-vocalic tokens were tap-like in the interview data. This is why *por exemplo* appears placed under the weak-r category, while the phonetic forms of a pre-consonantal *por* chunk such as *por mim* bare a closer resemblance to those of a word-medial or word-final coda context.

The coda category also overlaps the strong-R category in that glottal fricatives (but also uvular fricatives) can occur in both contexts. In coda context, the speaker may have stylistic information attached to these fricative variants which activates them in monitored speech; after all, the percentage of back fricatives was found to be higher in the sentence completion task than in the interview data. Back fricatives make up the strong-R category, which emerges as a generalisation over words such as *carro* 'car' and *ruim* 'bad', with intervocalic and word-initial back fricatives. Again, the speaker could have stylistic information attached to the uvular fricatives, allowing them to be activated in emphatic speech.

The overlapping of categories is what makes the phonological contrast incomplete in the rhotics of BP: coda and weak-r share some variants, and coda and strong-R share some other variants. On the other hand, weak-r and strong-R variants do not coincide (except in specific words such as *besouro* 'beetle' and *guelras* 'gills'), and most coda variants only occur in coda. This kind of fuzziness between phonological categories is easily accommodated in the Exemplar approach because language is seen as a cognitive process like any other human activity. As Ladd (2006) points out, in other cognitive domains no one is surprised to find complex relations between categories: a superordinate category (e.g. *animal, mammal, quadruped*) can comprise basic level categories (*cat*, *dog*) and subcategories (*spaniel*, *collie*). Ladd suggests that phonemes may be seen as language-specific phonetic categories that do not have to contrast with each other absolutely, establishing what he calls "quasi-contrast". Similarly, Hualde (2004) suggests that dialect, speaker and style affect the level of overlapping in a language, and this level may determine phonological categorisation for a given speaker. Scobbie & Stuart-Smith (2008) also conclude that a model that defines categorical phonemes in a situation in which phonological phenomena are "fuzzy" fails to capture the fact that the speakers can have alternative or intermediate solutions in their minds to the incomplete and ambiguous paradigms that surround them. This is why the authors suggest that an exemplar approach is better suited to encompass this sort of messy and ambiguous facts than many other approaches.

The archiphoneme has been the solution for neutralised contexts, which is what the coda context could be seen as in the Praguean tradition (e.g. Trubetzkoy 1939). However, there is evidence that adults categorise "neutralised" sounds as belonging to one of the neutralised categories (Mompeán-González 2004), i.e. speakers have allophonic awareness (Ladd 2006). A study on language attitudes has already demonstrated that in the context of Minas Gerais, coda rhotics can carry stereotypical information on origin, education level and personality (Rennicke 2011). For this reason, we argue that there is a perceptual and therefore cognitive difference between the coda variants, which is why the concepts of "neutralisation" or "archiphoneme" are not suitable for explaining the variation.

We propose, then, that the rhotics of BP are a superordinate category that consists of at least three categories (weak-r, strong-R and coda). These categories, in turn, may consist of subcategories regarding manner and place of articulation, and some of these subcategories may expand over more than one basic level category. Figure 8.3 is an attempt at visualizing the rhotic categories of BP and the variants of which they consist. We can see that, in fact, there are more variants that belong to two categories than variants that belong to only one category. In addition, if we accept that the aspirated approximants are a merger of the anterior and posterior coda lenition trajectories, even these two subcategories can be seen to overlap each other inside the coda category. Of course, one of the main points of this dissertation has been that rhotics themselves are not a closed and easily defined category; rather, they also overlap with other phonological categories such as vowels. This is why Figure 8.3 also attempts to represent this overlap of [ə], [w], [ɚ] and [j] with the vowel system of BP. [ə] can occur as the nucleus of unstressed syllables, and [w j] in diphthongs, but they are also variants of coda rhotics. In addition, [ɚ] is nuclear and therefore vocalic, but also rhotic due to its acoustic and perceptual quality. Thus the phonological representation of rhotics is a Complex Adaptive System shaped by the interaction and overlap of the subcategories it comprises, but also by other sound categories and the phonological system as a whole.

So far we have explained how the mental representation of rhotics emerges as generalisations over encountered tokens of words that contain rhotics. This explains the ability of BP speakers to perceive different rhotic variants: for instance, the speaker may hear a word with any of the 16 possible coda rhotics (in addition to deletion) and perceive that word correctly because the speaker may have already encountered that particular word or other words with a phonetically similar variant, and that variant has left a trace in the speaker's memory and possibly begun to form a generalisation over the possibility of that segment having the same phonological value as other, perhaps more familiar variants. However, if the variant were novel to the speaker, she relies on the semantics of the communication context to determine what lexical item is being used, and once meaning is attached

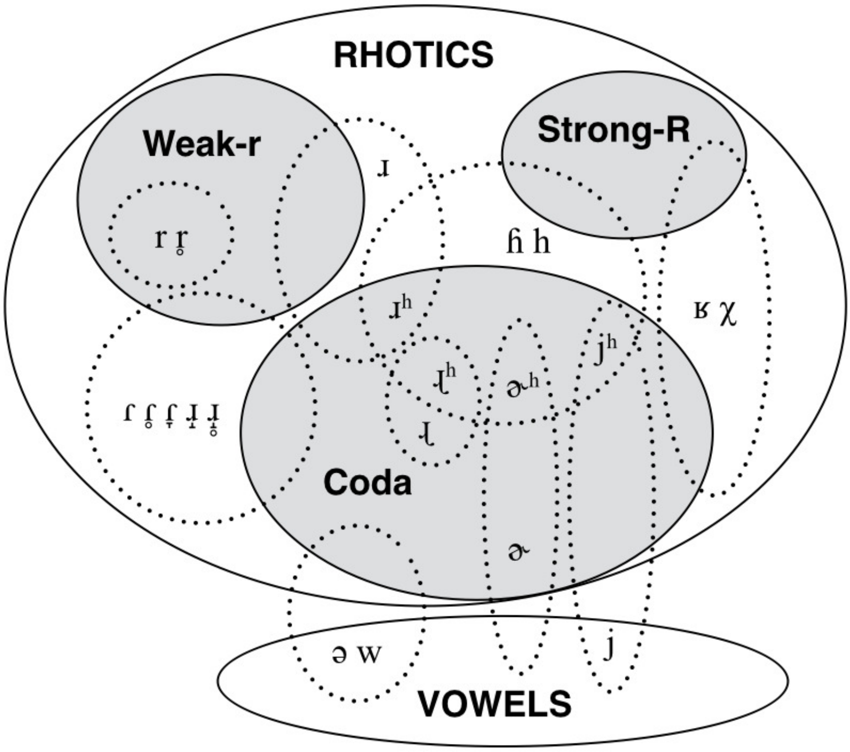


Figure 8.3: Categorisation and phonetic overlap of rhotics in BP

to the phonetic form, a mental representation of that novel variant can be formed, as described above.

What is the relation between perception and production in the model being outlined? Why do speakers grow up and live their lives perceiving several different variants, but only use a selection of them? Section 3.2.5 of this dissertation offered an introduction to applying the Exemplar approach to speech production. According to Pierrehumbert (2001), production is sensitive to exemplar strength in the same way as perceptual classification. In speech production, lexical items are activated, which also activates in a probabilistic manner the phonetic categories they are composed of: phonetic targets with the strongest mental representation are usually activated. These targets are not always achieved completely, and as they become more automatic over time, they suffer lenition, which leads to the reorganisation of sound categories in the speaker's mental representation, and possibly that of the speech community.

In order to produce the different rhotics of BP, the speaker has some phonetic target that already has a strong mental representation. This target is based on ego exemplars of articulation (Johnson 1997), or "phonetic imitation" (Pierrehumbert 2002), which are the articulatory patterns an individual has developed as corresponding to perceptual stimuli. The results of this dissertation have shown that the speakers produce rhotics within a range of gradient variation; that range is quite limited in strong-R contexts, moderate in weak-r contexts, and very wide in coda contexts. Therefore we can conclude that the gradient variation is a consequence of the speakers not reaching the phonetic target, and this ongoing automatisation and weakening of gestures has led to the variation observable in a synchronic data set.

This study has therefore established that articulatory lenition, or weakening, is the driving force behind change in the rhotics of BP. This lenition has mostly been approached in Brazilian linguistics in terms of coda context and the presence or absence of a rhotic segment. Table 8.6 presents a summary of the percentages found for *r*-deletion in word-medial codas and word-final codas by selected authors. Word-final codas appear separated into nominals and verbs, and information on the studied region and other observations can be found in the last column. The authors appear listed according to the approximate time of data collection, starting from the most remote. The data come from various geographically distant locations, and the NURC data used by Callou et al. (1996) come from five different cities (Porto Alegre, São Paulo, Rio de Janeiro, Salvador, Recife).

Table 8.6 demonstrates that irrespective of geographical location, coda lenition (and, as a consequence, coda deletion) of rhotics has advanced considerably since the 1970s. In addition, it becomes clear that verb forms with word-final *r*'s are leading this change, followed by nominals, and lastly by word-medial coda. Syllable coda is the context leading lenition in rhotics (and other consonants), but while these coda segments are being deleted through one strategy or another, other coda contexts are already emerging due to lenition processes in unstressed syllables. The innovation in this dissertation has been to show that the lenition and ultimate deletion

Reference	Medial	Final (nom.)	Final (verbs)	Region, observations
Callou et al. (1996)	3%	17%	65%	NURC data (circa 1970s)
Oliveira (1983, 1997)	12.08%	34%	95.4%	Belo Horizonte (MG)
Skeete (1997)	22%	n/a	n/a	João Pessoa (PB), data collected 1993-1995
Brandão (2008)	10%	n/a	n/a	Rio de Janeiro, data published 1995
Huback (2006)	n/a	22%	n/a	Belo Horizonte (MG), data only from spontaneous speech
Aguilera & Silva (2011)	0%	25%	75%	Lavras (MG)
Present study	22%	29%	97%	Southwestern MG

Table 8.6: Coda *r*-deletion in BP in selected sources

of rhotics not just in codas but in any position is not the result of applying a rule or one single mechanism; rather, rhotics in all positions undergo gradient lenition through articulatory reduction.

8.6 Conclusions

This dissertation set out to understand the system of rhotic consonants in a variety of Brazilian Portuguese. More specifically, the objective was to observe what causes sound change in rhotics, what is the direction of change, and how this affects the phonology of Brazilian Portuguese as a whole. Our hypothesis under the Complex Adaptive Systems approach was that many subsystems would contribute to sound change in rhotics, and this was confirmed by a thorough, unrestrained analysis of structural factors, articulatory factors, frequency effects, speaker, and speech style.

