Segmental and Prosodic Conditioning in the First Language Acquisition of Phonology

by

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Abstract

Children learning how to speak their first language must acquire the sounds and sound combinations which make up the phonological system of that language. This is a challenging task, especially given that these units may vary significantly depending on their position within syllables, words, or larger domains. In this thesis, I consider a number of factors which may influence the child's understanding of the target system. I study longitudinal data on the consonantal development of two children, Inês and Joana, who are learning European Portuguese as their first language, and show that the analysis that each child attains is influenced by different sets of cues. European Portuguese displays a number of phonological alternations at both syllable and word boundaries. I show that Inês attends to these alternations, as she displays clear differences in her consonantal development across positions. In contrast, Joana fails to attend to that evidence and, instead, shows more variable patterns of development.

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Chapter 1: Introduction

Speech sounds in natural languages may have different realizations depending on the environments in which they occur. For example, the /t/ sound in the word "turnip" is not the same as that in the word "stuffing;" in the former the consonant is aspirated, and in the latter it is not. Furthermore, these are not the only /t/ sounds we find in English, for example in "carrot," and in "butter," /t/ has different flavours yet again. These basic observations have significant implications for children learning their first language; they must not only be able to pick out and characterize the speech sounds from that language, but develop a working knowledge of where to use the sounds, and how to produce them in different contexts. To uncover how children perform tasks such as these, we must determine how they learn individual sounds (i.e. segmental development) as well as how they learn syllable structure, stress, and intonation (i.e. prosodic development), among other considerations.

When investigating phonological acquisition data, it is important to consider both segmental and prosodic development. Studies may focus on segmental considerations, such as the order of acquisition of features and segments (e.g. Jakobson 1941/1968; Levelt & van Oostendorp 2007; Costa 2010) without addressing the sequencing of these elements in spoken forms, or the emergence of segments across positions within syllable structure. Conversely, studies may focus on the level of prosodic structure, for example the acquisition of syllable shapes (e.g. Levelt et al. 1999/2000; Kehoe & Lleó 2003), without addressing the nature of the segments that make up these syllables. Certainly the field of language acquisition benefits from focused analyses of each type, as they provide insights into specific components of phonological structure. However, a more complete characterization of phonological development should ideally incorporate both segmental and prosodic development, as these dimensions interact with one another within individual languages. As the examples above suggest, segments may vary depending on their position within syllable structure, on whether they are in stressed or unstressed syllables, or on a number of other prosodic concerns, for example relative to word edges or positions within larger constituents such as the phrase. Conversely, variable patterns which are observed within specific prosodic environments may be attributed to independent segmental considerations.

While much of the literature on phonological development has highlighted actual or potential interactions between segmental and prosodic levels of representation (Spencer 1986; Chiat 1989; Fikkert 1994; Rose 2000; Freitas 2003; contributions to Goad & Rose 2003; Fikkert & Freitas 2004; Inkelas & Rose 2007; McAllister Byun 2009, to name a few), further research is required to better characterize these interactions. It is with this consideration in mind that I outline the main research objectives of this thesis:

(1) Main research objectives
  a. Identify and characterize developmental patterns of phonological production from both segmental and prosodic perspectives
  b. Contribute to a growing body of research on phonological development which draws formal relations between segmental and prosodic levels of development

Consider, for example, the development of consonant clusters. Patterns or errors in the production of clusters can often be analyzed as either segmental or prosodic in nature, since consonant clusters at word edges or within words consist of combinations of individual segments within and across syllables, and may be affected by other prosodic considerations, including word stress (whenever relevant). Similarly, production errors affecting singleton consonants (i.e. single onsets or codas) can also be analyzed as either segmental or prosodic, since individual sounds may be prone to mispronunciations related to their prosodic environments (e.g. Chiat 1989; Marshall & Chiat 2003; Bills & Golston 2002; Inkelas & Rose 2003; 2007). An implication of this is that virtually all levels of linguistic constituency may in fact be relevant to phonological development, both within words and across words, or within larger domains of representation such as the clitic group or the phrase. In the work below, I build on these observations. I track and compare the development of singleton consonants and of consonant clusters by two children learning European Portuguese (EP) as their first language. In particular, I focus on segmental development in light of syllable constituency as well as other prosodic domains potentially relevant for analysis (e.g. word boundaries).

The phonotactics of EP allow for interesting avenues of study. Among other observations, we note restrictions on the distribution of coda consonants, as well as phonological alternations at both syllable and word boundaries. Here I explore the hypothesis that these domains may indeed be relevant for phonological development, at least to the extent that the child attends to these alternations to understand the functioning of the target phonological system, for example how segmental positions within prosodic structure dictate the production of allophonic variants (Freitas 2003; Goad & Rose 2004; Fikkert & Freitas 2004; Fikkert & Levelt 2008). Conversely, I contend that in the absence of understanding of the relevant phonological alternations, children may display different patterns of consonantal development, a hallmark of which would be their failure to display positional conditioning.

The remainder of the thesis is organized as follows. In Chapter 2, I describe some of the literature on segmental and prosodic development. I also give a phonological description of EP, followed by an outline of my analytical framework. In Chapter 3, I describe my methodology, including the corpus data, which originate from research by Freitas (1997), Correia (2009), Costa (2010), and Correia et al. (2010). In Chapter 4, I describe and analyze data from the consonantal development of a child named Inês, who appears to attend to distributional effects in her language, as evidenced by clear differences in the development of consonants in specific contexts. In Chapter 5, I describe and analyze data from Joana, who does not appear to understand the distributional facts relevant to her target language, and so shows gradual development of her consonants, whose productions are mostly influenced by adjacent segments, as opposed to the type of prosodic conditioning that characterizes Inês's productions. I then conclude this work with a discussion of the overarching similarities and differences observed between both children's developmental paths, in Chapter 6.

Chapter 2: Background

In this chapter, I provide the background information relevant to this thesis. First, I discuss the literature on segmental and prosodic development in Sections 1 and 2. I then provide a sketch of the phonological system of EP in Section 3, after which I outline my analytical framework, in Section 4. Here, and throughout this work, underlying phonemes will be enclosed between slashes (e.g. /ʃ/), target (adult) forms of transcriptions will be enclosed between pipe markers (e.g. |mɐˈmɐ̃|), and actual (child/attested) forms will be enclosed between square brackets (e.g. [mɐˈmɐ̃]).

1. Segmental Development

According to Jakobson (1941/1968), sounds are acquired through the development of phonological features, which express segmental contrasts in spoken forms. First, broad featural contrasts are established by the child, and gradually more fine-grained contrasts are developed. For example, a child learning a word such as 'dent' /dɛnt/, might first establish a contrast between between consonants and vowels (i.e. /d, n, t/ versus /ɛ/). Later, the child subdivides the set of consonants by making a distinction between oral and nasal consonants (i.e. /d, t/ versus /n/). Then, the child distinguishes the finer featural difference between voiced and voiceless oral consonants (i.e. /d/ versus /t/).

This approach predicts that all acquired features may be freely combined in a child's mental representations, and that segments will be acquired in natural classes (e.g. all voiceless oral consonants should appear at around the same time). Even if Jakobson's (1941/1968) predictions appear to be generally supported by the literature on segmental development, they are not always borne out by the data. Also, segments do not emerge in a vacuum; many studies show that the development of consonants is affected by their prosodic context (e.g. Chiat 1983; Chiat 1989; Inkelas & Rose 2007, to name a few). Further, Levelt (1994) suggests that, in children's early spoken forms, the production of segments does not necessarily imply awareness of the precise featural makeup of each segment present in the target form. As illustrated by the examples of early productions by Dutch-learning children in (2) below, children may produce strings where all the uttered segments share a common place feature (such as [labial] or [coronal]).

(2) Featural over-application within words (data from child Eva; Levelt 1994:55–56)

a.	poes 'cat'	|ˈpus| → [ˈpuf]	1;4.12	|s| → [f] / [coronal] → [labial]
b.	bed 'bed'	|ˈbɛt| → [ˈdɛt]	1;4.12	|b| → [d] / [labial] → [coronal]

These data suggest that neither pattern is the result of a featurally underspecified (or otherwise lacking) consonant receiving a place specification from a nearby consonant through the process of 'consonant harmony' (e.g. Spencer 1986); both labial and coronal places of articulation must indeed be specified in Eva's representations, as both of these features are attested in her productions in (2). A key observation concerning these examples is the fact that the vowels present between the 'harmonized' consonants match the place of articulation of these consonants: in (2a) the vowel is round and therefore labial, and in (2b) the vowel is front and therefore coronal (Levelt 1994). Since each word can be associated to a unique place of articulation, Levelt draws the conclusion that units larger than the segment (here, the word) may host a unique place specification, which then applies to each segment produced. Therefore, the production of a segment may not imply a full featural specification for that segment. This hypothesis has consequences for Jakobson's (1941/1968) theory of segmental acquisition: the production of given segments may not depend on just the acquisition of their individual features, but on the features of nearby segments, depending on the degree of segmental differentiation attained by the child (see also Fikkert & Levelt 2008).

In a more recent study, Levelt & van Oostendorp (2007) show that sounds are not necessarily acquired in natural classes, contrary to what Jakobson (1941/1968) would predict. To determine the order of acquisition of consonants by Dutch children, Levelt & van Oostendorp focus on the production of consonants in word onset (initial) and offset (final, coda) positions. Their data reveal "paradigmatic gaps" in the early development of natural classes, where the emergence of small subsets of natural classes, predicted by any approach based on phonological features, appear to be lagging behind in child speech (Levelt & van Oostendorp 2007:163). According to Levelt & van Oostendorp, the production of individual segments in child speech may be restricted by feature co-occurrence constraints: markedness constraints which manifest themselves when a new feature is acquired, and prohibit specific combinations of this feature with other, previously acquired features.

Levelt & van Oostendorp diagnose a feature co-occurrence constraint from the non-production of a given feature in combination with other features attested in the system. For example, a child who produces [n, m, k] at an early stage but does not produce [ŋ] until later in development might have a constraint preventing the combination of [nasal] with [dorsal]. Importantly, Levelt & van Oostendorp also observe variability among the children they study; not all features are acquired at the same time, and the features that are acquired appear to interact in different ways in each individual developing system.

In sum, segmental development may be hindered by a number of factors: degree of segmentalization of word forms into smaller segmental units (Levelt 1994; Fikkert & Levelt

2008), as well as constraints on the combination of features (Levelt & van Oostendorp 2007). Furthermore, differences between various children's developmental paths may be due to individual difficulties within the perceptual or articulatory domains (e.g. Chiat 1983; 1989; Inkelas & Rose 2007; Rose 2009), or from a child's analysis of the grammatical (phonological) properties of the target language (e.g. Freitas 2003; Goad & Rose 2004; Fikkert & Freitas 2004; 2006; Fikkert & Levelt 2008). I turn now to discussion on the development of prosodic structure.

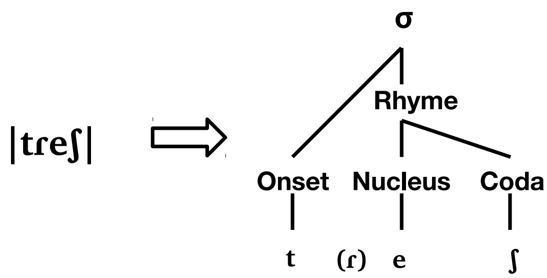
2. Prosodic Development

Just as the acquisition of a feature does not necessarily imply that this feature can be used in combination with all other acquired features, the acquisition of a given consonant does not mean that it may be used in all positions within the syllable or word, or applied in combination with all consonants within clusters (e.g. Fikkert 1994; Bernhardt & Stemberger 1998; Freitas 2003; Fikkert & Freitas 2004; Levelt et al. 1999/2000).

To begin, according to Spencer (1986), not all aspects of syllable structure are acquired at once (see also Fikkert 1994; Freitas 1997; Goad & Rose 2004). There is a seemingly universal trend for simple syllable structures to emerge before complex ones; for example, when they begin to attempt words with consonant clusters, children typically reduce those clusters in ways that yield more simple syllable structure, due to failure to fully prosodify the adult structure (e.g. Smith 1973; Spencer 1986; Fikkert 1994; Freitas 1997; Barlow 1997; Bernhardt & Stemberger 1998; Levelt et al. 1999/2000; Rose 2000; 2009; Goad & Rose 2004), as exemplified in Figure 1 below.

Figure 1: Branching onset reduction

três |ˈtɾeʃ| 'three' → [ˈteʃ] (Inês at 2;02.01)



A large number of studies referenced in Goad & Rose (2004) show that when children are at a stage where they do not produce consonant clusters, they will reduce target clusters to a single head constituent, which can be either the least sonorous element (e.g. the above example, or "slow" /ˈsloʊ/ → [ˈsoʊ]), or the structural head of the cluster, as per the (adult) target structure (e.g. "slow" /ˈsloʊ/ → [ˈloʊ]). As Goad & Rose (2004) suggest, reduction of the cluster to its structural head can be related to a more advanced stage in syllable structure development. This analysis, which makes the correct prediction that children may transition from the "sonority" to the "head" pattern, while the reverse pattern has never been attested, also highlights the importance of the child's understanding of the target structure. More generally, this study also suggests that while variation exists between learners, cluster reduction follows consistent patterns within the productions of individual learners.

Contrary to this, consider complex syllable constituents such as /pɹ/, /tɹ/ and /kɹ/, which can be uniformly analyzed as branching onsets (Selkirk 1980; Rice 1992; Goad & Rose 2004; Goad, in press). In spite of this, these clusters often emerge over large developmental sequences, in a gradual fashion. For example, consider the English words "pray" /ˈpɹeɪ/, and "tray" /ˈtɹeɪ/. Even though these words have identical structure, each containing one syllable with a branching onset followed by a tense vowel, a child may develop his/her ability to produce each cluster at different times; for example he/she may concomitantly produce [ˈp̲ɹ̲eɪ] for "pray", but [ˈt̲eɪ] for "tray" (Bernhardt & Stemberger 1998:489, 495). Finally, cases are also documented whereby a consonant cluster is not correctly produced because the child has not acquired one or more of the consonants that compose the target cluster (e.g. Santos 2007; Rose to appear).

In sum, as it is crucial to study the acquisition of segments in light of prosodic conditioning, it is equally important to consider the emergence of syllabic constituents such as onsets, codas, or branching onsets in light of the segments, and associated features, which comprise these constituents. With these considerations in mind, I now turn to observations about the phonological makeup of EP.

3. Phonological Description of European Portuguese

Portuguese is a Romance language in the Indo-European language family. The children whose productions I study in this thesis are learning European Portuguese as their first language, specifically the Lisbon dialect (Freitas 1997; Correia 2009; Costa 2010; Correia et al. 2010). In this section, I describe the phonological system of EP, including its consonants, syllable structure, and relevant phonotactics. As this description is based almost entirely on Mateus & d'Andrade (2000), I avoid repeating this reference each time I highlight a property of EP taken from their description, limiting explicit references to points in the discussion taken from additional works. I begin with the EP consonantal inventory.

Figure 2: Consonantal inventory of EP (Cruz-Ferreira 1999; Mateus & d'Andrade 2000)

	Bilabial	Labiodental	Alveolar	Postalveolar	Palatal	Velar	Uvular
Plosive	p b		t d			k g	
Nasal	m		n		ɲ		
Fricative		f v	s z	ʃ ʒ			ʀ
Lateral			l		ʎ	(ɫ)	
Flap			ɾ				
Glide	w				j		

All of these consonants may occur in syllable onsets (except for |ɫ|, which is discussed below; |w| only occurs in onsets following |k/g|). However, |ɾ| and |j| do not occur word-initially, nor do |ɲ| or |ʎ|, except in rare occasions.

EP has several stop consonants, |p/b, t/d, k/g|. In the Lisbon dialect, the voiced stops may be produced as fricatives (/b, d, g/ → |β, ð, ɣ|) in most syllable positions (Cruz-Ferreira 1999; Mateus & d'Andrade 2000). I use the symbol "ʀ" (rather than "ʁ") to represent the uvular fricative because this matches the target transcriptions in the data (Correia et al. 2010). Both Cruz-Ferreira (1999) and Mateus & d'Andrade (2000) mention that, in the Lisbon dialect of EP, the dominant variant for this phoneme is the fricative rather than the trill. This is also reflected in the data, as the production patterns of Inês's |ʀ| follow the same general pattern as the other fricatives in singleton onsets (as shown in Chapter 4, Section 4).

Branching onsets in EP consist of an oral stop |p/b, t/d, k/g| or a non-coronal fricative |f/v| followed by |ɾ| or |l|. Obstruent + lateral branching onsets (henceforth C|l|) are less frequent than obstruent + rhotic (C|ɾ|) ones, and are more limited in their inventory: C|l|

clusters typically do not begin with alveolar stops, except in infrequent word-medial cases, as in *atleta* 'athlete' (Mateus & d'Andrade 2000:40).[1]

Likewise, branching onsets that begin with a fricative are less frequent and more limited than those that begin with a stop. Although |fɾ| and |fl| may occur both word-initially and word-medially in EP, all but three examples of these clusters in the data are word-initial.[2] In addition, |vɾ| can only occur word-medially in EP, and |vl| is not a licit cluster.

Codas in EP are restricted to a limited number of consonants: |ɫ| (the 'dark' allophonic counterpart of |l|), |ɾ|, and |ʃ/ʒ| (Cruz-Ferreira 1999; Mateus & d'Andrade 2000). /ʃ/ in codas is susceptible to voicing alternation; when it precedes a voiced consonant, both within words and across word boundaries, it is produced as |ʒ| (Cruz-Ferreira 1999; Mateus & d'Andrade 2000). It is also subject to a sandhi phenomenon whereby it is produced as |z| when it precedes a word that begins with a vowel (as discussed in Chapter 4, Section 6.1).

EP has an additional consonantal position at the left edge of words, which is restricted to the alveolar fricative |ʃ/ʒ|. This position may precede either a singleton onset or a branching onset, resulting in a cluster of up to three consonants (Fikkert & Freitas 2004). It has been previously argued, for languages with similar sibilant-initial clusters such as Dutch and English, that this position is a left appendix which attaches to the following syllable (Trommelen 1984 for Dutch, Goad & Rose 2004 for English).[3] Following Fikkert & Freitas (2004) and Almeida

1 As we will see below, |tl| must be a branching onset, because |t| is not a valid coda in EP (Cruz-Ferreira 1999; Mateus & Andrade 2000).

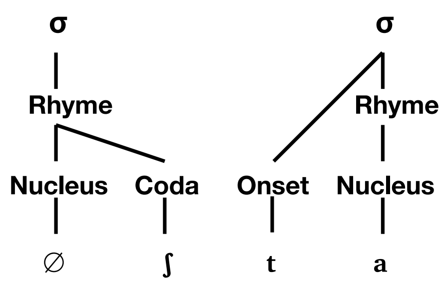
2 Inês attempts the word *aflito* 'afflicted' twice, and Joana attempts the word *Alfragide* (proper noun) once.

3 Goad (in press) argues that this position is in fact a coda of an empty-headed syllable in English. The arguments behind these analyses transcend the scope of this paper. In any case, the representation of this position should reflect distributional evidence; beyond formal representations, we do expect the learners of any language to be sensitive to this type of evidence (e.g. Goad & Rose 2004; Almeida 2011).

(2011), I assume that the position |ʃ/ʒ| fills in this type of cluster in EP is rather a coda of an empty-headed syllable (CEHS). See Figure 3 for an illustration of this structure.

Figure 3: CEHS structure

está |ʃ'ta| 'it is'



In addition to its many properties at the level of syllable structure, EP is a language with lexical stress: each content word has a primary stressed syllable. It is in the stressed syllable that the full set of consonantal and vocalic contrasts manifest themselves in the language. In unstressed syllables, however, consonants may be subject to devoicing (Cruz-Ferreira 1999), and vowels may be subject to a number of weakening effects, ranging from reduction all the way to vowel deletion (Mateus & d'Andrade 1998; 2000; Cruz-Ferreira 1999). As a consequence of vowel deletion, the language displays several phonetic consonant clusters which cannot be analyzed as structurally valid clusters in EP (Mateus & d'Andrade 1998). Also for this reason, according to Mateus & d'Andrade (2000), "phonetically any consonant may be found in word final position" (p.12).

I now turn to a discussion of the set of analytical considerations I used in my interpretations of Inês's and Joana's data.

4. Analytical Framework

I assume as a starting point that adult phonological systems are organized into sets of segmental categories (such as phonemes and their features) and syllable constituents (including branching and non-branching onsets, nuclei, and codas) (e.g. Jakobson 1941/1968; Chomsky & Halle 1968; Selkirk 1980). I am agnostic as to whether these categories and structures are innate; instead, I focus on the concrete challenges that the learner faces in order to acquire the sounds of their language and the distribution rules of those sounds within syllables and words. In the face of these learning tasks, it is thus expected that children's phonological grammars may initially be incomplete or inaccurate. Consequently, I take as a starting point the possibility that segments produced by children may not be represented featurally or prosodified in the same way as in the adult representation, since "children's inputs can only be prosodified to the extent that they reflect the knowledge that learners have at a particular stage in development" (Goad & Rose 2004:117). In line with Goad & Rose (2004), Fikkert & Freitas (2004, 2006), and Fikkert & Levelt (2008), I analyze the child's production patterns as reflecting the child's analysis of the properties of the language at any given stage of his/her development, both at the segmental level and at the level of syllable structure. I also consider the fact that children must develop their ability to reproduce these sounds within each prosodic position, which implies that productions may not entail fully accurate reflections of the child's phonological grammar, for example because of articulatory errors.

Additionally, following Inkelas & Rose (2007) and Rose (2009), I adopt a multiple-pronged approach to the data, rather than restricting myself to one particular framework (such as Optimality Theory, Prince & Smolensky 2004; or Templatic Phonology, Vihman & Croft 2007). By way of illustration, consider Rose's (2009) analysis of an apparent chain shift in the productions of child Amahl (Smith 1973) in (3). As we can see in these examples, the child produces target |z| as [d] in (3a) while, paradoxically, he produces target |d| as [g] in (3b). Taken together, it appears in the child's data that [d] is produced when |z| is attempted, but not when |d| itself is attempted.

(3) Chain shift (data from Smith 1973; examples adapted from Rose 2009)

a.	puzzle	|pʌzɫ̩| → [pʌdɫ̩]	|z| → [d]
b.	puddle	|pʌdɫ̩| → [pʌgɫ̩]	|d| → [g]

Patterns such as this have been interpreted from a number of perspectives, ranging from universalist accounts of their paradoxical nature (e.g. Dinnsen et al. 2011) to arguments utilizing this type of data to discredit child language data altogether (e.g. Hale & Reiss 1998; Hale et al. 2007). As Rose (2009) argues, however, building on earlier analyses by Braine (1976) and, especially, Macken (1980), these data must be considered for our understanding of child language phonology, but require an interpretation in light of the child's perceptual and productive abilities (see also Rose & Inkelas 2011). On the one hand, the substitution in (3a), [d] for |z|, is likely a case of fricative stopping, an articulatory error in which the child produces a full closure when attempting the controlled constriction required for a fricative. On the other hand, the substitution in (3b), [g] for |d|, independently arises from a perceptual issue, whereby the child perceives target |d| as |g| because of the velarity of the following word-final |ɫ|, perhaps even combined with some degree of |d| glottalization, given that the child was learning a British dialect of English. In sum, if different sources of error are factored into the data analysis, apparently paradoxical patterns can be analyzed in simple and principle ways (Rose 2009).

In the work below, I follow this perspective, and embrace the view that the patterns we observe in phonological productions may originate from a number of different sources, including the child's grammatical analysis of the properties of the target language as a whole, as well as perception and other issues which may affect the child's mental representation of segments, and articulatory issues which may influence the shape of spoken forms (Inkelas & Rose 2007; Rose 2009; Rose & Inkelas 2011; Rose in press; Rose to appear). Further, I seek not only to identify these factors, but also how they might interact to yield the patterns we observe in the data. (See also Pater & Barlow 2003; Pater 2004; Santos 2007; Almeida 2011, for similar approaches to the data, expressed within a number of different analytical frameworks.)

In the following chapter, I outline the methodology used to implement this study.

Chapter 3: Methodology

In this chapter, I describe the corpus data to be analyzed. I also highlight the most central considerations I take into account when interpreting the data under investigation. Finally, I describe the methods I used to prepare my data and perform my analyses.

1. Acquisition Data

To achieve my research objectives, I analyze and compare phonological productions of first language learner production data from recordings of two children learning European Portuguese.

The data I analyze come from the Portuguese-CCF corpus, which documents five children learning EP as their first language (Freitas 1997; Correia 2009; Costa 2010; Correia et al. 2010). The data consist of sets of naturalistic audio recordings and related transcripts, which contain orthography, model (target) and actual (produced) IPA transcriptions, and relevant notes. I study data from the children named Inês and Joana. Recordings for these children started when they were about 11 months of age, and were taken about once per month until the age of 4 years 2 months for Inês, and 4 years 10 months for Joana. I refer to each recording and associated transcript as a session. Inês's data consist of 10,796 utterances, documented across 30 sessions, and Joana's consist of 7,346 utterances across 33 sessions.

These data are freely available online through the PhonBank database (http://childes.talkbank.org/phon/), a recent offshoot of the Child Language Data Exchange System (CHILDES, http://childes.talkbank.org/; Rose & MacWhinney in press). I analyze the data using Phon (https://www.phon.ca/). Phon is a software program that greatly facilitates a number of tasks required for the analysis of phonological development. It supports multimedia data linkage, unit segmentation, multiple-blind transcription, automatic labelling of syllabification data, and systematic comparisons between target (model) and actual (produced) phonological forms (Rose et al. 2006; Rose & MacWhinney in press).

I selected the two children for my study based on the following criteria:

(4) Child speaker selection criteria

  a. High volume of sessions
  b. High number of utterances per session
  c. Absence of target productions of (most) phonological contexts at the beginning, to at least some accurate productions at the end of the period documented

These criteria generally ensure analyses based on rich datasets, likely to lend themselves to interpretable patterns of phonological development for analysis.

A number of studies already document various aspects of Inês's and Joana's patterns of phonological development, including Freitas (1997), who studied the acquisition of syllable structure; (Correia 2009), who studied the acquisition of primary word stress; Costa (2010), who studied the acquisition of place and manner of articulation in singleton onset consonants; and Rose (to appear), who studied Inês's onset and coda development; among others.

In the section below, I discuss the methodological considerations I used when analyzing the corpus data.

2. Phonological Investigation

As mentioned above, since speech sounds may have different realizations depending on the prosodic environments in which they occur, they can hardly be interpreted independently of these environments. While we can formally separate segmental phonology from prosodic phonology, this separation can only happen once the data have been interpreted in context. This also implies that theoretical investigations of phonetic and phonological errors should ideally consider both of these domains. This is one of the goals I pursue in my analyses below. Much of my empirical investigation thus consisted of tracking the development of consonants in specific positions in model (target) transcriptions, and comparing them to the children's actual productions, in terms of accuracy and error frequency. Without comparisons to target forms, the interpretation of patterns of segmental substitution, deletion, and epenthesis might be highly challenging, and at times lead to spurious analyses, as highlighted by Rose (2009) and Rose & Inkelas (2011), among others.

I also took syllable constituency into account, based in part on an observation by Levelt (1994) that when certain features initially become available in the speech of children learning Dutch, those features do not necessarily become available across all positions within the word. Syllable structure, or prosody more generally, may indeed play an important role in the acquisition of segments.

Using Phon, I queried all consonants in each of the positions listed in (5) below, in order to determine how syllable, word, and phrase positions manifested in each child's consonantal development. These positions were motivated by patterns observed in Inês's data.

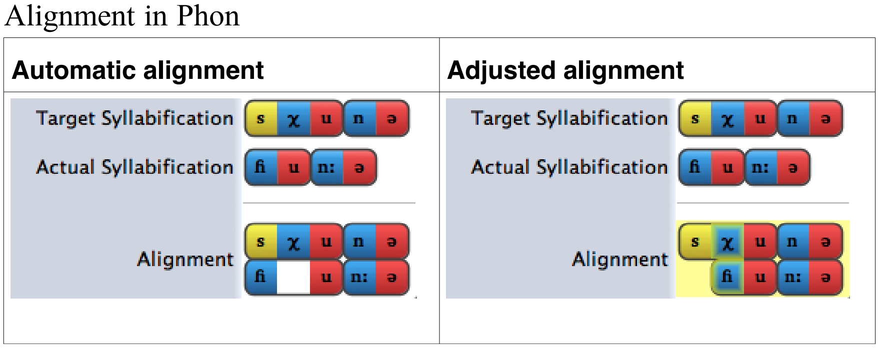
(5) Consonantal environments considered for analysis
  a. Singleton onsets
  b. Branching onsets (and separately, first and second positions of branching onsets)
  c. Codas (and separately, utterance-final, utterance-medial word-final, and word-medial codas)
  d. Codas of empty-headed syllables (CEHS)

I used the results of the aforementioned searches to build charts representing the development of each consonant in each position, in the manner described in Section 2.2. These charts allow for easy visual assessments of consonantal development. In the event that a consonant in any position did not show systematically correct productions across most sessions, I then compared its development to similar consonants in that position where possible (e.g. all fricative onsets) and considered the search results within the session in light of possible positional, perceptual, or articulatory effects. Building on results from these comparisons, I ran more specific searches in Phon whenever needed.

2.1 Data Preparation

In order to ensure systematic comparison between the transcriptions of target utterances and the transcriptions of the children's actual productions, I first reviewed each session in Phon. Phon draws 'alignment' associations between the phones in the target and corresponding produced forms of each word transcribed, which allow users to visualize and search for sounds that have been deleted, added, or mispronounced in child speech, as illustrated in example (6) below.

(6) Alignment in Phon

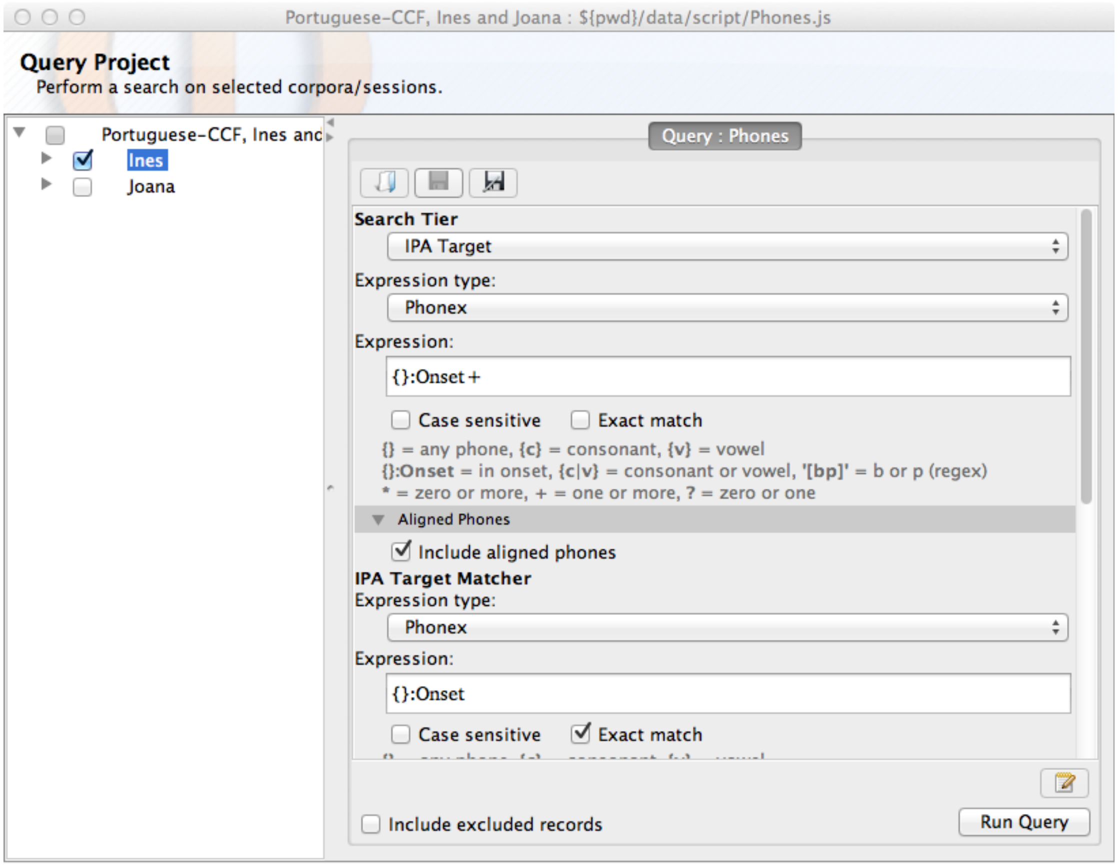


Because this alignment is performed automatically by the program, through probabilistic (best-guess) analyses of the target-actual pairs of IPA transcriptions, some productions which deviate from target words in certain ways may be aligned incorrectly and require adjustment. For example, in the automatic alignment in (6), the produced laryngeal fricative [ɦ] is aligned with the target alveolar fricative |s|, rather than the following uvular fricative |χ|. Because [ɦ] is laryngeal, it more closely resembles the uvular fricative than the alveolar one; the adjusted alignment more accurately represents this. While decisions about exact phone alignments may be difficult to make at times, I made sure to apply manual adjustments in a way that was both systematic and considerate of the remainder of the corpus data. Proper alignments between target and actual forms allowed me to perform positional searches, with results that accurately show how each constituent was produced by the child, and whether sounds were deleted or otherwise altered.

2.2 Data Analysis

As mentioned above, I ran general searches for each syllable constituent in all sessions for both children. Example (7) below shows an example query in Phon: in this query, I searched for each string of one or more onsets ({}:Onset+) in the data for Inês. I then filtered the query to return only results that matched singleton onsets (see the IPA Target filter, {}:Onset, which is then further specified as an exact match), thus returning all and only one-consonant onsets.

(7) Example query, Inês's attempts at singleton onsets



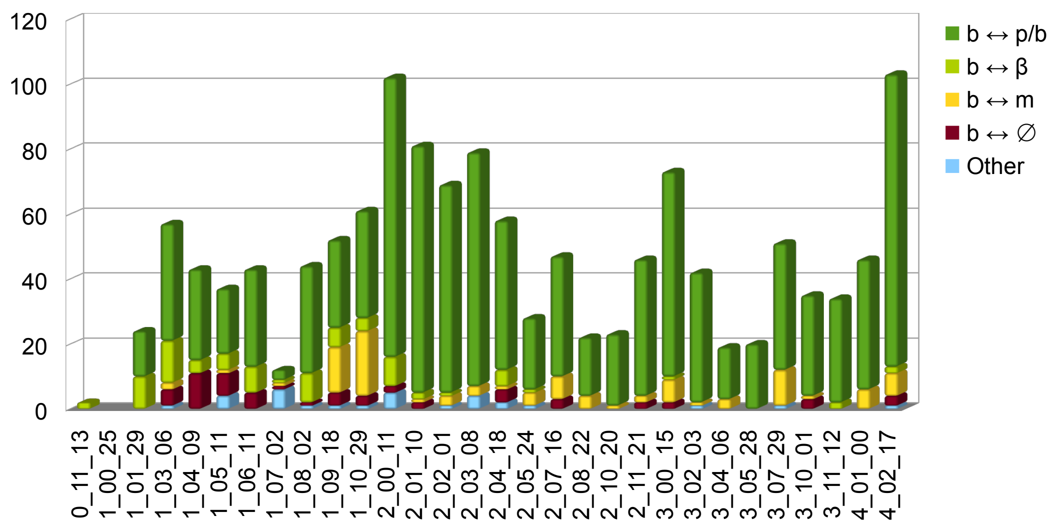
Next, I generated Phon data reports, detailing how each consonant attempted by the child was produced (or not) in each constituent. Phon allows users to generate aggregated reports of results: these consist of tables of all result values found across multiple sessions. See (8) below for a portion of the aggregated report generated from the query in (7).

(8) Sample aggregated report, Inês's productions of |b| in singleton onsets

	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11
b ↔ *	0	0	0	1	0	0	0	0	0	1	0	0
b ↔ b	0	0	14	31	28	20	29	3	33	26	31	85
b ↔ k	0	0	0	0	0	0	0	0	0	0	1	0
b ↔ l	0	0	0	0	0	0	0	0	0	0	0	3
b ↔ m	0	0	0	2	0	1	0	1	0	14	20	0
b ↔ n	0	0	0	0	0	0	0	0	0	0	0	1
b ↔ p	0	0	0	5	0	0	1	0	0	1	2	1
b ↔ t	0	0	0	0	0	0	0	0	1	0	0	0
b ↔ v	0	0	0	0	0	0	0	0	0	0	0	0
b ↔ g	0	0	0	0	0	0	0	0	0	0	0	0
b ↔ ɣ	0	0	0	0	0	1	0	6	0	0	0	0
b ↔ ɲ	0	0	0	0	0	3	0	0	0	0	0	0
b ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	1
b ↔ β	2	0	10	13	4	5	8	1	9	6	4	9
b ↔ ∅	0	0	0	5	11	7	5	1	1	4	3	2

Using LibreOffice Calc (http://www.libreoffice.org/), I carefully condensed the data from the aggregated reports to show only the most prevalent results, with marginal results grouped into a category called "Other" where applicable. I then generated charts based on these tables of results, such as the one in (9), to obtain the visual analysis mentioned in the introduction to this section.

(9) Inês's development of |b| in singleton onsets



Note that for the purpose of this study, because of potential consonant devoicing in adult EP mentioned in Chapter 2, Section 3, I merged voiced and voiceless obstruent data whenever they pattern in similar ways in the data (cf. Costa 2010, who maintains voicing distinctions in her study of singleton onsets).[4]

The resulting reports allowed me to assess the evolution of the patterns produced by the children, as well as the relative frequency of occurrence of each identified pattern throughout the time period observed.

In the following two chapters, I describe Inês's and Joana's respective consonantal development. Where relevant, I include charts such as the one in (9) for visual representation of the patterns observed. As we will see, these two children show both very similar and very different patterns of acquisition, depending on the context of occurrence of each consonant. I

4 Because of this, and because of other methodological differences (e.g the inclusion of word-medial singleton onsets in my study), there are some discrepancies between the order of acquisition described in Costa (2010) and in this work. These discrepancies are immaterial in the context of the current discussion.

interpret the results as analyses attained by each of the children which, I argue, were influenced by different aspects of the evidence available to the children from the ambient language.

Chapter 4: Positionally-conditioned Segmental Development

1. Introduction

In this chapter I describe the consonantal development of Inês from the Portuguese-CCF corpus (Freitas 1997; Correia 2009; Costa 2010; Correia et al. 2010). Over the course of her development, Inês shows many patterns which are affected by the environments in which those consonants occur (e.g. onsets versus codas, utterance-final versus utterance-medial, etc.).

I first offer a broad overview of Inês's acquisition of consonants in broad syllable positions, in Section 2. I highlight some lexical exceptions in Section 3, which I eliminate from further analysis, in order to provide more focused insight into Inês's phonological development. Then, in Sections 4 through 7, I turn to a more in-depth description of Inês's production of segments across different syllable positions, which will reveal more fine-grained, and grammatically meaningful patterns of development. After I describe the data, I focus on the error patterns observed in order to determine their possible sources. As I will show in Section 8, Inês's phonological development is subject to a series of interacting factors, for example concerning syllabification or the phonetics of specific phones and phone combinations.

Note that throughout my data description and analysis, I use the term 'mastery' to refer to cases where a consonant or position has been fully acquired. In some cases, I also use the term 'emerge,' in order to describe target-like productions where they begin in the child's data, but do not yet occur at rates that are high enough for the phone to be considered 'mastered'.

2. Overview of Inês's Consonantal Development

I begin with an overview of Inês's consonantal development across each position within the syllable. I limit this overview to a consideration of accuracy rates only. While this measure is useful in providing a general picture, it lacks the level of detail required to describe a number of significant patterns, which I then uncover through a closer look at the data.

Below is a timeline of Inês's development of consonants, divided into syllabic positions: singleton onsets, first and second positions of branching onsets, codas, and codas of empty-headed syllables (CEHS). Consonants in each position are arranged by order of acquisition, with early-acquired consonants at the top, and later-acquired consonants at the bottom. Numbers in the timeline represent the percent of accurate productions of each consonant in the specified session of transcript data. Consonants are considered to be mastered when their accuracy in Inês's productions reaches a threshold of 75%, which must then be consistently maintained. Sessions that display mastered consonants are highlighted in green.

Figure 4: Timeline of Inês's consonantal development[5]

		0;11.13	1;00.25	1;01.29	1;03.06	1;04.09	1;05.11	1;06.11	1;07.02	1;08.02	1;09.18	1;10.29	2;00.11	2;01.10	2;02.01	2;03.08	2;04.18	2;05.24	2;07.16	2;08.22	2;10.20	2;11.21	3;00.15	3;02.03	3;04.06	3;05.28	3;07.29	3;10.01	3;11.12	4;01.00	4;02.17
Singleton onsets	m	93	86	88	93	96	82	94	65	98	90	93	93	93	98	99	94	98	98	99	99	99	98	98	99	100	99	99	99	100	99
	t/d	50	92	76	70	64	53*	37*	68	80	72	81	92	94	95	97	95	93	95	95	95	97	96	99	95	95	96	97	96	95	96
	n	25	50	79	80	85	41*	76	43*	80	70	75	92	89	95	96	93	97	96	98	96	98	99	96	99	97	100	97	98	99	98
	p/b	75		96	88	83	85	91	67	82	82	78	96	96	98	96	95	94	94	96	97	96	93	98	97	100	90	97	99	95	95
	k/g			17	56	90	78	75	71	62	80	93	95	89	97	99	93	97	96	100	93	96	95	99	100	98	97	98	98	97	99
	j				25		0	0		0	64	100	100	100	100	100	100	100	100	0		100	88	100	100	100	100	100	100	94	100
	l			50	0	0	0	0	0	0	36	38	43	64	68	75	70	84	79	97	83	76	77	80	66	86	64	64	82	71	70
	f/v	0	0			0	0	0	0	0	0	0	3.8	0	0	4.4	12	20	77	58	84	97	100	94	98	98	96	95	100	99	98
	s/z			0	0	0	0	0	0	0	0	13	3.8	2.1	9.2	0	3.1	5.2	20	40	74	89	91	80	91	91	89	88	92	93	95
	ʃ/ʒ		67	21	0	0	0	5	0	0	0	0	0	0	0	0	0	7.8	17	20	64	81	87	97	84	100	94	89	93	96	93
	ʀ				100	0	0		0	0	0	0	0	14	0	0	0	0	0	0	0	36	50	67	75	100	78	67	82	75	100
	ɲ			0	0		7.7	100	0	0	0	25	41	0	0	0	10	0	3.2	0	0	11	0	13	89	100	88	100	82	91	98
	ɾ			0	0	0	0	0	0	0	7.1	33	15	39	15	22	24	3.6	16	17	24	14	20	32	22	28	35	68	56	68	52
	ʎ							0	0	0	4.3	0	13	4.9	2.7	0	0	0	25	0	0	0	0	0	0	0	29	0	9.1	4.8	7.7
P1 of branching onset	k/g						100		100	0	89	90	88	77	100	58	100	100	67	86		100	0	67	86	82	100	100	100	100	100
	p/b							100		100	100	100	100	97	100	100	100	100	100	100	100	100	100	100	100	100	89	100	100	100	100
	t/d					0				89	100	87	84	92	100	93	94	100	91	100	85	100	100	100	97	100	81	100	96	97	100
	f/v				0	0				0	0	0	0	0	0	0	0	100	100	100	100	100		100	100	90	100		100	100	100
P2 of branching onset	l									0	0	0	0	25	0	44	33	100	0	92	100	100		80	67	75	100		80	100	67
	ɾ				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.8	0	0	0	3.3	2.2	37	86	83	65	72
Codas	ʃ/ʒ	0	0	0	0	0	0	0	0	2.7	29	27	35	33	26	28	22	31	37	26	22	39	67	71	73	74	81	76	72	79	74
	ɾ	0	0		0	0	0	0	0	0	11	28	9.8	15	6.8	11	21	11	13	18	12	7.8	14	19	33	31	57	54	57	58	60
	ɫ			0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11	0	24	25	31	38	40	19	39
CEHS	ʃ		0	0	0		0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	9.5	15	30	43	38	54	66	50	54

5 Some of the percentages in this chart may vary slightly from those provided in Appendix A due to differences in the groupings of production patterns.

The large picture can be described as follows: all oral stops, and most nasal stops (including labial |m| and alveolar |n|, but excluding palatal |ɲ|) are mastered in onset position upon the first attempts documented in the corpus (i.e. between 0;11.13 and 1;04.09).[6] As well, the oral stops are produced accurately within target branching onsets as soon as words with these clusters are attempted, independent of the fact that the second consonant of the cluster may undergo deletion at early stages (see further below).

The palatal glide |j| is systematically produced in a target-like manner starting at 1;10.29. The next singleton onset to be mastered is the alveolar lateral |l|, at 2;03.08. Then, fricatives (|f/v, s/z, ʃ/ʒ, ʀ|) emerge together within a broad wave of development. Fricatives which can occur in the first position of branching onsets (|f| and |v|) are also mastered at approximately the same time as fricatives in singleton onsets. The palatal nasal |ɲ| does not emerge with accuracy until the latter portion of the period observed, while the flap |ɾ| is not mastered in singleton onsets during the period covered by the corpus.

Consonants in the second position of branching onsets, |l| and |ɾ|, are not mastered early in Inês's data, in contrast to singleton onsets and the first position of branching onsets. |l| is mastered in this position about 5 months after it is mastered in singleton onsets. Interestingly, |ɾ| in the second position of branching onsets is mastered by the end of the observed period, even though it is not mastered in either onsets or coda, as we will see below (see also Costa 2010 about Inês's acquisition of onsets).[7]

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6 The low percentage for |t/d| in onsets in 1;05.11 and 1;06.11 can be explained by two factors; a pattern of consonant harmony in 9 attempts of the word *dinheiro* 'money' in 1;05.11, and the truncation of whole syllables, which independently yields consonant deletion. If these cases are excluded, the accuracy rate for these sessions rise to 91% and 80%, respectively.
The low percentages for |n| in onsets in 1;05.11 and 1;07.02 are discussed in Section 4.

7 As we will see in Section 6.2, when we break down the data into more fine-grained categories, |ɾ| is in fact also mastered in word-medial codas. I will discuss the mastery of |ɾ| in these positions in Section 8.

Sounds in coda position are either acquired late (|ʃ/ʒ|) or not acquired by the end of the documented period (|ɫ|, |ɾ| in most positions). Finally, Inês does not fully master |ʃ/ʒ| in codas of empty-headed syllables during the period covered by the corpus.[8]

I provide a more in-depth look into this general picture below. I begin with a few exceptional patterns, which relate to the acquisition of specific lexical items, in the next section.

3. Lexical Effects

In this section, I highlight particular lexical exceptions, whose frequency in the data have influences on some of the results summarized above. In the following section I address the data sets independent of lexical effects, in order to offer the clearest description of Inês's systematic as well as more variable phonological behaviours.

I exclude three lexical items from the analysis of Inês's phonological development: *para* 'to' or 'for,' Inês's own name, and *estar* 'to be' (and related inflected forms).[9] In the paragraphs below, I provide the relevant motivation for these exclusions.

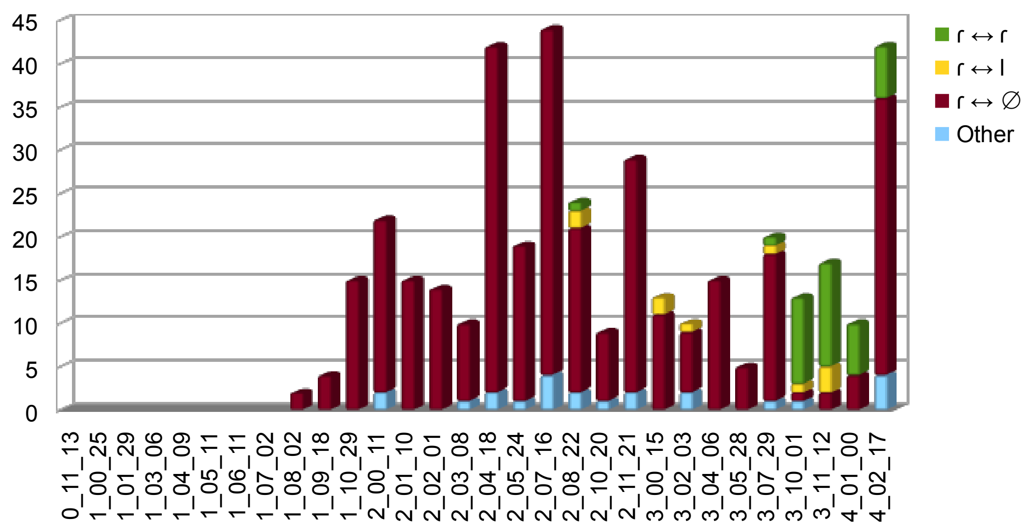
I remove the preposition *para* |pɐɾɐ| 'to/for' from the data on |ɾ| in singleton onsets because Inês's productions of |ɾ| in *para* more closely mirror her productions of |ɾ| in the branching onset |pɾ/bɾ| than in singleton onsets. In the majority of her productions of *para*, Inês reduces the word to the first syllable, [pa]. *Para* is a function word, typically unstressed in connected speech; as discussed in Section 3 of Chapter 2, in adult EP unstressed vowels are often reduced to the point of deletion (Cruz-Ferreira 1999; Mateus & d'Andrade 1998; 2000). The forms for this word which Inês was exposed to thus may have varied between |pɐɾɐ| and

8 Although as we will see in Section 7, with the removal of a major lexical exception, Inês masters |ʃ/ʒ| in this position at 3;07.29.

9 Excluded forms related to *estar* include: *estar*, *está* (the most common form in the corpus), *estás*, *estava*, *estavas*, *estavam*, *estão*, *estou*, *estamos*, *estiver*.

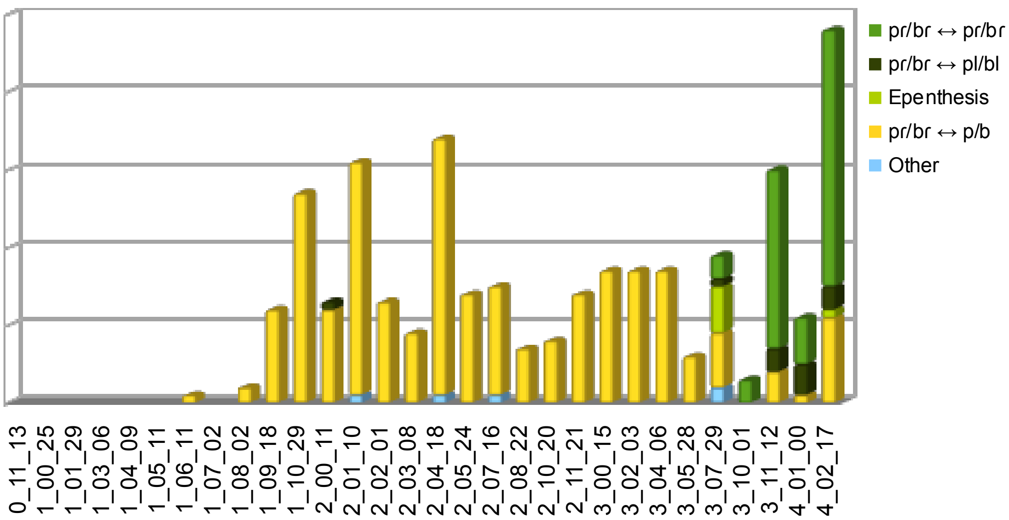
|pɐ|, with |pɾɐ| being the most likely input to the child (Maria João Freitas, p.c., June 2013). Both this reduction, and the relative variation between the various forms of *para*, are reflected in the comparison between Figure 5 and Figure 6 on page 31. As we can see, |pɾ/bɾ| begins to be produced correctly at the same time that [ɾ] begins to be produced in *para.*[10] The crucial comparisons are between "ɾ ↔ ∅" in Figure 5 and "pɾ/bɾ ↔ p/b" in Figure 6, as both refer to cases of |ɾ| deletion, and between "ɾ ↔ ɾ" in Figure 5 and "pɾ/bɾ ↔ pɾ/bɾ" in Figure 6, as both refer to cases of target-like |ɾ| production. As we can see in these figures, in both positions, |ɾ| is deleted throughout much of the documented period, and begins to emerge at 3;07.29.

Figure 5: |ɾ| in *para*



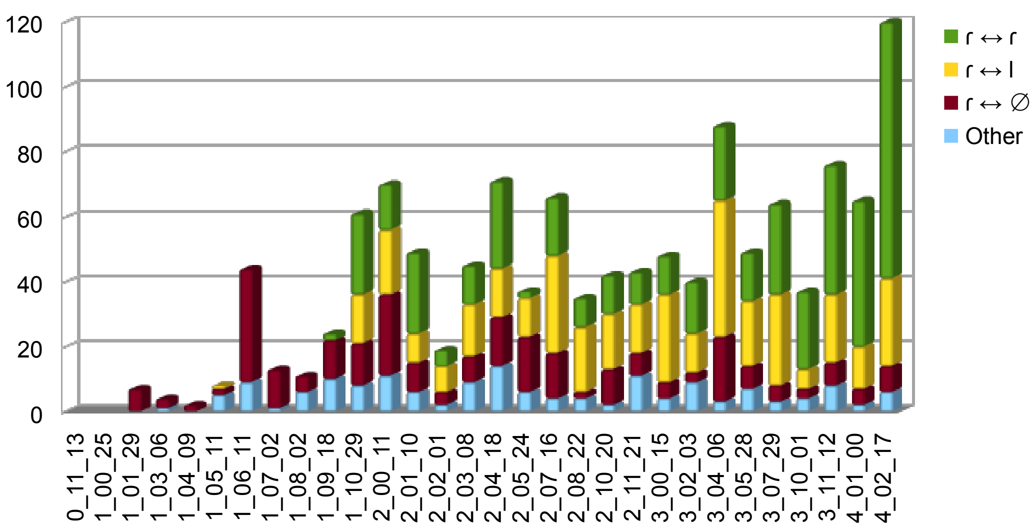
10 As we will see in Chapter 5, Section 3, Joana shows the same parallels between development of |ɾ| in *para* and in branching onsets.

Figure 6: |pɾ/bɾ| branching onsets (does not include cases of target *para*)



In contrast to these two figures above, |ɾ| in singleton onsets develops very differently, as shown in Figure 7.

Figure 7: |ɾ| in singleton onsets (does not include cases of target *para*)



I exclude *para* from my observations of the development of |ɾ| in singleton onsets, however without adding these examples to the set of target branching onsets, again due to the variable shape of this form in the input language.

I also exclude Inês's productions of her own name from the data compilation for |ʃ/ʒ| in codas (following Rose in press). Out of 303 documented instances of Inês attempting the production of her own name, which should be pronounced as |iˈneʃ| (according to transcriptions of target forms in the corpus), she deletes the final |ʃ| 285 times, referring to herself instead as [(ne)ˈne]. This pronunciation, which clearly departs from the remainder of the relevant data below, is not the result of any phonological operation; it represents Inês's nickname, which she arguably took as the target form for her name (Susana Correia, p.c. Spring 2012). An implication of this is that |ʃ| does not in fact occur in Inês's target form for her name, and occurrences from this word should be excluded from the data on this position.

Finally, the word *estar* 'to be' and related inflected forms behave as a systematic exception in the data on CEHS.[11] Of 856 total attempts at words containing codas of empty-headed syllables, 618 come from some form of this verb. Inês deleted the CEHS in 96% of these cases. As we will see in Section 7, however, CEHS are generally acquired by the child at 3;07.29, an observation which warrants the exclusion of this word. Further, as we will see in Chapter 5, Section 3, *estar* behaves as an exception in Joana's data as well. Similar to the initial vowel in *para*, the |ʃ| in *estar* is frequently deleted in adult speech (Maria João Freitas p.c., December 2013). In order not to bias my results on the acquisition of CEHS, I eliminate this verb and related inflected forms from my analyses.

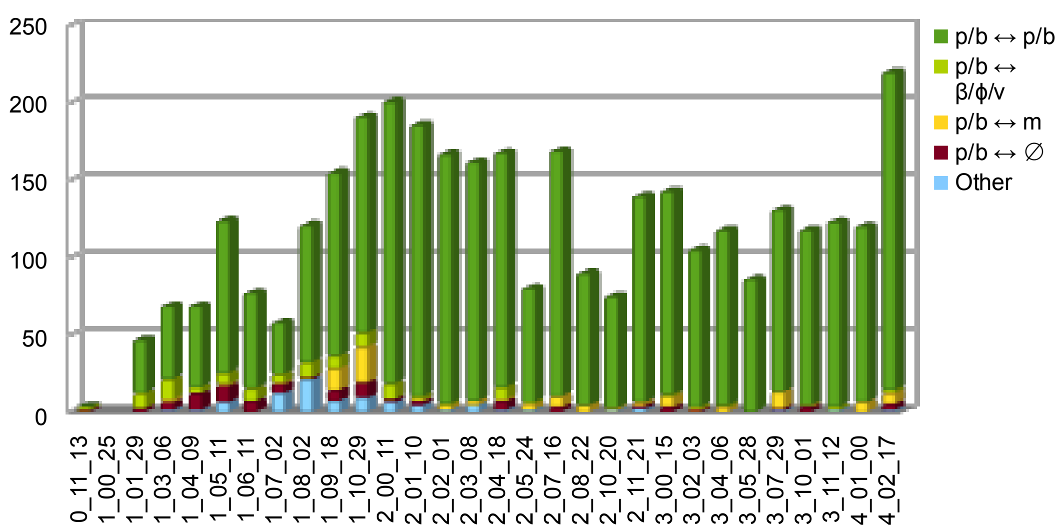
11 Words beginning with CEHS in EP are represented in orthography with an initial vowel, "e." This vowel is generally not pronounced.

In the sections below, I move on to detailed descriptions of Inês's development of each consonantal position in EP, abstracting away from the above lexical exceptions.

4. Singleton Onsets

As shown in the timeline in Section 2, the first consonants that Inês acquires are the oral stops |p/b, t/d, k/g| and the nasal stops |m, n| in singleton onsets. From Inês's earliest documented attempts at these onsets, the predominant form produced is the target-like one, as shown in the figure below for the production of |p/b|.

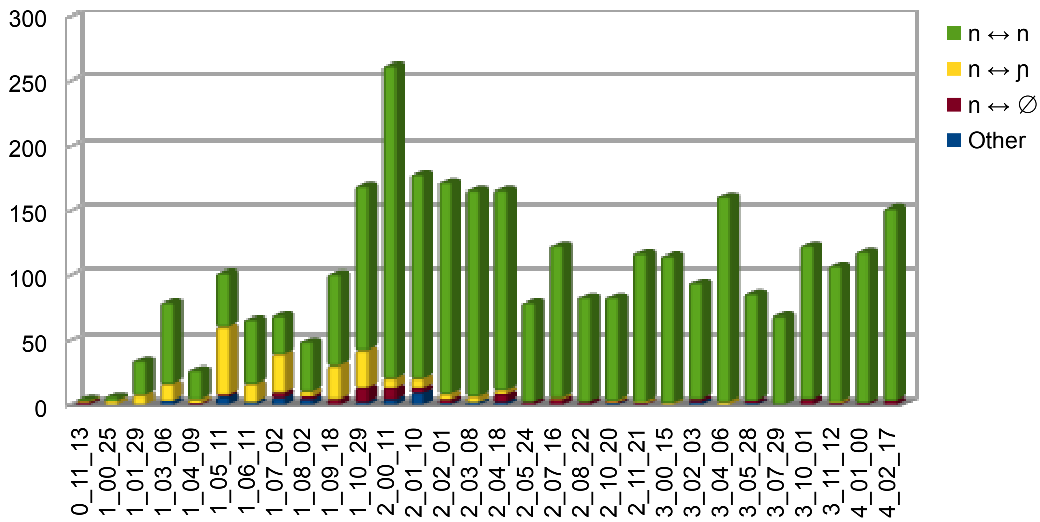
Figure 8: |p/b| in onsets



Note that target-like productions of |p/b| constitute the dominant pattern in all sessions. Production as a bilabial fricative (i.e. [β]) can also be considered an accurate production, as stops are sometimes realized as fricatives in adult forms (as mentioned in Chapter 2, Section 3).

Of the set of early-emerging consonants (|p/b, t/d, k/g, m, n|), only the alveolar nasal |n| is produced with any significant pattern of substitution, as shown in Figure 9. In several sessions, Inês produces |n| as the palatal nasal [ɲ]. This occurs at low to moderate rates (between 15% and 50%) until 1;10.29, after which [n] is clearly predominant.[12]

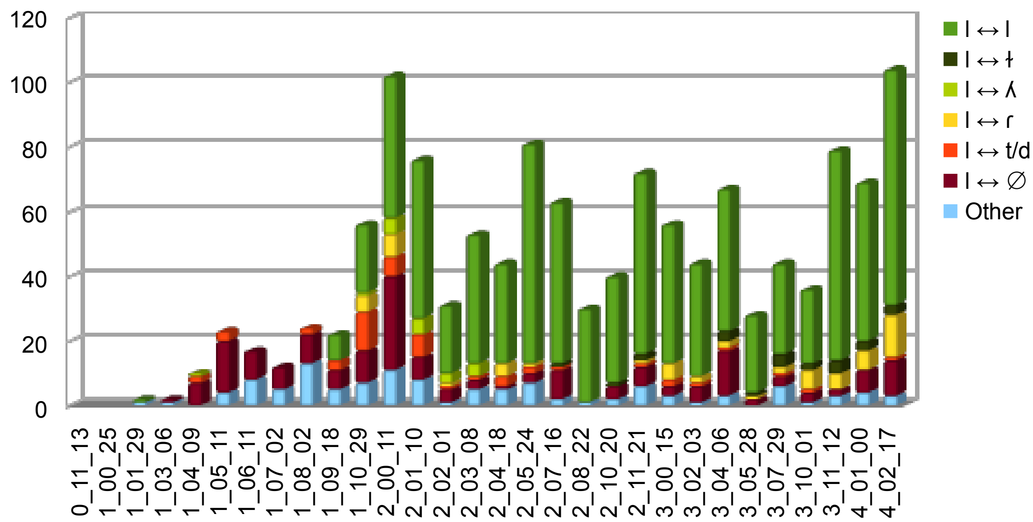
Figure 9: |n| in onsets



The next set of onset consonants that Inês acquires are non-rhotic approximants. The palatal glide |j| is acquired at 1;10.29. The alveolar lateral |l| is acquired at 2;03.08, although it is produced with less consistency than many previously acquired onsets, as shown in Figure 10. |l| is occasionally produced as one of the approximants [ɫ, ʎ, ɾ] or as [t]. This correlates with the fact that Inês has difficulty mastering the lateral coda |ɫ|, and with making distinctions between |ɾ| and the laterals more generally.

12 In early sessions, up to 1;07.02, Inês's utterances consist almost entirely of repeated CV syllables, where the repeated consonant is either an oral or a nasal stop (e.g. *não* 'not' as [ˈnɐːˈnɐ] or [ˈɲɐˈɲɐ], *chapéu* 'hat' as [pɛˈpæː], *banho* 'bath' as [bɐˈbɐbɐ]). At this early stage, no significant pattern can be drawn from the substitution of [ɲ] for |n|.

Figure 10: |l| in onsets

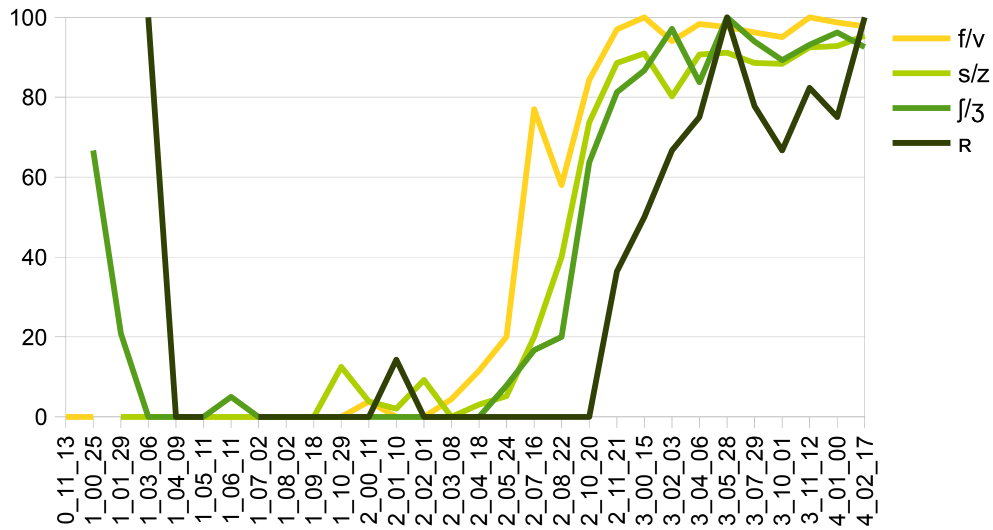


Although |l| does not reach the threshold for mastery (75%) until 2;03.08, frequent target-like productions of |l| begin around 1;10.29, which corresponds with the first substitutions of |ɾ| in singleton onsets as [l], as we will see later in this section.

Fricatives in onset position (i.e. |f/v, s/z, ʃ/ʒ, ʀ|) are mastered between 2;07.16 and 2;11.21,[13] as shown in Figure 11 below.

13 Mastery of |ʀ| occurs slightly later than with the other fricatives. Although target-like productions are predominant starting at 2;11.21, they do not reach 75% until 3;04.06.

Figure 11: Rate of accuracy of fricative onsets



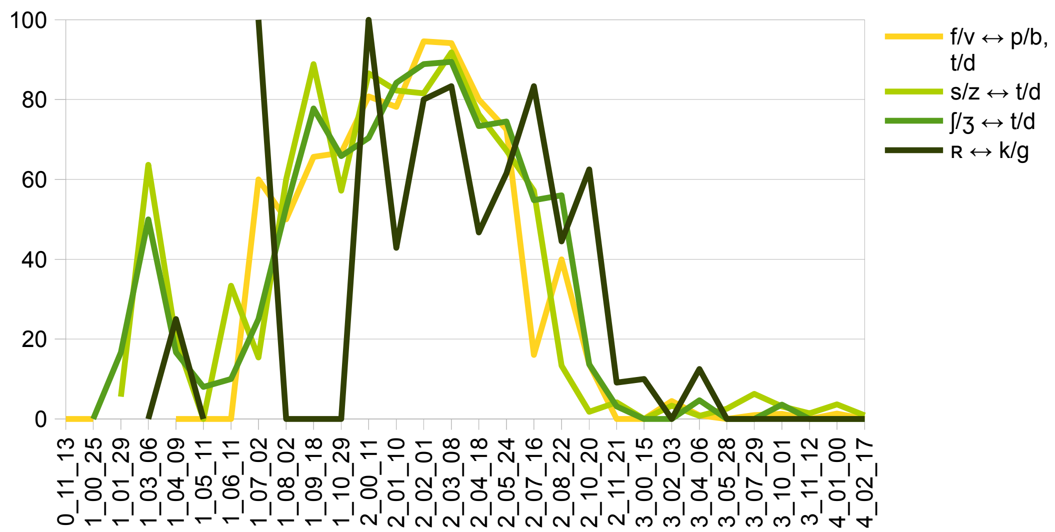
Starting from her first attempts at fricatives in onset (and in the case of |ʃ/ʒ|, after a short stage of deletion), Inês undergoes a stage of fricative stopping, as shown in Figure 12 and summarized in Table 1. During this stage, |f/v| is first produced as [t/d] (from 1;07.02 to 2;02.01), and then as a labial stop [p/b]. The coronals |s/z| and |ʃ/ʒ| are also produced as [t/d]. Finally, |ʀ| is produced as a velar stop [k/g]. At its peak, the stopping rate for each fricative is above 80%.[14]

14 Two additional lexical exceptions are excluded here: from |ʃ/ʒ| in 1;09.18, whereby the word *chupeta* |ʃuˈpetɐ| 'pacifier' is reduced to only the stressed syllable [ˈpe] thirty times, and from |ʀ| in 2;00.11, whereby the word *relógio* |ʀɨˈlɔʒiu| 'clock' is produced as [diˈɐdu] five times (in this case, the first [d] likely appears because of consonant harmony).

Table 1: Fricative stopping and mastery in singleton onsets, with starting sessions

	Stopped production	**Target-like**
f/v	t/d (1;07.02), p/b (2;03.08)	2;07.16
s/z	t/d (1;08.02)	2;10.20
ʃ/ʒ	t/d (1;08.02)	2;11.21
ʀ	k/g (2;00.11)	3;04.06

Figure 12: Rate of stopping of fricative onsets[15]



The four consonants are mastered in quick succession in onsets; the labiodental fricative |f/v| is mastered at 2;07.16,[16] followed by alveolar |s/z| at 2;10.20, postalveolar |ʃ/ʒ| at 2;11.21 and the

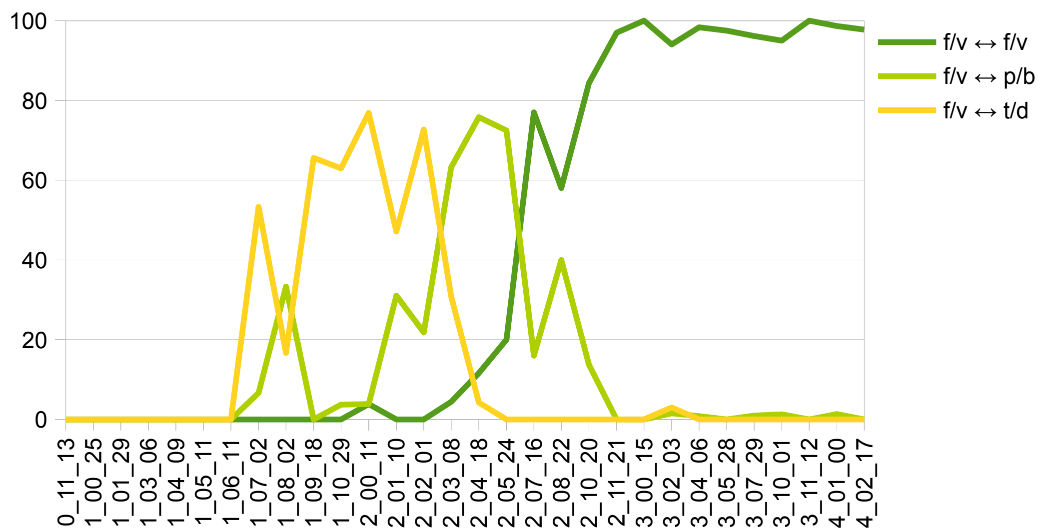
15 In early sessions, there are no more than four productions of |ʀ| in onset, and so the data for |ʀ| before 1;10.29 in Figure 12 is not very visually representative.

16 The rate of accuracy for |f/v| drops to 58% in the following session, 2;02.22. This percentage is still fairly high and the surrounding two sessions are above the threshold for mastery; if it is not mastered at this point, |f/v| is certainly close to mastery, and its accuracy rate is higher than that of |s/z|.

uvular fricative |ʀ| at 3;04.06 (with target-like productions of |ʀ| being predominant as early as 2;11.21).[17]

As mentioned previously, the stopping of |f/v| in onset position shows two distinct patterns; first |f/v| is predominantly produced as [t/d] between the ages of 1;07.02 and 2;02.01, then it is predominantly produced as [p/b] between the ages of 2;03.08 and 2;05.24. In Figure 12 above, I merged these two patterns together to show the parallels between the individual stopping patterns for |f/v, s/z, ʃ/ʒ| and |ʀ|.[18] The development of |f/v| in onset is depicted in more detail in Figure 13 below.

Figure 13: Rate of stopping and accuracy of |f/v| in onsets[19]



17 There may be some relation between the slight variation in ages at mastery and the progression from anterior to posterior place of articulation for the fricatives. Bernhardt & Stemberger (1998) state that, cross-linguistically, coronals and labials are likely to emerge earlier than other places of articulation (p. 290). Costa (2010) also says that across children learning EP, labials and coronals tend to be acquired first (p. 59), and that anterior sounds are acquired before non-anterior sounds (p. 75).

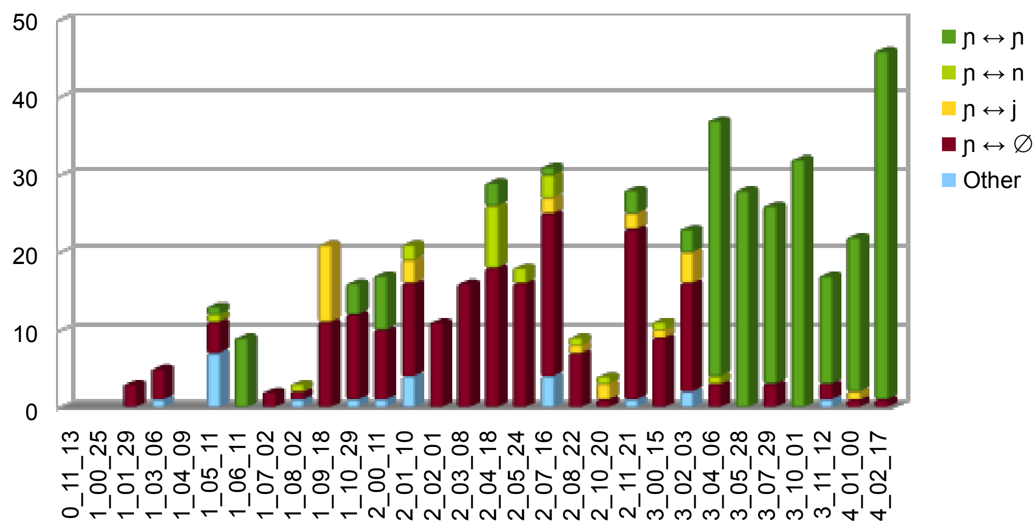
18 Similarly, Costa (2010) does not separate these patterns, instead considering both as a manner substitution whereby a fricative is produced as a stop.

19 This line graph does not show cases of deletion or other substitutions, as it is only focuses on the progression between stopping as [t/d] and as [p/b], before accurate production.

In brief, Inês initially produces all labial and coronal fricatives in onsets as [t] or [d], before the correct place of articulation is acquired for |f/v|.

As already mentioned, the last consonant that Inês acquires in onset position is the palatal nasal |ɲ|, whose development is shown below in Figure 14. It is mastered at 3;04.06. This is much later than the acquisition of the other nasals, |m| and |n|.

Figure 14: |ɲ| in onsets

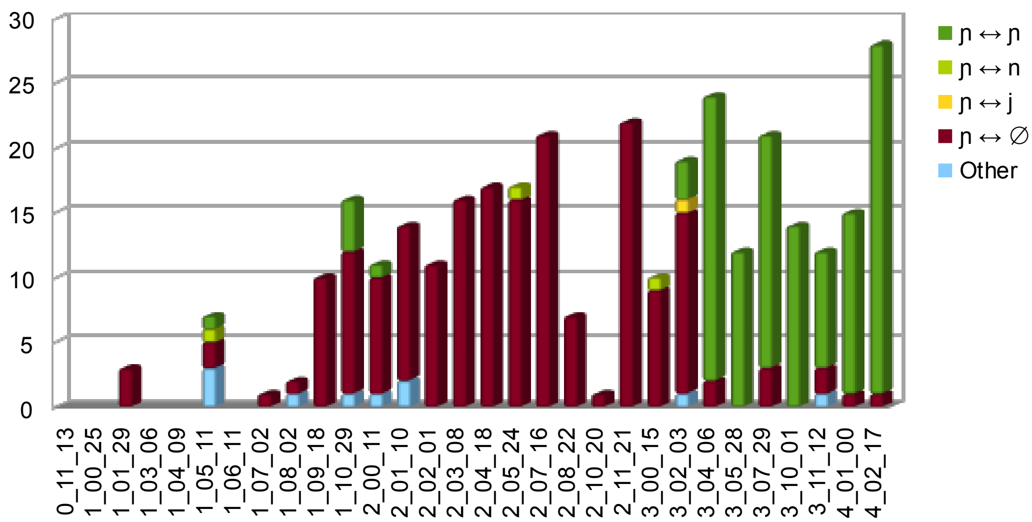


A number of factors may play a role in this delay, for example the fact that |ɲ| is rarely word-initial, and that it occurs in the target language at a lower frequency than the other nasals (Mateus & d'Andrade 2000; Costa 2010). These factors alone are not sufficient to explain the delayed mastery of |ɲ|, however; for example while the glide |j| is also a low frequency sound which is never word-initial in EP, it is mastered a year and a half earlier than |ɲ|.

Explorations into the environments in which |ɲ| occurs in target forms in fact reveal a more intricate pattern, whose source is arguably perceptual in nature (as I will discuss further in

Section 8.1). Prior to mastery of |ɲ| at 3;04.06, we observe a high rate of deletion of the sound. The vast majority of these deletions occur in one particular environment, namely in onsets of unstressed syllables following the vowel |i| (in many cases these correspond to diminutive suffixes, such as in *bebezinho* 'little baby'). Of 498 occurrences of the palatal nasal in target forms in the data, 331 (66%) occur in this environment. The development of |ɲ| in these occurrences is depicted in Figure 15. (See Table 2 further below for examples.)

Figure 15: |ɲ| in onsets of unstressed syllables following |i|



As shown in Figure 16 below, |ɲ| is attempted in lower numbers in other environments (i.e. in the onset of stressed syllables and/or following any vowel other than |i|) until 3;04.06. However, when it is attempted in these environments, it is rarely deleted, as exemplified in Table 3 below.