The articulation of strong-R (e.g. *rio* 'river', *carro* 'car') in BP is a dynamic process with at least three articulatory parameters: place of articulation (glottal *versus* uvular), degree of constriction (realisation *versus* deletion), and voicing. In terms of a Complex Adaptive System, the variation in the synchronic speech data collected for this study indicate a lenition trajectory from uvular fricatives to glottal fricatives and ultimately to deletion, with articulatory undershoot as its mechanism. Post-tonic position and adjacency to voiceless [s] are leading the leniting change towards deletion, and as such may be considered *attractors* in the lenition trajectory of strong-R. Articulatory reduction takes place in both of these contexts: post-tonic segmental material is being reduced in the studied dialect both substantially and temporally, and the change from [shV] to [sØV] can be considered temporal reduction by retiming, as the fricative airflow ceases before the articulatory configuration of the following vowel.

The average weak-r (e.g. *ca*<u>*r*</u>*o* 'expensive', *p*<u>*r*</u>*ato* 'plate') in any position was found to be a voiced alveolar tap [ɾ] or voiced alveolar approximant tap [ɾ̞]. In clusters, these two segment types may or may not be preceded by a vocalic segment that eases the articulation of a Cɾ-sequence. Fricative and approximant variants as well as deletion, all considered lenited from a synchronic point of view, belong to a more informal register. Fricatives and approximants are weak-r variants emerging from a reduction in the magnitude of the tap gesture, and this reduction ultimately leads to deletion. Weak-r lenition is part of a bigger picture involving word stress and the reduction of all unstressed segments in BP through the devoicing or deletion of adjacent vowels, which turns post-tonic weak-r into a word-final coda segment. This post-tonic lenition is driven by adjacent high vowels ([i ɪ u ʊ]) and the plural marker [s]. The voicing of the preceding consonant in Cɾ-clusters can also determine the realisation of weak-r: lenition is somewhat more frequent after voiceless consonants. The high-frequency preposition *para* 'to; by; for' was found to involve more lenition than the average for pɾ-clusters. Higher type frequency was found to possibly hinder devoicing lenition of weak-r in *-ra* and *-ram* words, whereas lenition is more advanced in words ending in *-ro, -ros* and *-ris.* The articulation of weak-r is dynamic, and takes place within at least two articulatory parametres: stricture and voicing.

In codas, the rhotic variants range from alveolar taps and approximant taps to various approximants of different tongue configurations, uvular and glottal fricatives, and deletion (following which the nucleus vowel may remain intact or be centralised). The articulatory gesture(s) responsible for the lowering of the third formant in retroflex approximants may overlap the configuration of the preceding vowel, resulting in a syllabic schwar-like vowel. Another alternative is for the diphthong-like VR to lose rhoticity and become a centralizing V[ə] diphthong. VR sequences in syllable rhyme (V[ɹ] ∼ V[j] ∼ V[ɻ] ∼ [ɚ]) can also be produced with an additional aspiration. The factors causing lenition in coda rhotics can be related to both structure and frequency effects. Structural factors that were found to cause increased lenition in the data are frontness of the preceding vowel (as it promotes [ɚ]); unstressed position in general; and in word-final position, a qualitative analysis found rhotics to undergo less deletion in one-syllable nominals. The conjunction *porque* 'because' involved more lenition than the average for word-medial codas. In word-final codas, alternating environments (most likely combined with morphophonetic changes in BP) determine the course of word-final lenition in nominals, verbs and the preposition *por*. Speakers use *r*-variants from two different lenition trajectories (anterior and posterior) influenced in varying degrees by sociolinguistic notions attached to these trajectories, which points to a non-deterministic tendency of coda lenition in the studied dialect.

The results of this study show that not only the rhotics but also the whole consonantal system, vowel system and the stress system of Brazilian Portuguese are self-organizing. As predicted in the Complex Adaptive Systems approach, changes in subsystems interacting with each other cause changes in the system as a whole. This means that the system (or in this case, language) is not aiming towards a goal (*top-down*); instead, change in the system is brought on by alterations in inferior structures (*bottom-up*), and these alterations may or may not conspire to affect higher-level structures. When unstressed (especially post-tonic) vowels are reduced, new consonant clusters and coda contexts emerge. This brings about a new stress pattern of oxytone words with word-final consonants—including rhotics—that can eventually go through the same reductive changes that are taking place in word-final consonants at this moment.

The *state-space* for the rhotics of Brazilian Portuguese has been and still is articulatorily wide: they can occupy alveolar, alveo-palatal, velar, uvular, and glottal places of articulation; and trill, tap, fricative, approximant, and other vowel-like manners of articulation. Diachronically speaking, the rhotics of BP have taken two different paths of change, one anterior (alveolar and alveo-palatal places of articulation) and another posterior path (velar, uvular, and glottal places of articulation). In both of these paths, the universal mechanisms of substantive and temporal reduction have acted as the driving force behind change. In the anterior trajectory, substantive reduction has turned full-constriction variants into fricatives and approximants, and temporal reduction has given rise to [ɚ] by overlapping the gestures of a vowel and a following approximant. The posterior trajectory has also undergone substantive reduction not only in the passage from full-constriction variants to fricatives, but also the debuccalisation of these velar-uvular fricatives into glottal fricatives. In turn, these glottal fricatives are being deleted when friction is retimed according to an adjacent fricative with a supraglottal constriction (such as [s]).

This study has pointed out some factors that are pulling the leniting change in rhotics towards themselves. These factors, called *attractors* in the CAS approach (Bybee 2010; Massip-Bonet 2013; Bybee & Beckner 2015), include post-tonic position, adjacency to the voiceless fricative [s] and/or the high vowels [i ɪ u ʊ], and coda position, which involves more lenited *r*-variants and deletion than any other context. Once sound change begins to generalise in these contexts, it can also spread to other *r*-contexts. All sound changes are initiated by individuals interacting in a speech community, and this study has shown that not all speakers take on general lenition tendencies at the same pace or in the same manner even if they are from the same region, speech community, age group, education level, or of the same gender. This is further evidence for the essential non-determinism of lenition in the rhotics of BP.

This dissertation also had the objective of outlining a model of the rhotics of BP, defining a basis for *r*-classhood, and addressing the phonological status of BP rhotics. As for modelling the rhotics, we established that most relations between rhotic variants are based on lenition, i.e. substantive or temporal reduction of the articulatory gesture. In the network of rhotic variants, we found that [r] → [ɾ] and the possible diachronical change [r] → [ʀ] were the only exceptions to this tendency; all other variants can be explained as the result of gestural undershoot. Classhood, then, is based on historical and synchronic allophonic connections between variants. Rhotics can *resemble* each other (Lindau 1985), but more often lenition has distanced variants to an extent that there is no observable resemblance, but only *relationships* (Sebregts 2014). In addition, we would like to emphasise that rhotics must always be considered *language-specific* because, being the "elsewhere category" that they are (Scobbie 2006), the lenition processes they are subject to can lead them to occupy any articulatory space that does not defy phonological contrast.

The incomplete contrast created by overlapping rhotic variants is a challenge for feature-based phonological definitions. Gradient lenition has lead to a situation in which strong-R can be defined in terms of manner but not place of articulation; weak-r, on the other hand, has a stable place of articulation, but varies in manner; and coda rhotics cannot be defined by either parameter. Therefore, instead of assigning articulatory labels, we proposed that the rhotics of Brazilian Portuguese are best understood as part of a phonetic-semantic network of linguistic structures under the Exemplar Models approach. Phonological generalisations (or categories) arise from the detailed phonetic information that is stored with every lexical item. These categories depend on the individual language experience of the speaker, and that is why no two speakers produce rhotics, or any other speech sounds, in exactly the same way.

The driving motivation behind the conception of this dissertation has been to produce a detailed description and analysis of rhotics without the interference of pre-established nomenclature, categorisation and, up to some extent, the human ear. This is why we have dealt with many more variants than previous studies contemplating the rhotics of Brazilian Portuguese in the sociolinguistic or phonological tradition, thus avoiding the simplistic attribution of gradient variation phenomena to macro-categories recycled from other scholars. In particular we would like to point out the discovery of a gradient lenition trajectory from alveolar taps to approximants and schwar ([ɾ] → [ɾ̞] → [ɹ] → [ɻ] → [ɚ]). This is what we mean by the interference of the human ear: without a computer-assisted acoustic analysis, this chain of events would most likely go unnoticed, and these variants be fit into two predetermined categories ([ɾ] and [ɻ]), which obscures the origin of the different approximants and encourages explanations for sound change based on phonetic loans or alterations in distinctive features. Phonetic detail has been speaking for itself throughout this dissertation and in favour of the articulatory motivations behind sound change.

The methodological implication of this study is that the type of data collected for phonological analysis makes a difference. More specifically, we have demonstrated that in order to observe reduction phenomena in Brazilian Portuguese, it is necessary to collect "laboratory speech" through elicitation, but also spontaneous speech. Laboratory speech establishes a baseline articulation against which the elevated reduction of spontaneous speech can be compared. Of course, not all speakers produce citation forms even in an elicitation task (as was obvious in the fair amount of coda deletion in the task data of this study), which raises the interesting question as to what exactly constitutes the citation form if some speakers are already more advanced in the leniting change. The results obtained by two different data collection methods also underline the importance of speech style: not only can elicitation prompt more *complete* forms, it can prompt *different* forms. This was the case when some of the recorded speakers introduced back fricatives as coda variants in the sentence completion task when they used none in the interviews. Socially related factors are present in any recording situation, and it is the researcher's task to assign them the importance they deserve in the speech community in question, as this can affect the outcome of the recordings and, consequently, any analyses performed on those recordings.

Another issue related to methodology concerns avenues for future research on the rhotics of Brazilian Portuguese. As we have pointed out on several occasions throughout this dissertation, to our knowledge there have been no articulatory studies on the production of BP rhotics. Therefore, the exact gestures causing different formant trajectories in coda approximants, for instance, remain unknown, and any articulatory label assigned to these variants is speculative and based on studies on other languages. An Ultrasound Tongue Imaging (UTI) study of these approximants could confirm or refute the sound change trajectories outlined in this dissertation. The link between alveolar and uvular rhotics—deemed essentially perceptual in this study based on the existing literature—could also be articulatory in Portuguese, and this can only be verified by looking at possible secondary articulations. In addition, a study focusing on vowel quality after *r*-deletion in coda could shed light on other ways of cueing rhoticity: these can include centralisation and lengthening of the nucleus vowel.

Rhotics are a tiny fraction of all the linguistic phenomena—phonological, morphological, syntactic, semantic, pragmatic—that form a Complex Adaptive System called the Portuguese language. This study has been a modest contribution to understanding what causes change in one subsystem, and how that subsystem affects and is affected by changes in other subsystems. Understanding this particular subsystem makes it possible to understand why and how the system as a whole changes.

Speakers, idiolects, and languages—or rhotics—are never the same today as they were yesterday. Small variations that seem insignificant at one moment in time may eventually lead to changes that render the earlier *status quo* unrecognisable. We hope to have shown that this is exactly what happened (and is happening) to the rhotics of Brazilian Portuguese: rhotics change because other sounds change, because words change, and because the people who use these words also change.

Appendices

Appendix A

Sentence completion task

Tables A.1–A.9 list the target words included in the sentence completion task, phonological contexts for rhotics in the target words, and carrier sentences used in the task. "R" stands for strong-R, "r" for weak-r and "c" for coda. Surrounding segments are denoted with "C" (consonant) and "V" (vowel).

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning	Observation
rádio	#RV	S	20,020	Eu ouço rádio para saber as últimas notícias. 'I listen to the radio to hear the latest news.'	
rainha	#RV	U	9,207	A rainha é a mulher do rei. 'The queen is the king's wife.'	
garrafa	VRV	S	2,876	A garrafa de cerveja está cheia. 'The beer bottle is full.'	
barra	VRV	U	10,713	Eu quero comer uma barra de chocolate. 'I want to eat a chocolate bar.'	
carro	VRV	U	62,766	O carro é vermelho. 'The car is red.'	Minimal pair with *caro*

Table A.1: Target words for strong-R

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning	Observation
barata	VrV	S	3,885	Tem uma barata no chão. ‘There is a cockroach on the floor.’	
cara	VrV	U	22,483	Eu jogo a moeda para sair cara ou coroa. ‘I throw the coin to get heads or tails.’	
caro	VrV	U	9,266	O carro é mais caro que a bicicleta. ‘The car is more expensive than the bicycle.’	Minimal pair with *carro*
tráfico	#CrV	S	12,754	O tráfico de drogas é um problema nas fronteiras. ‘Drug trafficking is a problem at borders.’	
trabalho	#CrV	U	129,023	A criatividade é uma vantagem do trabalho em equipe. ‘Creativity is an advantage of team work.’	

Table A.2: Target words for weak-r

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning
carta	Vc$	S	23,774	Eu coloco a carta no envelope. ‘I put the letter in the envelope.’
cartão	Vc$	U	15,274	Para pagar com cartão é preciso saber a senha. ‘In order to pay by card it is necessary to know the PIN number.’
barco	Vc$	S	6,195	Um passeio de barco é uma boa forma de relaxar. ‘A boat trip is a good way to relax.’
arquitetura	Vc$	U	8,665	A arquitetura é a arte de projetar construções. ‘Architecture is the art of designing buildings.’

Table A.3: Target words for word-medial coda

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning	Observation
mar	Vc#C	S	21,625	Para um navegador inexperiente o mar pode ser perigoso. 'For an inexperienced sailor, the sea can be dangerous.'	Monosyllabic nouns ending in *-er*, *-ir*, *-ur* not present in the ASPA corpus or semantically unsuitable for sentence completion task
	Vc#V			O mar é vasto e azul. 'The sea is vast and blue.'	
	Vc##			A tartaruga é um animal que vive no mar. 'The turtle is an animal that lives in the sea.'	
dor	Vc#C	S	10,131	Estou com dor de cabeça. 'I have a headache.'	
	Vc#V			Sinto uma dor insuportável nas costas. 'I feel unbearable pain in my back.'	
	Vc##			Uma má postura pode causar dor. 'A bad posture can cause pain.'	

Table A.4: Target words for word-final coda: monosyllabic nouns

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning	Observation
mulher	Vc#C	S	70,112	O homem tem cabelo castanho, e a mulher tem cabelo louro. 'The man has brown hair, and the woman has blonde hair.'	Stressed *-ar*, *-ir*, *-ur* nouns not present in the ASPA corpus or semantically unsuitable for sentence completion task
	Vc#V			A mulher é mais alta que o homem. 'The woman is taller than the man.'	
	Vc##			O homem é mais alto que a mulher. 'The man is taller than the woman.'	
computador	Vc#C	S	20,532	O computador tem um monitor, um teclado e um mouse. 'The computer has a screen, a keyboard and a mouse.'	
	Vc#V			Escrever no computador é mais fácil que à mão. 'Writing on the computer is easier than by hand.'	
	Vc##			Três pessoas estão usando o computador. 'Three people are using the computer.'	
açúcar	Vc#C	U	9,801	O açúcar pode ser substituido por adoçante. 'Sugar can be replaced with sweetener.'	
	Vc#V			O açúcar é doce. 'Sugar is sweet.'	
	Vc##			O café pode ser consumido com leite e açúcar. 'Coffee can be consumed with milk and sugar.'	

Table A.5: Target words for word-final coda: polysyllabic nouns

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning
melhor	Vc#C	S	119,542	Gostei muito do filme. A melhor parte foi a perseguição. 'I liked the movie a lot. The best part was the chase.'
	Vc#V			O Pedro é meu melhor amigo. 'Pedro is my best friend.'
maior	Vc#C	S	175,984	O elefante é maior que o rato. 'The elephant is bigger than the mouse.'
	Vc#V			A baleia-azul é o maior animal do mundo. 'The blue whale is the biggest animal in the world.'

Table A.6: Target words for word-final coda: *melhor* and *maior*

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning
dar	Vc#C	S	69,635	Não vai dar tempo de eu chegar na hora. ‘There is not enough time for me to get there on time.’
	Vc#V			Eu vou dar um presente para minha amiga. ‘I’m going to give my friend a present.’
	Vc##			Preciso consertar meu carro mas hoje já não vai dar. ‘I need to fix my car but today it’s not possible anymore.’
ser	Vc#C	S	514,408	Eu quero ser professor quando crescer. ‘I want to be a teacher when I grow up.’
	Vc#V			Eu quero ser um bom amigo para você. ‘I want to be a good friend to you.’
	Vc##			Estou ansioso para saber minha nota. Não sei qual vai ser. ‘I’m eager to know my grade. I don’t know what it will be.’
ir	Vc#C	S	38,938	Quero ir para a praia. ‘I want to go to the beach.’
	Vc#V			Eu preciso ir ao supermercado. ‘I need to go to the supermarket.’
	Vc##			Estou perdido. Não sei para onde eu devo ir. ‘I’m lost. I don’t know where to go.’

Table A.7: Target words for word-final coda: monosyllabic verbs

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning
falar	Vc#C	S	39,119	Na biblioteca é preciso falar baixo. 'In the library you need to talk quietly.'
	Vc#V			É bom saber falar uma língua estrangeira. 'It's good to know a foreign language.'
	Vc##			Estou com dor de garganta e não consigo falar. 'I have a sore throat and I can't speak.'
fazer	Vc#C	S	165,380	A Luísa quer fazer cócegas nos pés do Pedro. 'Luísa wants to tickle Pedro's feet.'
	Vc#V			Amanhã a Luísa vai fazer oito anos. 'Tomorrow Luísa will be eight years old.'
	Vc##			Tenho que encontrar uma solução. Não sei o que devo fazer. 'I have to find a solution. I don't know what I should do.'
sair	Vc#C	S	30,091	Não posso sair de casa porque estou de castigo. 'I can't leave the house because I'm grounded.'
	Vc#V			A Maria quer sair à noite com suas amigas. 'Maria wants to go out at night with her friends.'
	Vc##			Estou perdido no labirinto e não consigo sair. 'I'm lost in the labyrinth and can't find my way out.'

Table A.8: Target words for word-final coda: two-syllable verbs

Lexical item	Phonological context	Stressed (S) / Unstressed (U)	ASPA frequency	Sentence and meaning
qualquer	Vc#C	S	87,041	O João ama a Maria. Ele faria qualquer coisa por ela. 'João loves Maria. He would do anything for her.'
	Vc#V			A Maria pode comprar o carro que quiser. Ela pode comprar qualquer um. 'Maria can buy any car she wants. She can buy any car.'
por	Vc#C	S	1,273,087	Não posso sair de casa por causa da gripe. 'I can't leave the house because of the flu.'
	Vc#V			O João quase morreu. A vida dele estava por um fio. 'João almost died. His life was hanging by a thread.'
besouro	VrV or VRV	U	208	O besouro é um inseto que tem uma casca dura. 'The beetle is an insect that has a hard shell.'
guelras	VrV or VRV	U	24	Com as guelras os peixes respiram. 'With gills, fish breathe.'

Table A.9: Other target words: *qualquer*, *por*, *besouro*, *guelras*

Appendix B

Consent form

Termo de consentimento livre e esclarecido

Nome do participante:	________________________________
Telefone:	________________________________
Nome da Pesquisadora Principal:	IIRIS RENNICKE
Instituição:	UNIVERSIDADE DE HELSINQUE /DEPARTAMENTO DE LÍNGUAS MODERNAS
Tema da pesquisa:	Representações fonológicas no português
Propósito da pesquisa:	Estudar as representações fonológicas de falantes de português através de entrevistas e um experimento de preenchimento de lacunas.
Compensação financeira:	Não existirão despesas ou compensações financeiras relacionadas à participação no estudo.
Incorporação ao banco de dados da pesquisa acima referida:	Os dados obtidos na forma de gravações em áudio serão incorporados ao banco de dados, cujos responsáveis zelarão pelo uso anônimo e aplicabilidade das amostras exclusivamente para fins científicos.
Confidencialidade:	Os resultados desta pesquisa poderão ser publicados em jornais profissionais ou apresentados em congressos internacionais, sem que a identidade do participante seja revelada.
Contato da pesquisadora:	E-mail: [redacted] Telefone: [redacted]

Aceito participar neste estudo e em ceder os meus dados para o banco de dados e a sua utilização para fins científicos. Receberei uma cópia assinada deste termo de consentimento.

Data ______ / ______ / ___________

____
Assinatura do participante

____
Assinatura da pesquisadora

Appendix C

Strong-R: individual speakers

Variants of strong-R in the semi-structured interviews. Token count appears in parentheses.