Figure 16: |ɲ| in onsets, elsewhere

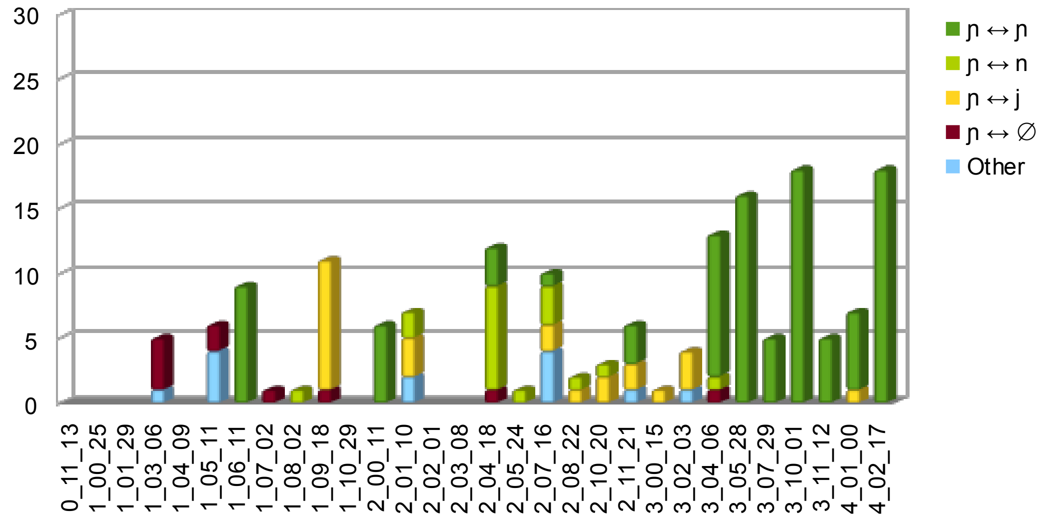


Table 2: |ɲ| in onsets of unstressed syllables following |i|

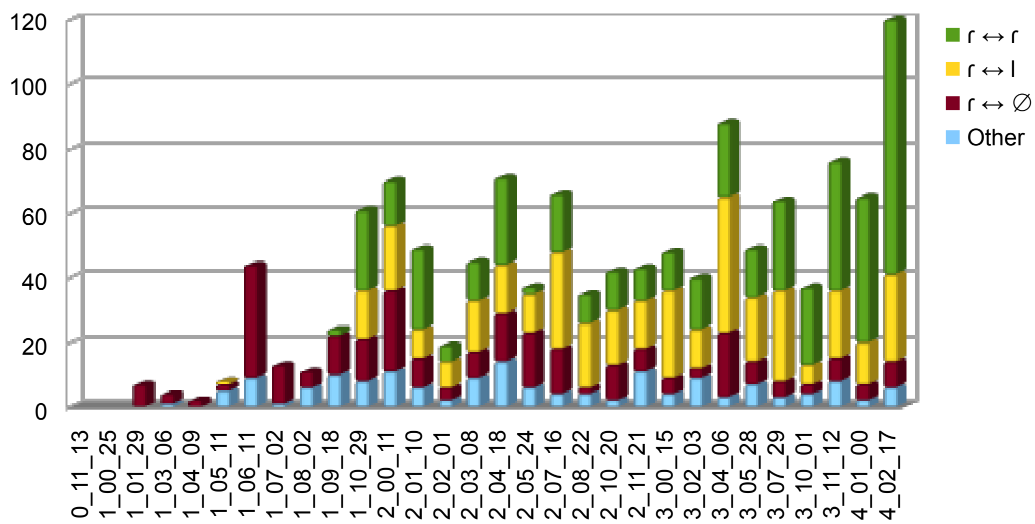
Session: Record	**1;10.29: 285**	**2;04.18: 145**	**2;05.24: 96**	**3;00.15: 60**
Orthography	minha	ursinho	cozinha	pintinhas
IPA Target	ˈmiɲɐ	uɾˈsiɲu	kuˈziɲɐ	pĩˈtiɲɐʃ
IPA Actual	ˈmiɐ	uˈtiu	kuˈʒiɐ	pĩˈtiɐʃ

Table 3: |ɲ| in onsets, elsewhere

Session: Record	**1;09.18: 77**	**2;00.11: 226**	**2;04.18: 232**	**2;07.16: 144**
Orthography	banho	dinheiro	senhor	nenhum
IPA Target	ˈbɐɲu	diˈɲɐjɾu	sɨˈɲoɾ	nɨˈɲũ
IPA Actual	ˈbaju	diˈɲɛɾu	tiˈno	niˈgũ

While she shows systematic behaviour in virtually every other consonant, Inês does not acquire the alveolar flap |ɾ| in onset position; even in the last session documenting Inês's productions, she only produces this consonant with 65% accuracy, as shown in Figure 17. This is consistent with the observation that rhotics are generally acquired late cross-linguistically (Costa 2010:15).

Figure 17: |ɾ| in onsets



Although |ɾ| in onset is not fully acquired during the period covered by the corpus, Inês does show a gradual improvement in her productions. Note, however, that productions of |ɾ| are quite variable; although it is frequently produced in a target-like manner, there is a high rate of substitutions by [l], starting at 1;10.29, the same point where target-like productions of |l| in singleton onsets begin to emerge. This substitution occurs at an average rate of 35% over the last 20 sessions.

Because |ɾ| and |l| (and its coda allophone, |ɫ|) will come up in future discussion of onsets and several other positions, I provide an interim summary of Inês's productions of these consonants in singleton onsets in Table 4.

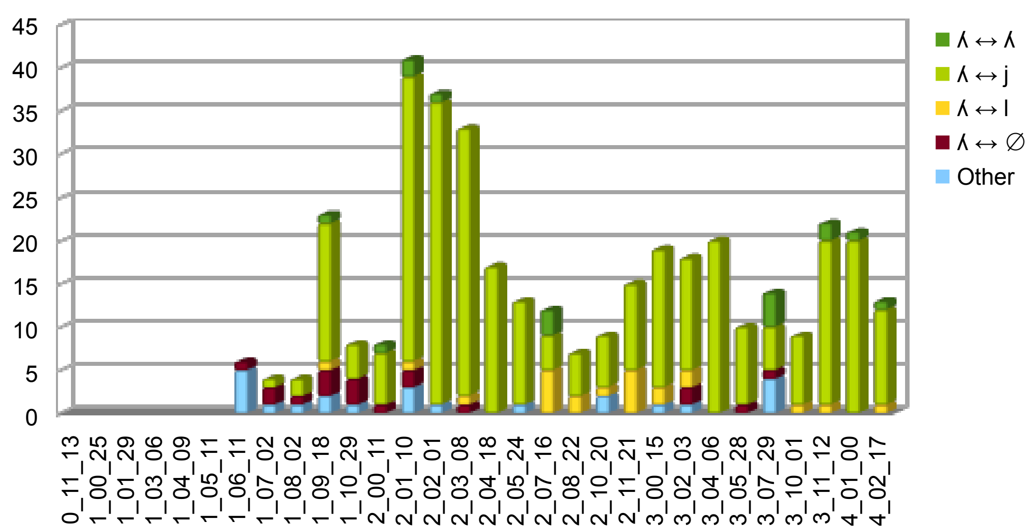
Table 4: Inês's productions of |ɾ| and |l| in singleton onsets

Target onset	**Actual production(s)**	**Emergence/Mastery**
ɾ	l ɾ	Emerges at 1;09.18. Emerges at 1;10.29.
l	l	Emerges at 1;10.29, mastered at 2;03.08.

I discuss the variation of Inês's productions of |ɾ| and |l/ɫ| further in Section 8.

Finally, Inês rarely produces the palatal lateral approximant |ʎ| correctly. She instead produces it as the palatal glide [j], as shown in Figure 18 below.

Figure 18: |ʎ| in onsets



This is a common substitution among children learning EP as their first language, and may be linked to general difficulties with posterior coronal consonants (Maria João Freitas p.c., June 2013). According to Bernhardt & Stemberger (1998:277), this type of substitution (glide for liquid) is also common cross-linguistically.

4.1 Summary of Observations

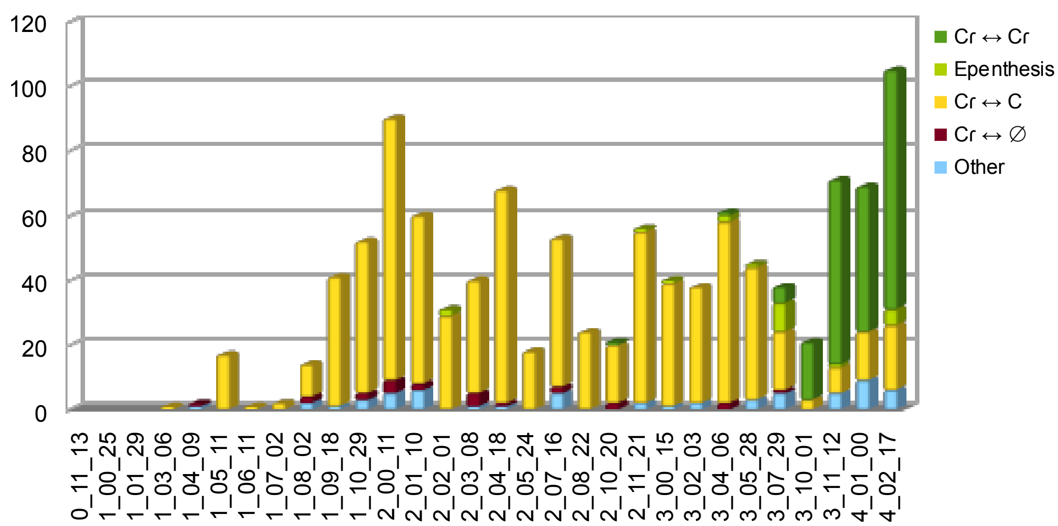
As we saw above, Inês displays a number of observable patterns in singleton onsets. First is the systematic stopping of fricatives. In addition, we note the systematic production of the palatal lateral |ʎ| as a glide [j]. Conversely, we also note the rather unsystematic production of |ɾ| in singleton onsets either in a target-like manner or as [l]. We also witnessed the deletion of |ɲ| in unstressed syllables following |i|, and the fact that |f/v| is stopped with alveolar place of articulation before labial place of articulation.

I return to these patterns in Section 8, where I focus on their analyses more specifically, which combine the types of articulatory, perceptual, and representational considerations introduced in Chapter 2, Section 4. In the next section, I continue my description of Inês's data, this time focusing on branching onsets.

5. Branching Onsets

As discussed in Chapter 2, Section 3, branching onsets in EP consist of either an oral stop |p/b, t/d, k/g| or a labial fricative |f/v| followed by |ɾ| or |l|. The data for C|ɾ| branching onsets in Inês's corpus are quite rich; the corpus documents more attempts at each of these clusters than at all of the C|l| branching onsets put together. All C|ɾ| branching onsets are produced accurately at a rate of 75% or higher by 3;11.12, the third-to-last session of the corpus, as shown in Figure 19.[20]

Figure 19: C|ɾ| branching onsets



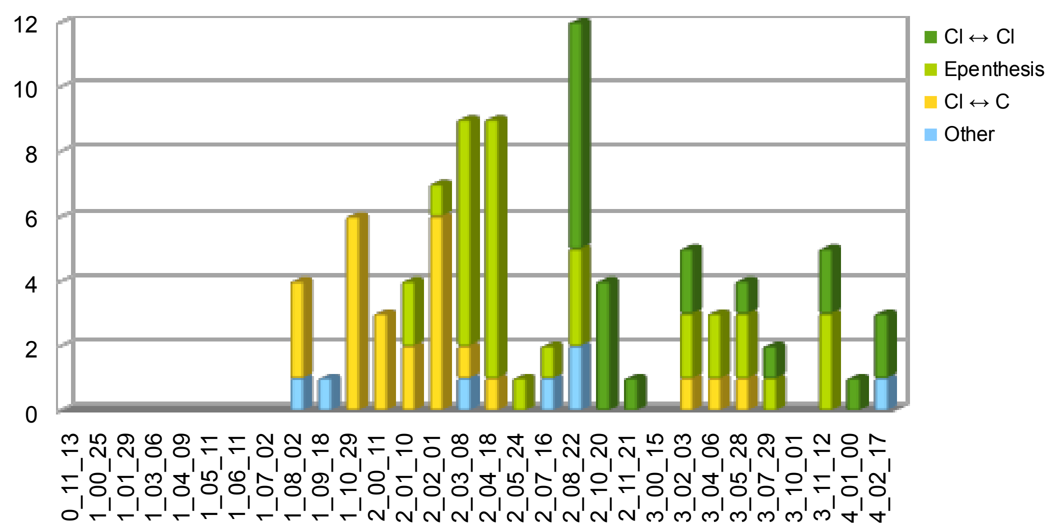
Each C|ɾ| branching onset displays roughly the same pattern of acquisition: as soon as Inês begins to attempt these clusters, she reduces them to the first element (including some predictable substitutions in the case of |f/v| in |fɾ/vɾ| clusters, which I discuss in the following section). This pattern of reduction is commonly attested in studies of onset cluster development

20 Inês's productions of C|ɾ| show a dip in accuracy to 65% at 4;01.10, but since this only occurs in one session and accuracy is fairly high, I still consider this cluster mastered at 3;11.12.

(e.g. Smith 1973; Spencer 1986; Fikkert 1994; Freitas 1997; Barlow 1997; Rose 2000; Goad & Rose 2004), and can be attributed either to reduction to the least sonorous element, or, structurally, to the head constituent of the cluster.[21] This reduction is predominant in Inês's attempts, occurring at a rate of above 90% for every session until target-like productions emerge.

As mentioned already, we find relatively few examples of C|l| branching onsets attempted by Inês, which makes it difficult to draw a clear picture of her acquisition of this cluster type. Even when the data for |pl/bl|, |kl/gl| and |fl| are combined, none of the last 11 sessions of the corpus contain more than 5 attempts at C|l| branching onsets, the overall behaviour of which is somewhat variable, as illustrated in Figure 20.

Figure 20: C|l| branching onsets

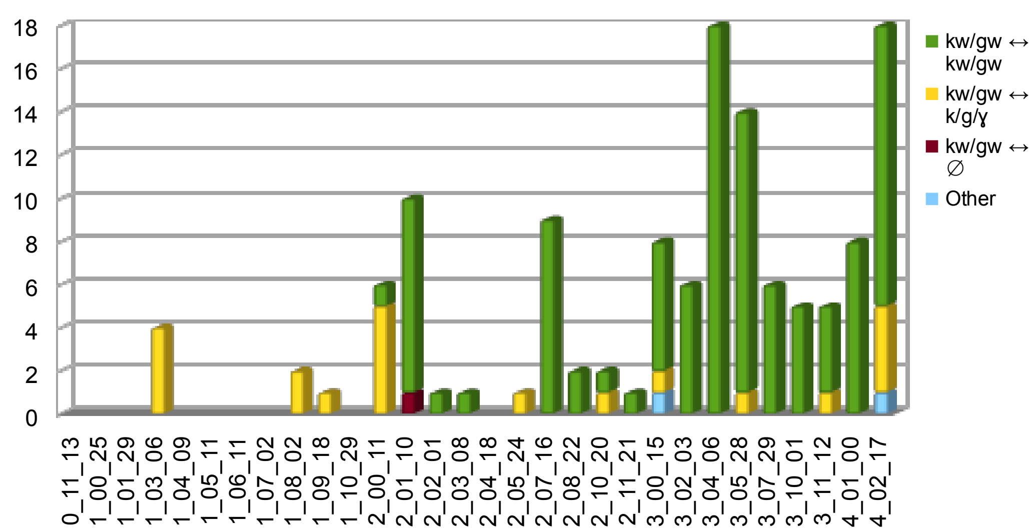


21 Whether Inês's reductions of branching onsets follow sonority-based or structure-based conditioning (cf. Goad & Rose 2004) is beyond the scope of this paper. In either case, the predicted result is borne out: she reduces branching onsets to the consonant in the first position (i.e. the stop or fricative).

Although, as mentioned, production patterns are not as clear for C|l| clusters as they are for C|ɾ|, the development of C|l| can be roughly described as follows. First, the cluster is reduced to the first position until 2;02.01, then productions with a vowel epenthesized between the two consonants occur, at an especially high rate at 2;03.08 and 2;04.08.[22] Target-like productions emerge at 2;08.22, after which target-like productions and epenthesis variably co-occur.

Freitas (2003:42) also discusses sequences of velar stops followed by labiovelar approximants (|kw/gw|) as "complex segments" which may influence the development of branching onsets. In contrast to this, Mateus & d'Andrade (2000) say that "glides preceding vowels are vowels in underlying structure" (p. 51), which would make |w| in these examples a part of the syllable nucleus, and |k/g| singleton onsets. The development of these sequences is depicted in Figure 21.

Figure 21: |kw/gw|



22 Note that in early cases of C|l| epenthesis, especially in these sessions, the second consonant may be produced as either [l] or [ɾ].

With the exception of the word *água* 'water',[23] Inês masters |kw/gw| at 2;01.10, and the development of this sequence does not closely resemble that of either C|l| clusters or C|ɾ| clusters. Because of this dissimilarity, and because of the analysis by Mateus & d'Andrade (2000) mentioned above, I leave |kw/gw| out of the remainder of this section.

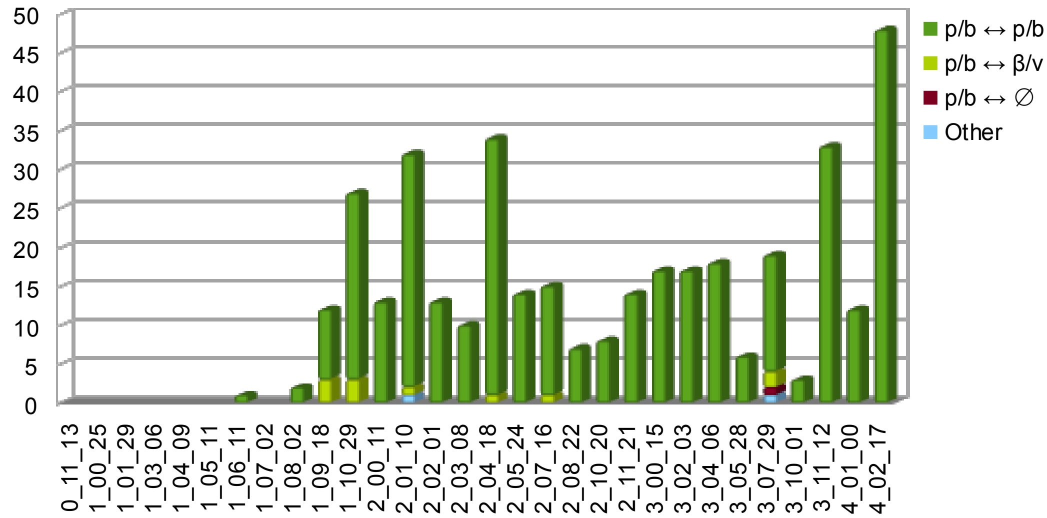
In sum, when Inês reduces branching onsets to single constituents, her production patterns closely match those of corresponding singleton onsets; plosives are produced in an overwhelmingly target-like manner, and fricatives undergo a stage of stopping before they are fully acquired. Given this, and given the fact that all C|ɾ| clusters emerge correctly at the same time, it is useful to analyze branching onsets on the level of their component positions. I do so in Sections 5.1 and 5.2 below.

5.1 First Position of Branching Onsets

In this section, I discuss Inês's development of the first position of branching onsets, irrespective of the consonants which occupy the second position of the cluster. As we saw above, Inês's acquisition of the first consonants in branching onsets (|p/b, t/d, k/g, f/v|) closely matches her acquisition of the same consonants in singleton onsets. Just as with singletons, oral stops in the first position of branching onsets are mastered during Inês's earliest attempts at clusters containing them (i.e. between 1;07.02 and 1;08.02), as exemplified in Figure 22.

23 In most attempts up to 1;08.02, Inês deletes |gw| in *água*. In 1;09.18 and 1;10.29, she produces the cluster predominantly as [w], and for the remainder of the data attempts at this word are few.

Figure 22: |p/b| in branching onsets



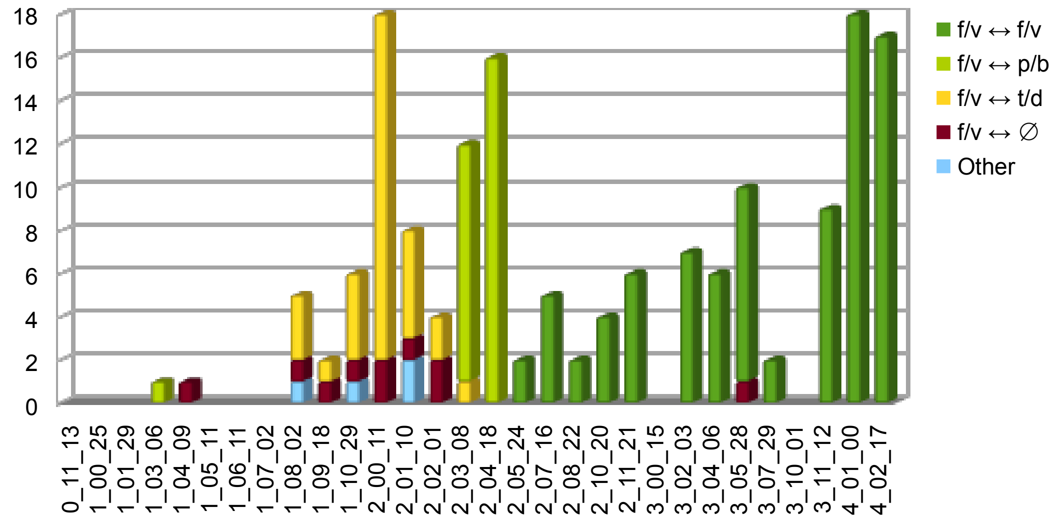
Only |f/v| is not immediately produced accurately when it is present in a branching onset. Attempts at |f/v| in the first position of branching onsets follow the same substitution patterns that we saw for |f/v| in singleton onsets (as discussed in Section 4). Recall that Inês acquires |f/v| in singleton onsets in three distinct stages, as shown in Table 1, repeated below in Table 5 for convenience.

Table 5: Fricative stopping and mastery in singleton onsets, with starting sessions

	Stopped production(s)	**Target-like**
f/v	t/d (1;07.02), p/b (2;03.08)	2;07.16
s/z	t/d (1;08.02)	2;10.20
ʃ/ʒ	t/d (1;08.02)	2;11.21
ʀ	k/g (2;00.11)	3;04.06

In the first position of branching onsets, |f/v| shows these same stages, as shown below in Figure 23.

Figure 23: |f/v| in branching onsets



First, |f/v| in branching onsets is predominantly produced as [t/d] between the ages of 1;08.02 and 2;02.01, then it is predominantly produced as [p/b] between the ages of 2;03.08 and 2;04.18, before it is accurately produced starting at 2;05.24.[24]

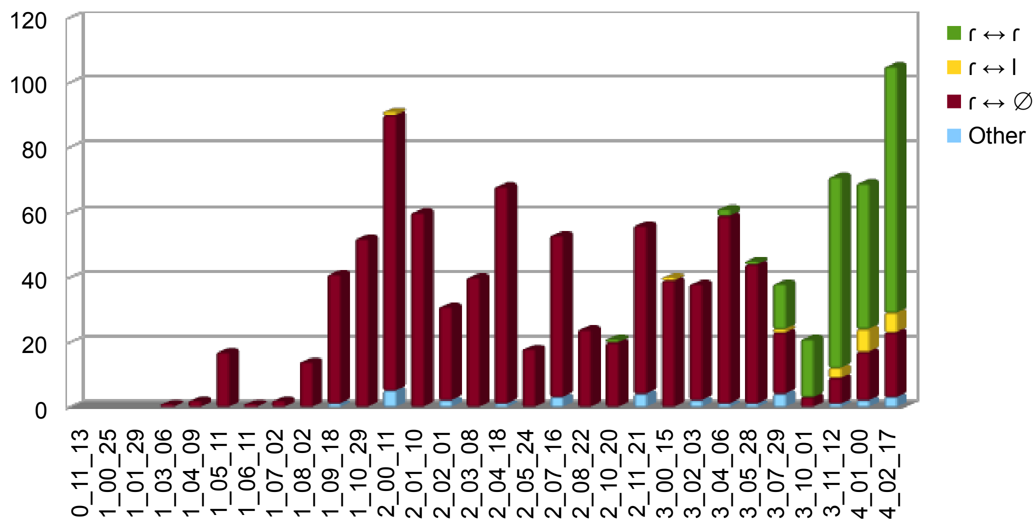
5.2 Second Position of Branching Onsets

In contrast to the first position of branching onsets, consonants in the second position do not behave the same as their singleton onset counterparts. In this section I focus on the second position of branching onsets, again irrespective of the segments which occur in the first position.

24 Although this is the session before which |f/v| is mastered in singleton onsets, only two examples of |fɾ/vɾ| occur in 2;05.24. We can say, then, that |f/v| in these two contexts are acquired at roughly the same time.

The deletion rate for |ɾ| in the second position of branching onsets is consistently above 90% until 3;07.29, when target-like realizations begin to emerge.[25] |ɾ| is mastered in this position at 3;10.01.

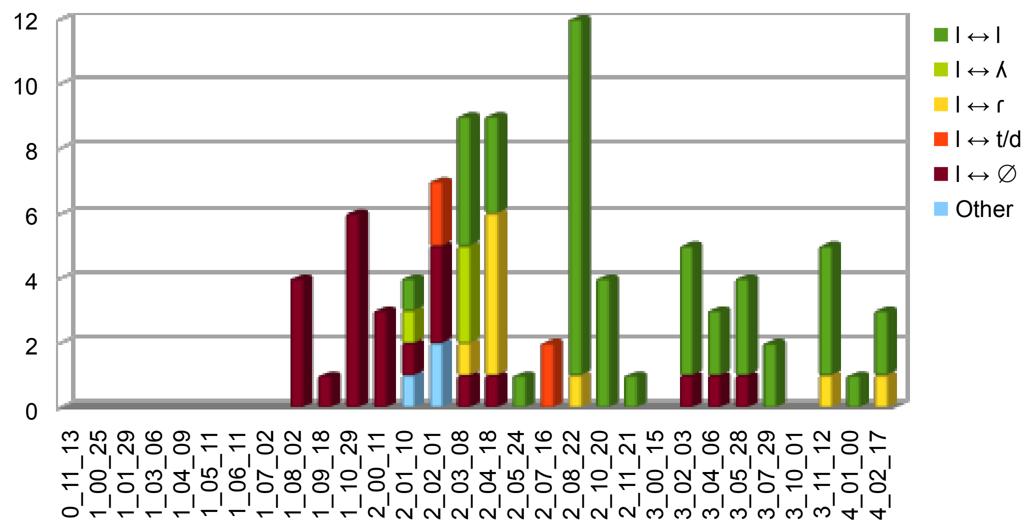
Figure 24: |ɾ| in branching onsets



As discussed in the beginning of Section 5, the number of lateral branching onsets that Inês attempts is much less than the number of rhotic branching onsets. However, when analyzing the production and substitution of the consonant in the second position, a clear distinction can be made between the laterals and the rhotics: |l| is produced in this position well before |ɾ| is. Compare Figure 24 with Figure 25:

25 As we will see in later sections, this corresponds to an increase in accuracy of |ɾ| productions in other syllable positions as well.

Figure 25: |l| in branching onsets



By 2;01.10, even though |l| is not accurately produced at a consistent rate, the deletion rate is less than 50%. Although the data for |l| are sparse, we can tentatively say that this consonant is acquired at 2;08.22, given the low rate of deletion and substitution after this point. This is approximately 1 year 2 months before |ɾ| is mastered in this context.

5.3 Summary of Observations

I will revisit several patterns from the above description in the analysis presented in Section 8. The first is that Inês predominantly reduces branching onsets to single constituents corresponding to the first consonant in the cluster. The second is that she frequently produces a vowel intervening within C|l| branching onsets. I argue that both of these patterns arise from Inês's analysis of the segmental distributions of her target language. I will also discuss Inês's development of |ɾ| across syllable positions.

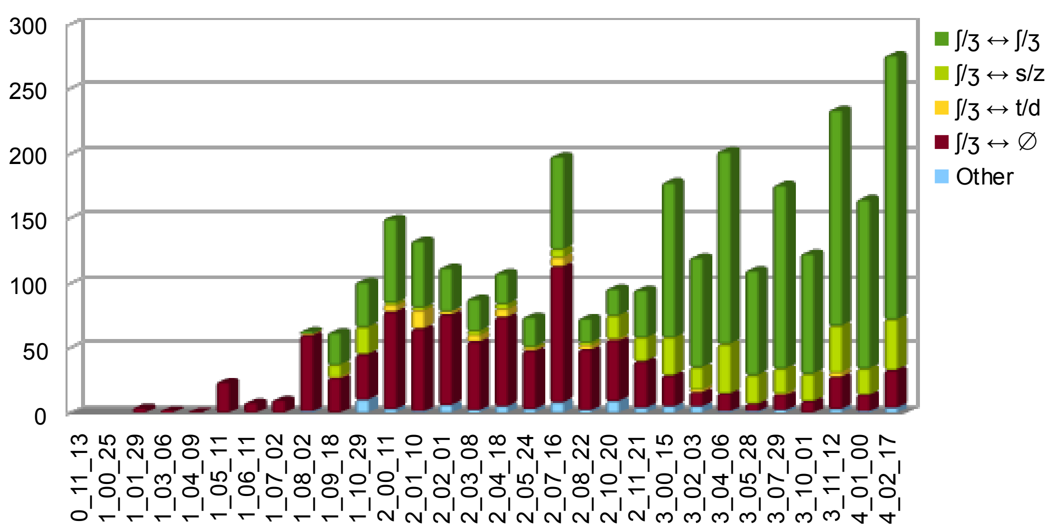
In the following section I give a description of Inês's coda development, which involves effects related to word and utterance domains.

6. Codas

As previously mentioned, EP allows only three phonemes in coda position: |ʃ| (or its voiced counterpart |ʒ|), |ɾ| and |ɫ|. Inês first begins to attempt words containing codas in earnest at 1;01.29.[26] |ʃ/ʒ| is the most frequently attempted, with 3,290 attempts, followed by |ɾ| with 1,703, and |ɫ| with 312. Inês's development of consonants in this position is variable; although she appears to master |ʃ/ʒ| at 3;04.06 (see Figure 26),[27] she does not master |ɾ| or |ɫ| in the recorded period. By the end of the corpus, |ɾ| is produced with only 60% accuracy (see Figure 27) and |ɫ| is produced with only 40% accuracy (see Figure 28).

First, I show |ʃ/ʒ| productions in Figure 26.

Figure 26: |ʃ/ʒ| in codas



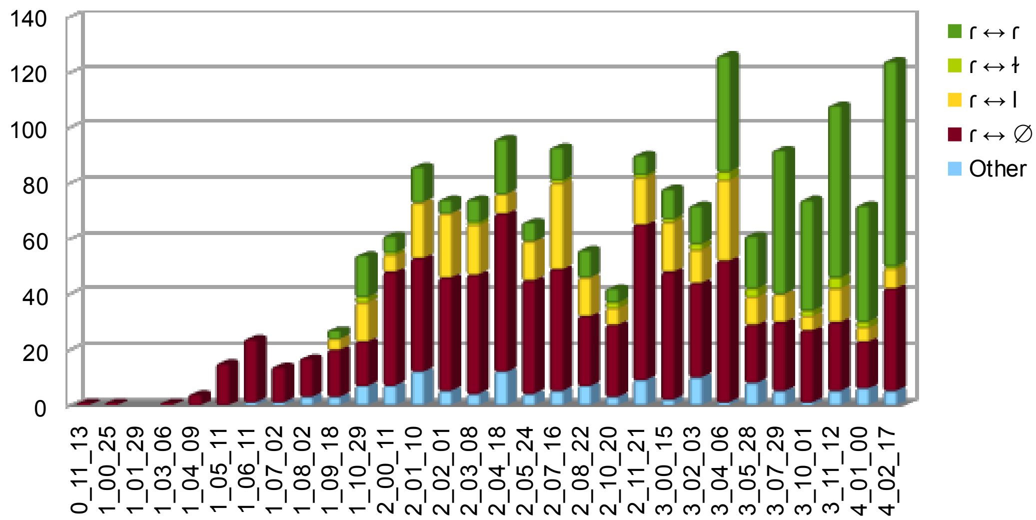
26 In the previous two sessions, there are only 6 total attempts at codas. At 1;01.29 there are 38.

27 Further consideration of the data in Section 6.1 reveals that she actually masters |ʃ/ʒ| slightly earlier than this.

In the earlier portion of the data, we see a high rate of deletion of |ʃ/ʒ| in codas, accompanied by infrequent target-appropriate productions of |ʃ/ʒ|. Inês's accuracy rate begins to increase at 3;00.15, and reaches 75% by 3;04.06.

Productions of |ɾ| are depicted below in Figure 27.

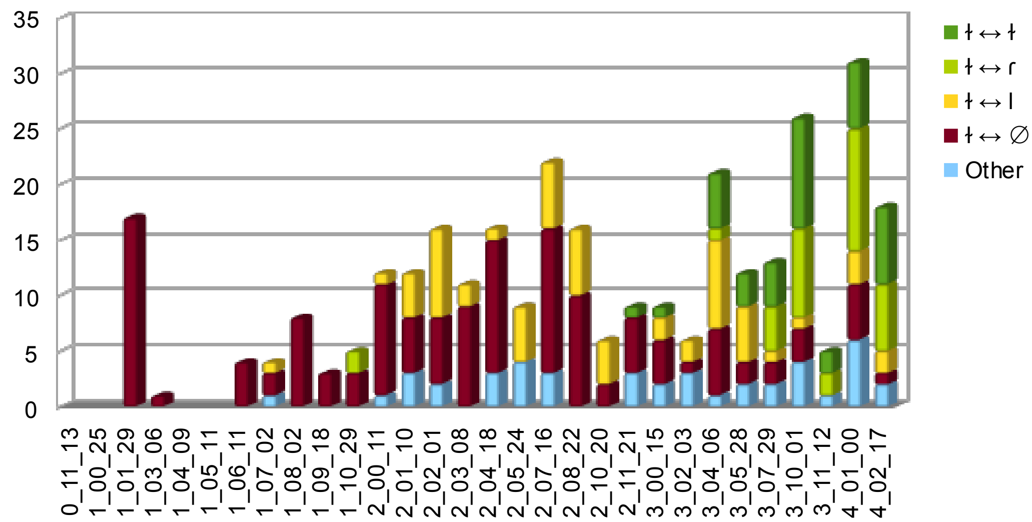
Figure 27: |ɾ| in codas



Note the high rate of deletion of |ɾ| across all sessions. Correct productions of |ɾ| gradually increase in frequency over the course of the data, with rates of deletion dropping and giving way to steadily improving accuracy starting at around 3;07.29, which is the same session where we first observe the emergence of target-like productions of |ɾ| in the second position of branching onsets. |ɾ| in codas is also frequently produced as [l] throughout most of the corpus.

As mentioned previously, |ɫ| is attempted much less frequently than |ʃ/ʒ| or |ɾ| in codas, but by the end of the corpus a rise in production as [ɫ] or [ɾ] is visible, as shown in Figure 28 below.

Figure 28: |ɫ| in codas



Note that starting at the age of two, |ɫ| is also frequently produced as [l], the counterpart of |ɫ| which, in EP, occurs in singleton onsets and branching onsets.

Below I discuss Inês's productions of codas in light of the resyllabification of codas at word edges.

6.1 Resyllabification of Codas

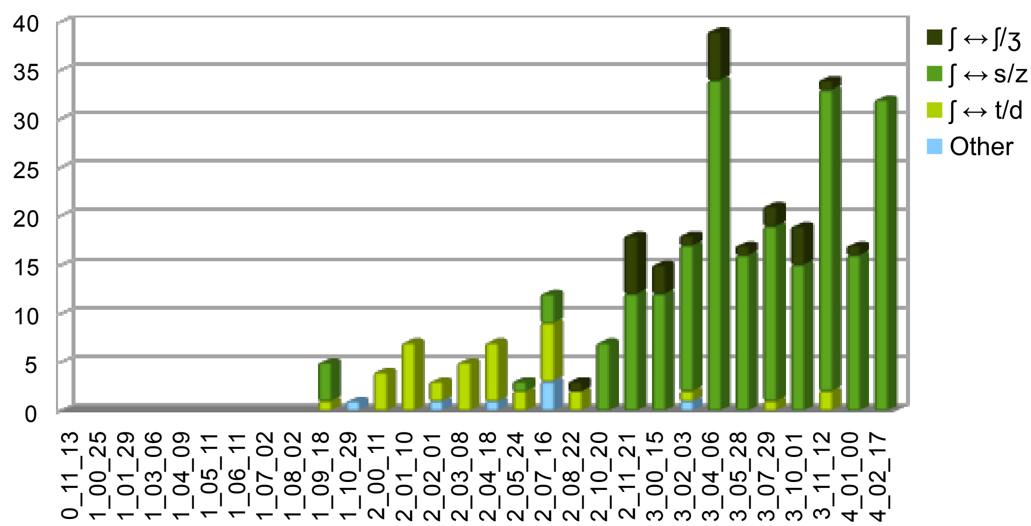
Starting at 2;10.20, Inês has a relatively high frequency of substitution of alveolar fricatives [s] or [z] in place of the postalveolar fricative |ʃ/ʒ|. This fricative substitution has its roots in a sandhi phenomenon in the target system, as described in Chapter 2, Section 3. In adult speech, when /ʃ/ in a word-final coda precedes a word that begins with a vowel, it is resyllabified as an onset and produced as |z| (Mateus & d'Andrade 2000; Rose in press).[28] This is reflected in Inês's productions, as exemplified in Table 6 below.

Table 6: Resyllabification of /ʃ/ in utterance-medial, word-final codas

Session: Record	**2;11.21: 262**	**3;00.15: 58**	**3;05.28: 6**	**3;11.12: 16**
Orthography	pois é	umas orelhas	grandes eu	Mas aqui
IPA Target (underlying form)	ˈpojʃ ˈɛ	ˈumɐʃ ɔˈrɐʎɐʃ	ˈgɾɐ̃dɨʃ ˈew	mɐʃ ɐˈki
IPA Actual	ˈpoj ˈzɛ	ˈumɐ zɔˈlɛlɐs	ˈgɐ̃dɐ ˈzew	mɐ zɐˈki

By 2;10.20, in resyllabification contexts, Inês produces /ʃ/ as either [s/z] or [ʃ/ʒ] almost 100% of the time, as shown in Figure 29.

Figure 29: /ʃ/ in codas resyllabified as onsets[29]

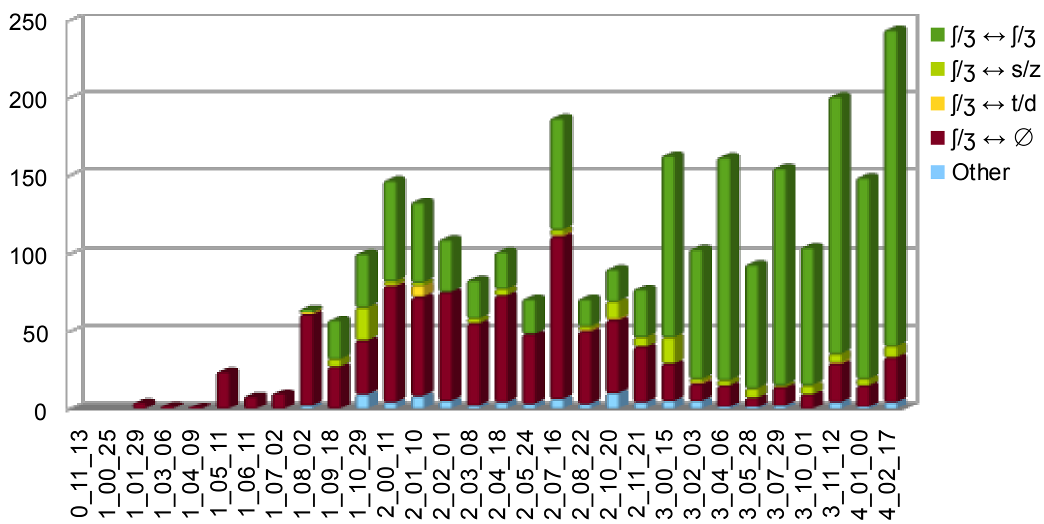


28 /ʃ/ is also susceptible to voicing alternation; when it occurs utterance-finally or preceding a voiceless consonant it is produced as |ʃ|, and when it precedes a voiced consonant it is produced as |ʒ|.

29 Recall that |ʒ| can only occur in pre-consonantal positions in EP, so it is never resyllabified in the corpus.

Note that between 1;09.18 and 2;08.22, /ʃ/ in this context is frequently stopped as [t/d]. This is further support that these codas have been syllabified as onsets, because these sessions fall within the range where Inês stops target fricatives in singleton onsets. When resyllabification is excluded from the data, as in Figure 30 below (i.e. the target coda has been either produced as a coda or deleted), virtually no cases of |ʃ/ʒ| being stopped as [t/d] can be found in the data.[30]

Figure 30: |ʃ/ʒ| in codas, excluding resyllabification



Removing cases of resyllabification makes the pattern in the data clearer. Initially, coda |ʃ/ʒ| is deleted in Inês's attempted words. Then, between 1;09.18 and 2;11.21, |ʃ/ʒ| is produced accurately at a rate of 30% on average and deleted at a rate of 60% on average (this split will be discussed further in Section 6.2). Finally, |ʃ/ʒ| is mastered in codas at 3;00.15.

30 Note that I did not add the cases of resyllabification to the data on singleton onsets, for two reasons. First, these cases would not contribute anything new to the already-established observations about onsets. Second, adding the resyllabification data to those on singleton onsets would introduce a number of unnecessary difficulties in the quantitative descriptions of Inês's developmental patterns, again here with no gain in empirical adequacy.

|ʃ/ʒ| is not the only coda that may be affected by sandhi phenomena in EP. In adult speech, words and utterances that end in |ɫ| or |ɾ| are often produced with an epenthetic vowel at the end, allowing them to be syllabified as onsets (Freitas 2003). Inês displays this behaviour as well, as shown in Table 7 and Table 8.

Table 7: Resyllabification of |ɾ| in word-final codas, with epenthetic vowel

Session: Record	**1;10.29: 379**	**1;10.29: 526**	**2;01.10: 76**	**2;03.08: 2**
Orthography	meu flor?	papar	açúcar	brincar
IPA Target	ˈmew ˈfloɾ	pɐˈpaɾ	ɐˈsukɐɾ	bɾĩˈkaɾ
IPA Actual	ˈmew ˈtʲoɾɨ	paˈpaɾi	ɐˈtukɐli	bikaˈli

Table 8: Resyllabification of |ɫ| in word-final codas, with epenthetic vowel

Session: Record	**2;02.01: 408**	**2;05.24: 252**	**2;08.22: 272**	**3;04.06: 327**
Orthography	Ao hospital.	É azul.	pincel	igual
IPA Target	aw ɔʃpiˈtaɫ	ˈɛ ɐˈzuɫ	pĩˈsɛɫ	iˈgwaɫ
IPA Actual	aw βɔpiˈtali	ˈɛ ɐˈduli	piˈʃɛli	iˈgwali̥

Even utterance-medially, Inês resyllabifies |ɫ| and |ɾ| frequently, as shown below in Table 9 and Table 10.

Table 9: Resyllabification of |ɾ| in utterance-medial codas

Session: Record	**2;03.08: 3**	**2;07.16: 18**	**3;02.03: 127**	**3;10.01: 60**
Orthography	brincar à	pôr aqui	fazer ao	abrir esta
IPA Target	bɾĩˈkaɾ a	ˈpoɾ ɐˈki	fɐˈzeɾ aw	ɐˈbɾiɾ ˈɛʃtɐ
IPA Actual	biˈka la	ˈpo lɐˈki	fɐˈze lɔ	ɐˈbɾi ˈɾɛʃtɐ

Table 10: Resyllabification of |ɫ| in utterance-medial codas

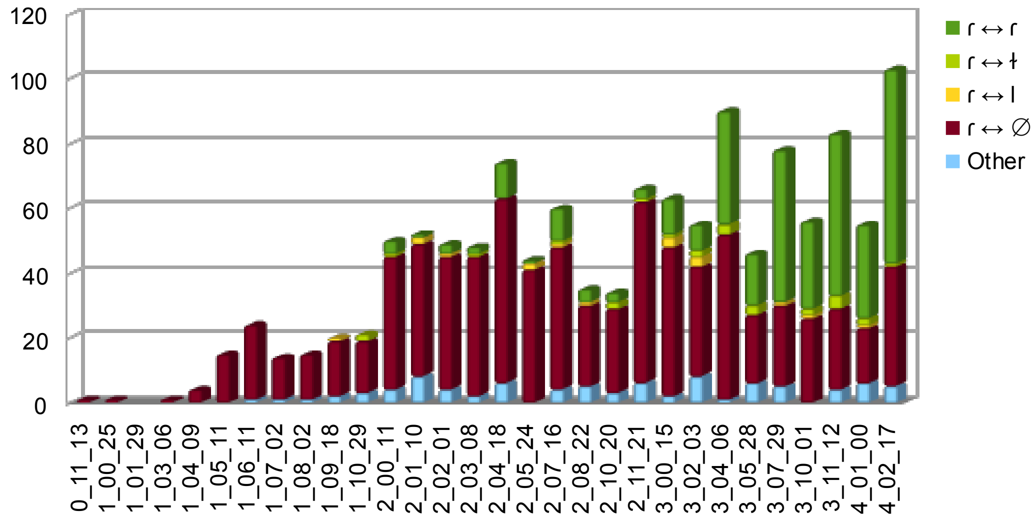
Session: Record	**2;02.01: 228**	**3;02.03: 275**	**3;04.06: 332**	**4;02.17: 108**
Orthography	Natal é	mal à	igual à	mal, eram
IPA Target	nɐˈtaɫ ˈɛ	ˈmaɫ a	iˈgwaɫ a	ˈmaɫ ˈɛɾɐ̃w
IPA Actual	nəˈta li	ˈma la	ˈgwa la	ˈma ˈlɛlɐ̃w̃

When Inês resyllabifies coda |ɾ| as an onset, she may produce it as either [ɾ] (at an average rate of 33% for the last 20 sessions) or [l] (at an average rate of 60% for the last 20 sessions). This pattern is similar to that of |ɾ| in singleton onsets, which Inês produces as [l] at a rate of about 35% over the last 20 sessions. However, when she resyllabifies |ɫ| in onsets, she produces it as [l] almost 100% of the time, which highlights her understanding of the distribution of |l/ɫ| in EP.

Mirroring the procedure for |ʃ/ʒ| in Figure 30, I exclude cases of resyllabification of |ɾ| in Figure 31. This includes both utterance-medial and utterance-final resyllabification.[31]

31 Since I excluded all cases where |ɾ| in coda is produced as an onset, some cases where |ɾ| was produced correctly are excluded as well, e.g. *quer* |ˈkɛɾ| produced as [ˈkɛɾi], or *quer a* |ˈkɛɾ ɐ| produced as [ˈkə ɾɐ].

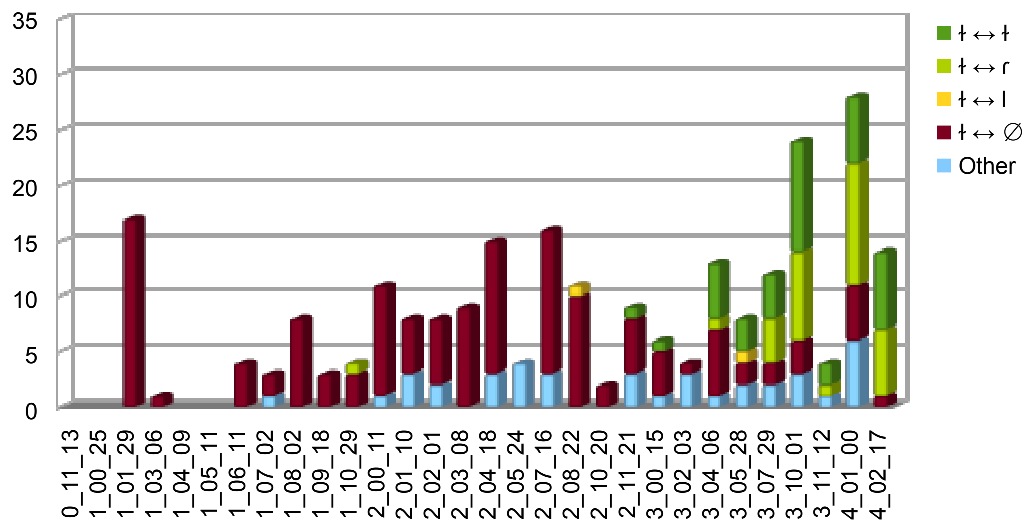
Figure 31: |ɾ| in codas, excluding resyllabification



When Inês does not resyllabify |ɾ| in coda position, she predominantly deletes it. She does produce |ɾ| in a target-like manner at an increasing rate, but only reaches 60% accuracy during the documented data.

Below, I show production data for coda |ɫ|, with utterance-medial and utterance-final resyllabification excluded.

Figure 32: |ɫ| in codas, excluding resyllabification



Inês has fewer documented attempts at |ɫ| in coda position than |ʃ/ʒ| or |ɾ|, as mentioned above, and she seems to have more difficulty with mastering this coda than with the other two. In the last few sessions, Inês produces |ɫ| as [ɾ] just as often as she produces it correctly.

Because Inês's productions of |ɾ| and |l/ɫ| factor heavily into my analysis, I provide an interim summary of Inês's productions of |ɾ| and |l/ɫ| in both onsets and codas below.

Table 11: Inês's productions of |ɾ| and |ɫ| in singleton onsets and codas

Target consonant	**Actual production(s)**	**Emergence/Mastery**
ɾ in onsets	l ɾ	Emerges at 1;09.18. Emerges at 1;10.29.
l in onsets	l	Emerges at 1;10.29, mastered at 2;03.08.
ɾ in codas	ɾ	Emerges at 2;00.11.
ɫ in codas	ɫ[32] ɾ	Emerges at 2;11.21. Emerges at 3;04.06.

Note that although [ɾ] may occur in either codas or onsets, [l/ɫ] are more restricted: Inês only produces [l] in contexts where it is in onset position, and she only produces [ɫ] in contexts where it is in coda position. Therefore, although it may appear paradoxical that |ɫ| is sometimes produced as [ɾ] while |ɾ| is sometimes produced as [l], these are in fact separate phenomena, occurring in different syllable positions.

6.2 Final versus Medial Codas

As mentioned in Section 6.1, Inês goes through a stage between 1;09.18 and 2;11.21 during which she produces coda |ʃ/ʒ| correctly at a rate of 30%, while she deletes the sound in her attempted words at a rate of 60%. When analyzing coda |ʃ/ʒ| productions, this may appear as a strange plateau in development, during which Inês produces this coda correctly one third of the time for over a year. Further exploration into the data reveals why this rate is so consistent: just as Inês does not master |ʃ/ʒ| in coda at the same time that she masters it in onsets, she does not acquire all occurrences of |ʃ/ʒ| in codas at the same time. She masters |ʃ/ʒ| in utterance final codas well before she masters it in utterance medial codas. The two environments are shown in Figure 33 and Figure 34 below.[33] Note that no cases of resyllabification occurred for this coda in the utterance final environment.

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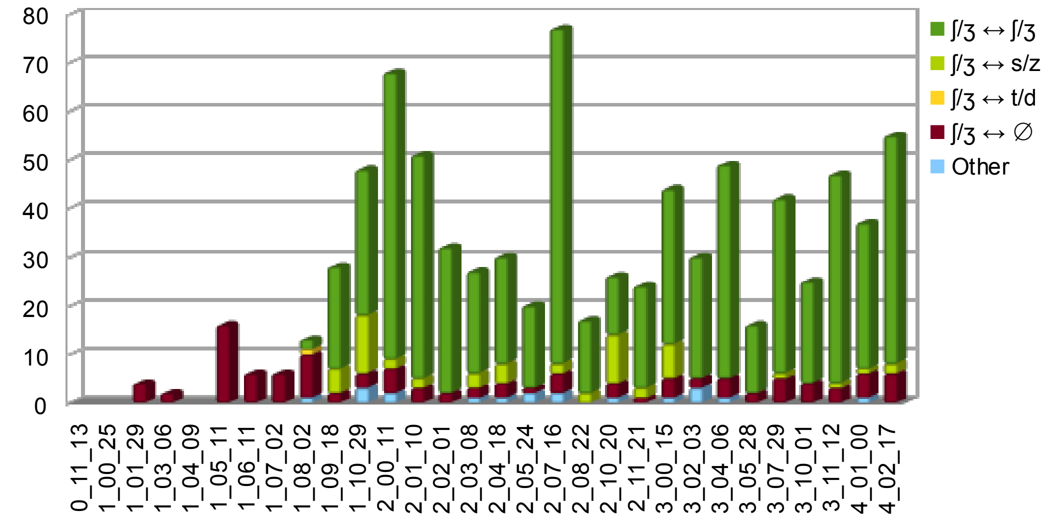
32 |ɫ| is only produced as [l] when it is resyllabified as an onset, therefore these cases would fall under the category of 'l in onsets' being produced as [l].

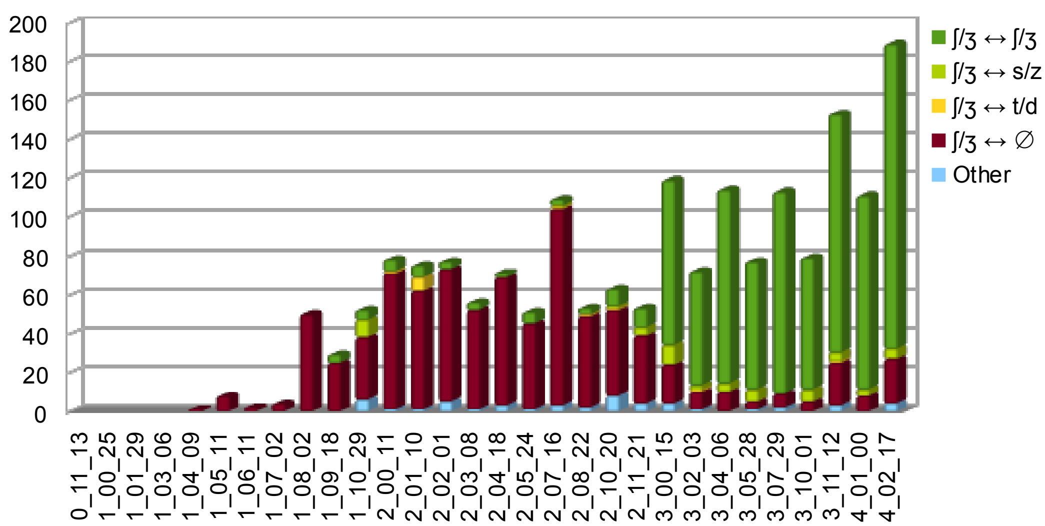
33 Henceforth, all cases of resyllabification are excluded from figures depicting Inês's development of |ʃ/ʒ| in coda.

Figure 33: |ʃ/ʒ| in utterance-final codas



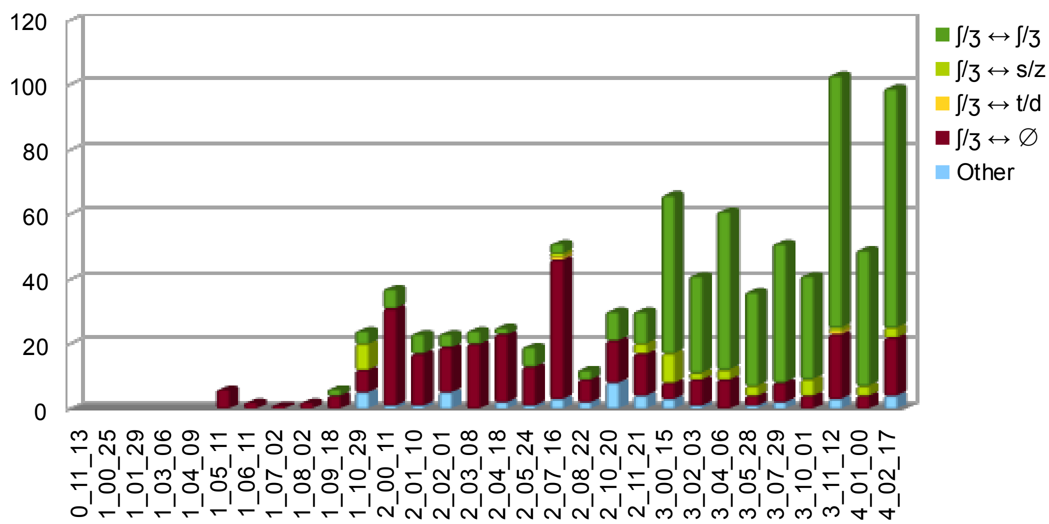
By 1;09.18, Inês produces |ʃ/ʒ| in utterance final codas at around 75% accuracy. She does not reach this rate of accuracy in utterance medial codas until 3;00.15, as depicted in Figure 34.

Figure 34: |ʃ/ʒ| in utterance-medial codas



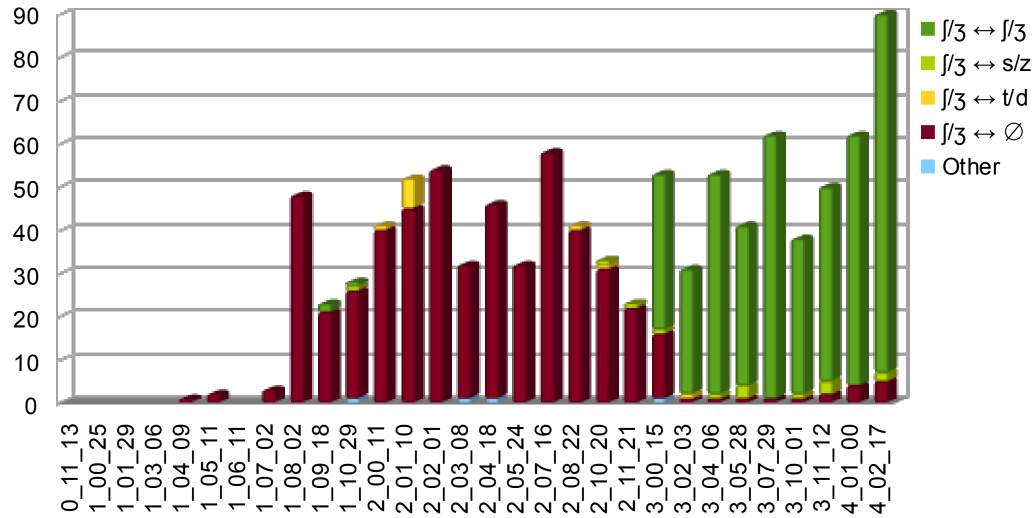
Before Inês mastered |ʃ/ʒ| in the utterance-medial environment, she predominantly deleted it, at a rate of almost 90% over the first 17 sessions where it is attempted. The utterance medial environment can be further broken down to show that virtually all of the few correct productions of |ʃ/ʒ| before 3;00.15 occur word-finally (Figure 35) rather than word-medially (Figure 36),[34] and that more of the deletions up to 2;11.21 occur word-medially.

Figure 35: |ʃ/ʒ| in utterance-medial, word-final codas



34 Note that there is a difference in scale between these charts, for readability.

Figure 36: |ʃ/ʒ| in word-medial codas



Note the clear dichotomy within Figure 36: until 3;00.15, virtually all word-medial codas are deleted, and after 3;00.15 they are correctly produced.

While Inês correctly produces |ʃ/ʒ| in utterance final codas before she does so in utterance medial codas, this pattern is not clearly mirrored in her productions of |ɾ|, although we observe a higher rate of deletion in utterance-medial codas than in utterance-final ones, especially before 3;05.28. Compare Figure 37 and Figure 38:

Figure 37: |ɾ| in utterance-final codas

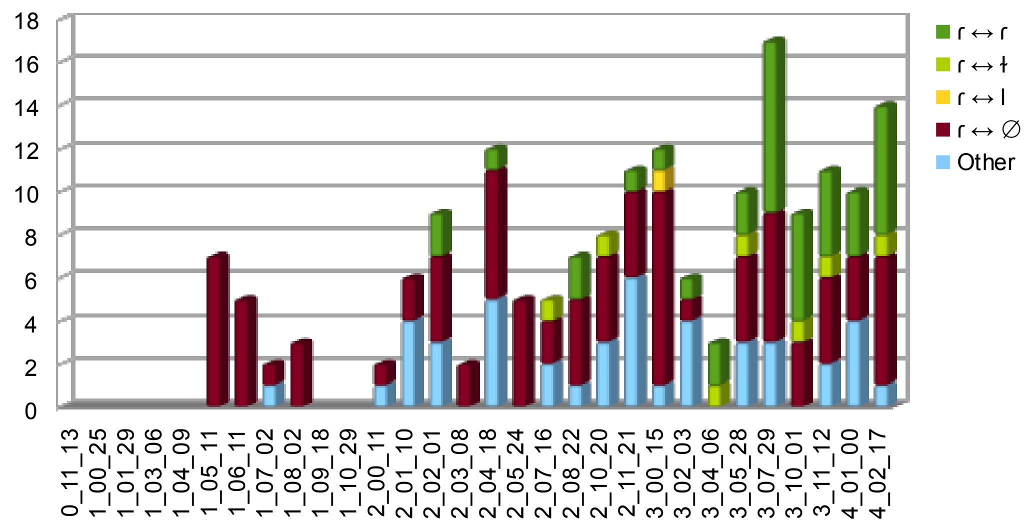
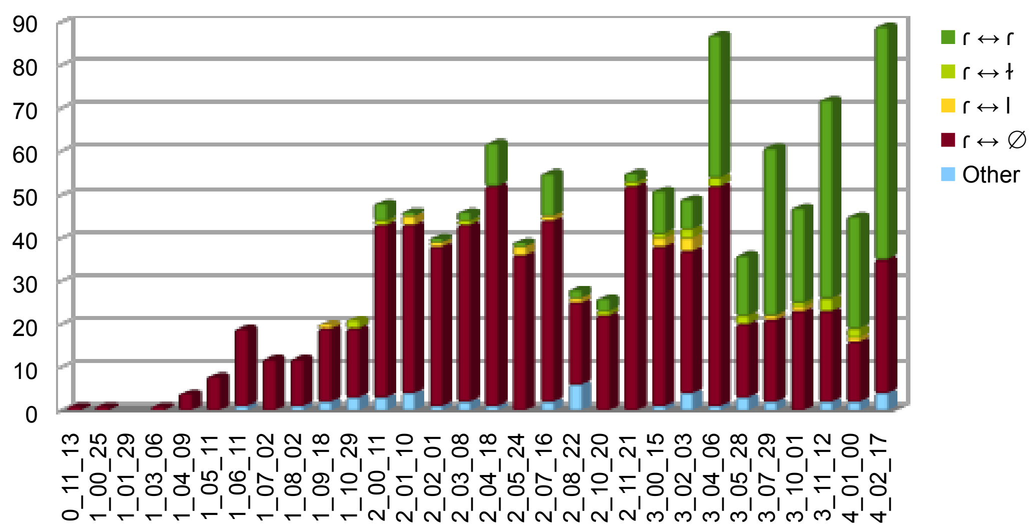


Figure 38: |ɾ| in utterance-medial codas[35]



35 Note that there are far fewer productions of |ɾ| in utterance-final codas than in utterance-medial ones; Figure 37 and Figure 38 differ in scale for readability.

Just as we saw with utterance-medial |ʃ/ʒ| in codas, productions of utterance-medial |ɾ| can be further subdivided to show a meaningful pattern: the majority of correct productions of utterance-medial |ɾ| before 3;05.28 are word-final, as shown through a comparison of Figure 39 and Figure 40.

Figure 39: |ɾ| in utterance-medial, word-final codas

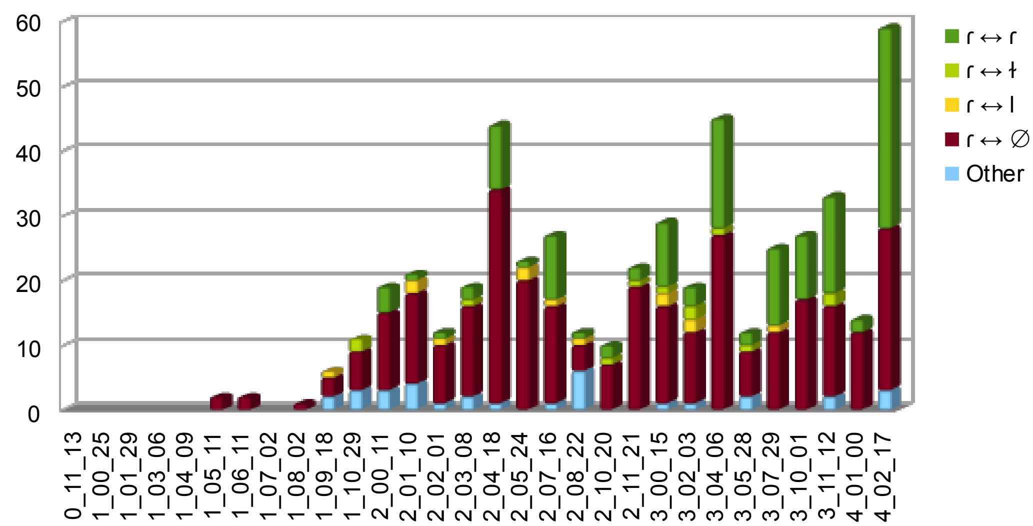
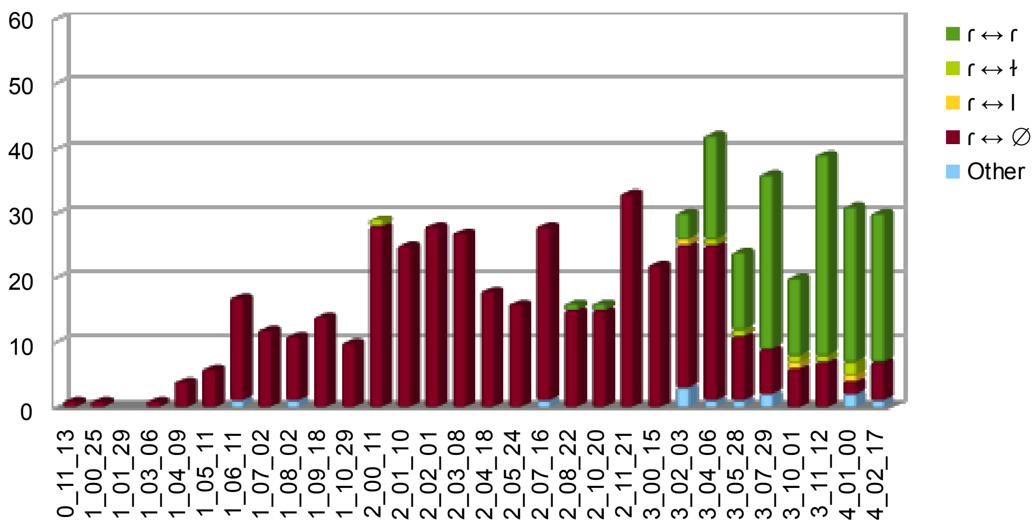


Figure 40: |ɾ| in word-medial codas



98% of all attempts at |ɾ| in word-medial codas before 3;02.03 result in deletion, as opposed to |ɾ| in utterance-medial word-final codas, where it is deleted in 71% of attempts before 3;02.03. Inês masters |ɾ| in word-medial codas at 3;11.12, although we note a general increase in accuracy of |ɾ| productions in both environments beginning around 3;07.29.

The data for |ɫ| in codas are more sparse and also less clear cut than that of |ʃ/ʒ| and |ɾ|. The corpus contains 246 examples of coda |ɫ| in the data that are not resyllabified. 157 of these examples are word-medial (shown in Figure 43 on page 71). This leaves 54 non-resyllabified attempts at utterance-final |ɫ| (Figure 41), and 35 non-resyllabified attempts at utterance-medial word-final |ɫ| (Figure 42). With so few examples spread across 30 sessions, clear patterns cannot be obtained from the data for either the utterance-final or the word-final environments.

Figure 41: |ɫ| in utterance-final codas

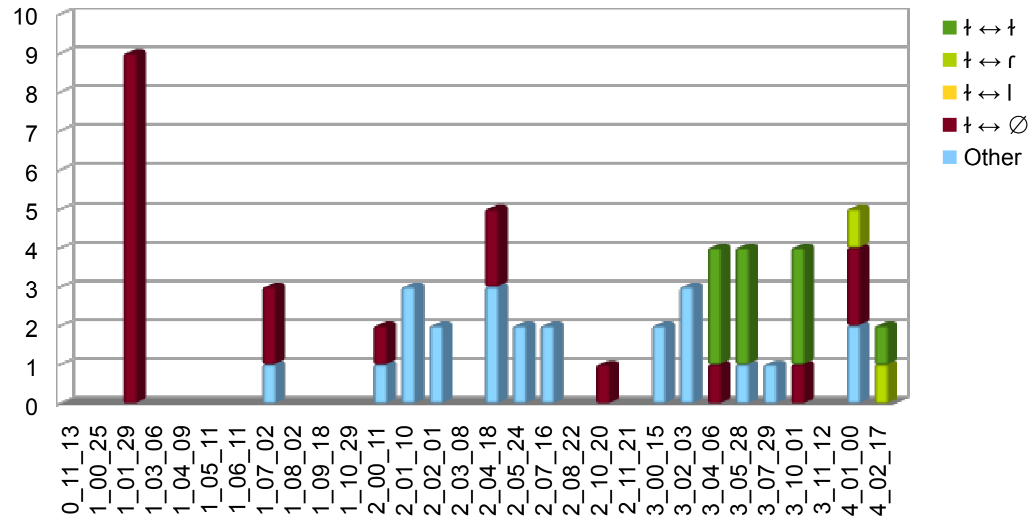
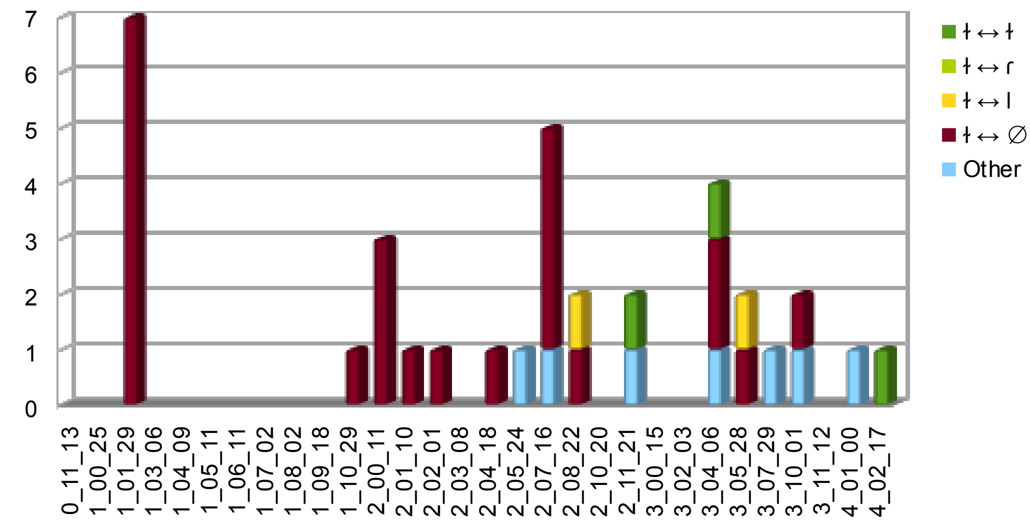
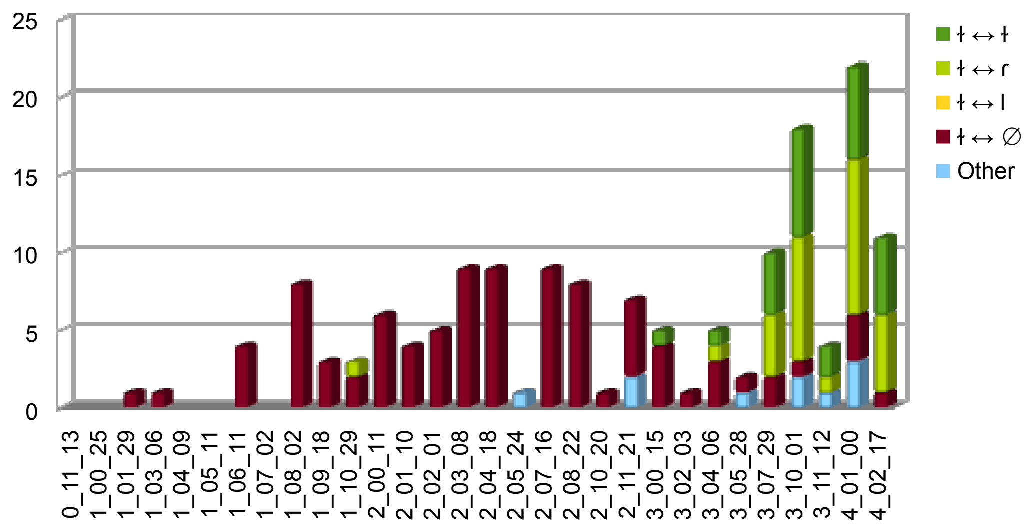


Figure 42: |ɫ| in utterance-medial, word-final codas



The data for |ɫ| in word-medial codas, shown below, are clearer.

Figure 43: |ɫ| in word-medial codas



Until session 3;02.03, about 95% of attempts of |ɫ| in word-medial codas result in deletion. At 3;07.29 there is a rise in production of |ɫ| in a target-like manner and as [ɾ]. By the end of the corpus, |ɫ| in codas is not fully mastered in any domain.

6.3 The Segmental Conditioning of /ʃ/ in Codas

As mentioned in Chapter 2, Section 3, /ʃ/ in underlying codas in EP alternates in place of articulation (from postalveolar to alveolar) and voicing depending on its phonological context; it may thus surface as |ʃ|, |ʒ|, or |z|. The patterns in the previous section suggest that Inês attends to phonological alternations by paying attention to prosodic conditioning; utterance-final codas are acquired earliest, with word-final utterance-medial and word-medial codas falling into place later. However, prosodic cues to word and phrase domains are not the only cues available to the learning of phonemic alternations. Segmental distributions arguably play a role as well; /ʃ/ surfaces as |z| when preceding vowels (across word boundaries), as |ʒ| when preceding voiced consonants both word-internally and across word boundaries, and as |ʃ| before voiceless consonants and at the end of utterances. In this section, I discuss Inês's acquisition of /ʃ/ in codas based on these segmental contexts. Although prosodic conditioning is sufficient to explain Inês's acquisition patterns, as I will show in Chapter 5, it is insufficient to explain Joana's development, which arguably follows a more segmental-based conditioning.

'Segmental context,' as I analyze it here, refers to the segment which immediately follows the position in which /ʃ/ is produced or deleted in the child's production, as opposed to that which would normally follow in the target form. In cases where attempted /ʃ/ is word-final but utterance-medial, I look at the first phone of the following word produced by Inês. Also, I exclude cases in which the target coda /ʃ/ is immediately followed by a strident fricative, due to the fact that, in EP speech, sequences of adjacent stridents are simplified to a single segment (Mateus & d'Andrade 2000:145).[36]

I divide the data on /ʃ/ in codas into four groups based on segmental environment: voiceless consonants, voiced consonants, vowels, and utterance boundaries (i.e. utterance-final codas). Note also that for the remainder of this section I will not collapse voicing in productions of /ʃ/, because voicing of this coda differs depending on the following environment. The correct allophone of /ʃ/ for each environment is shown in Table 12.

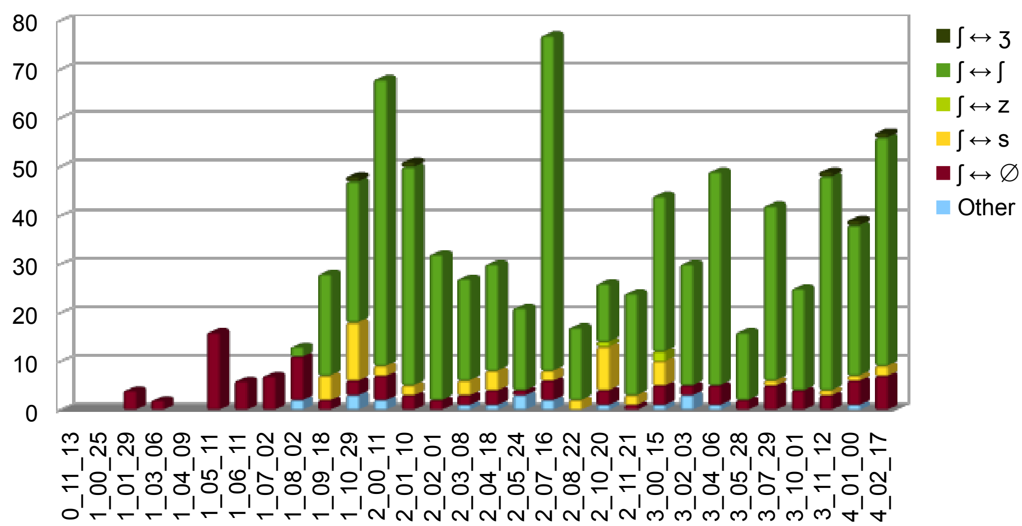
36 I also exclude productions of the aforementioned lexical exception *Inês;* as well as cases in which the following segment in the target or the child's production could not be transcribed, or the syllable containing /ʃ/ was deleted in its entirety; and, in the utterance-final position, cases where additional segments were appended to the end of the child's production.

Table 12: Coda /ʃ/, per phonological environment (Mateus & d'Andrade 2000)

Environment	**Realization of /ʃ/**	**Example**
$\_C_{[voiceless]}$	ʃ	*buscar* |buʃˈkaɾ|
$\_C_{[voiced]}$	ʒ	*mesmo* |ˈmeʒmu|
_V	z	*mas aqui* |mɐ zɐˈki|
_#	ʃ	*Queres?* |ˈkɛɾɨʃ|

Inês displays a deletion stage for every context but the utterance-final position (which is mastered almost immediately, as discussed in Chapter 4, Section 6.2). As shown in Figure 44 below, Inês makes virtually no voicing errors in this environment.

Figure 44: /ʃ/ in utterance-final codas



Conversely, Inês begins to produce the correct variant of /ʃ/ preceding consonants ([ʃ] before voiceless consonants, and [ʒ] before voiced ones) at about 3;00.15, as shown in Figure 45 and Figure 46.