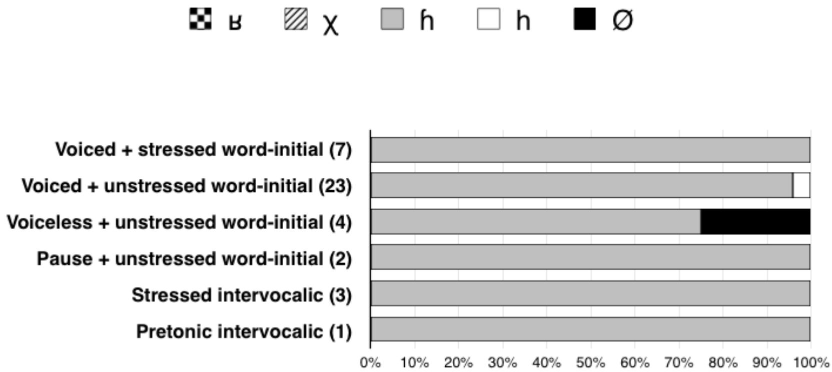


Figure C.1: F1

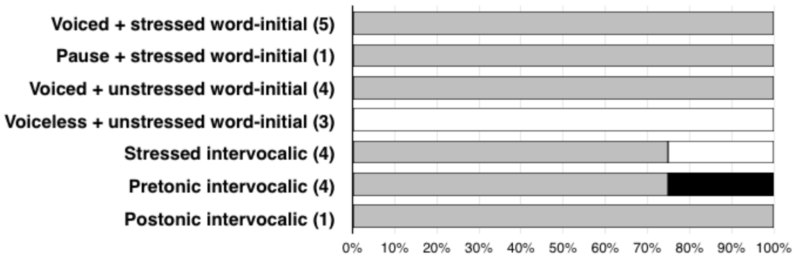


Figure C.2: F2

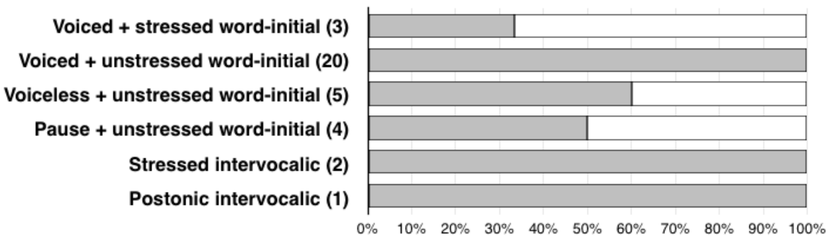


Figure C.3: F3

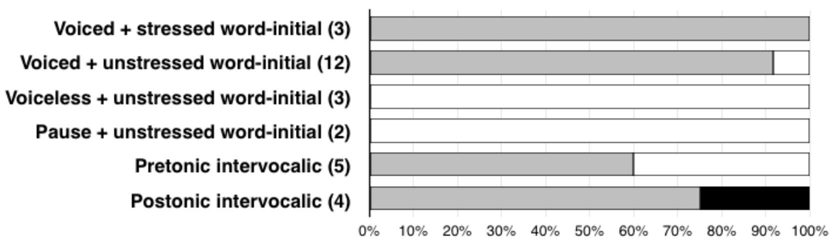


Figure C.4: F4

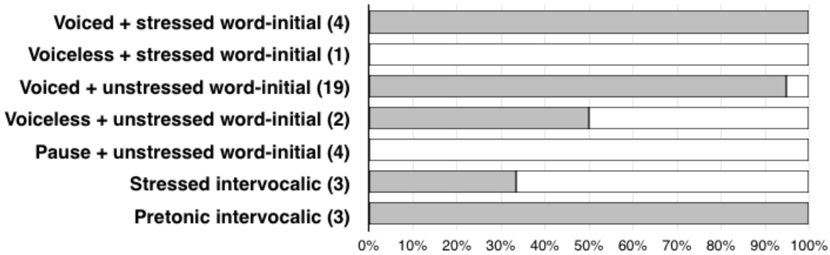


Figure C.5: F5

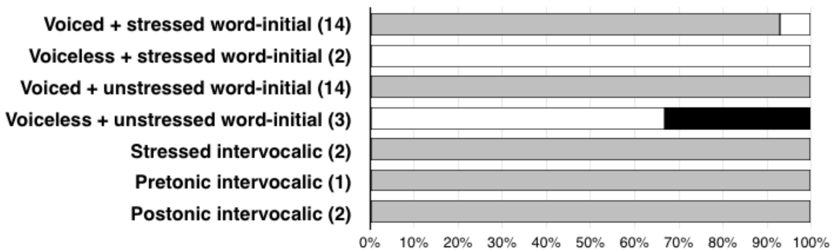


Figure C.6: F6

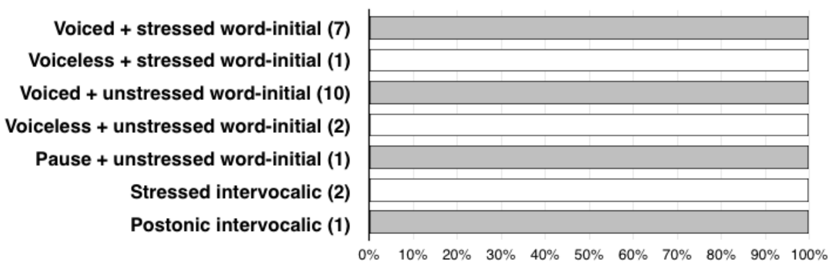


Figure C.7: F7

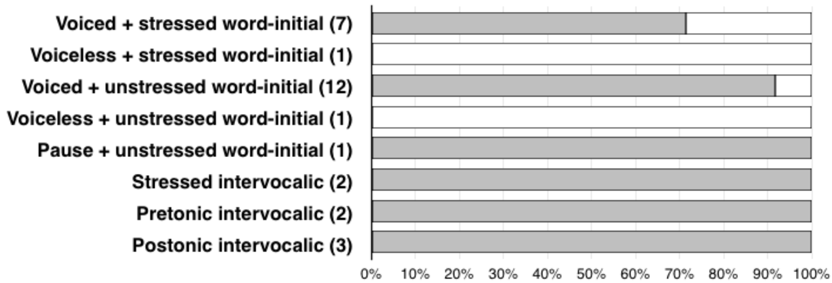


Figure C.8: M1

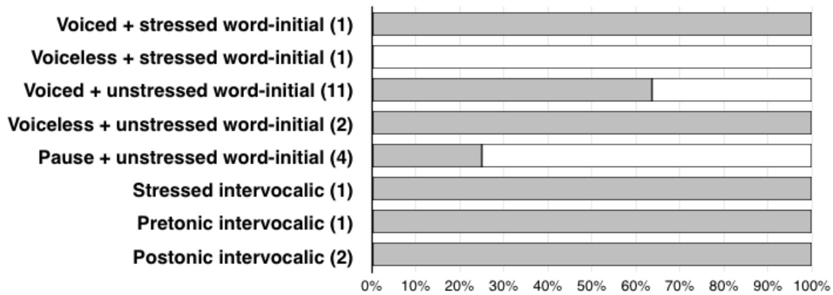


Figure C.9: M2

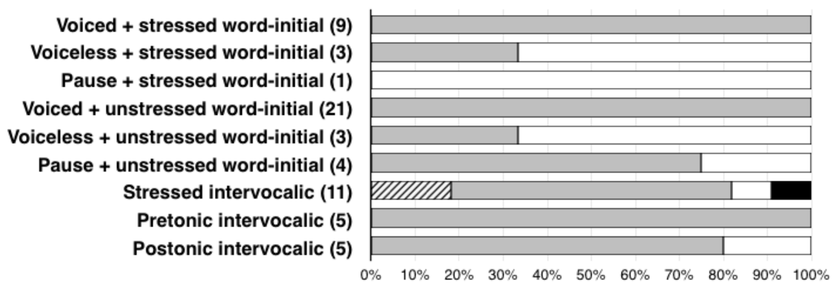


Figure C.10: M3

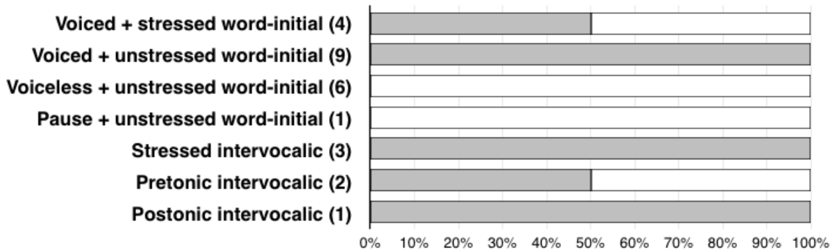
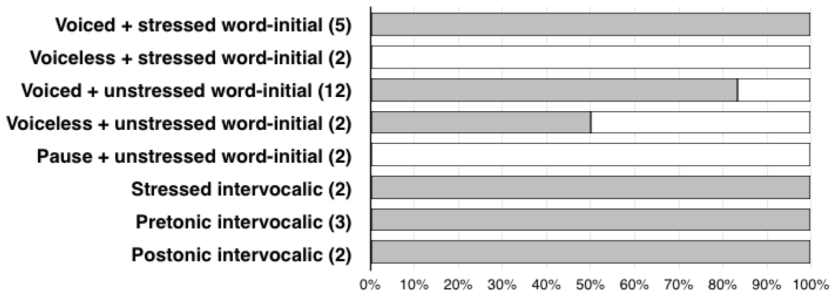


Figure C.11: M4



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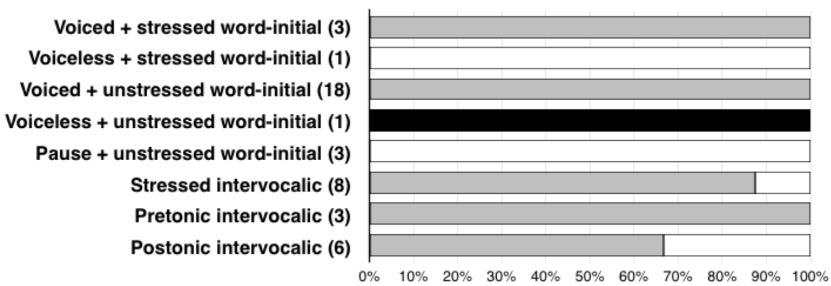


Figure C.13: M6

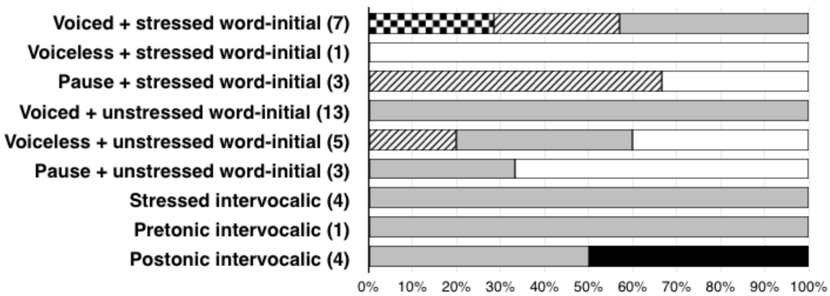
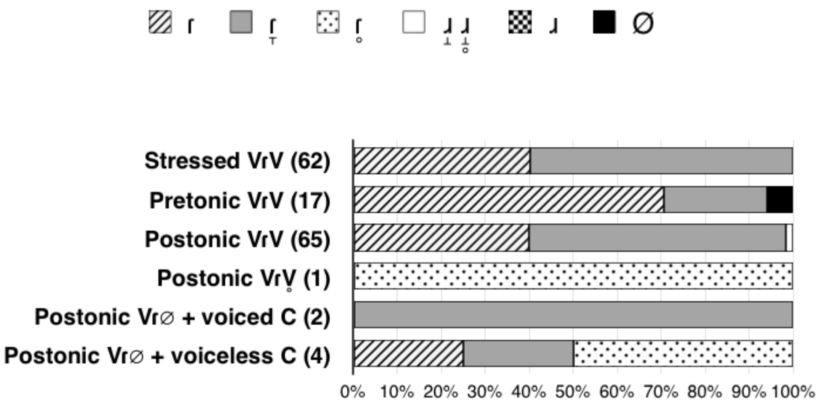


Figure C.14: M7

Appendix D

Intervocalic weak-r: individual speakers

Variants of intervocalic weak-r in the semi-structured interviews. Token count appears in parentheses.