Figure 45: /ʃ/ before voiceless consonants

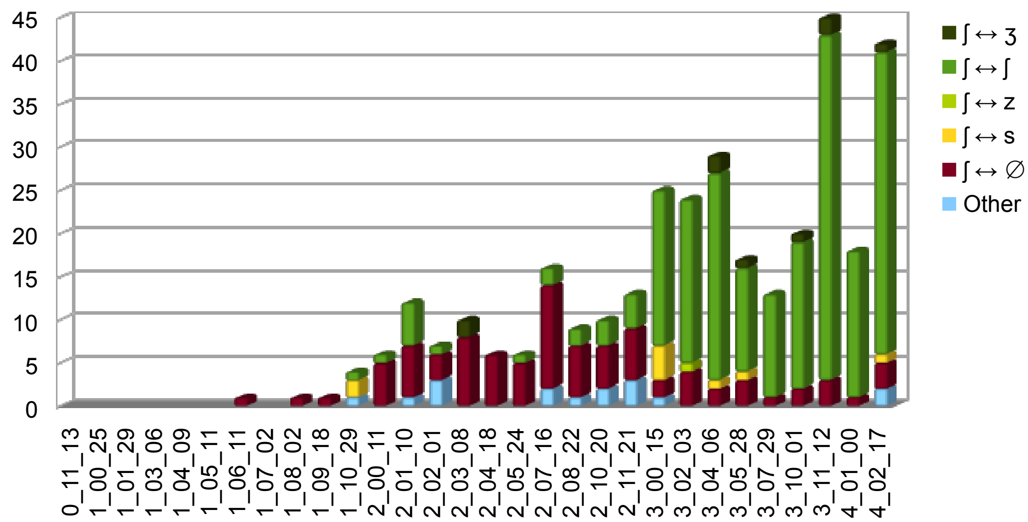
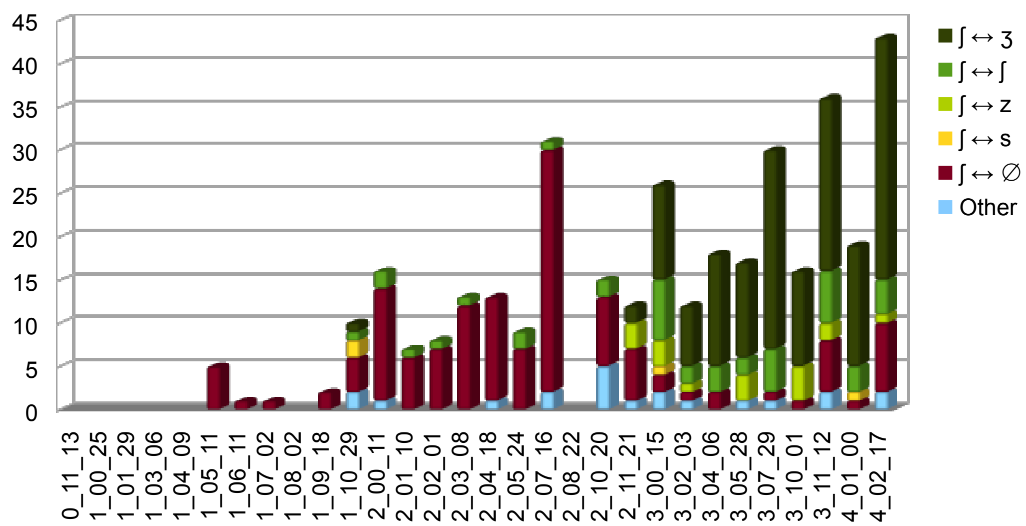
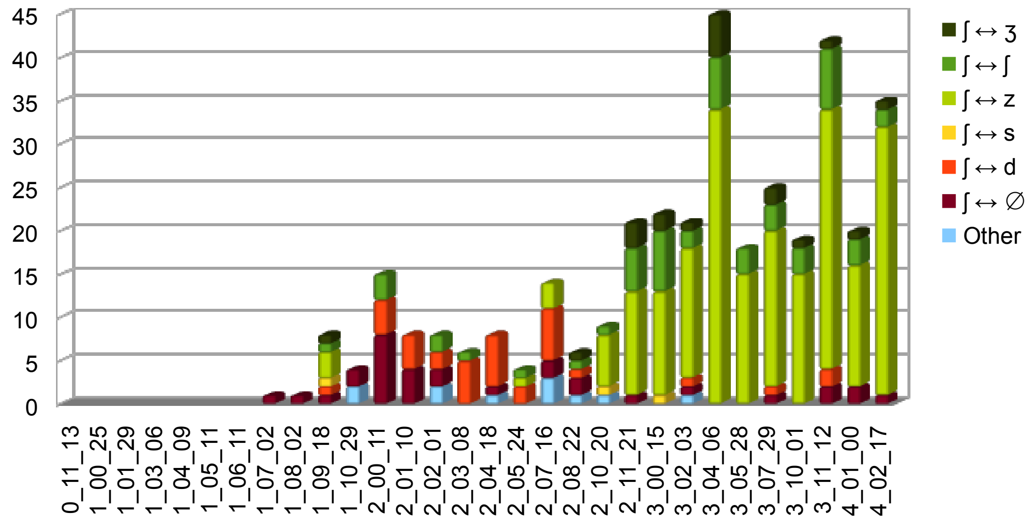


Figure 46: /ʃ/ before voiced consonants



In the prevocalic context (where resyllabification applies), as shown in Figure 47, Inês first produces /ʃ/ as [d] (because /ʃ/ has been resyllabified and fricative onsets in Inês's productions are subject to stopping, as discussed in Section 4), then at 2;10.20 she begins to predominantly produce /ʃ/ as [z], which is the correct variant in this context.

Figure 47: /ʃ/ in prevocalic context[37]



I further illustrate the stage-like nature of Inês's development in each environment through line graphs in Figure 48 below.[38] Each figure begins from the first session in which /ʃ/ is attempted in a coda in the specified position, and includes a trend line depicting her rate of development over time.[39]

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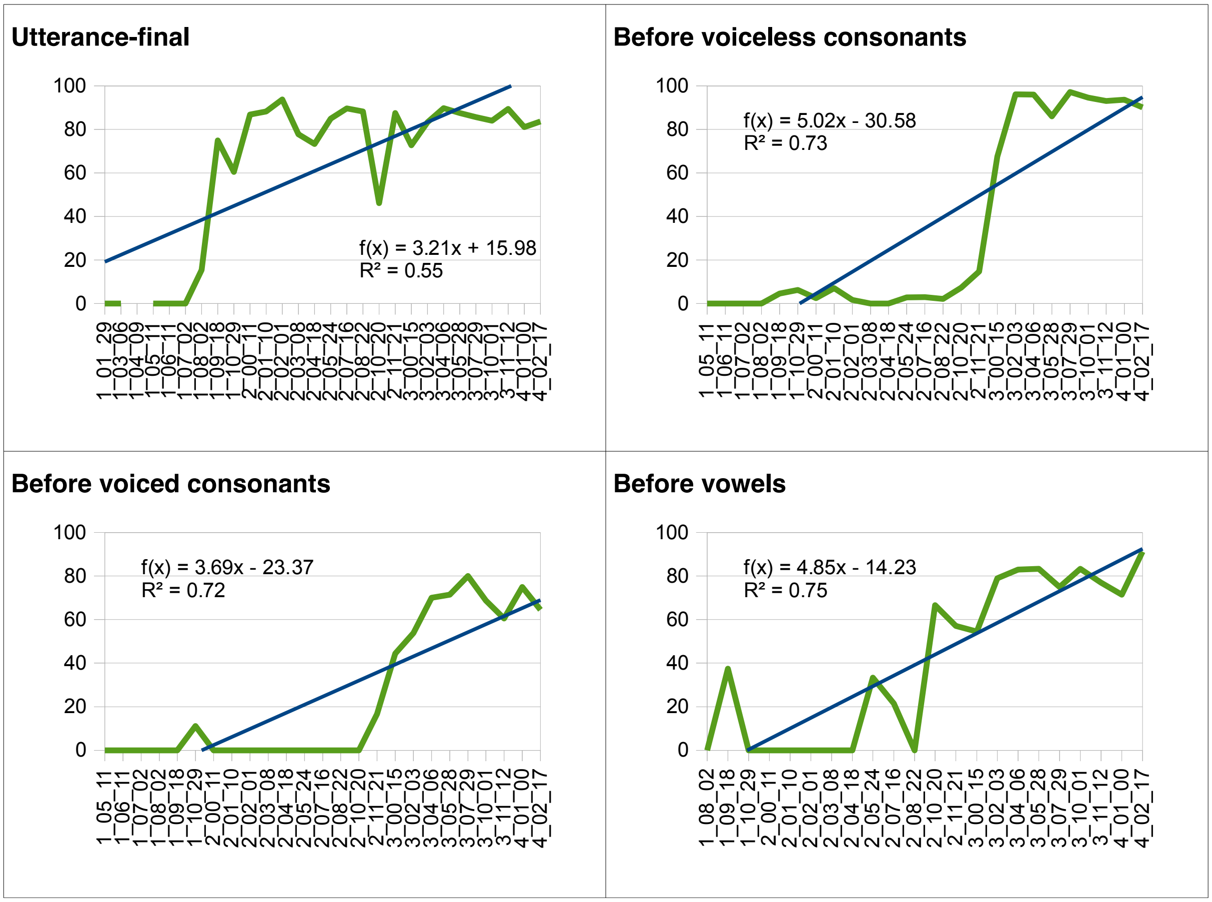
37 Cases of resyllabification are included in this figure.

38 Where a correct production constitutes using the correct allophone for each given context (e.g. [ʃ] utterance-finally, [z] before a vowel).

39 Trend lines have been automatically inserted using LibreOffice Calc, and the equation ("f(x)") and coefficient of determination ("R^2") for each trend line is displayed.

Figure 48: Inês's percentages of correct productions of /ʃ/ in codas



In each chart, we see a sudden increase in accurate productions, occurring at 1;09.18 in the utterance-final environment, at 2;10.20 before vowels, and at 3;00.15 in both pre-consonantal environments.

6.4 Summary of Observations

In this section, I highlight the most central patterns observed in Inês's development of codas, which I analyze in Section 8. Notably, most coda consonants develop later in the data than their counterparts in onsets. I attribute this difference to Inês's analysis of the distributions of codas in EP.

Recall that |ʃ/ʒ| first emerges in utterance-final codas. |ɾ| and |ɫ| are not initially mastered in utterance-final codas, but do show a lower rate of deletion in this environment than in utterance-medial environments. Also, to some extent, utterance-medial word-final codas are acquired earlier than word-medial codas. Of the three domains (utterance-final, utterance-medial word-final, and word-medial), the word-medial codas behave the most systematically across all consonants; until about 3 years of age, Inês deletes almost all word-medial codas. I discuss these issues in light of Inês's distributional analyses in Section 8.4.

Inês's production of |ɫ| in codas is less systematic than that of |ɾ| and |ʃ/ʒ|; even word-medially, by the end of the corpus |ɫ| is produced almost equally as either [ɫ] or [ɾ]. In Section 8.1, I argue that this pattern arises from issues that Inês had with building an adult-like phonological representation of this consonant.

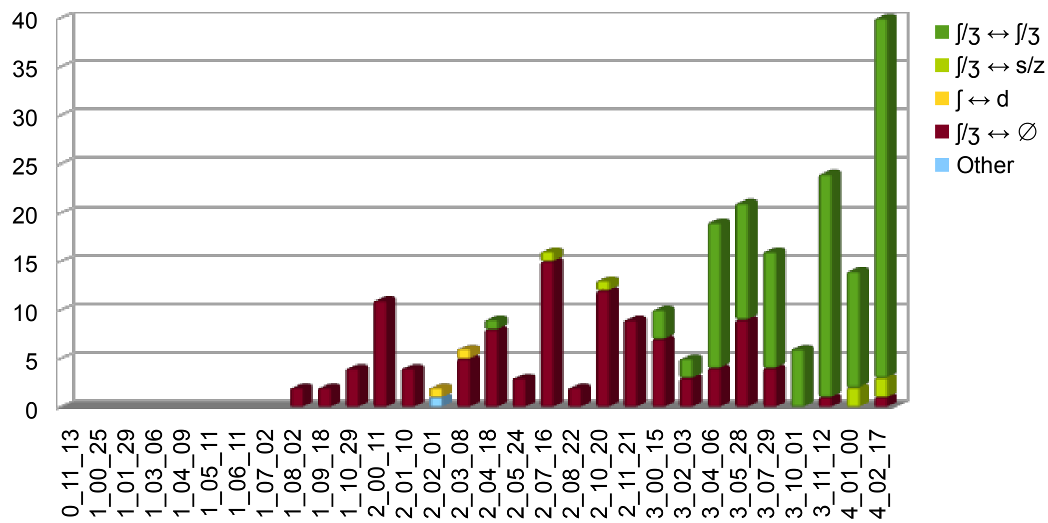
7. Codas of Empty-headed Syllables

As mentioned in Chapter 2, Section 3, EP allows for an extra consonant position (CEHS) at the beginning of words, which is restricted to only the postalveolar fricative |ʃ/ʒ|. As with word-medial codas, we see a clear dichotomy in Inês's attempts at words containing |ʃ/ʒ| in this position, as shown in Figure 49.[40] From 1;08.02, when such words are first attempted, to

40 Recall that attempts at the word *estar* 'to be' (and related forms) have been excluded from this description, which thus differs from the pattern described in Section 2.

2;11.21, Inês deletes the coda at a rate between 83% and 100%.[41] At 3;00.15, Inês begins to produce the sound correctly in this position, although the rate at which this occurs is still low (approximately 30%).

Figure 49: |ʃ/ʒ| in CEHS



Starting at 3;04.06, we see an increase in Inês's target-like productions of |ʃ/ʒ| in CEHS, and she reaches mastery by 3;07.29. Very few substitutions of |ʃ/ʒ| are found in this position; for the most part Inês either produces it correctly or deletes it altogether.

7.1 Summary of Observations

CEHS is the last syllable position in which Inês masters |ʃ/ʒ|; before mastery in this position, |ʃ/ʒ| is predominantly deleted. As I argue in Section 8.4, the late mastery of the fricative in this context relates to Inês's analysis of the segmental distributions of EP.

41 Except at 2;02.01, when there are only two attempts at words containing CEHS that are not related to *estar*.

I now turn to the analysis of Inês's patterns of phonological development described above. Throughout the discussion, I focus on the types of factors, for example perceptual, representational, or articulatory, which may underly the child's production patterns throughout the developmental period covered by the corpus.

8. Analysis

In this section, I analyze the issues raised in the preceding sections (4 through 7). As we will see, a consideration of prosodic factors is crucial for the analysis of Inês's data. Beyond prosodic considerations, I argue that aspects of the child's productions are related to other factors, for example perceptual issues, which had an influence on the child's analysis of certain contexts, and articulatory issues, which played a role in the child's production of certain phones in given contexts. This hypothesis follows earlier works in the area of phonological development, such as Rose (2003), Goad & Rose (2004), Fikkert & Freitas (2004), (2006), and Fikkert & Levelt (2008), all of which tackle phonological development from the perspective of the child's understanding of the sounds and sound distributions of the target language.

I begin with perceptual effects, then move on to representational effects, articulatory effects, and, finally, distributional effects. As discussed in Chapter 2, Section 4, I seek to understand how these factors interact to yield the patterns observed in the data. In line with recent work, I situate the child's phonological patterns in the larger context of the child's perceptual and articulatory abilities (e.g. Inkelas & Rose 2007; Rose 2009).

8.1 Perceptual Effects

Perceptual effects may arise because of a child's difficulty in correctly perceiving phonological data in particular contexts, which may in turn lead to the deletion of segments in these contexts. Such effects may occur when adjacent phones share acoustic properties with each other, or when the perception of given phones is otherwise hindered by acoustic properties of their environment. From the perspective of production data, perceptual effects may be difficult to diagnose; however, perceptual issues can be motivated through a consideration of the specific acoustic properties present in the target forms, in cases where deletion (or substitution) patterns are systematic.

A clear example of a perceptual effect in Inês's data relates to her late acquisition of the palatal nasal |ɲ|, a sound which only occurs in singleton onsets, as mentioned in Chapter 2, Section 3. Previous studies, for example Costa (2010), attribute substitutions of this nasal to general problems with the production coronal posterior consonants. However, in contrast to this, Inês displayed systematic deletion of |ɲ| in the onset of unstressed syllables which follow the vowel |i|; I propose that this occurred because Inês had difficulty perceiving |ɲ| in this particular environment.[42] According to Raphael et al. (2007:219), high vowels are acoustically similar to nasals, due to a pattern of low-frequency resonance that high vowels and nasal consonants both exhibit. Additionally, |ɲ| and |i| are both articulated within the palatal region, which may further contribute to making |ɲ| hard to perceive in this context. This analysis is further supported by the fact that |ɲ| virtually never undergoes deletion in other contexts.

Also, in general, Inês's development of |ɾ| and |ɫ| in codas may have been affected by perceptual issues which would not have applied to |ʃ/ʒ|. I propose that the discrepancy in

42 Recall that Costa (2010) only considers singleton onsets, and so does not focus on data which would occur in this environment.

overall performance between |ɾ, ɫ| and |ʃ/ʒ| is due to the relative acoustic opacity of each of these consonants in codas. Although strident fricatives are easily perceptible in any environment because they are characterized by relatively long stretches of aperiodic noise (Raphael el al. 2007), |ɾ| and |ɫ| are much less easily perceived. Lack of acoustic salience in general may have affected Inês's ability to build adult-like mental representations of consonants, as I discuss in the following section.

8.2 Representational Effects

In addition to perceptual effects relating to the child's inability to perceive segments in certain contexts, the development of consonants may be hindered by difficulties with *understanding* perceptual cues, and thus building mental representations for the adult-like motor articulations required to produce these cues in spoken form. Inês showed several effects related to impoverished mental representations of target consonants: the substitution of the palatal lateral |ʎ| as the palatal glide [j], early productions of labiodental fricatives |f/v| as alveolar stops [t/d], and her difficulties with productions of |ɾ| across different syllable positions.

I begin with the palatal lateral |ʎ|. Inês failed to master this consonant during the period documented by the corpus, and instead produced it as the palatal glide [j]. This is a common substitution among learners of EP (Maria João Freitas, p.c., June 2013), which I suggest, perhaps more speculatively, resulted from Inês's inability to (fully) distinguish |ʎ| from |j| in her representations. According to Ladefoged & Maddieson (1996), palatal laterals are produced with contact between the tongue dorsum and the hard palate, and may not include any contact with the tongue tip. The tongue position required for |ʎ| is comparable to that of the glide, and the two sounds are acoustically quite similar. Although Inês may have perceived a difference between the two consonants, we must also note that the palatal lateral is relatively infrequent in EP. As a result, Inês had little evidence available to determine how to articulate the perceived difference, if any.

Another issue which likely occurred because of representational concerns relates to Inês's early productions of |f/v| as [t/d] (from 1;07.02 to 2;02.01), during the stage where she stopped her target fricatives in onsets. During this stage, the labial fricative |f/v| was produced with the same substitution as the alveolar fricative |s/z| and the postalveolar fricative |ʃ/ʒ|, all yielding [t/d] productions. I suggest that at this early stage, Inês lacked a place distinction between labial and coronal fricatives (although she did distinguish all places of articulation among stop consonants). While labial and coronal fricatives were likely distinguished in perception, it is indeed possible that Inês initially did not associate the lower-intensity of the labial fricative with the labiodental articulation (Raphael et al. 2007). At 2;03.08, Inês acquired this distinction, and thus began to produce |f/v| with the correct place of articulation. I argue in Section 8.3 below that Inês's overall stage of production of fricatives in onsets as stops was a result of articulatory issues. With this in mind, her productions of fricatives in onsets, including two stages for |f/v|, can be schematized as in Table 13.

Table 13: Representation and production of fricatives in onsets

Target fricative	**Representation**	**Output at stopping stage**
f/v	coronal (1;07.02 to 2;02.01) labiodental (from 2;03.08)	t/d p/b[43]
s/z	coronal (from 1;08.02)	t/d
ʃ/ʒ	coronal (from 1;08.02)	t/d
ʀ	velar (from 2;00.11)	k/g

Another issue we observe in Inês's data relates to the production of coda |ɫ| as either [ɫ] or [ɾ] at almost equal rates (especially in word-medial codas) in the final few sessions of the data, starting at 3;07.29.[44] According to Ladefoged & Maddieson (1996), the coda |ɫ| in Portuguese is "unoccluded" (p. 193); it is produced with little contact between its articulators and may seem quite vocalic.[45] While it is difficult to explain Inês's variability here with certainty, it is likely that she had perceptual difficulties with determining the required articulatory movements to produce the lateral, and thus optionally produced it as [ɾ], a substitution which is faithful to the approximant nature of |ɫ|.[46]

Around 3;07.29, we observe an improvement in Inês's productions of |ɾ| in branching onsets and in codas (which may be also reflected in the gradually increasing accuracy of |ɾ| productions in singleton onsets). By 3;10.01, her accuracy was above 60% in singleton onsets, branching onsets, and word-medial codas. Word-final codas (including utterance-medial and utterance-final occurrences) were also produced at increasing rates of accuracy at this point, although not as prominently as in the other environments. Because her accuracy with target |ɾ| increased in all positions at around the same time, I argue that Inês's difficulty with producing

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43 Although we see Inês producing a labiodental consonant as full labial here, on the whole she did maintain the correct place dimension. There are three possible reasons why this place change occurred: it may have been a stronger instance of overshooting the fricative gesture (see Section 8.3 for discussion of overshooting), she may not have yet fully distinguished the proper place of articulation for this consonant, or this may relate to transcriber methodology since there is no labiodental stop in EP.

44 This may relate to the systematic increase of accurate productions of |ɾ| across all positions at around 3;07.29, discussed below.

45 In fact, in Brazilian Portuguese, this sound is produced as a glide (Ladefoged & Maddieson 1996; Mateus & Andrade 2000).

46 A similar substitution, discussed in Section 8.3, occurs in singleton onsets, where |ɾ| is frequently produced as [l].

|ɾ| was relatively independent of its phonological context: she has\d difficulty with mapping the cues for |ɾ| to the proper articulation.[47]

Inês's segmental development was thus influenced, in some cases, by difficulties with mapping the auditory cues of sounds in certain contexts to the articulatory gestures necessary to reproduce those cues.

In the next section, I focus on patterns which relate to Inês's difficulties with the physical reproduction of the required gestures for some EP consonants.

8.3 Articulatory Effects

We observe several patterns which suggest the interference of articulatory pressures on Inês's productions: the substitution of stops for fricatives in singleton onsets and the substitution of |ɾ| as [l], also in singleton onsets. I argue that these substitutions were articulatory in nature, based on the systematic ways in which the substituted segments differ from the target segments: in each case, the difference is in manner only, as shown in Table 14 below. This is not to say that articulatory pressures only affect consonant manner, however, as place and voicing substitutions may also result from articulatory pressures (e.g., Inkelas & Rose 2007; Rose 2009; McAllister Byun 2009).

Table 14: Substitutions which arise because of articulatory effects

Target onset(s)	**Produced segment**	**Manner change**
f/v, s/z, ʃ/ʒ	p/b (or t/d),[48] t/d, t/d	fricative → stop
ɾ	l	rhotic → lateral

47 Although as we will see in the following section, phonological context did play a role in the way Inês dealt with this general difficulty.

48 Recall that this place substitution is a representational issue, as discussed in Section 8.2.

The fricative stopping in Inês's singleton onset data was likely the result of overshooting the gesture(s) required to produce a fricative. According to McAllister Byun et al. (2012), gestures such as those required for the production of fricatives require millimetre precision in the control of speech articulators, which must come very close to their point of constriction without however coming into full contact with it. As Crelin (1987), Kent (1992), and Kent & Miolo (1995) show, children's early phonological productions are limited by poor articulatory control, which is characterized by generally ballistic gestures toward broad articulatory targets. When attempting fricatives in onsets, Inês overshot her speech gestures, and thereby fully obstructed the airflow at the point of articulation. Note that fricatives in other positions in the data did not follow this pattern (i.e. |ʃ/ʒ| in codas or CEHS). Articulatory errors of the 'overshooting' type are more likely to occur in onsets than in other positions, because typically onsets are more prominent than other positions in terms of the articulatory force required for adult-like productions (Chiat 1983; Inkelas & Rose 2007; Rose in press). Stopping of fricatives in onset matches other prosodically-defined articulatory errors described in child language development literature, namely positional velar fronting, in which a target velar stop is produced as an alveolar one in word onsets or onsets of stressed syllables (Chiat 1983; Marshall & Chiat 2003; Inkelas & Rose 2003; Inkelas & Rose 2007; also see Chiat 1989 for discussion of fricative stopping).

Inês's productions of |ɾ| in singleton onsets showed the fingerprints of articulatory effects as well. Although Inês systematically deleted |ɾ| when she attempted it in coda position (as discussed in the Section 8.4), her productions of |ɾ| in singleton onsets were robustly consonantal: she produced it as [ɾ] or as [l] at almost equal rates throughout the corpus (with increasing accuracy toward the end of the recorded period).[49] According to Ladefoged & Maddieson (1996), |ɾ| is produced with quick apical closure, whereby the tongue tip strikes the roof of the mouth in passing, or directly "tap[s]" it (p. 231). I hypothesize that when Inês produced |ɾ| as [l], it was because she could not reliably execute the rapid gesture required to produce a flap, much in the way that she produced fricatives as stops because she could not execute the controlled restriction of airflow required for them. Her productions of |ɾ| as [l] matched the properties of |ɾ| in both place of articulation and continuancy, and also the phonotactics of EP, as [l] is a licit allophone in singleton onsets in the language.[50]

In the next section, I turn to another type of influence on Inês's consonantal development, this time focusing on some of the most central aspects of sound distributions in the target language, as opposed to its segmental makeup.

8.4 Distributional Effects

Throughout the descriptions in Sections 4 through 7, I made several mentions of Inês attending to the prosodic contexts in which sounds occur in her language, which at times resulted in sudden changes in her production patterns. For example, we saw that |ʃ/ʒ| in word-medial codas underwent across-the-board deletion until 3;00.15, when it started being produced in a target-like manner in a relatively abrupt and systematic way. In line with Goad & Rose (2004) and Fikkert & Levelt (2008), I argue that through the course of the documented period, Inês revised her grammar based on her developing understanding of the distributional properties of EP.

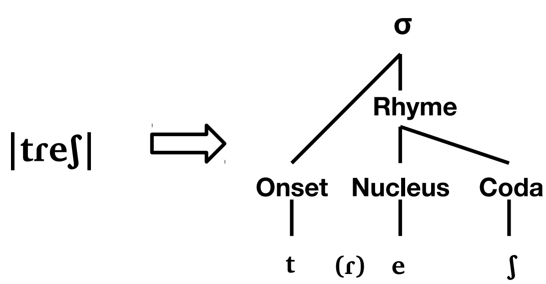
49 Note also that this substitution begins at 1;10.29, which is the point when target-like productions of |l| began to emerge in earnest.

50 The substitution may also only affect singleton onsets because, in general, they are produced with extra articulatory pressure. This may have made the position more perceptually salient to Inês, or stronger in her own productions.

From Inês's first attempts, branching onsets were overwhelmingly produced as singletons corresponding to the first consonant of the cluster, which is a common pattern among learners cross-linguistically (as mentioned in Section 5). Inês's productions of these reduced clusters in fact matched her production of singleton onsets. Following Fikkert (1994), Barlow (1997), Freitas (1997), Rose (2000), and Goad & Rose (2004), I argue that the deletion of the second consonant of a target cluster stems from the child's incomplete prosodification of the target branching onset structure, as shown in the example in Figure 1, repeated here as Figure 50 for convenience.

Figure 50: Branching onset reduction

três |ˈtɾeʃ| 'three' → [ˈteʃ] (Inês at 2;02.01)



Lacking a structural position to host |ɾ|, Inês did not produce this element.

A second pattern visible in Inês's acquisition of branching onsets that is suggestive of her learning of the distributional properties of Portuguese is that once |l| emerged as the second position in branching onsets, Inês either produced C|l| clusters correctly, or produced them with a vowel intervening between the two consonants, as exemplified in Table 15.[51]

51 Development of C|ɾ| clusters is delayed because of representational issues with |ɾ| itself, as discussed in Sections 8.2 and 8.3.

Table 15: Epenthesis between C|l| branching onsets

Session: Record	**2;01.10: 536**	**2;03.08: 38**	**2;04.18: 127**	**3;11.12: 187**
Orthography	triciclo	flores	Cláudia	plasticina
IPA Target	tɾiˈsiklu	ˈfloɾɨʃ	ˈklawdiɐ	plɐʃtiˈsinɐ
IPA Actual	tiˈtiku̥lu	pɨˈlolis	kɨˈɾadjɐ	pɐlɐʃtiˈsinɐ

Following Freitas (1997; 2003) and Fikkert & Freitas (2004), I hypothesize that Inês initially lacked the structural representation required for branching onsets, and that early in the data, she may have produced C|l| branching onsets correctly because she had analyzed them as a sort of complex segment, possibly similar to |kw/gw| (Freitas 1997); epenthesis in C|l| clusters arguably arose because of the child's awareness that, in EP, vowels which are not (fully) audible may intervene between consonants (as described in Chapter 2, Section 3). From this perspective, Inês's production of a vowel between these consonants was not ungrammatical but rather reflected an over-application of her analysis of the available structural positions in EP (Freitas 1997, 2003; Fikkert & Freitas 2004).[52]

Finally, note the systematic deletion of codas until Inês was about 3 years of age (3;00.15 for |ʃ/ʒ|, 3;02.03 for |ɾ|, 3;04.06 for |ɫ|). CEHS were also categorically deleted until 3;00.15. Because all three coda consonants were categorically deleted throughout so much of the period, and because the points at which they began to emerge were so close together, I argue, following

52 Freitas (2003) hypothesizes that target-like productions of branching onsets which fluctuate with epenthesis may still be represented as complex singleton onsets. In epenthesized productions, consonants are associated with single skeletal positions which are separate from each other, and in target-like productions, both consonants are together linked to a single skeletal position. According to Freitas (2003), alternation between these two patterns occurs because Inês is revising and second-guessing her analyses. Of further note is the low frequency of attempts at C|l| clusters, especially toward the end of the documented period (as mentioned in Section 5): if the input was lacking in examples of C|l| clusters, Inês would have had little evidence with which to revise her analysis.

Freitas (1997), that Inês only developed a coda position within her syllable structure as of 3;00.15.[53]

In sum, Inês's development of consonants suggests a number of domains from which she garnered the relevant evidence required for the full mastery of the phonotactics of Portuguese, as introduced in example (5) (in Chapter 3, Section 2), and listed in (10) below.

(10) Relevant positions for Inês's consonantal development
- a. Singleton onsets
- b. First position of branching onsets
- c. Second position of branching onsets
- d. Utterance-final codas
- e. Utterance-medial, word-final codas
- f. Word-medial codas
- g. Codas of empty-headed syllables (CEHS)

We can draw several implications from Inês's development which relate to these positions. First, singleton onsets and the first position of branching onsets, which were initially treated the same in Inês's productions, both emerged immediately. According to Rose (2000), this is because singleton onsets "do not involve complexity at the level of syllable constituents" (p. 96). The second position of branching onsets did not follow the same pattern; because it does add complexity to the syllable structure (as mentioned in Chapter 2, Section 2), it emerged later in the data.

Following the same logic, since codas involve complexity in the syllable rhyme, they should generally emerge later than onsets (Rose 2000; Levelt et al. 1999/2000). As we saw in Section 6, this holds true for Inês, who developed most coda consonants later than their onset

53 Earlier emergence of utterance-final codas and utterance-medial word-final codas is discussed below.

counterparts. The first type of coda that Inês produced was utterance-final; utterance-medial word-final codas emerged at around the same time (but were not produced with as high a rate of accuracy as the utterance-finals).[54] The early emergence of final codas is consistent with Freitas's (1997) proposal that learners of EP may initially posit that final codas are in fact onsets of empty-headed syllables (OEHS). This may be due to the frequent deletion of unstressed vowels in adult speech, which results in phonetic appearance of word-final onsets (as mentioned in Chapter 2, Section 3; see also Goad & Brannen 2000; Rose 2000, 2003; Barlow 2003, for similar analyses of asymmetries between medial and final codas in early phonological productions). These final onsets are predicted to emerge earlier than codas, as they do not involve structural complexity.[55] Word-medial codas thus emerged later in Inês's productions. Again here, following Freitas (1997), I hypothesize that the initial emergence of word-medial codas marks the point where Inês developed complexity within the rhyme. The development of CEHS is concomitant to this, as this position also involves complexity within the rhymal constituent.[56]

In the upcoming chapter, I describe and analyze Joana's consonantal development in light of the patterns and effects which we saw here for Inês. Although the developmental paths displayed by both children do show some similarities, I argue that crucial differences in their distributional analyses of EP result in overarching differences in their development.

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54 This is the case with |ʃ/ʒ|, however |ɾ| and |ɫ| did not show the same pattern, due to issues related to their relative acoustic opacity, as discussed in Section 8.2.

55 Although OEHS may emerge later than onsets because of the abstraction required to posit the empty nuclei to which they attach (Rose 2000).

56 Similar to OEHS, CEHS may emerge later than codas.

Chapter 5: Segmental Development in the Absence of Positional Conditioning

1. Introduction

In the previous chapter, we witnessed several patterns of segmental development arguably influenced by the intricate rules of sound distributions in EP. According to, e.g., Freitas (2003), Rose (2003), Goad & Rose (2004), Fikkert & Freitas (2004), (2006), Fikkert & Levelt (2008), the development of the correct representations of sounds requires the child's understanding of the target sounds and their distributions. This hypothesis also raises the possibility that individual learners who are slow in their development of this understanding might display different patterns of development. Further, in the absence of generalizations about the distribution of phones within prosodic structure, we can also expect less clear-cut patterns of development, especially if the child is exposed to variable (even if not random) phonetic patterns, as we find in EP.

In this chapter, I describe and analyze data from Joana, whose phonological development reflects this type of pattern, in contrast to that of Inês. Although Joana's patterns of development share a number of similarities with Inês's, the data are most striking in that they fail to reveal positional effects within the utterance domain. Concomitant with this apparent lack of systematicity at the prosodic level, we also note the absence of sweeping changes in the development of individual consonants within specific positions. The most central observations about Joana's development instead suggest conditioning by primarily segmental factors. We will see this most clearly in Joana's development of /ʃ/ in codas, where she shows gradual improvements in her productions which depend on whether they occur before voiced consonants, voiceless consonants, vowels, or utterance-finally, in the absence of any following phone. I begin with an overview of Joana's development in the next section.

2. Overview of Joana's Consonantal Development

In this section, I provide a broad overview of Joana's consonantal development, in a way similar to my exposition of Inês's data in Chapter 4, Section 2. I also highlight the major differences between the two children's patterns of development.

Joana's consonantal development is depicted in the timeline below. Note that, in general, it is more difficult to clearly define mastery in Joana's data than with Inês's, as her rates of accurate productions for each consonant increase only gradually, as opposed to the tidier stage-like learning curves we saw with Inês. Where possible, I followed the same rubric for Joana as for Inês: consonants are considered to be mastered when their accuracy reaches 75% and is consistently maintained at this level or higher. For Joana, minor dips below this rate may occur even after a consonant has been mastered (e.g. productions of |ʃ| in codas before voiceless consonants dip in accuracy to 57% at 4;04.29, which is linked, at least in part, with a low number of attempts at this position in this session). While in many cases I still consider a consonant to be mastered despite such dips, where possible I attempt to account for them within the descriptions below.

Figure 51: Timeline of Joana's consonantal development[57]

		0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07
Singleton onsets	p/b				50		0	55	50	85	89	65	77	73	94	89	90	98	94	93	90	93	97	96	94	88	92	99	92	98	95	99	95	88
	f/v							0	0	0	13	81	73	86	91	71	84	90	93	93	87	94	96	93	96	97	100	97	96	92	99	95	89	96
	m	0	63	75	50				100	83	64	72	65	87	90	90	92	96	80	97	94	97	98	92	92	99	100	100	97	98	100	97	96	98
	ɲ								0	0	100	90	67	80	86	95	92	88	86	100	87	97	95	82	84	94	92	94	90	100	90	100	93	100
	k/g							25	57	85	70	71	60	74	84	90	90	96	97	97	89	95	97	78	93	98	94	96	95	96	98	95	88	98
	t/d			0				0	0	13	40	21	60	72	81	88	83	88	69*	71*	66*	82	87	80	82	87	87	91	94	95	86	94	90	92
	j			0								100	33	100			89	80	100	100	100	100	100	100	100	100	100	88	100	100	100	80	100	100
	n	100	0		0	0	100	0	0	20	15	33	34	31	39	49	75	65	84	83	86	79	91	75	94	93	95	95	97	94	95	91	95	90
	s/z									0	0	0	4.5	21	33	53	46	59	65	69	66	66	81	44	68	68	82	85	91	91	95	96	77	92
	ʃ/ʒ								0	0	0	28	62	35	50	17	66	53	60	76	49	58	40	83	42	70	62	86	90	72	93	74	88	98
	ʀ									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1	31	33	55	50	75	80	67
	l							0	0	0	0	0	0	8.7	13	10	11	23	19	16	25	22	12	0	16	13	11	26	37	52	31	67	34	69
	ɾ								0	0	0	0	7.7	0	0	0	1.5	3.2	0	20	18	5.2	6.3	6.8	18	19	29	38	30	26	51	49	53	68
	ʎ										0	0	0	0	4.5	0	9.1	3.8	0	0	4.8	4.8	0	0	0	21	0	0	0	0	5.6	0	0	0
P1 of branching onset	p/b										0	100	100	80	100	63	100	89	100	91	94	100	94	89	73	98	94	95	94	90	94	100	100	100
	f/v										0	75	100	100	78	60	70	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	t/d									0			100	80	60	78	79	100	80	64	52	86	100	62	85	95	91	88	94	95	88	96	81	100
	k/g											50	0	57	80	83	100	89	100	100	86	67	100	67	90	100	100	100	86	71	88	67	50	75
P2 of branching onset	ɾ									0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	1.1	0	2	41	38	34	43	17	65
	l										0	0	0	0	0	0	0	0	0	25	0	0	25	0	0	50	33	13	50	100	50	0	0	40
Codas	ʃ/ʒ									0	0	16	35	50	35	43	51	62	54	57	42	64	44	64	59	70	66	68	64	66	59	68	58	82
	ɾ							0	0	0	0	0	0	10	0	0	1.1	1.2	0	1.5	10	10	6.1	6.3	13	19	36	33	30	50	53	63	52	40
	ɫ									0	0	0	0	0	0	25	13	11	9.1	0	22	17	0	0	0	0	3.3	0	35	50	12	23	14	52
CEHS	ʃ/ʒ			0					0	0	0	0	0	0	13	21	60	69	80	60	42	19	7.1	40	50	38	37	36	39	62	14	75	6.3	54

57 Some of the percentages in this chart may vary slightly from those provided in Appendix B due to differences in the groupings of production patterns.

Figures for Joana beyond this timeline will exclude the first three sessions of the recorded corpus, as these early sessions do not contain data that warrant any discussion in the context of this thesis. Between these three sessions, only 26 consonantal productions are recorded, virtually all from babbled and/or unintelligible utterances.

A striking difference in Joana's development, compared to Inês's, is that she does not master any consonants which occur in the more restricted phonological environments during the period covered by the corpus, namely codas, the second position of branching onsets, or codas of empty-headed syllables.[58]

Also, while we observed that Inês's mastery of consonants progressed in broad strokes involving natural classes of phones (e.g. oral stops emerged all at once, as did fricatives), Joana's development appears to be less systematic. In singleton onsets (and in the first position of branching onsets, where applicable), we do note a general tendency for stops to be mastered before continuants. An exception to this observation is the labial fricative |f/v|, which is the second consonant mastered. Joana does not master the class of fricatives within a unique stage: |f/v| is mastered at 2;00.09; |s/z| at 4;00.13; |ʃ/ʒ| in the immediately following session, 4;02.11; and |ʀ| at 4;07.07. By the end of the documented period (4;10.07), Joana does not master |ʎ| in singleton onsets, or |ɾ| and |l/ɫ| in any position.

Before I turn to these descriptions, I briefly note lexical exceptions in Joana's data below.

3. Lexical Effects

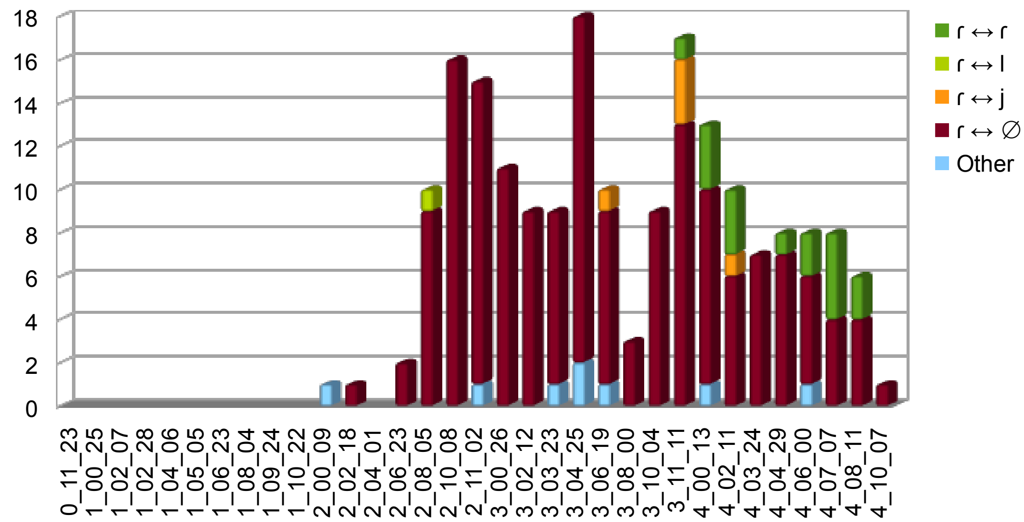
I have excluded two lexical effects from my analysis of Joana's data: *para* 'to' or 'for', and *estar* 'to be' (and related inflected forms). These exceptions were both excluded from Inês's data in the

58 We will see in Section 6 that when cases of resyllabification are removed from the data, |ʃ/ʒ| does appear to be mastered in codas (although barely, and to varying extents in different segmental environments).

previous chapter, and so while I motivate their exclusion from Joana's data in this section, I refer to Chapter 4, Section 3 for more in-depth discussion.