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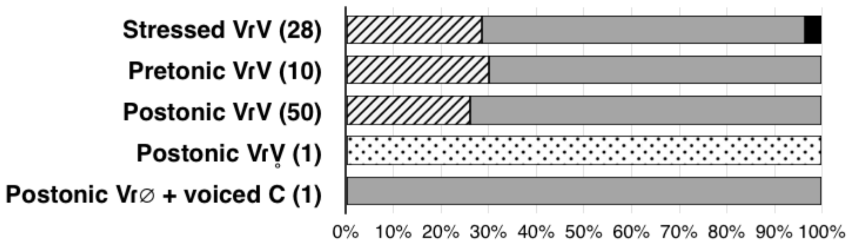


Figure D.2: F2

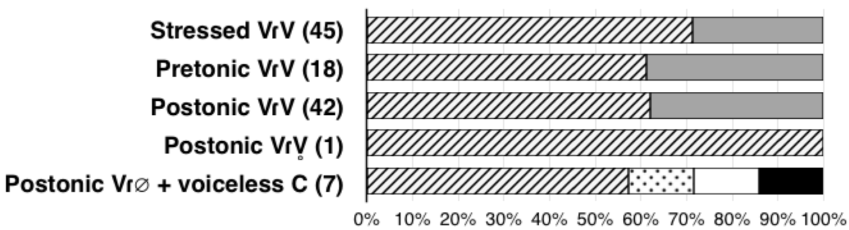


Figure D.3: F3

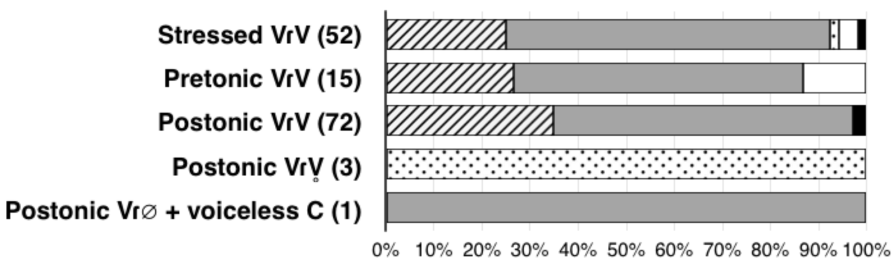


Figure D.4: F4

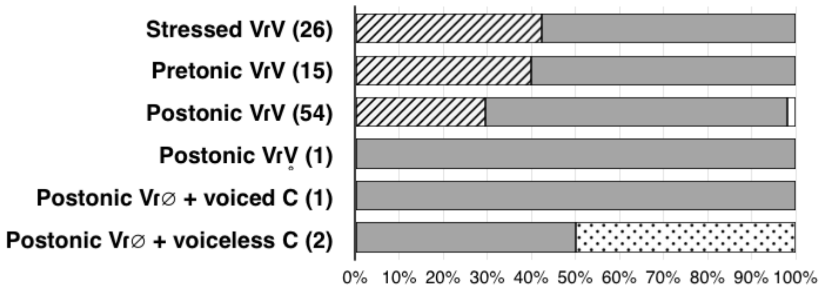


Figure D.5: F5

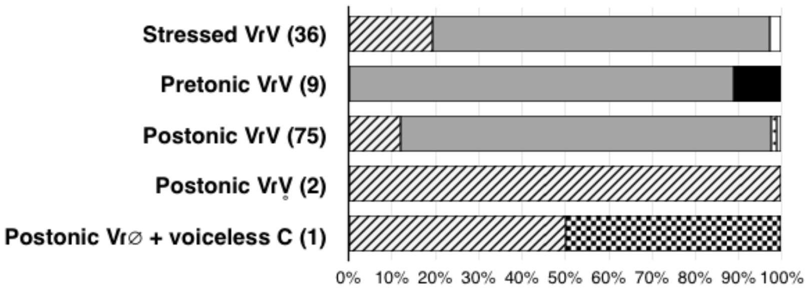


Figure D.6: F6

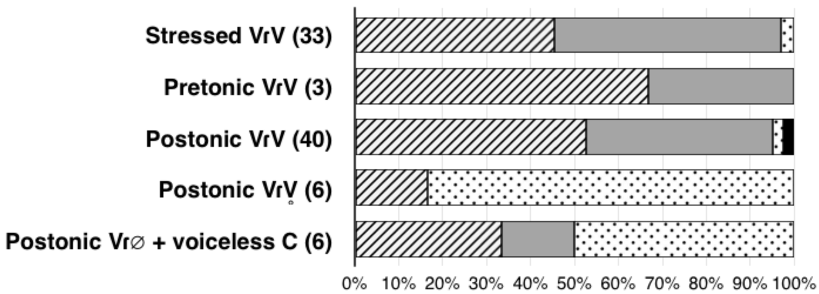


Figure D.7: F7

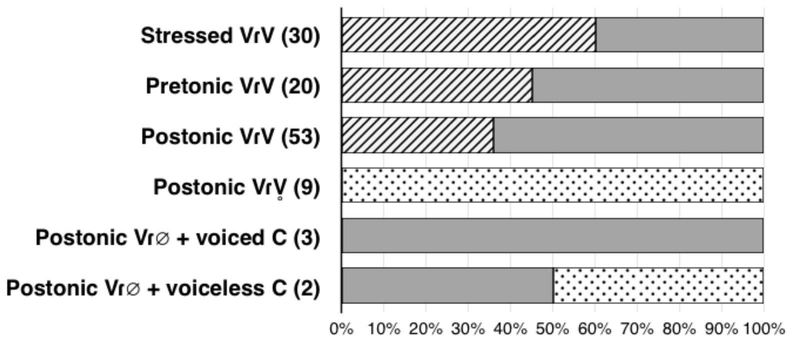


Figure D.8: M1

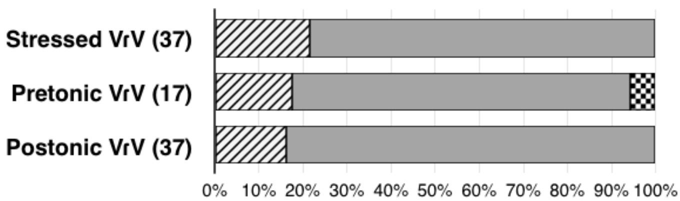


Figure D.9: M2

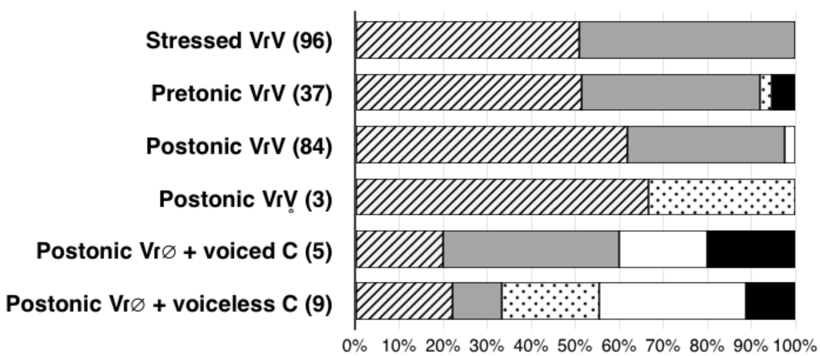


Figure D.10: M3

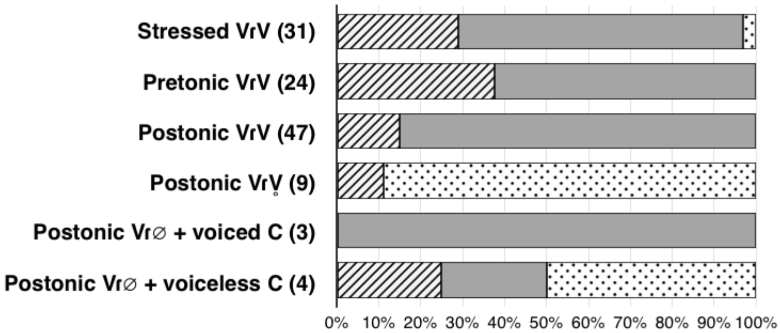


Figure D.11: M4

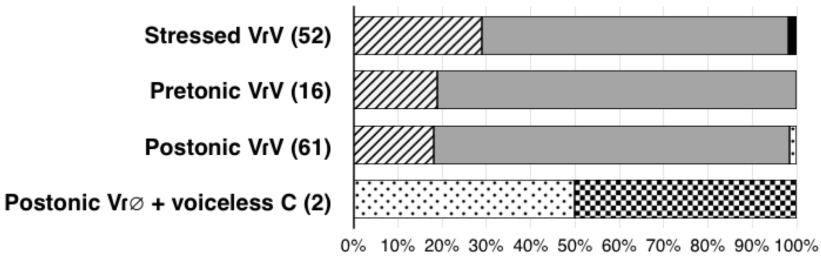


Figure D.12: M5

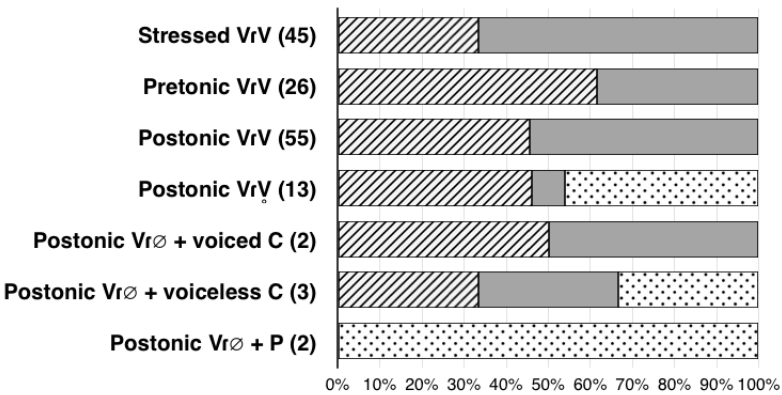


Figure D.13: M6

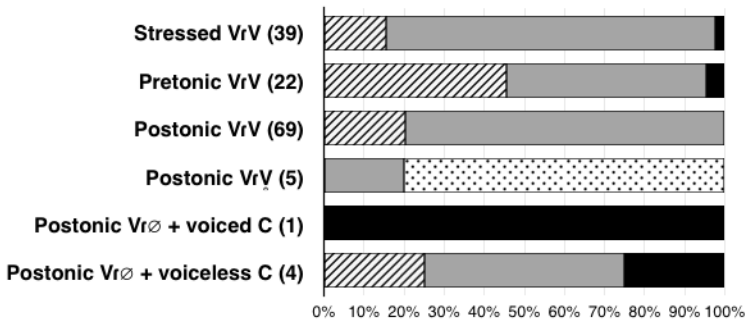
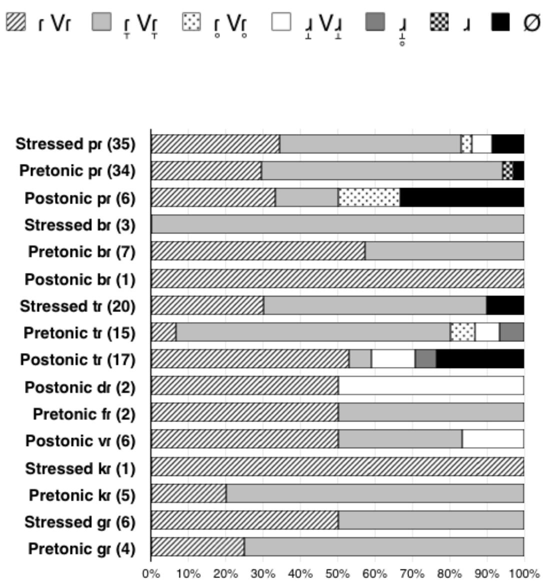


Figure D.14: M7

Appendix E

Weak-r in clusters: individual speakers

Variants of weak-r as the second member of consonant clusters in the semi-structured interviews. Token count appears in parentheses.



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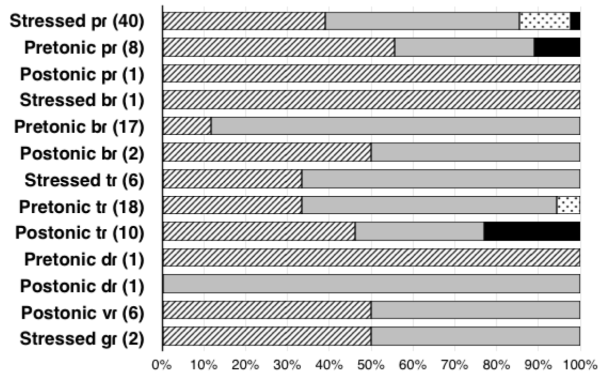


Figure E.2: F2

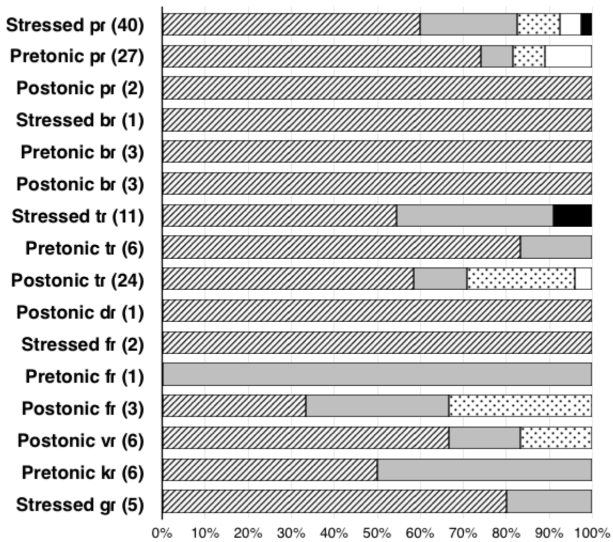


Figure E.3: F3

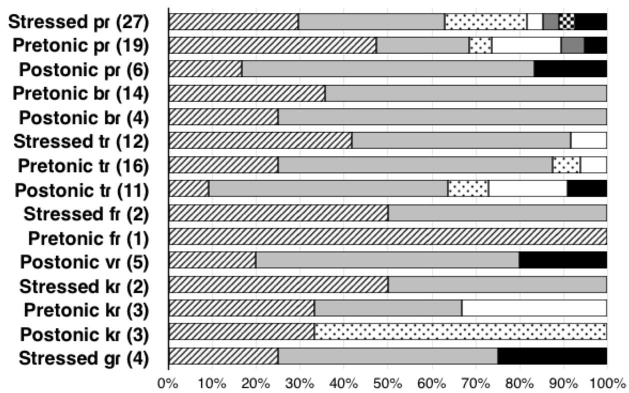


Figure E.4: F4

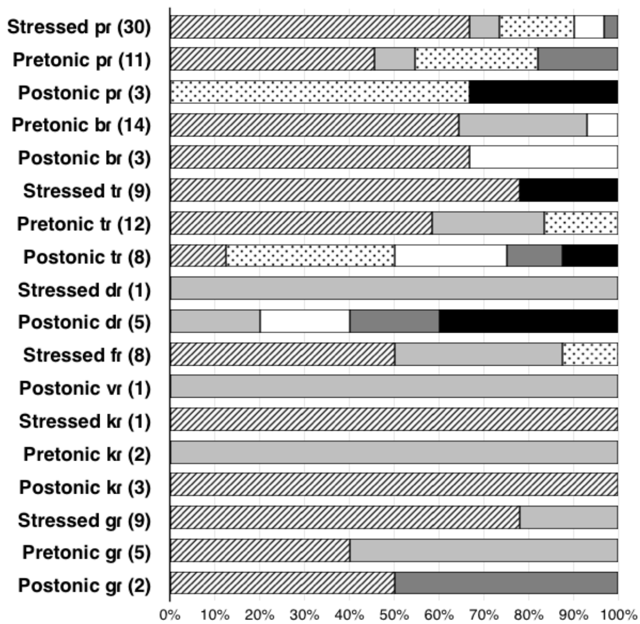


Figure E.5: F5

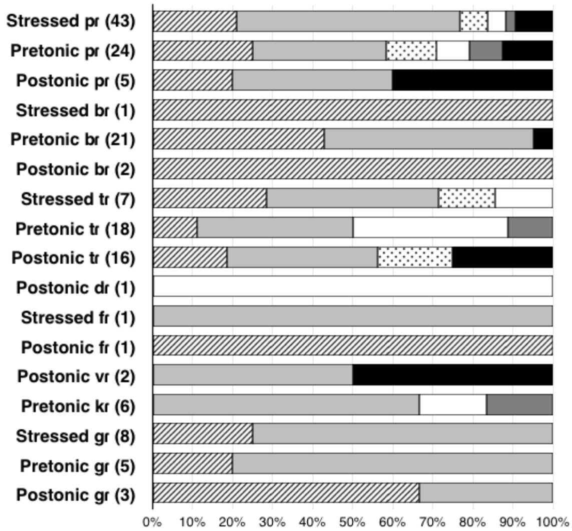


Figure E.6: F6

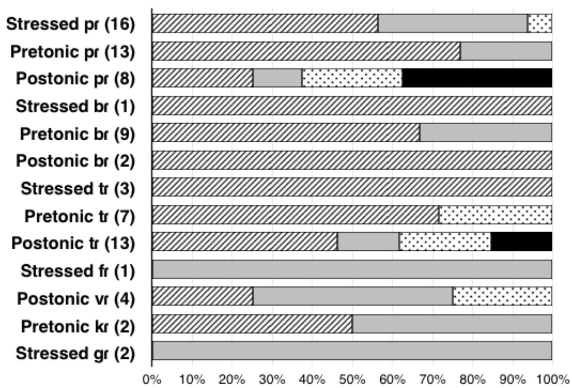


Figure E.7: F7

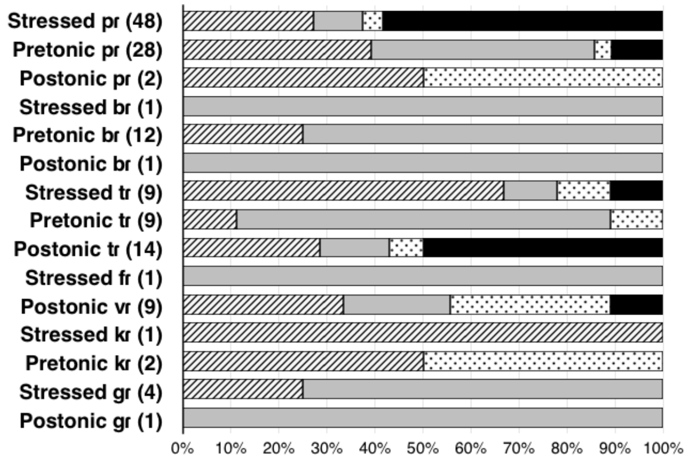


Figure E.8: M1

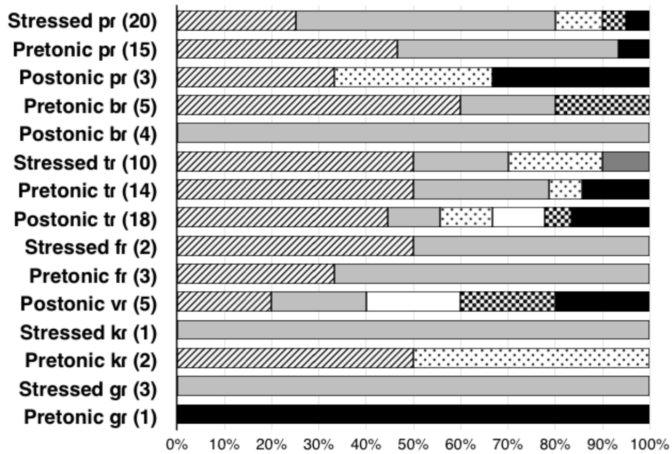


Figure E.9: M2

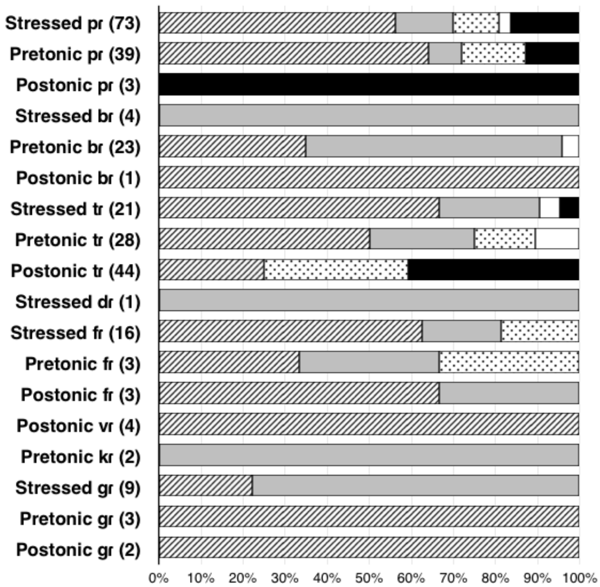


Figure E.10: M3

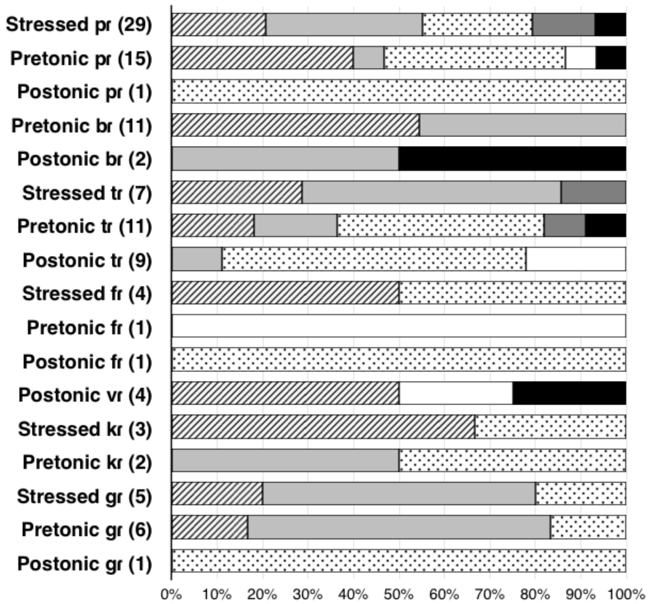


Figure E.11: M4

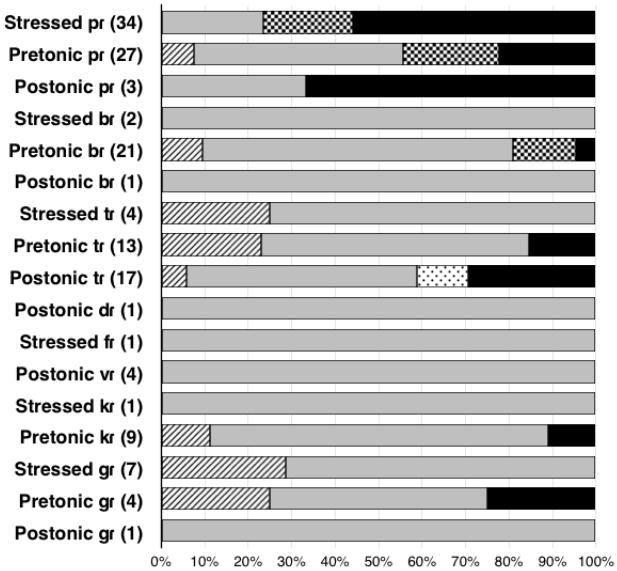


Figure E.12: M5

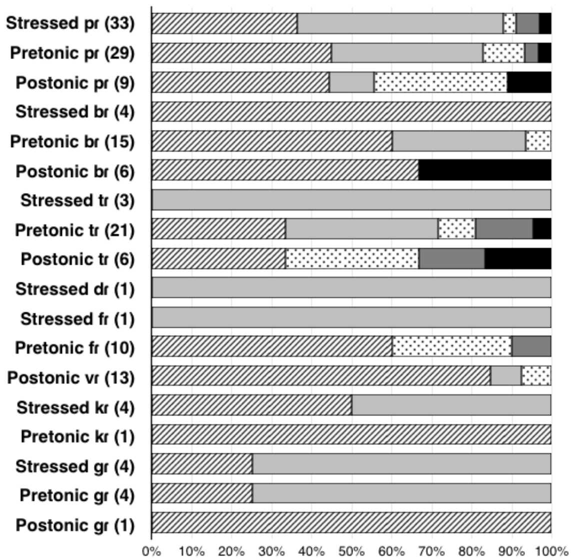


Figure E.13: M6

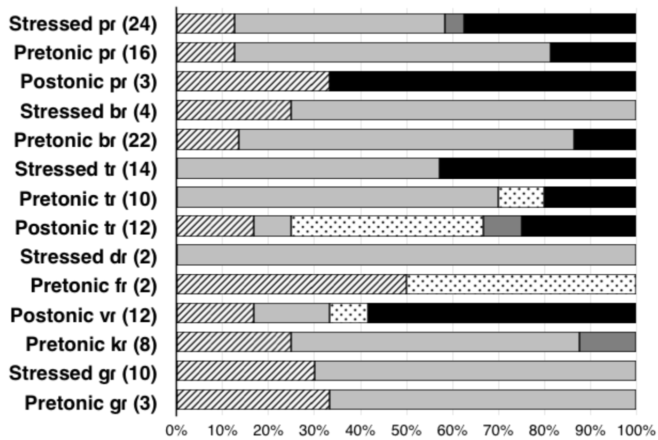
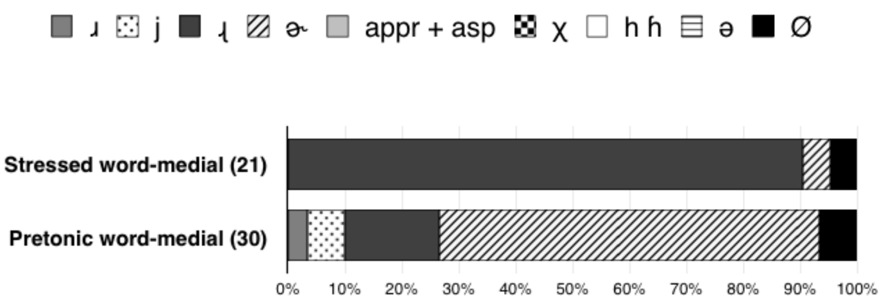


Figure E.14: M7

Appendix F

Word-medial coda: individual speakers

Coda variants in the semi-structured interviews, excluding the conjunction *porque* 'because' (see Section 7.1.1.3). Token count appears in parentheses.