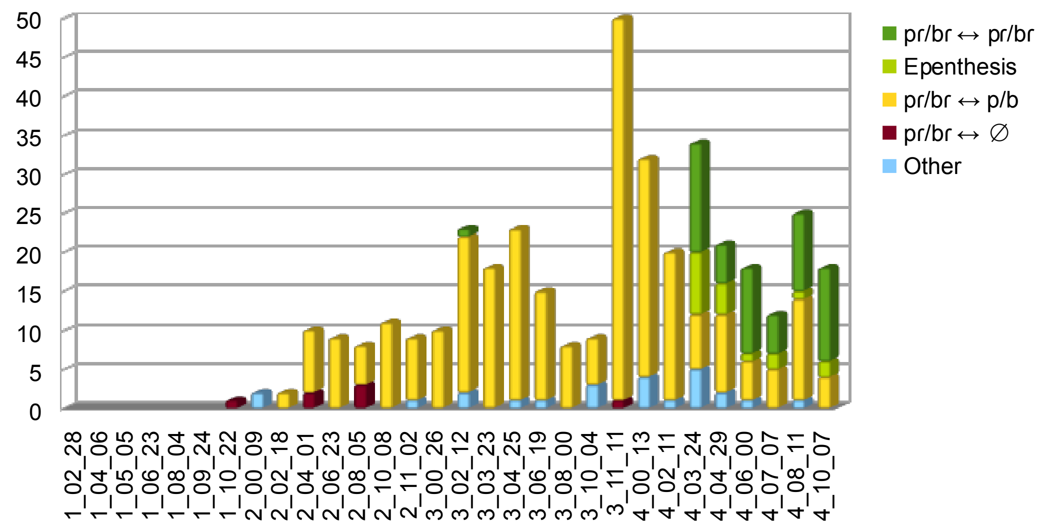
I exclude *para* from the data on development of |ɾ| in singleton onsets. The development of |ɾ| in *para* is depicted Figure 52 below.

Figure 52: |ɾ| in *para*



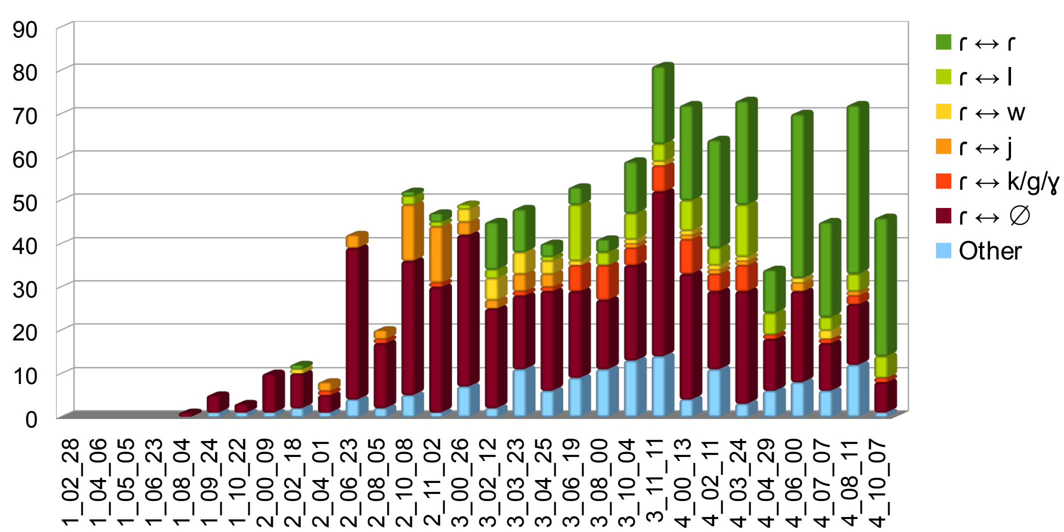
As we saw with Inês, this development closely reflects Joana's development of |ɾ| in |pɾ/bɾ| branching onsets, shown in Figure 53 below. Note that the crucial comparisons are between "ɾ ↔ ∅" in Figure 52 and "pɾ/bɾ ↔ p/b" in Figure 53 (both cases of |ɾ| deletion), and between "ɾ ↔ ɾ" in Figure 52 and "pɾ/bɾ ↔ pɾ/bɾ" in Figure 53 (both cases of target-like |ɾ| production). In both positions, |ɾ| is deleted throughout much of the documented period, and begins to emerge when Joana reaches about 4 years of age.

Figure 53: |pɾ/bɾ| branching onsets



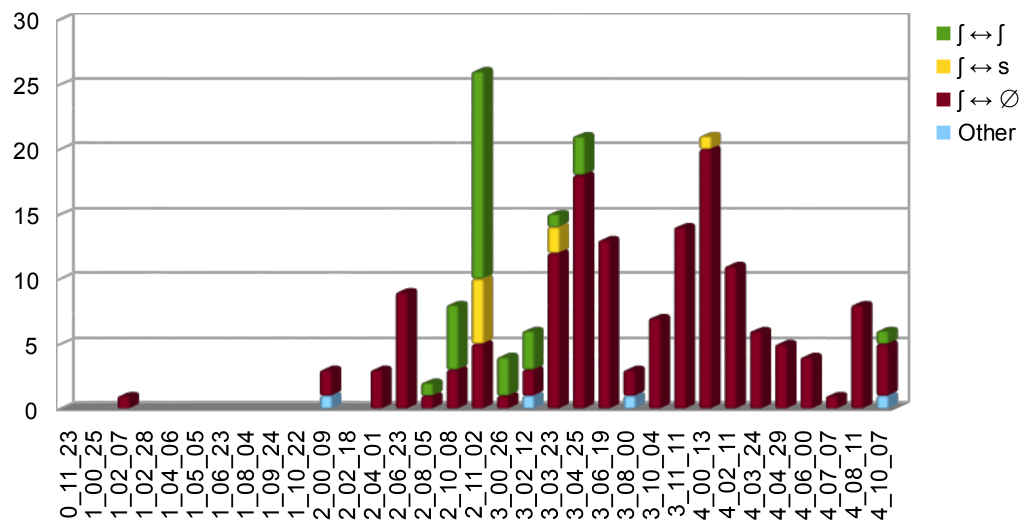
In other singleton onsets (depicted in Figure 54 below), |ɾ| emerges much earlier than in either of the above contexts, and undergoes less deletion throughout the documented period.

Figure 54: |ɾ| in singleton onsets



I also exclude *estar* 'to be' and related forms from Joana's development of CEHS. The development of |ʃ| in these words is depicted below.

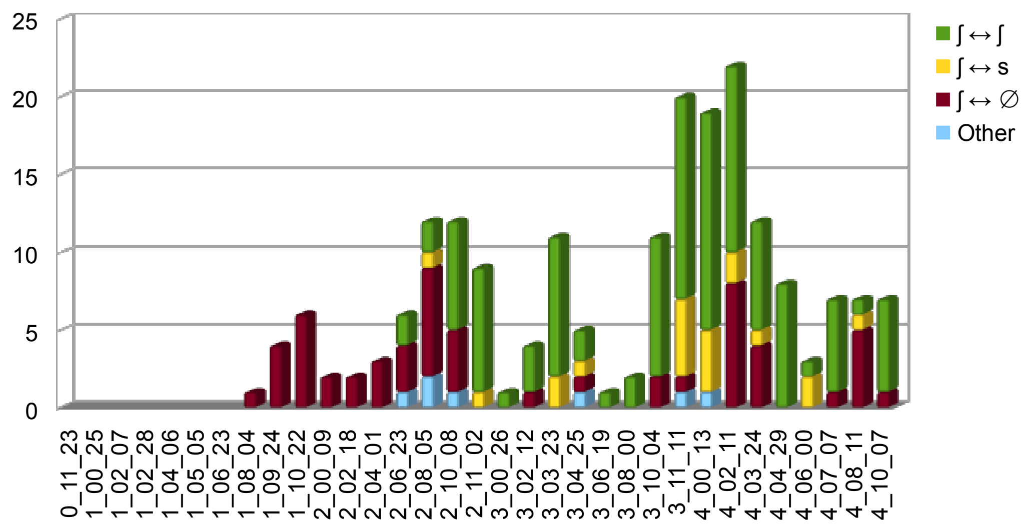
Figure 55: |ʃ| in *estar*[59]



Recall that Inês deleted |ʃ| in CEHS in 96% of all attempts at this verb. Joana, on the other hand, does initially produce the CEHS (at rates at or above 50% per session between 2;08.05 and 3;02.12), but in later sessions she deletes it (in 93% of all attempts from 3;02.03 to 4;10.07). The opposite pattern is revealed in Joana's attempts at this position in other words, depicted in Figure 56 below: although she deletes |ʃ| among her earliest attempts at it in this position, she is more likely to produce it in later sessions.

59 There were no examples of |ʒ| in CEHS in Joana's productions.

Figure 56: |ʃ| in CEHS, excluding *estar*



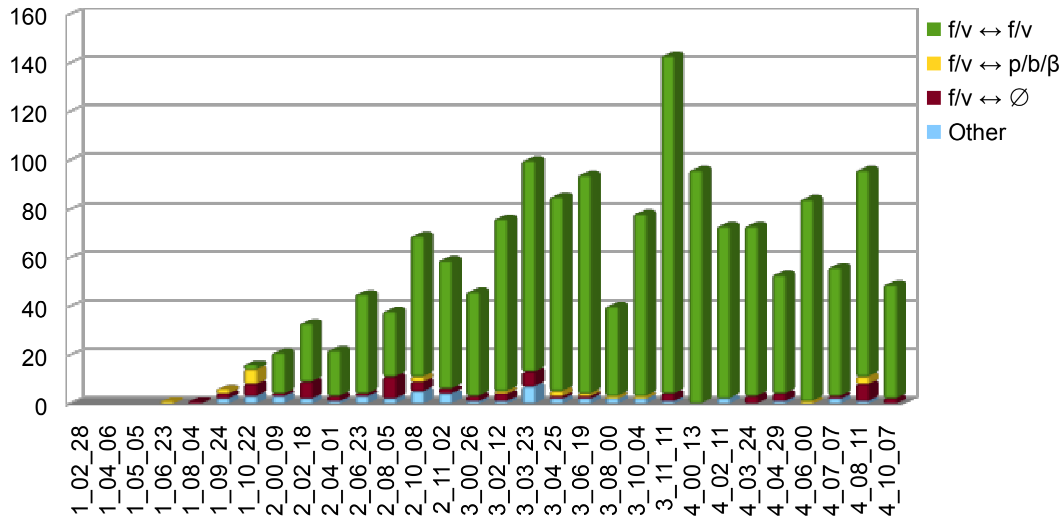
The development of |ʃ| in CEHS is discussed in further detail in Section 7. In the following sections, I describe Joana's development of consonants across syllable positions in EP, beginning with singleton onsets.

4. Singleton Onsets

The first consonants that Joana acquires in onset position are |p/b| at 1;09.24 and |f/v| at 2;00.09. Next, Joana masters both the labial nasal |m| and the palatal nasal |ɲ|, at 2;04.01.[60] All of these consonants are produced in a target-like fashion during Joana's earliest documented attempts at words containing them, as exemplified in Figure 57 below. At this point (2;04.01), all labials are mastered by Joana.

60 Recall from Chapter 4 that Inês did not master |ɲ| until late in her development, at around 3;04.06. She deleted |ɲ| in unstressed syllables following |i|, which, in Section 8.1, I attributed to perceptual issues. Joana has in all appearances no such issue with the palatal nasal, which she masters earlier than the alveolar nasal |n|.

Figure 57: |f/v| in onsets



Joana masters the remainder of the EP oral stops (|t/d, k/g|) at 2;06.23, in spite of some remaining substitutions. In contrast to her rapid development of labials, Joana has more difficulty producing the distinction between lingual stops, both oral and nasal. As we can see in Figure 58 and Figure 59, Joana produces a number of target alveolars with backed place of articulation: |t/d| as [k/g], and |n| as [ɲ].[61]

61 Recall from Chapter 4, Section 4 that Inês also substituted [ɲ] for |n| in early sessions, but that those substitutions appeared only in babbling-type words (e.g. *não* 'not' as [ˈnɐːˈnɐ]). Joana's substitutions appear in more grammatically meaningful positions (e.g. *chinelo* 'slipper' as [ʃiˈɲaw]).

Figure 58: |t/d| in onsets

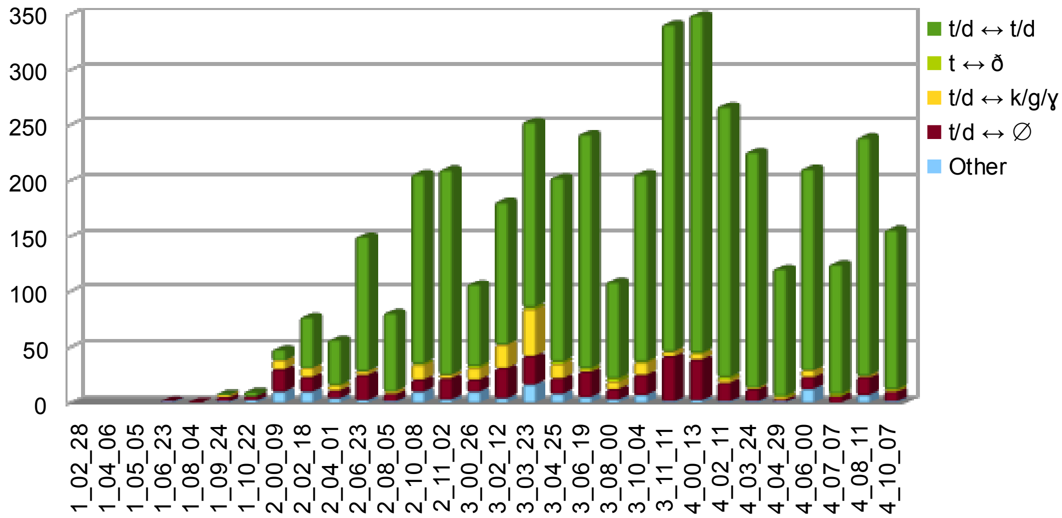
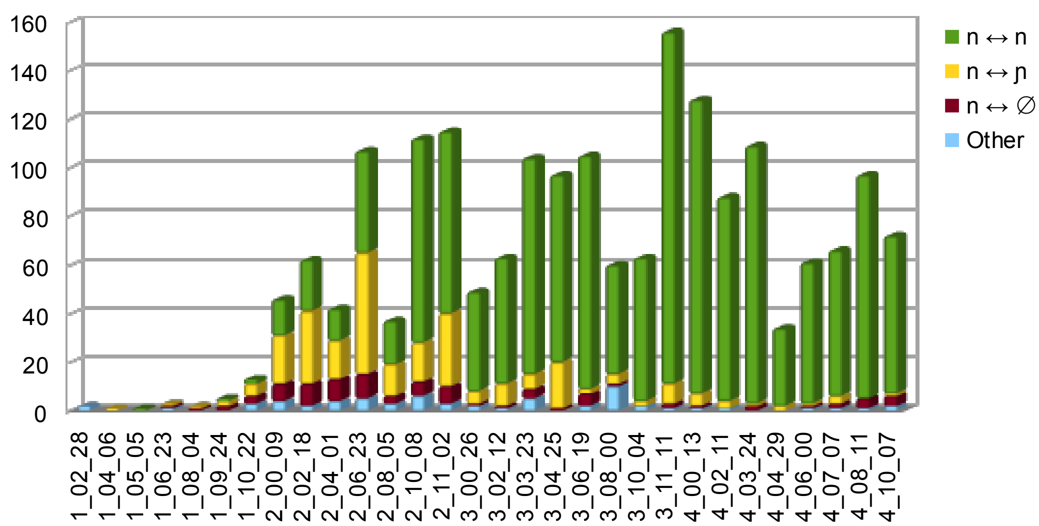


Figure 59: |n| in onsets



These substitutions do not appear to be restricted to particular positions: as shown in Table 16 and Table 17 below, they optionally occur in both initial and medial onsets as well as in stressed and unstressed syllables.

Table 16: |t/d| produced as [k/g]

Session: Record	**3;02.12: 126**	**3;02.12: 148**	**3;03.23: 279**	**3;03.23: 286**
Orthography	David	gosto	sandália	destas
IPA Target	dɐˈvid	ˈgɔʃtu	sɐ̃ˈdaliɐ	ˈdɛʃtɐʃ
IPA Actual	gɐˈvidʲ	ˈgɔʃkw	ʃɐ̃ˈgaljɐ	ˈgɛʃkɐʃ

Table 17: |n| produced as [ɲ]

Session: Record	**2;00.09: 22**	**2;10.08: 263**	**3;04.25: 10**	**3;04.25: 16**
Orthography	não	Joana	noite	chinelo
IPA Target	ˈnɐ̃w̃	ʒuˈɐnɐ	ˈnojtɨ	ʃiˈnɛlu
IPA Actual	ˈɲɐ̃ːw̃	ˈʒwɐɲɐ	ˈɲojtʲɨ	ʃiˈɲaw

In Section 8.2, I argue that Joana's seemingly optional mispronunciation of alveolar stops is related to articulatory issues. In spite of these substitutions, Joana masters the alveolar nasal |n| at 3;00.26, after the palatal glide |j|, at 2;10.08. Similar to Inês, Joana produces |j| in a systematically target-like manner.

Joana masters the EP strident fricatives almost a year later: |s/z| at 4;00.13 (as shown in Figure 60) and |ʃ/ʒ| at 4;02.11 (as shown in Figure 61).

Figure 60: |s/z| in onsets

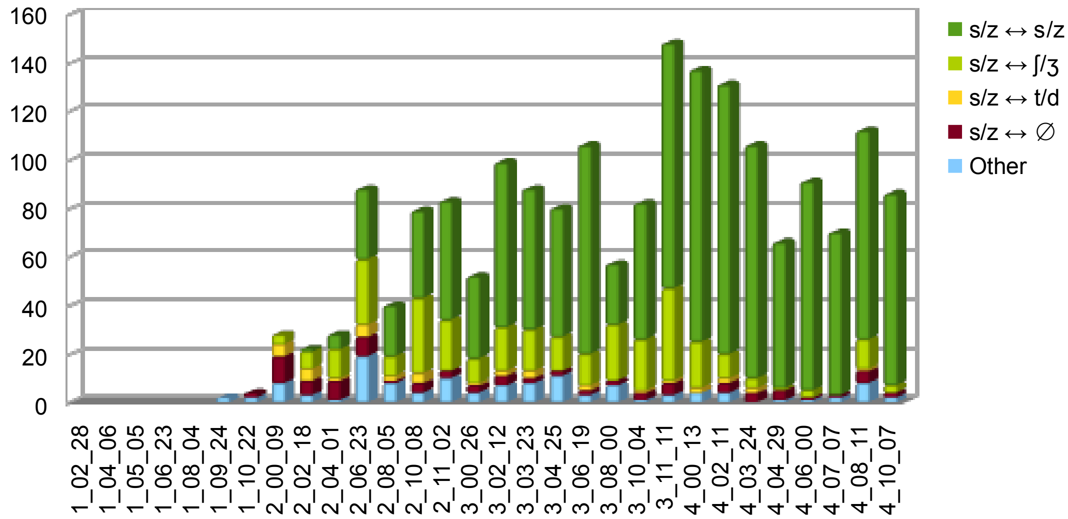
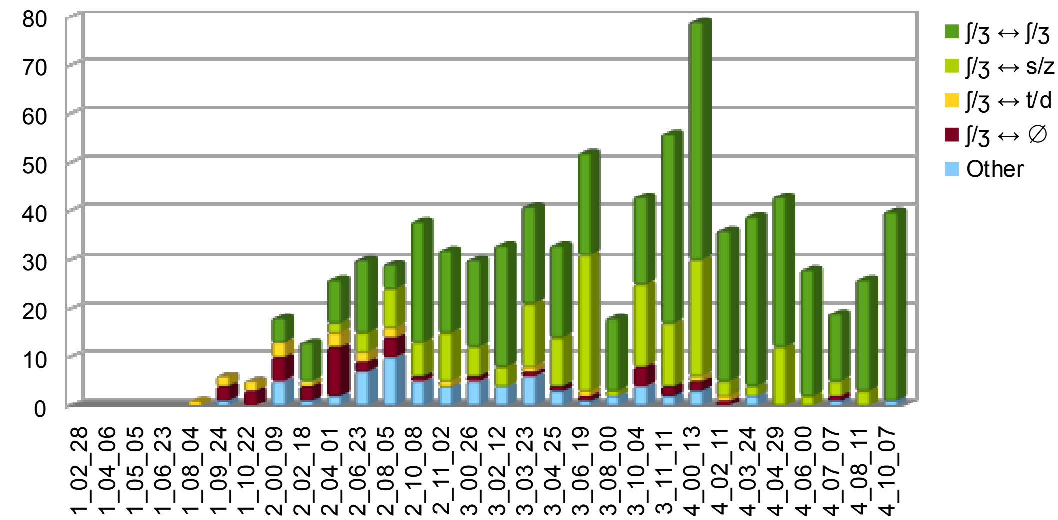


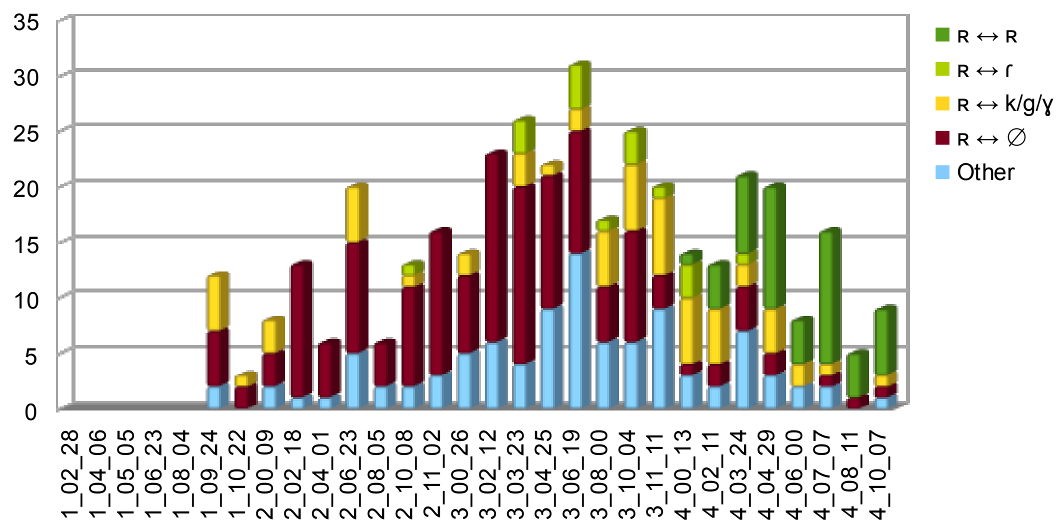
Figure 61: |ʃ/ʒ| in onsets



Note, however, that Joana's productions of both strident fricatives frequently display noticeable error patterns, even if the errors are confined within the coronal region: from 2;10.08, the point where strident fricatives account for over 75% of productions of both consonants, regardless of place of articulation, until mastery, |s/z| is produced as [ʃ/ʒ] at an average rate of 24% per session, and |ʃ/ʒ| is produced as [s/z] at an average rate of 27% per session. (These substitutions also occur in codas and CEHS, as we will see below.)

The final consonant that Joana masters during the documented period is the uvular fricative |ʀ|, at 4;07.07. The development of |ʀ| is depicted in Figure 62 below:

Figure 62: |ʀ| in onsets[62]

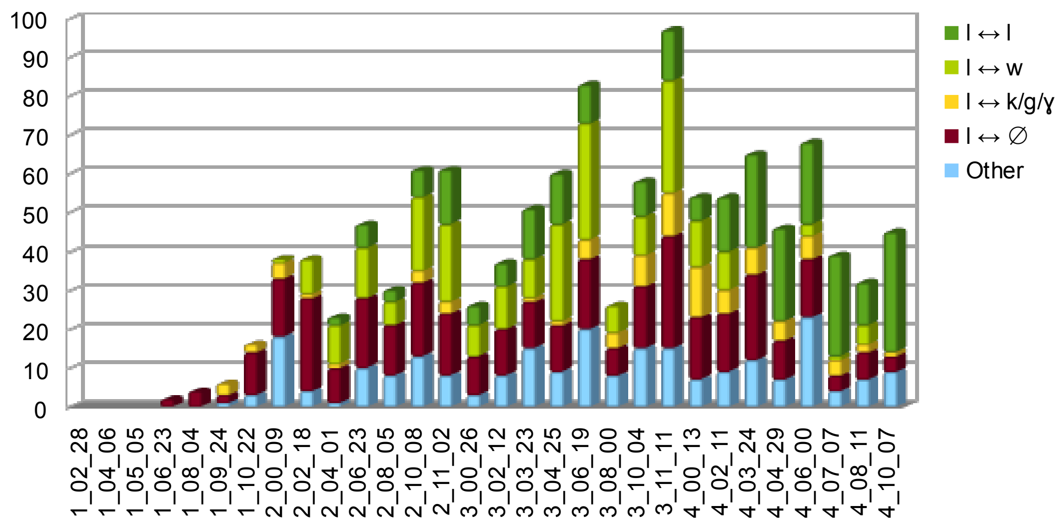


Similar to what we observed in Inês's productions, Joana frequently realizes this consonant as a velar stop or continuant (|k, g, ɣ|). These substitutions slowly decrease in frequency, giving way to an increasing rate of target-like productions, which begin to emerge at 4;00.13, approximately seven months before the consonant was mastered.

62 There is a high rate of production of |ʀ| as 'Other' in the data; these are most frequently cases where Joana's production was transcribed with an asterisk [*], which means that the transcribers could not accurately characterize the sound being produced.

Joana does not master the approximants |ʎ|, |ɾ| or |l| in singleton onsets. Her productions of |l| do, however, approach mastery by the end of the corpus, reaching an accuracy rate of 69% at 4;10.07, as shown in Figure 63 below. Earlier in the data (from 2;02.18 to 4;02.11), Joana frequently substitutes the labiovelar glide [w] in place of the lateral approximant, which is a common substitution cross-linguistically in child language acquisition, and occurs in other positions in Joana's data (i.e. branching onsets and codas).

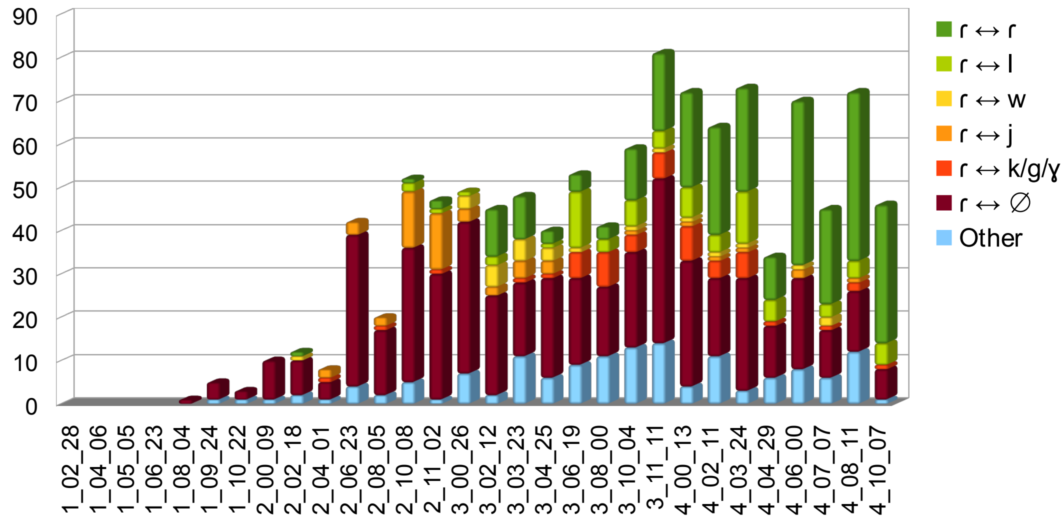
Figure 63: |l| in singleton onsets



Productions of the glide in place of the lateral slowly decrease towards the end of the corpus, as more significant proportions of target-like productions begin to take place, at around 4;02.11.

As mentioned above, Joana does not master |ɾ| in singleton onsets. Attempts at |ɾ| in this position frequently result in deletion, as shown in Figure 64.

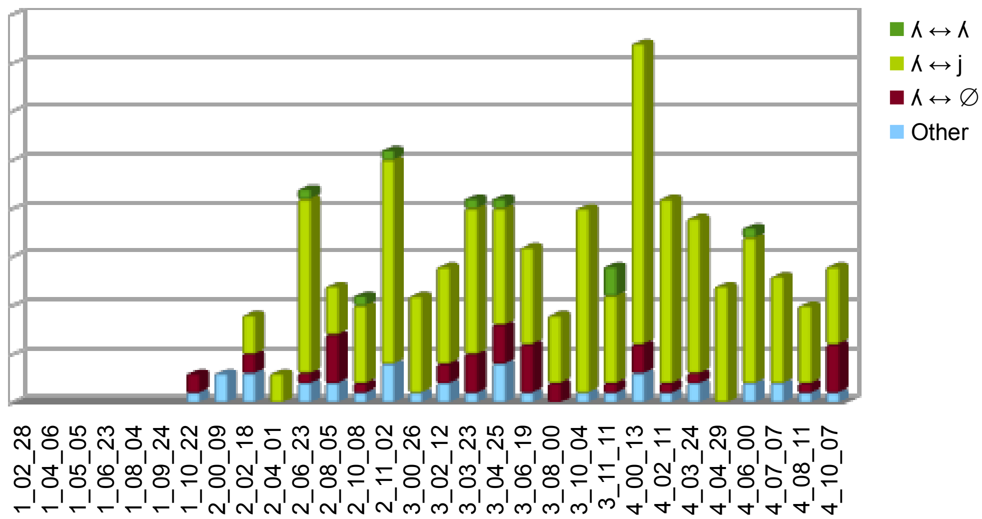
Figure 64: |ɾ| in singleton onsets



The number of deletions slowly decreases towards the end of the data, concomitant with an increase in the rate of target-like productions. As with |l|, Joana approaches mastery of this consonant by the end of the corpus, her productions reaching 68% accuracy at 4;10.07.

Joana does not, however, show any progression towards mastery of the palatal lateral |ʎ|. Just as we saw with Inês in Chapter 4, Section 4, Joana substitutes the palatal glide [j] for the palatal lateral in almost every attempt, as shown in Figure 65 below.

Figure 65: |ʎ| in singleton onsets



As discussed in Chapter 4, Section 8.2, this systematic substitution likely occurs because of articulatory and acoustic similarities between |ʎ| and |j|, which make distinguishing between these two phones difficult.

4.1 Summary of Observations

In this section I highlight patterns from Joana's development of singleton onsets to be discussed further in Section 8. First, I will address Joana's difficulties with |l|, |ɾ|, and |ʎ| in light of representational issues. I will also discuss Joana's tendency to produce target coronal stops with backed place of articulation (e.g. [ɲ] for |n|, [k/g] for |t/d|), which likely arises from articulatory issues.

We also saw a tendency for Joana to make errors in the choice between |s/z| and |ʃ/ʒ|: she substitutes the alveolar |s/z| for the postalveolar |ʃ/ʒ| equally as often as she substitutes the postalveolar for the alveolar. I argue in Section 8.3 that this dual substitution relates to the phonological alternation of |s/z| and |ʃ/ʒ| in codas.

I now turn to discussion of Joana's development of branching onsets, which follows patterns very similar to those observed in Inês's development of the same structure.

5. Branching Onsets

Similar to Inês in Chapter 4, Section 5, far fewer attempts at C|l| onsets are attested in Joana's data, if compared to the number of attempts at C|ɾ| clusters. However, we notice developmental differences between the two types of branching onsets, as can be seen through a comparison of Figure 66 and Figure 67 below:

Figure 66: C|ɾ| branching onsets

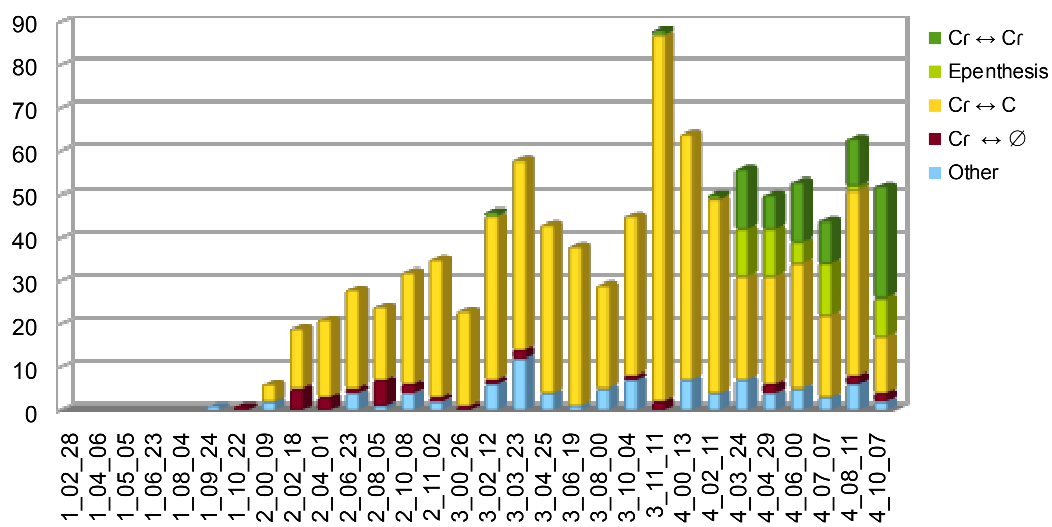
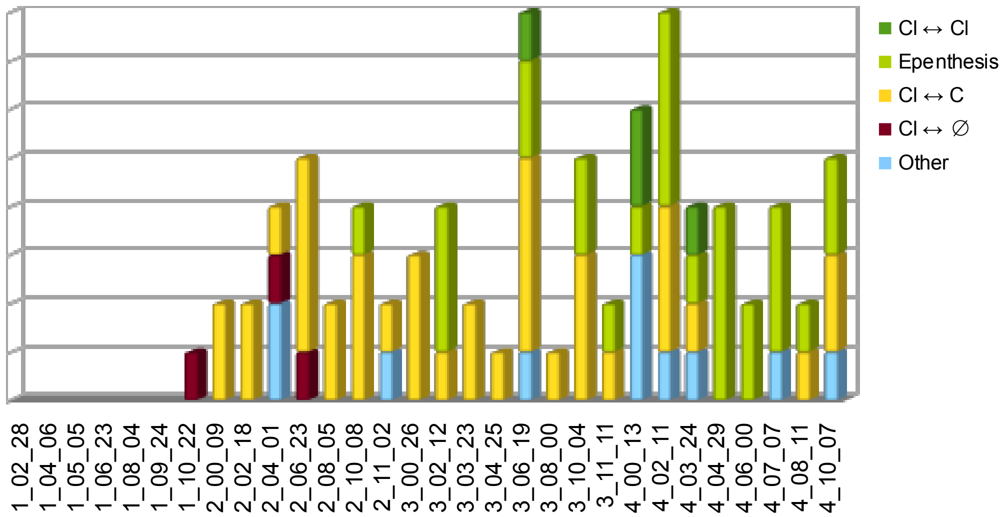


Figure 67: C|l| branching onsets[63]

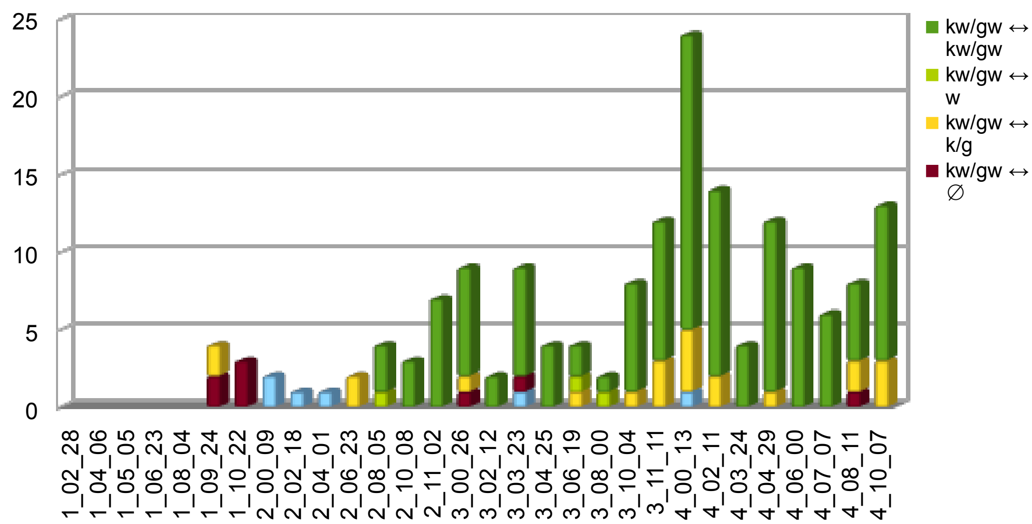


By the end of the documented period, C|ɾ| clusters emerge with greater accuracy than C|l| ones. Recall that Inês only produced epenthesis when attempting C|l| clusters, not C|ɾ| ones. Joana differs in that she also produces epenthetic vowels in the context of target C|ɾ| clusters (e.g. *branco* 'white' [ˈbɨ̥ɾɐːku̥]).

Joana's productions of |kw/gw| (shown in Figure 68) do not resemble her development of C|l| and C|ɾ| clusters, and are not included in the remainder of this section, as was the case with Inês in Chapter 4, Section 5.

63 Note that, as with Inês in Chapter 4, Section 5, examples with epenthesis may entail substitutions of |l|.

Figure 68: |kw/gw|[64]



As I did in the previous chapter, I separate observations on Joana's development of branching onsets between the first and second positions of the cluster (filled by |p/b, t/d, k/g, f/v| and |ɾ, l| respectively).

5.1 First Position of Branching Onsets

Similar to what we observed with Inês, Joana masters consonants in the first position of branching onsets at roughly the same time as she masters their counterparts in singleton onsets: |p/b| and |f/v| at 2;00.09,[65] |t/d| at 2;02.18,[66] and |k/g| at 2;06.23. All consonants in this position

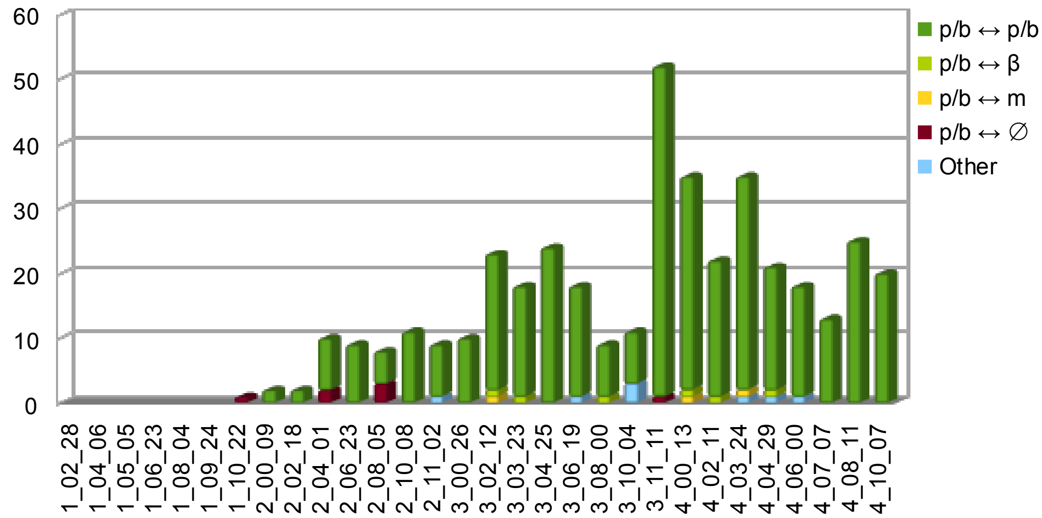
64 Contrary to Inês, I do not exclude *água* from Joana's data on |kw/gw|, as her productions of this word do not appear to constitute a lexical exception.

65 |p/b| is mastered earlier in singleton onsets, at 1;09.24, but is only attempted once prior to 2;00.09 in branching onsets.

66 |t/d| appears to be mastered two sessions earlier in branching onsets than in singletons (2;06.23), but the percentage of correct productions in singleton onsets is high for those two sessions, approaching the threshold of 75% accuracy.

are thus mastered in Joana's earliest attempts at words containing this structure, as exemplified by the development of |p/b| in branching onsets in Figure 69.

Figure 69: |p/b| in branching onsets



Also similar to Inês, the substitutions that Joana made in singleton onsets manifest themselves in the first position of branching onsets (i.e. |t/d| is occasionally produced as [k/g]).

5.2 Second Position of Branching Onsets

Turning now to the development of consonants in the second position of branching onsets, the general observation, outlined above, is that Joana masters neither of the target consonants in this position (|ɾ, l|) during the period observed. The (ongoing) development of these consonants is illustrated in Figure 70 and Figure 71.

Figure 70: |ɾ| in branching onsets

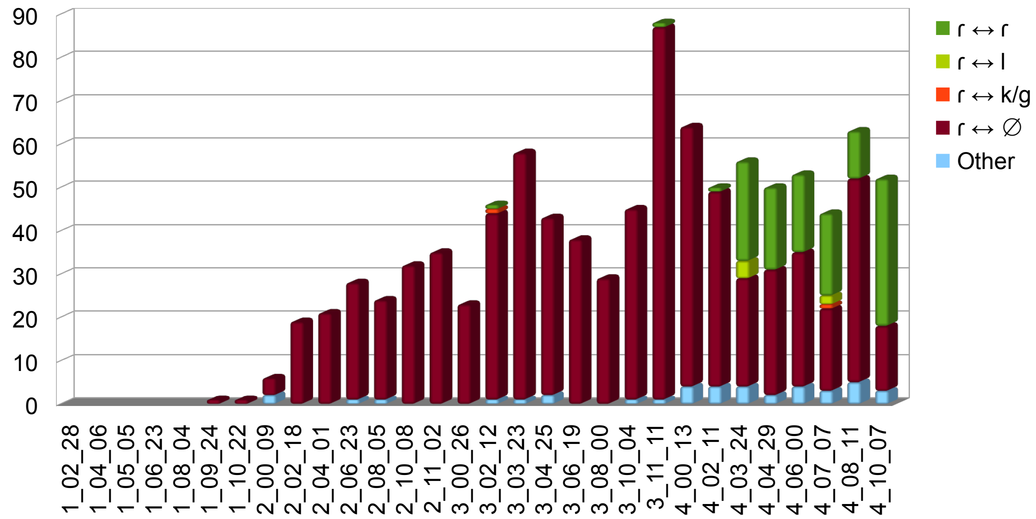
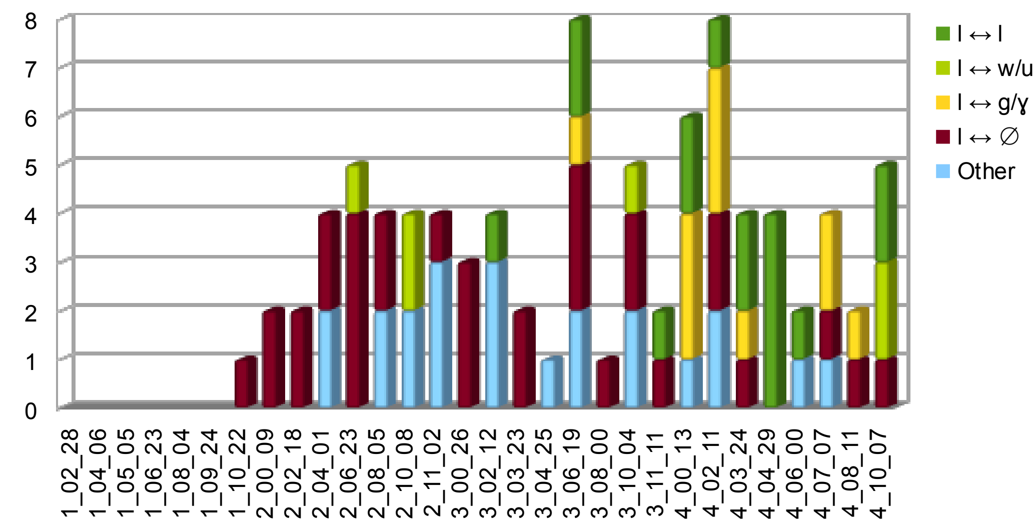


Figure 71: |l| in branching onsets



Despite having a higher and more consistent rate of accuracy by the end of the documented period, |ɾ| is deleted in this position at a much higher rate than |l| (in 97% of all attempts at

C|ɾ| clusters between 1;09.24 and 4;02.11). Target-like productions begin to emerge at 4;03.24, reaching 65% accuracy by the end of the documented period.

Similar to its behaviour in singleton onsets, |l| in the second position of branching onsets is variably substituted by either [w] or [u], or a velar stop or continuant [g, ɣ], in addition to a few other marginal productions. Because of the variability of these productions, it is not clear whether Joana was approaching mastery of |l| in this position by the end of the documented data.

5.3 Summary of Observations

Joana's development of branching onsets is quite similar to that of Inês, including a higher rate of deletion for |ɾ| than for |l|, and a higher rate of accuracy for C|ɾ| clusters than for C|l| ones by the end of the data, with some epenthesis occurring amidst the target clusters. Since these observations are shared across both children, I will not analyze them further in this chapter (see Chapter 4, Section 8 for analysis).

In the following section I give a description of Joana's development of codas.

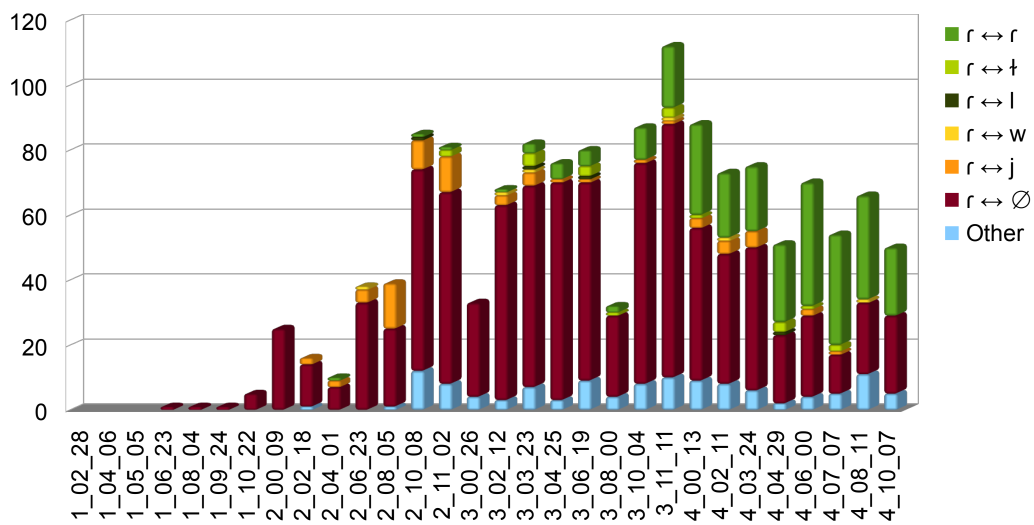
6. Codas

Joana begins to attempt words containing codas in earnest at 1;09.24 (recall from Chapter 4, Section 6 that Inês began attempting such words much earlier, at 1;01.29). Just as we saw with Inês, |ʃ/ʒ| is the most frequently attempted coda in Joana's data, with 2,828 attempts, followed by |ɾ| with 1,484, and |ɫ| with only 370. In this section I describe Joana's development of codas, beginning with |ɾ| and |ɫ|, and I focus the latter portion of the section on |ʃ/ʒ|. I divide and analyze only Joana's attempts at |ʃ/ʒ| in the same ways as I did with Inês in Chapter 4, Section

6.2, in order to show that Joana does not display the same positional effects as Inês, thus highlighting the differences between the two children's development.

By the end of the documented period, Joana's productions of |ɾ| reach 63% accuracy (attained at 4;07.07; the last session displays only 42% accuracy), and her productions of |ɫ| reach 63%.[67] The development of |ɾ| is depicted below in Figure 72.

Figure 72: |ɾ| in codas

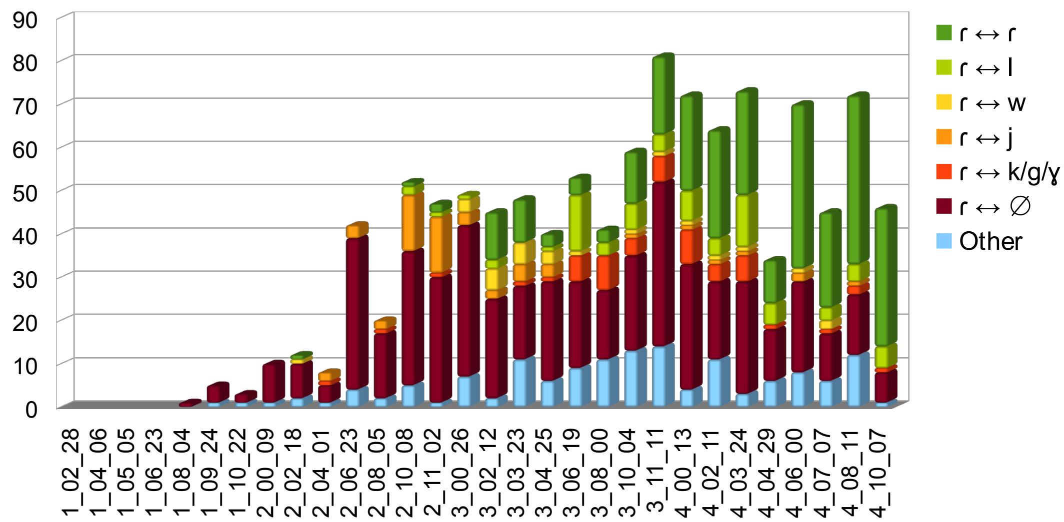


From her earliest attempts at |ɾ| until she reaches 4 years of age, Joana deletes this target consonant between 60% and 100% of attempts per session. For the remainder of the corpus, her accuracy slowly increases, reaching up to 63% in the final session. This improvement suggests that Joana is approaching mastery of this consonant in codas.

Importantly, Joana's development of |ɾ| in codas is very similar to that of |ɾ| in singleton onsets, as shown previously in Figure 64, and repeated in Figure 73 for convenience.

67 Although Joana does not resyllabify |ɾ| or |ɫ| in codas in high quantity, cases of resyllabification are excluded from all charts in this section, except where otherwise mentioned.

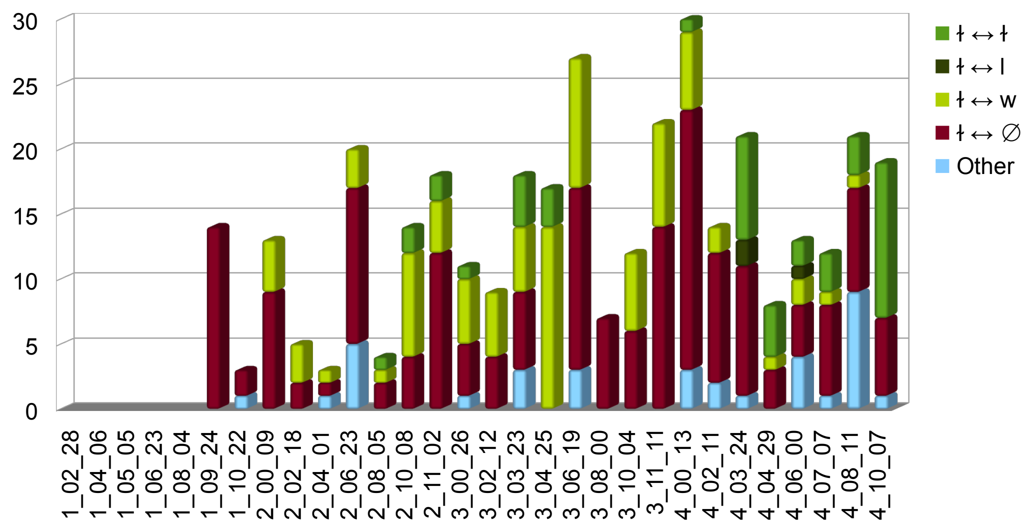
Figure 73: |ɾ| in singleton onsets



The parallel development of |ɾ| in codas and in singleton onsets is characterized by high rates of deletion and slowly-emerging target-like productions. Recall from Chapter 4, Section 8.3 that Inês's development of |ɾ| showed an increase in accuracy across all positions at 3;07.29. Joana's productions of |ɾ| are also similar across positions.

I now briefly address the development of |ɫ| in codas, as depicted in Figure 74.

Figure 74: |ɫ| in codas

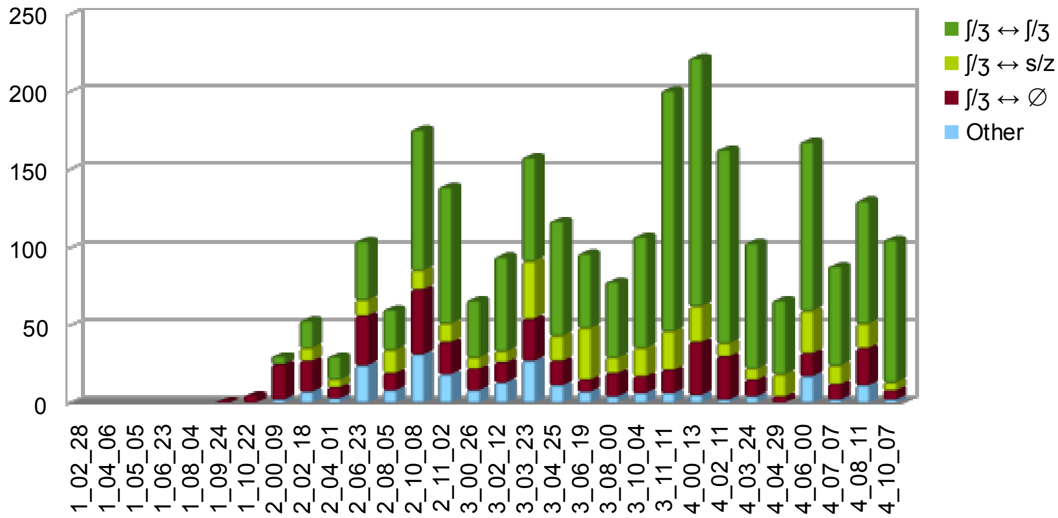


Similar to singleton onsets and the second position of branching onsets, we observe that Joana substitutes [w] for |ɫ| at rates that gradually decrease with a concomitant increase in accuracy rates. As we saw with Inês, Joana does not have a consistently high rate of deletion of this coda, especially when compared with |ɾ| (Figure 72 above).

Turning now to Joana's development of |ʃ/ʒ| in codas, I mentioned above that, overall, Joana does not master any of the three EP codas during the course of the period covered by the corpus. With cases of resyllabification removed, however, we can claim that Joana's productions of |ʃ/ʒ| in codas reach mastery levels by 3;11.11, although she barely exceeds the 75% threshold, only reaching as high as 88% in the final session (4;10.07).[68]

68 We note dips to 65% at 4;06.00 and 61% at 4;08.11. As with Joana's timeline in Figure 51, I ignore these dips for the purpose of assigning stages; however it is important to note that Joana's 'mastery' of |ʃ/ʒ| in codas is not perfectly robust, at least during the period covered by the corpus.

Figure 75: |ʃ/ʒ| in codas



In contrast to the liquids, we observe correct productions of |ʃ/ʒ| among Joana's earliest attempts of this coda. Also, recall from Chapter 4, Section 6.1 that Inês substituted [s/z] for |ʃ/ʒ| in cases where she had resyllabified codas as onsets. Even when we exclude resyllabified codas from Joana's data, she still frequently substitutes [s/z] for |ʃ/ʒ|, starting at 2;02.18 and continuing throughout the observed period, at a rate of about 15% per session. Recall as well from Chapter 4, Section 6.2 that Inês mastered |ʃ/ʒ| in utterance-final codas at 1;09.18, well before she mastered utterance-medial codas, at 3;00.15. In line with the absence of larger prosodic conditioning highlighted at the outset of this chapter, we observe no such positional pattern in Joana's data, as evidenced in Figure 76 and Figure 77 below, which show the development of |ʃ/ʒ| in utterance-final and utterance-medial codas, respectively. In both environments, target-like productions of |ʃ/ʒ| are predominant and reach mastery at 3;11.11, while [s/z] substitution, though optional, can be observed throughout the data set.[69]

69 The utterance-final environment shows slightly higher rates of accuracy at the point of mastery, but both environments have dips in accuracy between 4;04.29 and 4;08.11.

Figure 76: |ʃ/ʒ| in utterance-final codas

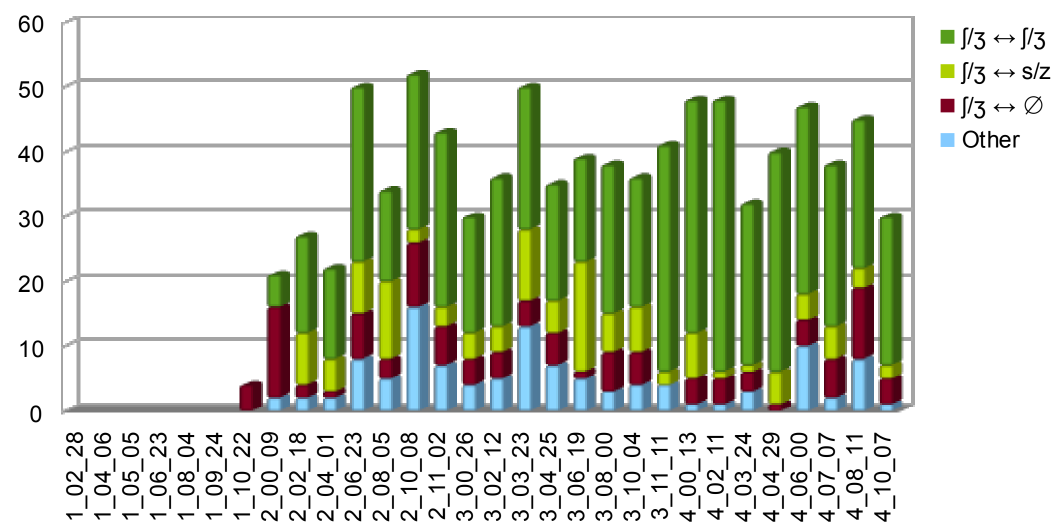
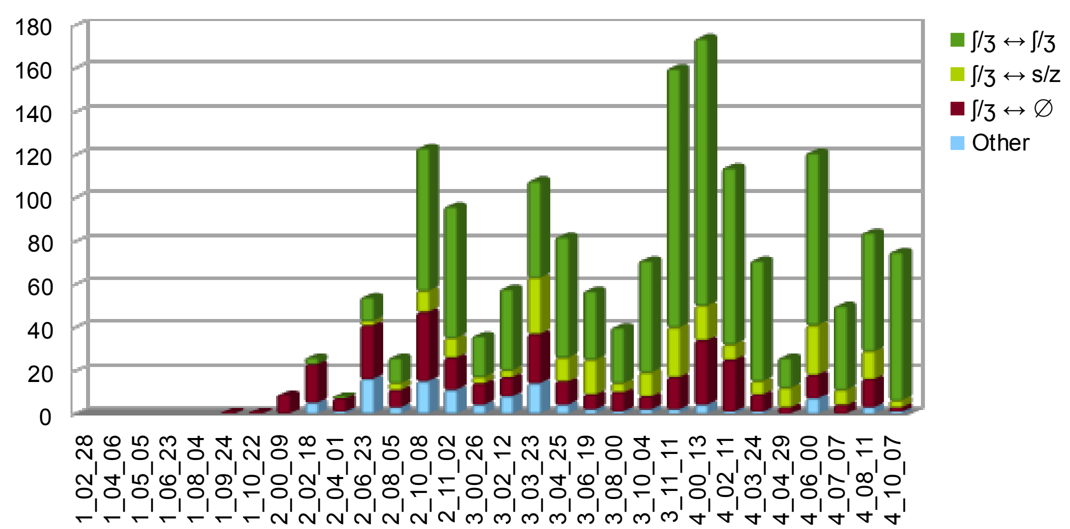


Figure 77: |ʃ/ʒ| in utterance-medial codas

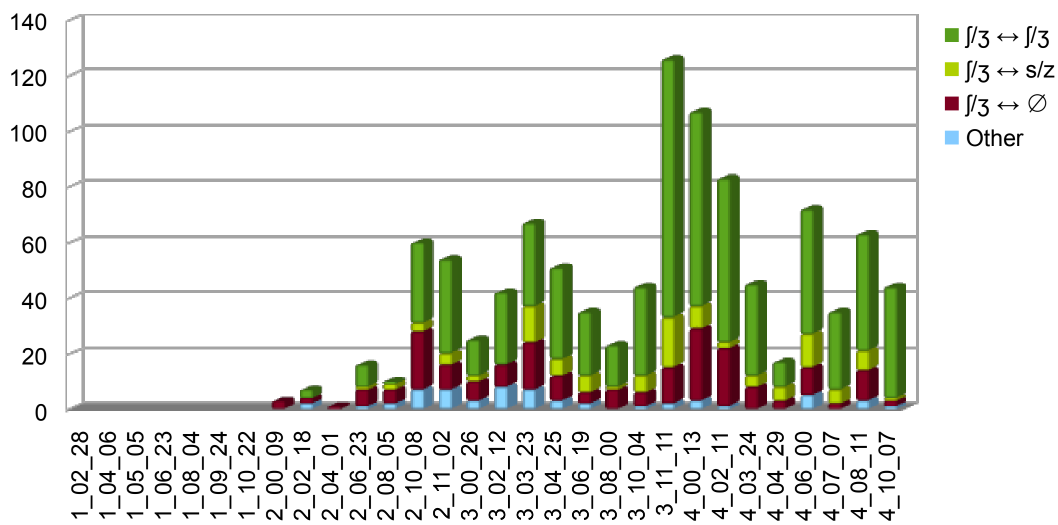


Although |ʃ/ʒ| is not acquired early in utterance-final codas as it was for Inês, these two environments differ slightly in terms of early rates of deletion. The rate of deletion drops below

20% in the utterance-final context by 2;02.18, earlier than utterance-medially, where we observe deletion rates below 30% only starting at 2;10.08.[70]

Likewise, while Inês showed differences between utterance-medial word-final codas and word-medial codas (as shown in Chapter 4, Section 6.2), no such pattern manifests itself in Joana's data, as we can see through a comparison of Figure 78 and Figure 79 below.[71]

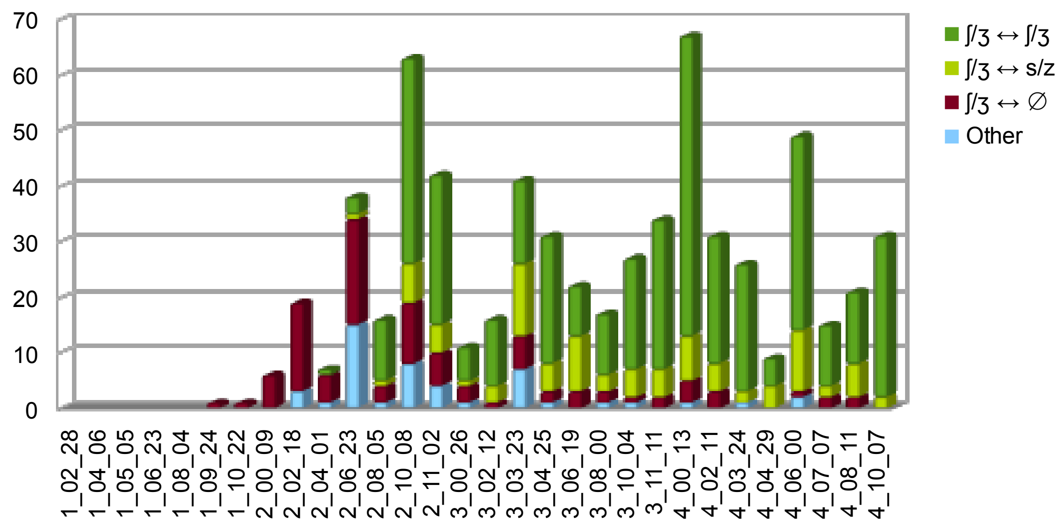
Figure 78: |ʃ/ʒ| in utterance-medial, word-final codas



70 This difference provides further support for Freitas's (1997) hypothesis that final codas are interpreted as OEHS by children learning EP, as discussed previously in Chapter 4, Section 8.4.

71 Note that Figure 78 and Figure 79 differ in scale for readability.

Figure 79: |ʃ/ʒ| in word-medial codas



In sum, while Inês's data showed clear positional patterns in the development of codas, Joana's data reveal no such effects. In fact, it is segmental conditioning which seems to govern Joana's productions of the allophones of /ʃ/ in codas. I describe this conditioning in the next section.

6.1 The Segmental Conditioning of /ʃ/ in Codas

In this section, I consider Joana's development of /ʃ/ in underlying codas based on the segmental environment in which the target consonants are found in her productions, following the procedure used for Inês in Chapter 4, Section 6.3. Below, I divide the data into four different segmental contexts: before voiceless consonants, before voiced consonants, before vowels, and utterance boundaries. I show that Joana tends to produce the correct allophone for each environment, with gradually improving rates of accuracy. This suggests that, in the absence of understanding of the broad distributional facts of EP, Joana attends to the cues available from the immediate segmental environment.

Recall the target system of allophony of /ʃ/ in codas from Table 12, repeated in Table 18 for convenience.

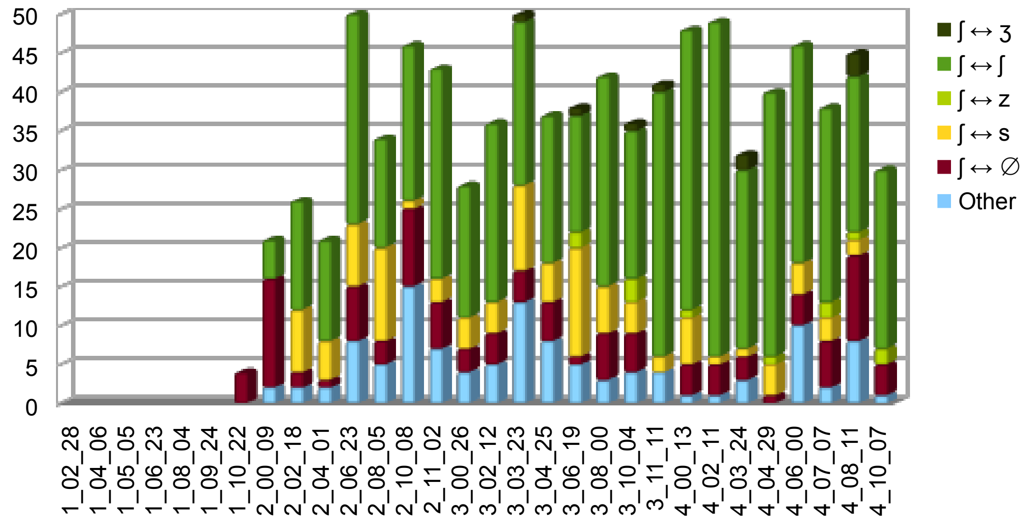
Table 18: Coda /ʃ/, per phonological environment (Mateus & d'Andrade 2000)

Environment	**Realization of /ʃ/**	**Example**
$\_C_{[voiceless]}$	ʃ	*buscar* |buʃˈkaɾ|
$\_C_{[voiced]}$	ʒ	*mesmo* |ˈmeʒmu|
_V	z	*mas aqui* |mɐ zɐˈki|
_#	ʃ	*Queres?* |ˈkɛɾɨʃ|

Recall also that Inês went through a stage during which she deleted all |ʃ/ʒ| in codas, for all contexts but the utterance-final one (where |ʃ| is mastered almost immediately). In contrast to this, Joana does not display any stage of across-the-board deletion. From her earliest attempts at words containing /ʃ/ in codas, Joana produces a consonant in all four segmental environments, however with a high degree of variability. In brief, her progression towards a target-like system is much slower than what we witnessed with Inês, and progresses in less clearly definable stages.

As mentioned above, in the target system, |ʃ| is the correct allophone of /ʃ/ in utterance-final position. As we can see in Figure 80 below, target-like productions of |ʃ| in this position emerge among Joana's earliest attempts at utterances containing them, at 2;00.09. In the next session, substitutions of |ʃ| as [s] begin to emerge. From 2;02.18 onwards, [ʃ] and [s] together account for a general average of 77% percent of productions. Further, Joana makes very few voicing errors in this environment; the majority of the strident fricatives produced here are voiceless.

Figure 80: /ʃ/ in utterance-final codas[72]



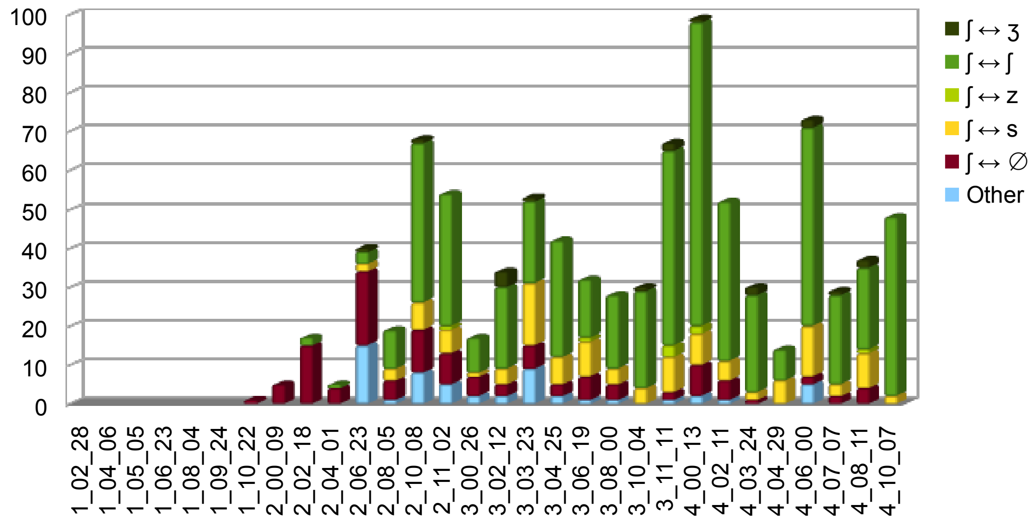
Note that by the end of the corpus, the rate of alveolar substitutions decreases. By 3;11.11, Joana reaches over 75% target-like productions of |ʃ| in this environment (although accuracy dips below mastery levels between 4;06.00 and 4;08.11).

In the target system, |ʃ| is also the correct allophone in codas followed by voiceless consonants, both word-medially and across word boundaries. Although we find some deletions in this context in earlier sessions, and some alveolar substitutions, target-like productions are predominant in this environment. Again, we note only a few voicing errors, and Joana's accuracy in this position reaches 83% at 3;10.04. This pattern remains predominant until the

72 Note that Figure 80 is not identical to the previous chart of utterance-final |ʃ/ʒ| productions (Figure 76), because it includes separation between voiced and voiceless productions and excludes cases where the target utterance-final coda is not utterance-final in Joana's actual production (i.e. cases where additional segments occur after the attempted coda).

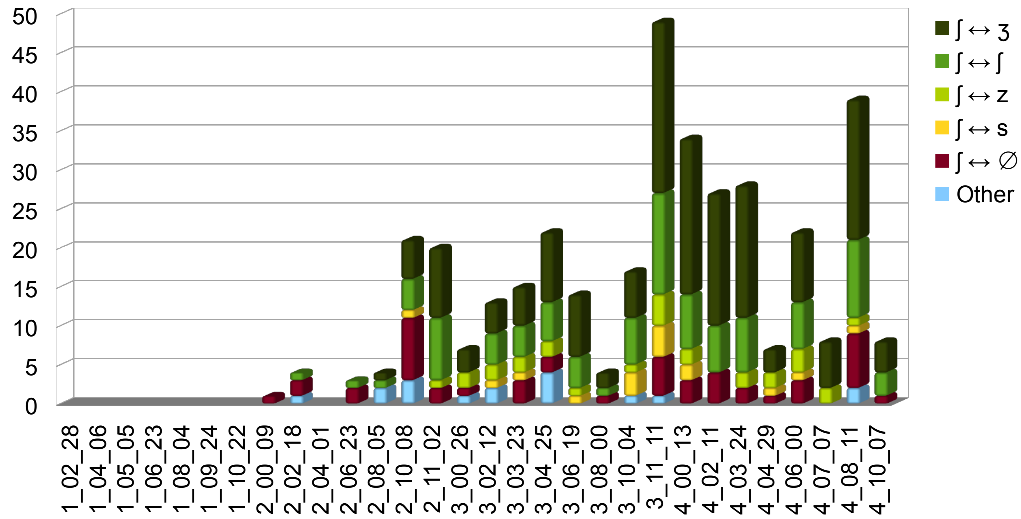
end of the documented period, except for a dip to 57% at 4;04.29 and again at 4;08.11, as shown in Figure 81 below.

Figure 81: /ʃ/ in codas before voiceless consonants



Conversely, when /ʃ/ occurs in codas before voiced consonants, the correct allophone in the target system is the voiced postalveolar fricative |ʒ|, rather than the voiceless |ʃ|. Joana shows some command of this rule, as shown in Figure 82 below, although she does not reach mastery levels in this environment by the end of the recorded period.

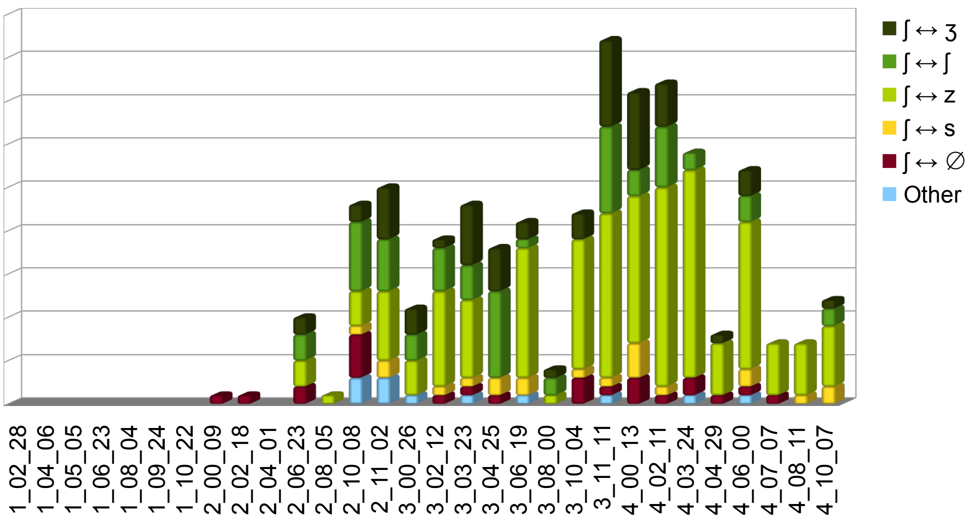
Figure 82: /ʃ/ in codas before voiced consonants



Even though Joana produces roughly the same amount of postalveolar fricatives in this environment as before voiceless consonants, she makes fairly frequent voicing errors.

In contrast to the other environments, the correct allophone of /ʃ/ in word-final position preceding a vowel is the voiced alveolar fricative |z|. In prevocalic position, Joana's data show increasingly high rates of target-like productions, as we can see in Figure 83 below, although she does not maintain mastery levels of accuracy in this environment.

Figure 83: /ʃ/ in prevocalic context[73]



Note, however, that within Joana's productions of /ʃ/ in this environment as a postalveolar fricative, she was equally as likely to produce [ʃ] as [ʒ].

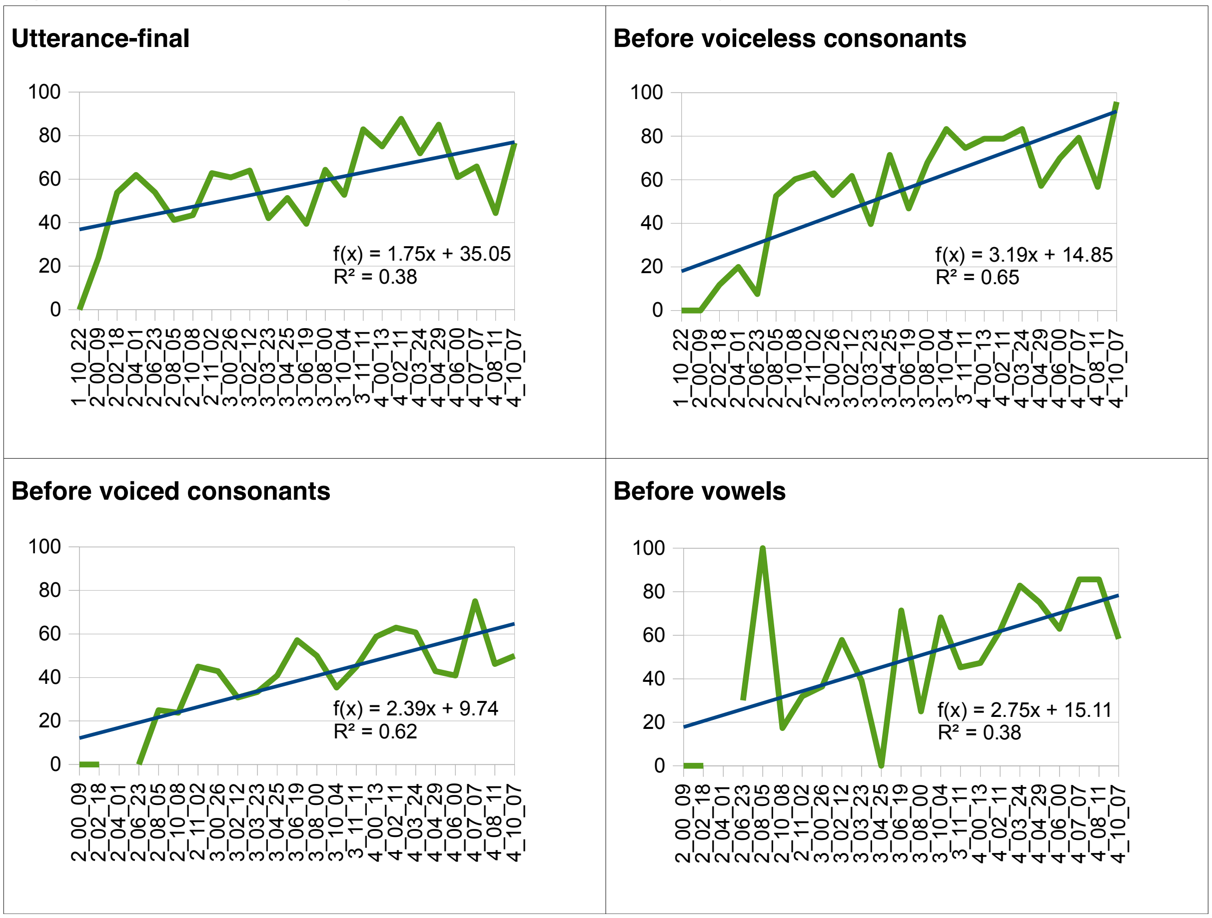
If we consider only Joana's productions of /ʃ/ with the postalveolar place of articulation, we can see that although the child has a fairly strong command of the voicing required in most environments, in cases where her productions should be voiced (i.e. before voiced consonants or before vowels), she does often produce a voiceless postalveolar. This may indicate an awareness that the underlying form of the target phoneme is voiceless.