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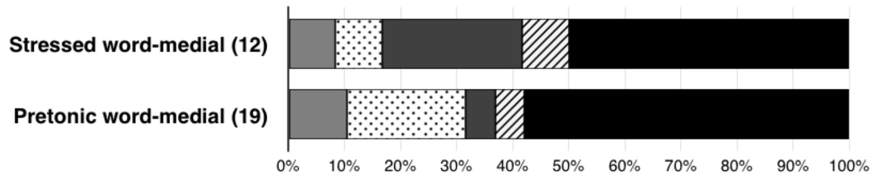


Figure F.2: F2

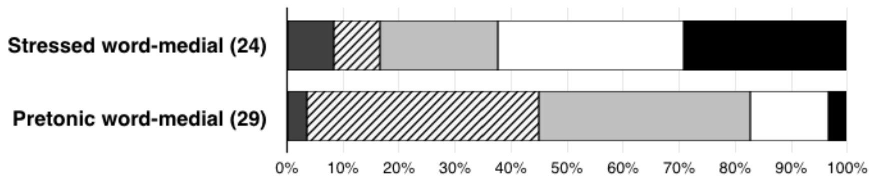
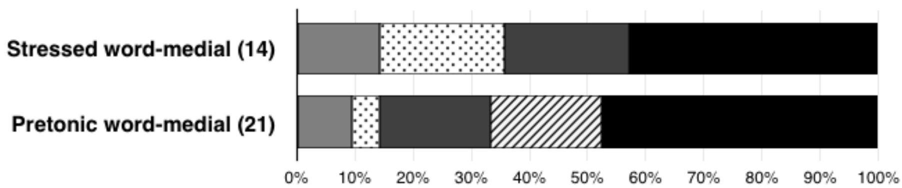


Figure F.3: F3



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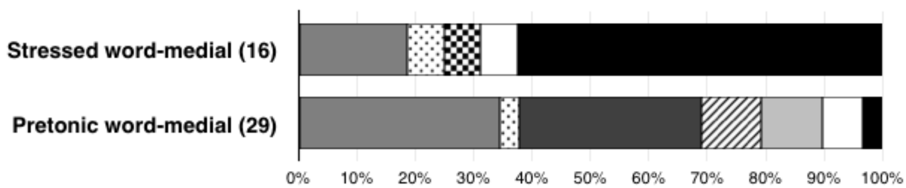

Figure F.5: F5

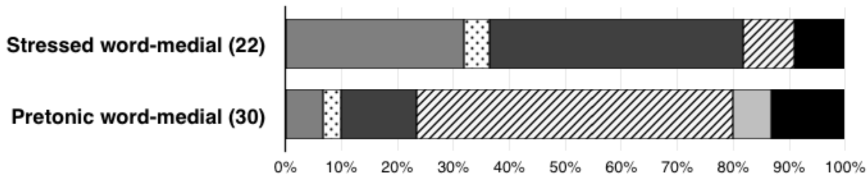

Figure F.6: F6

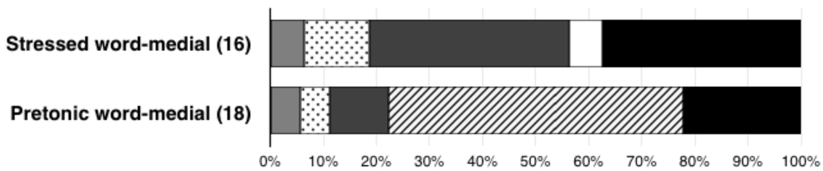

Figure F.7: F7

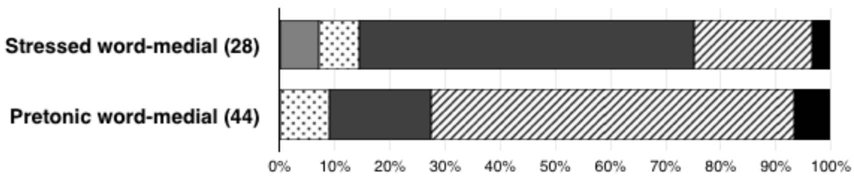

Figure F.8: M1

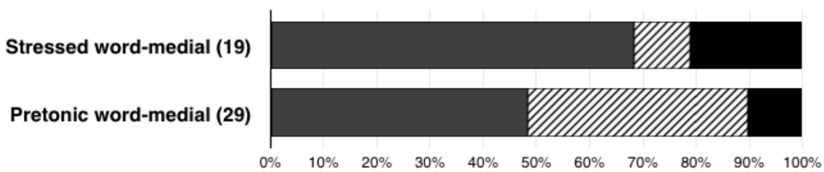

Figure F.9: M2

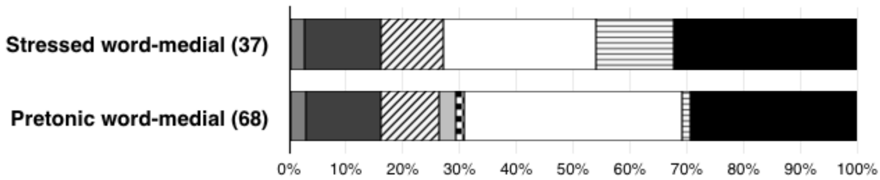

Figure F.10: M3

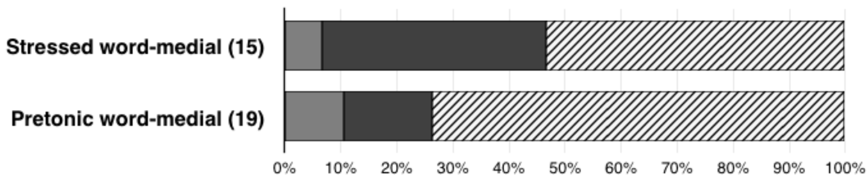

Figure F.11: M4

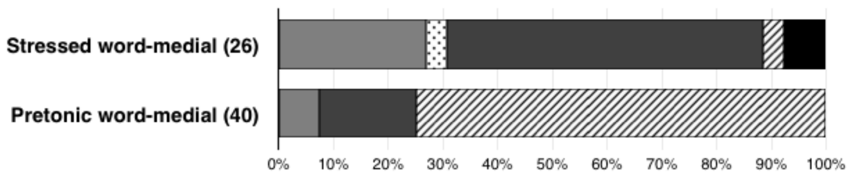

Figure F.12: M5

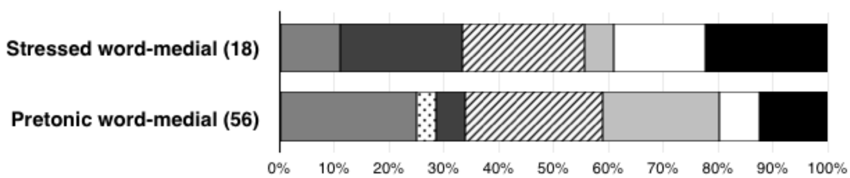

Figure F.13: M6

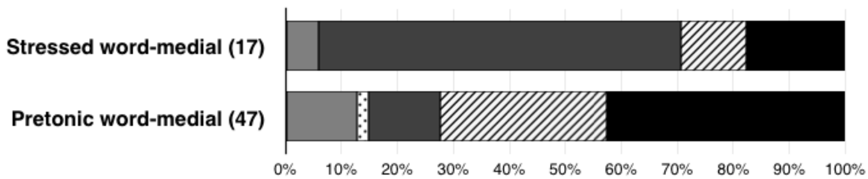

Figure F.14: M7

Appendix G

Word-final coda: individual speakers

Coda variants in nominals (Nom.), infinitive verb forms (Inf.) and the preposition *por* in the semi-structured interviews. Word-final coda may be followed by a consonant (C), vowel (V) or pause (P). Token count appears in parentheses.

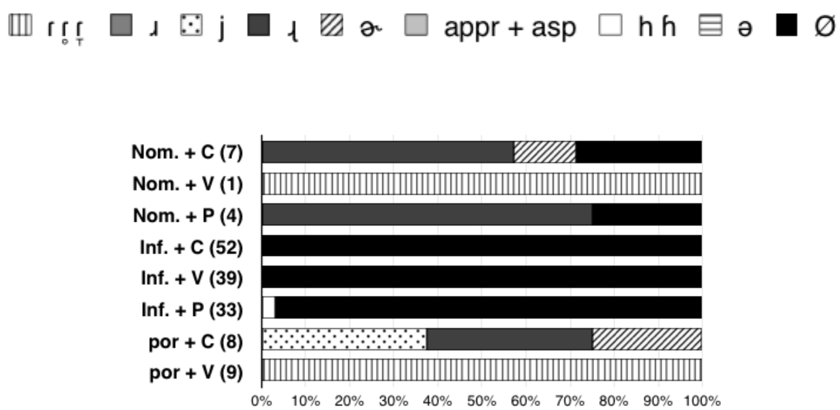

Figure G.1: F1

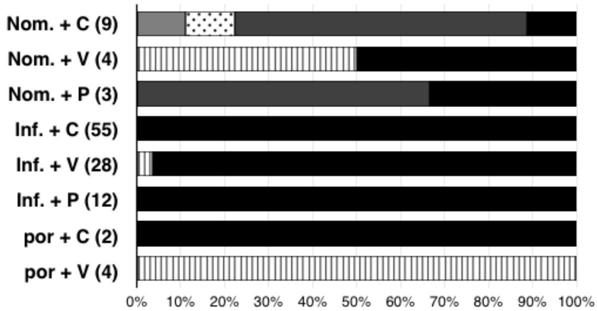

Figure G.2: F2

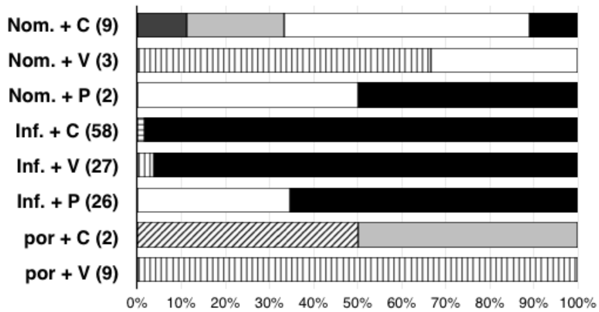

Figure G.3: F3

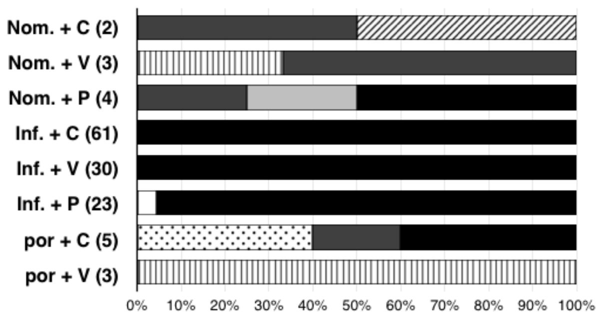

Figure G.4: F4

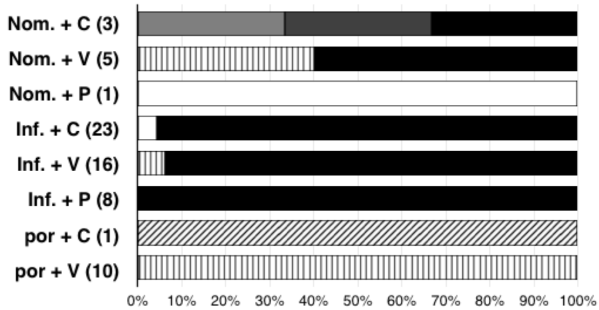

Figure G.5: F5

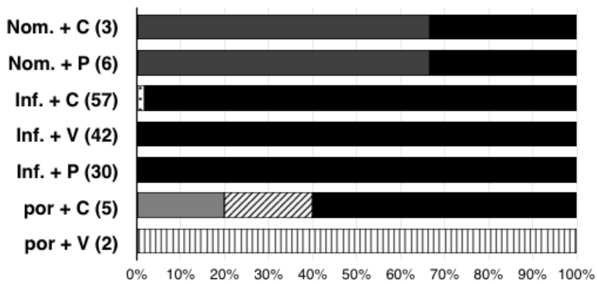

Figure G.6: F6

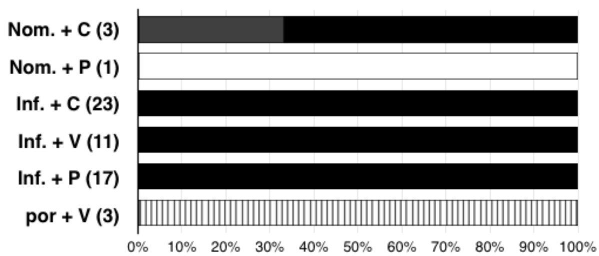

Figure G.7: F7

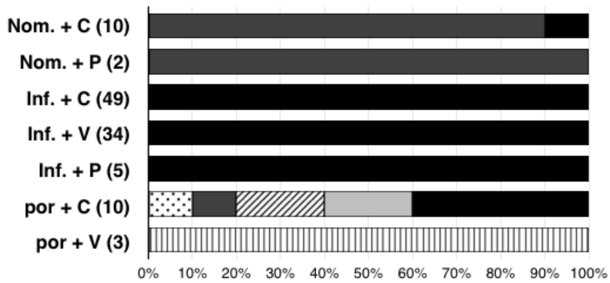

Figure G.8: M1

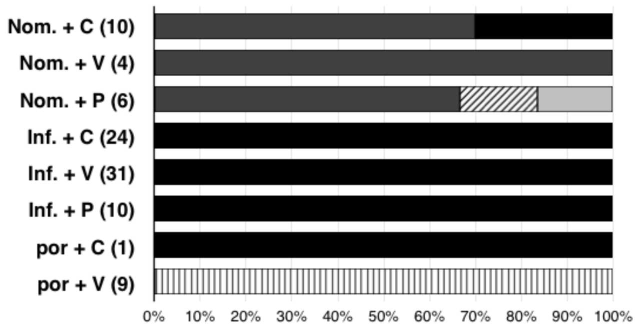

Figure G.9: M2

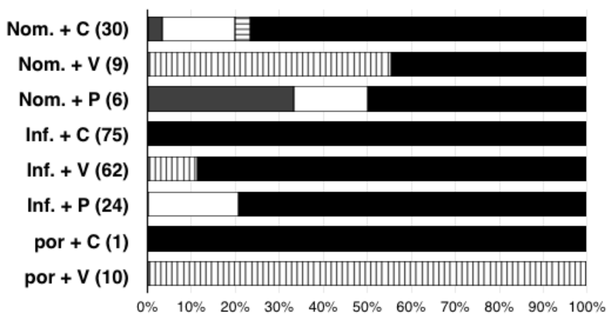

Figure G.10: M3

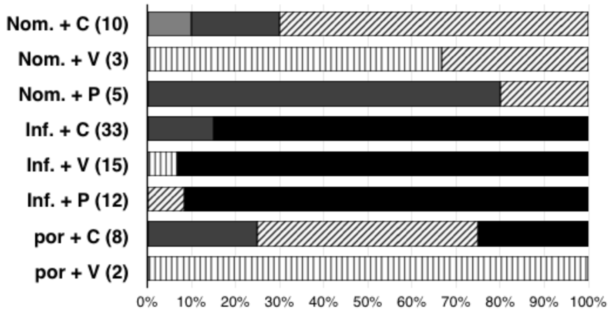

Figure G.11: M4

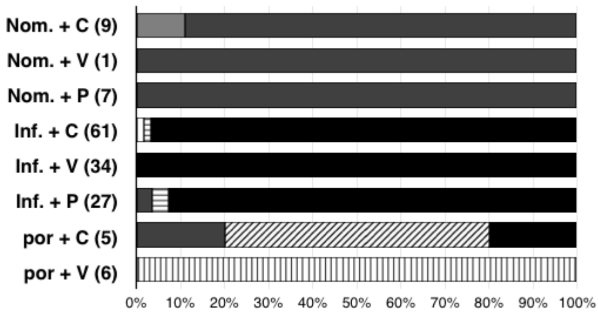

Figure G.12: M5

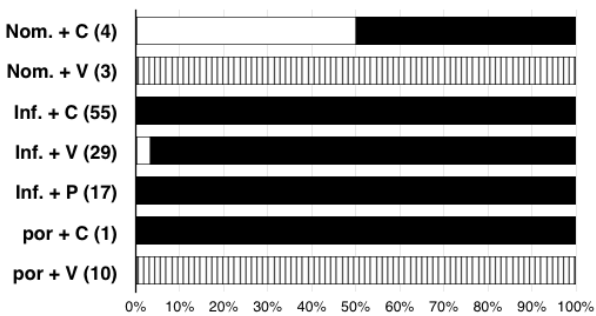

Figure G.13: M6

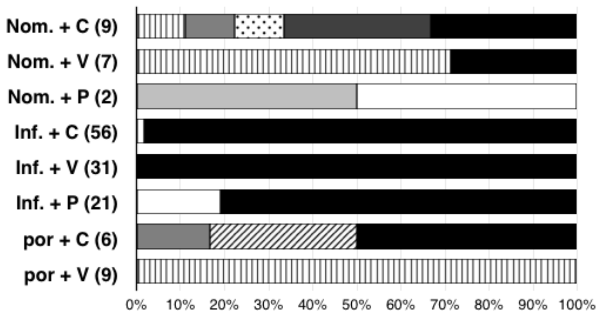

Figure G.14: M7

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