In sum, Joana's productions of /ʃ/ in various coda environments show gradual improvements toward mastery, as opposed to the prosodically-defined stages of acquisition we

73 As discussed in Chapter 2, Section 3, the prevocalic context is where resyllabification occurs; however, in Joana's data there are sometimes pauses between words, which may intervene between the fricative and the following vowel. These cases have not been coded as resyllabification, and so the number of attempts at /ʃ/ before a vowel may be higher than the number of cases of resyllabification. The presence or absence of a pause before a vowel did not appear to affect Joana's choice of allophone (e.g. from 3;02.23 we get both *mas (...) não* 'but ... no' [mɐs(.) ˈnɐ̃w̃] and *faz, também* 'is ... also' [ˈfas(.) tɐ̃ˈbɐ̃j̃]; although the segmental environments are different in these cases, Joana produces [s] in both).

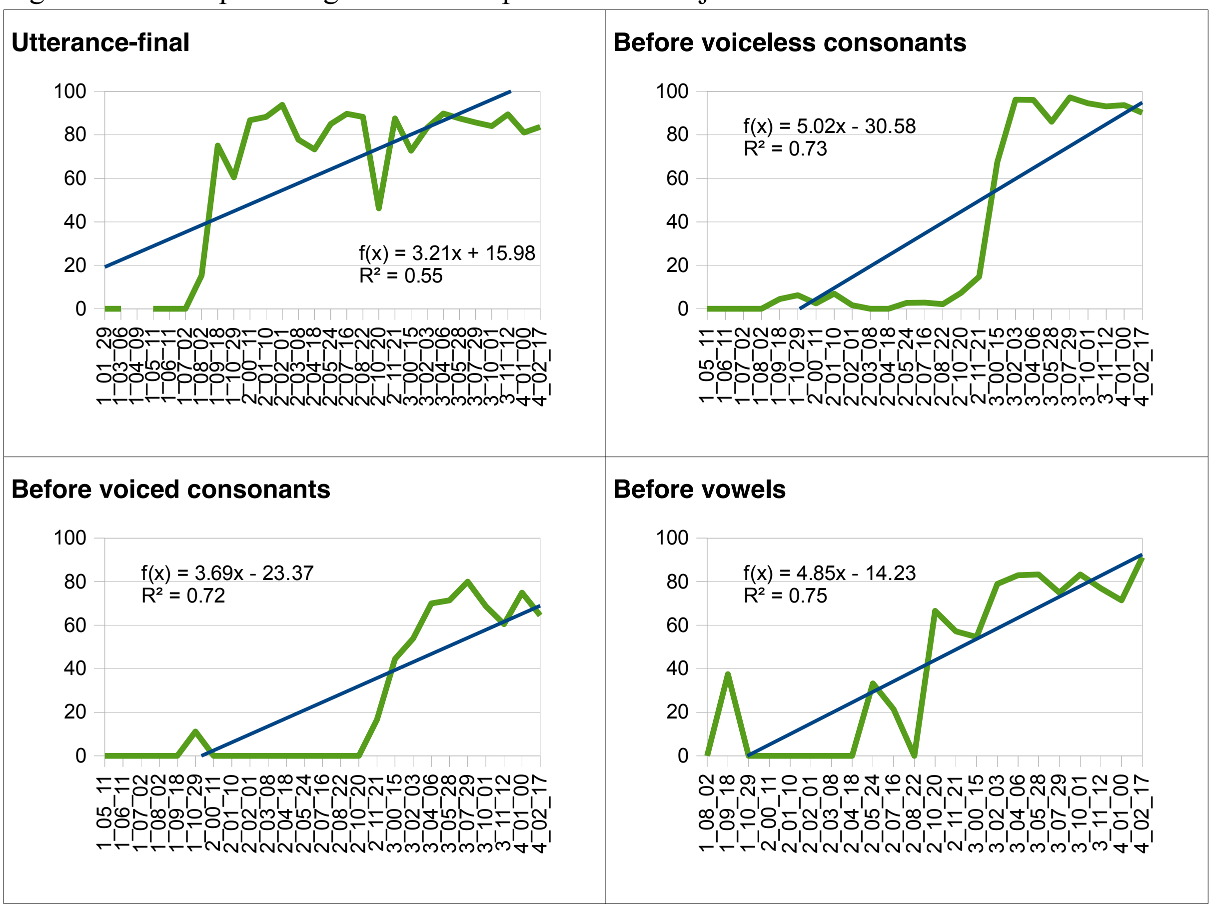
observed in Inês's data. I further illustrate the gradual nature of Joana's accuracy rate in each environment through line graphs in Figure 84 below. As with those for Inês in Chapter 4, Section 6.3, each figure begins from the first session in which /ʃ/ is attempted in the specified position, and includes a trend line. The relative flatness of Joana's trend lines as compared with Inês's highlights her slower rate of improvement over time.

Figure 84: Joana's percentages of correct productions of /ʃ/ in codas



Recall that the same charts for Inês in Chapter 4, Section 6.3 look very different, as they are characterized for the most part by very clear stages and steeper trend lines. I repeat these charts below for an easy comparison with Joana's.

Figure 85: Inês's percentages of correct productions of /ʃ/ in codas



Inês's development of /ʃ/ in codas shows steep changes between stages, none of which are paralleled in Joana's development. In all coda environments, Inês initially deletes /ʃ/, until she makes a generalization about which allophone she should use in each environment, after which we see a plateau of accurate productions. Joana makes no such generalizations, and so her rates of accuracy only increase gradually.

6.2 Summary of Observations

In this section, I highlight observations from Joana's development of codas to be analyzed in Section 8.

One pattern of segmental substitution which occurs at a high rate in Joana's data, but did not occur in Inês's data, is the production of coda |ɫ| as a labiovelar glide [w]. This happens across all positions where |l/ɫ| may occur. I discuss this substitution in Section 8.1. I will also discuss the fact that Joana appears to have no positional effects which affect her development of |ʃ/ʒ| in codas.

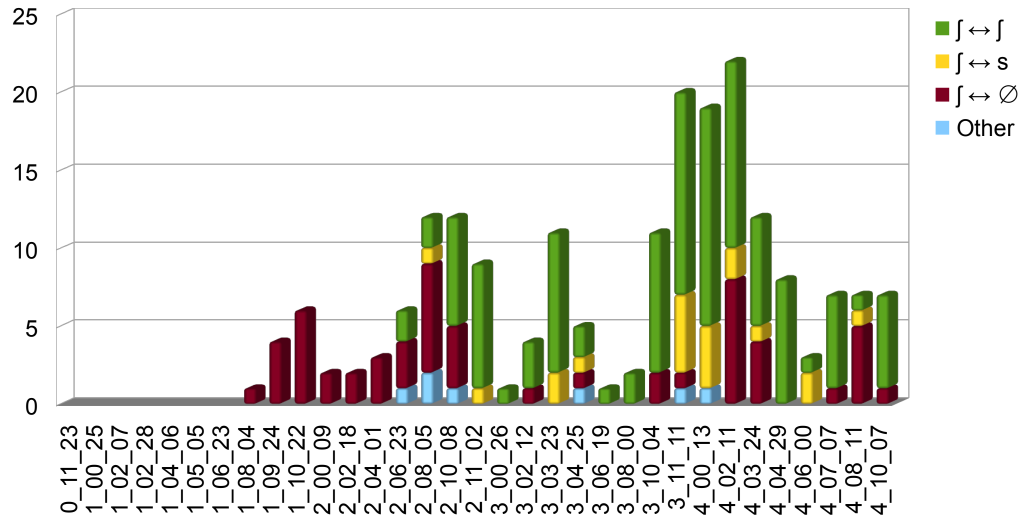
Together, these observations lend support to the hypothesis that Joana's developmental paths depend largely on segmental factors, rather than prosodic domains. Before I discuss this analysis further, I survey Joana's development of CEHSs in the next section.

7. Codas of Empty-headed Syllables

Joana's earliest attempts at |ʃ|[74] in CEHS result in deletion, as depicted in Figure 86 below.

74 There were no examples of a CEHS preceding a voiced consonant in Joana's data, and there were no cases where |ʃ| in this position was produced as [ʒ] or [z].

Figure 86: |ʃ| in CEHS



This early deletion pattern is in contrast to her development of |ʃ/ʒ| in other positions. In both singleton onsets and codas (as shown in Sections 4 and 6, respectively), target-like productions of |ʃ/ʒ| begin to emerge at 2;00.09, but they do not emerge in CEHS until 6 months later, at 2;06.23.

With the exclusion of the lexical exception *estar* 'to be' and related conjugated forms (as motivated in Section 3), Joana only makes 197 attempts at words containing CEHS. Because of this low number of attempts, it is difficult to say with certainty whether Joana masters |ʃ| in CEHS within the recorded period. Target-like productions are however the predominant pattern from 2;10.08 onwards.[75] Joana also produces some substitution of [s] for |ʃ| in this position.

75 Except for dips in accuracy in 4;06.00 and 4;08.11.

7.1 Summary of Observations

In the following section I will discuss Joana's pattern of early deletion of CEHS, which occurs despite no similar deletion stage for onsets or codas. The variable nature of Joana's later development of this position, and the substitution of the alveolar fricative for the postalveolar one, follows the same logic as what we saw with Joana's coda development.

8. Analysis

In this section I describe representational, distributional, and articulatory effects observed in Joana's data. As mentioned above, the most central way in which Joana differs from Inês relates to her understanding (or lack thereof) of the distributional properties of EP. Also, she shows no effects which can be related to perceptual shortcomings (cf. Inês's deletion of the palatal nasal), and few effects which can be interpreted as strictly articulatory (cf. Inês's stopping of fricatives in onsets). Joana's consonantal productions are instead affected by difficulties with building accurate representations and with understanding consonantal distributions.

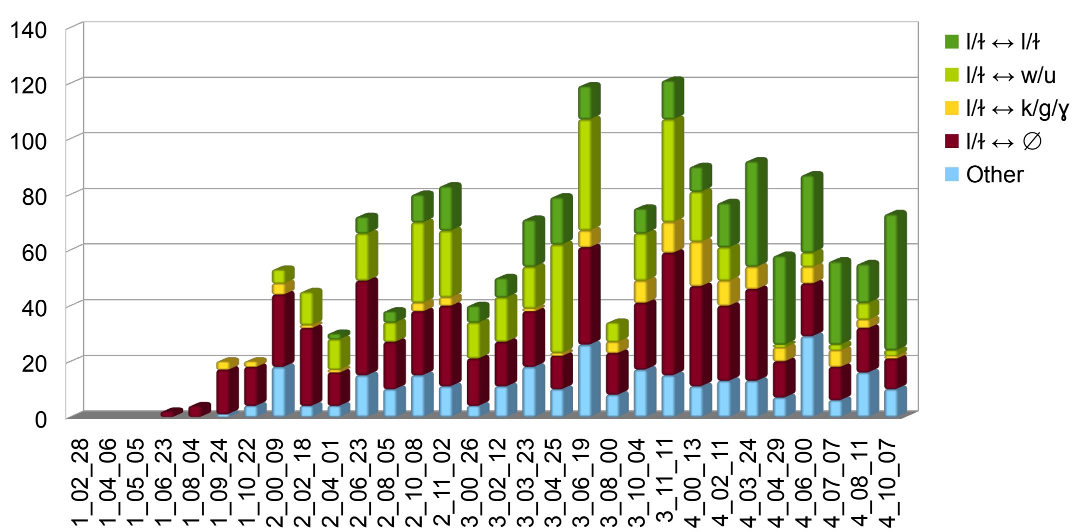
8.1 Representational Effects

As discussed in Chapter 4, Section 8.2, some patterns of development occur because the child cannot (yet) map the target perceptual cues to adult-like articulations. Recall that Inês showed several patterns which reflected these sort of effects, including the substitution of the palatal lateral |ʎ| as the glide |j|, and early productions of |f/v| as [t/d]. Joana also showed several examples of the same sort of perceptual effect, including the substitution of |ʎ| as [j] and of |l/ɫ| as [w], and general difficulties with producing |ɾ|. I discuss |l/ɫ| and |ɾ| in this respect below, but refer to Chapter 4, Section 8.1 for the analysis of |ʎ| substitutions.

As we saw above, Joana's attempts at |l| in singleton and branching onsets, and at |ɫ| in codas, all frequently resulted in productions of the labiovelar glide [w]. According to Bernhardt & Stemberger (1998), the production of laterals as [w] is common cross-linguistically in first language acquisition. Raphael et al. (2007) group |l| and |w| (along with the alveolar approximant |ɹ| and the palatal glide |j|) into the category of semivowels, which are characterized by certain formant transitions which "provide critical acoustic cues to their identification" (p. 217). If Joana failed to understand the fine relations between these acoustic cues and their articulatory correlates, then |l/ɫ| and |w| were likely similar enough in her perception that [w] was a suitable approximation of |l/ɫ|.

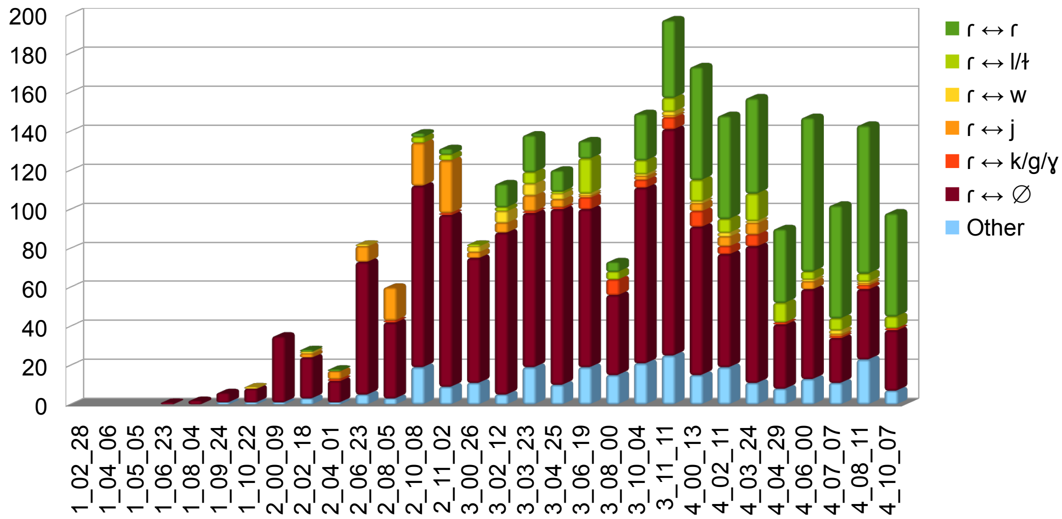
In Figure 87 below, I group Joana's attempts at |l/ɫ| in all positions (i.e. singleton onsets, the second position of branching onsets, and codas) into one data set, in order to more clearly show her productions of [w], which decreased as target-like productions of |l/ɫ| gradually emerged.

Figure 87: Joana's production of |l/ɫ| in all positions



I turn now to Joana's development of |ɾ| in both onsets and codas, depicted in Figure 88 below. Recall from Chapter 4 that, although Inês showed at least one common trend in |ɾ| production across all positions (i.e. general improvement in accuracy of all positions at 3;07.29), her productions were also affected by distributions (i.e. high rates of deletion of |ɾ| in branching onsets) and articulation (i.e. substitution of [l] for |ɾ| in singleton onsets). Joana did show the same pattern for branching onsets, suggesting that structural complexity was a factor for both children, at least at the level of consonant clusters, but she did not show any effects in |ɾ| production related to other syllable positions. Joana did not master the consonant in either onsets or codas, but rather predominantly deleted it in both for much of the documented period.

Figure 88: Joana's productions of |ɾ| in onsets and codas[76]



I argue that Joana had similar difficulties with |ɾ| that she did with |l/ɫ| and |ʎ|, with the difference that she had not (yet) come up with an articulation sufficiently similar to |ɾ| to serve

76 I exclude |ɾ| in the second position of branching onsets from this data set, due to the structurally-motivated deletion that occurs in this position.

as a reliable substitute for it (in any position), hence the high degree of variability observed throughout her data. This hypothesis finds support in the articulatory properties of |ɾ| as described in Ladefoged & Maddieson (1996), which do not offer a sustained target that the child could reproduce, even partially.

I now discuss the patterns that Joana displayed which had sources in articulatory issues.

8.2 Articulatory Effects

Although Joana displayed some representational effects which negatively affected her ability to articulate consonants correctly (as discussed in the section above), on the whole, she was less susceptible to purely articulatory effects than Inês (who produced |ɾ| as [l] and fricatives as stops in singleton onsets).

We observed one articulatory effect in Joana's productions which we did not find in Inês's, namely the optional production of coronal consonants |t/d| and |n| with backed articulations ([k/g][77] and [ɲ], respectively). These substitutions did not follow a categorical pattern, as they arose from a relatively low proportion of target coronals. As highlighted above, however, it appears that most of Joana's segmental mispronunciations arose from either difficulties in perceiving the relevant contrasts in the target forms or, perhaps more fundamentally, from her difficulties in analyzing the sound distributions of EP, which I discuss in the following section.

8.3 Distributional Effects

Although Joana's productions tended much less toward clear distributional effects than Inês's did, Joana did show two such effects in her productions, namely through her early deletion of

77 It is possible that 'backed' coronal stops in the data may be more palatal in nature than their transcriptions suggest; since EP has no oral palatal stops, they have been interpreted as velars by transcribers.

CEHS, and frequent errors in the place of articulation of |ʃ/ʒ| and |s/z| which, I argue, arose because of how the target distributions affected the child's understanding of her language.

Joana's early deletion of |ʃ| in CEHS likely occurred because this position requires additional structural complexity over codas. As discussed in Chapter 2, Section 2, and in Chapter 4, Section 8.4, children often reduce consonant clusters in ways which result in more simplistic structures (Smith 1973; Spencer 1986; Fikkert 1994; Freitas 1997; Barlow 1997; Bernhardt & Stemberger 1998; Levelt et al. 1999/2000; Rose 2000; 2009; Goad & Rose 2004).

Recall from Section 4 that, in onsets, Joana substituted both [ʃ/ʒ] for |s/z| and [s/z] for |ʃ/ʒ| at a rate of about 25% per session, until she reached four years of age. Recall as well that she substituted [s/z] for |ʃ/ʒ| in codas, and that this optional substitution pattern was not restricted to resyllabification contexts as it was for Inês (see Chapter 4, Section 6.1). Although |ʃ/ʒ| and |s/z| are distinct phonemes in EP onsets, this is not the case for codas: as mentioned in Chapter 2, Section 3, when /ʃ/ occurs in word-final codas which are followed by vowel-initial words, it is produced as |z| in adult speech (Mateus & d'Andrade 2000). I argue that without proper understanding of these distributional facts, Joana could only proceed on what may amount to example-by-example learning of the codas consonants, which in turn yielded substitutions between |ʃ/ʒ| and |s/z|, even though at relatively low rates, across all environments.

This completes my discussion on Joana's productions, which I addressed in ways that facilitate comparisons with Inês's productions. I now turn to a more general discussion of the overarching similarities and differences between Inês and Joana's development, and how to situate this work within the larger scheme of research on the first language acquisition of phonology.

Chapter 6: Discussion

As previously mentioned, in order to build mental representations of the sounds and structures in language, children must first develop an understanding of the distributions and related alternations which may affect those sounds and structures (Freitas 2003; Rose 2003; Goad & Rose 2004; Fikkert & Freitas 2006; Fikkert & Levelt 2008). As segments are affected in both perception and production by their prosodic context, children must attend to these contexts in order to reproduce their target segments in ways that are meaningful to those around them.

However, phonological development is, overall, a relatively complex process which involves not only perceiving, segmenting, and understanding sounds, but also mapping them to motor articulations so that they can be reproduced. In the face of this complex learning task, children may not always be able to develop the required building blocks with ease. This logical outcome, in turn, yields the question as to how children's development might unfold in the case that they lack some of those building blocks, for example the allophonic distributions that make up the phonotactics of their target languages.

The phonology of European Portuguese displays intricate positional effects. Among other details, while a wide range of consonants may occur in singleton onsets, codas are restricted to |ʃ/ʒ|, |ɾ|, and |ɫ|. EP codas are also subject to resyllabification, a phenomenon in which between-word relationships may obscure the distinction between codas and onsets at word edges.

In the above work, we observed the consonantal development of two children, Inês and Joana. Overall, Inês showed a number of behaviours which we may relate to consonantal distributions (e.g. production of |ʃ/ʒ| as [s/z] and of |ɫ| as [l] in resyllabified contexts; early emergence of utterance-final codas, etc.). Joana, on the other hand, showed almost no such effects, instead developing the more difficult consonants (e.g. |ɾ| and |l/ɫ|, which are commonly late-attested in EP development) and positions (e.g. codas) in ways which were rather slow and progressive.

Nonetheless, Inês and Joana did show parallels between their respective developmental paths. For example, they both mastered most stops relatively early, while approximants developed much later, if at all during the period observed; both also had similar issues with the palatal lateral. Finally, the children also displayed differences which we can set aside as superficial because they do not reflect the children's grammatical knowledge, for example Inês's deletion of the palatal nasal in hard-to-perceive contexts, as well as her articulatorily-motivated substitution of stops for fricatives, and Joana's (optional) backing of coronals (|t/d| and |ɲ|). It is the overarching differences in the children's developmental data which I take as truly significant, in order to understand the ways in which their respective phonological development unfolded. I briefly elaborate on these differences below.

As we saw in Chapter 4, Inês's development of /ʃ/ in underlying codas clearly reflects an understanding of the sandhi phenomenon in EP: when cases of resyllabification are excluded from her data on codas, so are most of her substitutions of |ʃ/ʒ| in target codas as [s/z] (in addition to the overall stopping pattern we observed in her syllable onsets). This is not the case for Joana; the same consideration of resyllabification still leaves behind fairly high rates of variability, suggesting that she is not fully aware of the environments in which these substitutions should occur. Overall, in Joana's data, we see relatively few positional effects which can be used to differentiate between |ʃ/ʒ|, |ɾ|, or |l/ɫ| productions in onsets and codas.

On the whole, we saw evidence of grammatical understanding of the EP phonological system from Inês, even though we sometimes saw her performance in word productions being indirectly or directly affected by perceptual and articulatory difficulties (e.g. fricative stopping, which occurred only in onsets). Conversely, Joana showed few purely perceptual or articulatory effects, and only showed understanding of adjacent segmental environments (e.g. whether a coda occurred before a voiced consonant, a voiceless consonant, or a vowel), rather than broad prosodic contexts such as word edges or positions within phrases.

Each child's development was thus driven by different sets of factors; Inês was far more influenced by differences between prosodic contexts than Joana was. Inês's data also showed cases where grammatical understanding was preceded by stages of across-the-board deletion (e.g. |ʃ/ʒ| in non-final codas). This, in turn, indicates structural awareness on Inês's part: in the face of structural elements for which she had no analysis, she produced no segment. Joana showed no stages of deletion on an equivalent scale, and no evidence of sweeping changes in production, which indicates a relative lack of awareness of the target conditioning environments: she generally attempted each target sound, irrespective of its structural position.

These differences are revealed in the above work through the longitudinal tracking of target consonants in different positions (e.g. onsets, codas, branching onsets). The study of individual positions then allowed for further breakdown of the data into narrower contexts whose significance varied according to the extent to which each child differentiated these contexts in their analyses. This study, however, is limited in the respect that it considers only two children, both of whom are learning a relatively tricky phonological system. Nonetheless, the methods developed in the context of this thesis may offer new avenues for the study of segmental development, in relation to both phonological factors, such as stress and intonation, and peripheral factors, such as perceptual and articulatory difficulties affecting the child's overall performance. It would be beneficial to apply these methods to more diverse languages, such as those with more complex syllable structures (e.g. Polish), and more complex word structure (e.g. polysynthetic languages like Turkish or Cree), so as to reveal further relationships between the various components of phonological systems across all natural languages, and how these factors might play a role in phonological development.

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Appendix A: Aggregated Inventories of Inês's Consonantal Development

1. Singleton Onsets

|p/b|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	1	1	6	0	12	21	7	9	6	4	1	4	1	1	0	0	1	2	0	0	0	0	1	0	1	0	1	80
p/b ↔ ∅	1	0	2	5	11	11	7	6	1	7	10	2	3	0	0	6	0	3	0	0	2	3	1	0	0	1	3	0	0	4	89
p/b ↔ m	0	0	0	2	0	1	0	1	0	14	23	0	1	3	3	1	4	7	4	1	2	7	1	3	0	11	1	0	6	7	103
p/b ↔ β/ɸ/v	2	0	10	13	4	7	8	5	10	8	9	10	2	1	0	8	1	0	0	0	0	1	1	1	0	0	0	2	0	2	105
p/b ↔ p/b	1	0	35	48	53	99	62	34	89	119	140	183	176	162	155	152	74	159	86	73	134	132	102	114	86	118	114	120	114	206	3140
Accuracy Rate	25	---	74	70	77	80	81	59	74	77	73	91	95	97	96	90	93	94	96	97	96	92	97	97	100	90	97	98	95	94	

|t/d|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	1	0	2	3	0	10	0	12	4	2	3	6	2	1	1	2	2	1	2	3	3	1	2	1	1	1	2	1	1	70
t/d ↔ ∅	1	1	9	7	9	15	16	10	5	36	21	15	7	10	6	13	12	11	7	4	3	7	2	15	9	12	7	9	18	16	313
t/d ↔ k/g/ɣ	0	0	0	1	0	2	1	2	12	0	14	6	6	1	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	50
t/d ↔ ð	0	0	1	1	0	0	0	0	0	0	1	1	0	0	3	3	2	5	0	2	2	3	0	2	2	2	2	3	2	2	39
t/d ↔ t/d	1	23	28	22	21	19	16	25	116	103	158	277	288	274	215	286	195	284	185	145	228	266	203	314	186	276	222	284	327	466	5453
Accuracy Rate	50	92	74	67	64	53	37	68	80	72	81	92	94	95	96	94	92	94	95	94	97	95	99	94	94	95	96	95	94	96	

|k/g|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	2	0	5	3	3	4	6	4	1	7	0	0	3	3	0	0	3	2	3	0	0	0	0	2	0	1	0	52
k/g ↔ ∅	0	0	2	4	1	9	10	11	2	4	6	6	8	2	1	10	2	3	0	5	3	2	1	1	2	4	1	2	6	2	110
k/g ↔ t/d	0	0	3	1	0	3	0	5	17	11	3	5	9	4	1	7	0	5	0	2	1	4	1	0	1	1	0	1	0	0	85
k/g ↔ ɣ	0	0	0	0	0	0	8	8	3	7	17	19	17	3	2	12	1	5	1	1	4	1	0	1	0	1	0	2	0	1	114
k/g ↔ k/g	0	0	1	9	9	59	32	39	35	76	159	200	182	195	165	236	144	167	104	140	142	165	136	209	121	178	166	185	253	303	3810
Accuracy Rate	---	---	17	56	90	78	60	59	57	73	84	87	82	96	98	88	96	93	99	93	93	94	99	99	98	97	98	97	97	99	

|f/v|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	1	0	0	1	3	14	8	5	8	2	5	6	2	0	3	2	6	1	0	0	0	1	0	0	0	1	0	0	0	69
f/v ↔ ∅	1	0	0	0	4	4	11	4	1	3	7	3	13	1	1	5	1	1	0	1	2	0	0	1	2	3	2	0	0	3	74
f/v ↔ t/d	0	0	0	0	0	0	0	16	2	21	17	40	41	40	21	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	204
f/v ↔ p/b	0	0	0	0	0	0	0	2	4	0	1	2	27	12	43	72	29	16	20	7	0	0	1	1	0	1	1	0	1	0	240
f/v ↔ f/v	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	11	8	77	29	43	64	62	63	117	78	100	76	117	75	130	1055
Accuracy Rate	0	0	---	---	0	0	0	0	0	0	0	3.8	0	0	4.4	12	20	77	58	84	97	100	94	98	98	96	95	100	99	98	

|s/z|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	5	1	1	1	4	5	6	3	15	2	10	3	4	17	10	11	6	5	2	3	9	2	3	2	4	5	1	1	141
s/z ↔ ∅	0	0	12	2	2	0	12	6	0	0	2	3	4	4	1	2	1	6	3	1	1	3	1	0	2	1	5	0	2	2	78
s/z ↔ t/d	0	0	1	7	1	0	8	2	9	24	32	45	79	62	56	74	39	60	6	1	4	0	3	1	2	6	4	2	4	2	534
s/z ↔ ʃ/ʒ	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	5	7	12	8	4	4	5	10	0	2	2	4	1	6	74
s/z ↔ s/z	0	0	0	0	0	0	0	0	0	0	7	2	2	7	0	3	3	21	18	42	85	100	73	126	72	85	114	135	103	226	1224
Accuracy Rate	---	---	0	0	0	0	0	0	0	0	13	3.8	2.1	9.2	0	3.1	5.2	20	40	74	89	91	80	91	91	89	88	92	93	95	

|ʃ/ʒ|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	2	1	0	10	9	2	10	2	7	2	2	1	4	7	3	6	3	0	3	2	1	1	0	1	0	0	0	4	83
ʃ/ʒ ↔ ∅	0	0	13	0	5	13	8	7	6	0	7	5	4	2	0	1	4	2	0	0	1	0	0	4	0	0	1	1	0	1	85
ʃ/ʒ ↔ t/d	0	0	4	1	1	2	2	3	18	7	27	19	32	24	34	33	38	23	14	3	1	0	0	2	0	0	1	0	0	0	289
ʃ/ʒ ↔ s/z	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	4	2	4	3	5	1	2	0	0	0	1	1	1	1	1	28
ʃ/ʒ ↔ ʃ/ʒ	0	2	5	0	0	0	1	0	0	0	0	0	0	0	0	0	4	7	5	14	26	26	33	36	12	31	25	27	25	74	353
Accuracy Rate	---	67	21	0	0	0	5	0	0	0	0	0	0	0	0	0	7.8	17	20	64	81	87	97	84	100	94	89	93	96	93	

|ʀ|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	2	1	0	0	3	1	1	7	3	2	5	3	5	4	1	2	0	3	1	3	2	0	49
ʀ ↔ ∅	0	0	0	0	3	1	0	0	2	0	1	0	0	0	0	1	2	0	0	0	1	0	3	0	0	1	0	0	0	0	15
ʀ ↔ g/k	0	0	0	0	1	0	0	1	0	0	0	3	3	4	5	7	8	10	4	5	1	1	0	2	0	0	0	0	0	0	55
ʀ ↔ ʀ	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	5	8	12	11	14	2	14	6	40	120
Accuracy Rate	---	---	---	100	0	0	---	0	0	0	0	0	14	0	0	0	0	0	0	0	36	50	67	75	100	78	67	82	75	100	

|m|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	1	0	0	0	3	1	6	0	1	1	0	2	0	0	2	1	0	0	0	0	0	1	0	0	1	0	0	0	0	20
m ↔ ∅	2	10	8	4	2	18	4	17	1	11	7	2	4	3	1	6	1	2	1	1	1	2	1	0	0	0	1	1	0	0	111
m ↔ p/b/β	0	0	1	1	0	0	0	0	0	4	3	11	7	0	0	3	0	2	0	0	0	0	0	1	0	0	0	0	0	1	34
m ↔ m	26	69	68	69	54	97	72	43	59	145	148	167	171	146	165	161	105	159	74	70	77	95	86	109	83	111	117	135	118	191	3190
Accuracy Rate	93	86	88	93	96	82	94	65	98	90	93	93	93	98	99	94	98	98	99	99	99	98	98	99	100	99	99	99	100	99	

|n|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	3	0	6	2	5	4	0	2	4	9	1	2	2	0	0	0	1	0	0	2	0	1	0	0	0	0	0	44
n ↔ ∅	2	0	0	0	1	1	0	4	2	4	11	9	4	3	0	6	2	4	2	1	1	0	2	0	2	0	4	1	1	3	70
n ↔ ɲ	1	3	7	13	3	53	14	30	4	26	29	7	7	4	4	3	0	1	0	1	1	1	0	2	0	0	0	1	0	0	215
n ↔ n	1	3	27	63	23	42	50	30	39	71	127	242	158	164	160	155	77	118	81	80	115	114	90	159	83	69	119	105	117	149	2831
Accuracy Rate	25	50	79	80	85	41	76	43	80	70	75	92	89	95	96	93	97	96	98	96	98	99	96	99	97	100	97	98	99	98	

|ɲ|, excluding unstressed syllables following |i|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	1	0	4	0	0	0	0	0	0	2	0	0	0	0	4	0	0	1	0	1	0	0	0	0	0	0	0	13
ɲ ↔ ∅	0	0	0	4	0	2	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10
ɲ ↔ j	0	0	0	0	0	0	0	0	0	10	0	0	3	0	0	0	0	2	1	2	2	1	3	0	0	0	0	0	1	0	25
ɲ ↔ n	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	8	1	3	1	1	0	0	0	1	0	0	0	0	0	0	18
ɲ ↔ ɲ	0	0	0	0	0	0	9	0	0	0	0	6	0	0	0	3	0	1	0	0	3	0	0	11	16	5	18	5	6	18	101
Accuracy Rate	---	---	---	0	---	0	100	0	0	0	---	100	0	---	---	25	0	10	0	0	50	0	0	85	100	100	100	100	86	100	

|ɲ| in unstressed syllables following |i|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	3	0	0	1	0	1	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	10
ɲ ↔ ∅	0	0	3	0	0	2	0	1	1	10	11	9	12	11	16	17	16	21	7	1	22	9	14	2	0	3	0	2	1	1	192
ɲ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
ɲ ↔ n	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	3
ɲ ↔ ɲ	0	0	0	0	0	1	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	3	22	12	18	14	9	14	27	125
Accuracy Rate	---	---	0	---	---	14	---	0	0	0	25	9.1	0	0	0	0	0	0	0	0	0	0	16	92	100	86	100	75	93	96	

|l|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	1	1	0	4	8	5	13	5	7	11	8	1	5	5	7	2	1	2	6	3	1	3	0	6	1	3	4	3	116
l ↔ ∅	0	0	0	1	7	16	9	7	9	6	10	29	7	4	3	1	3	9	0	4	6	3	5	14	2	3	3	2	7	11	181
l ↔ t/d	0	0	0	0	2	3	0	0	2	3	12	6	7	1	1	3	2	1	0	0	1	2	1	1	0	1	1	0	0	1	51
l ↔ ɾ	0	0	0	0	0	0	0	0	0	0	5	7	0	1	0	4	1	0	0	0	1	5	2	2	1	2	6	5	6	13	61
l ↔ ʎ	0	0	0	0	1	0	0	0	0	0	1	5	5	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
l ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	3	1	4	2	4	3	3	24
l ↔ l	0	0	1	0	0	0	0	0	0	8	21	44	49	21	40	31	68	50	29	33	56	43	35	44	24	28	23	65	49	73	835
Accuracy Rate	---	---	50	0	0	0	0	0	0	36	38	43	64	68	75	70	84	79	97	83	78	77	80	66	86	64	64	82	71	70	

|ʎ|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	5	1	1	2	1	0	3	1	0	0	1	0	0	2	0	1	1	0	0	4	0	0	0	0	23
ʎ ↔ ∅	0	0	0	0	0	0	1	2	1	3	3	1	2	0	1	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	18
ʎ ↔ l	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	5	2	1	5	2	2	0	0	0	1	1	0	1	23
ʎ ↔ j	0	0	0	0	0	0	0	1	2	16	4	6	33	35	31	17	12	4	5	6	10	16	13	20	9	5	8	19	20	11	303
ʎ ↔ ʎ	0	0	0	0	0	0	0	0	0	1	0	1	2	1	0	0	0	3	0	0	0	0	0	0	0	4	0	2	1	1	16
Accuracy Rate	---	---	---	---	---	---	0	0	0	4.3	0	13	4.9	2.7	0	0	0	25	0	0	0	0	0	0	0	29	0	9.1	4.8	7.7	

|j|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	3	0	0	1	0	1	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	10
j ↔ ∅	0	0	0	0	0	8	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	17
j ↔ j	0	0	0	1	0	0	0	0	0	7	5	3	2	1	1	2	1	6	0	0	1	7	5	3	2	10	3	1	16	11	88
Accuracy Rate	---	---	---	25	---	0	0	---	0	64	100	100	100	100	100	100	100	100	0	---	100	88	100	100	100	100	100	100	94	100	

|ɾ|, excluding in *para*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	1	0	5	9	1	6	10	8	11	6	2	9	14	6	4	4	2	11	4	9	3	7	3	4	8	2	6	155
ɾ ↔ ∅	0	0	7	3	2	2	35	12	5	12	13	25	9	4	8	15	17	14	2	11	7	5	3	20	7	5	3	7	5	8	266
ɾ ↔ l	0	0	0	0	0	1	0	0	0	0	15	20	9	8	16	15	12	30	20	17	15	27	12	42	20	28	6	21	13	27	374
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	2	25	14	25	5	12	27	2	18	9	12	10	12	16	23	15	28	24	40	45	79	443
Accuracy Rate	---	---	0	0	0	0	0	0	0	8.3	41	20	51	26	27	38	5.4	27	26	29	23	25	40	26	31	44	65	53	69	66	

|r| in *para*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	2	1	4	2	1	2	0	2	0	0	1	1	0	0	4	23
ɾ ↔ ∅	0	0	0	0	0	0	0	0	2	4	15	20	15	14	9	40	18	40	19	8	27	11	7	15	5	17	1	2	4	32	325
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1	0	0	1	1	3	0	0	10
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	10	12	6	6	36
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	4.2	0	0	0	0	0	0	5	77	71	60	14	

2. Branching Onsets

C|r|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	1	0	0	0	2	1	3	5	6	0	1	1	0	5	0	0	2	1	2	0	3	5	0	5	9	6	58
Cr ↔ ∅	0	0	0	0	1	0	0	0	2	0	2	4	2	0	4	1	0	2	0	2	0	0	0	2	0	1	0	0	0	0	23
Cr ↔ C	0	0	0	1	0	17	1	2	10	40	47	81	52	29	35	66	18	46	24	18	53	38	36	56	41	18	3	8	15	20	775
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	2	1	9	0	1	0	5	22
Cr ↔ Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	5	18	57	45	74	201
Accuracy Rate	---	---	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.8	0	0	0	1.6	0	13	86	80	65	70	

C|l|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	7
Cl ↔ C	0	0	0	0	0	0	0	0	3	0	6	3	2	6	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	25
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	2	1	7	8	1	1	3	0	0	0	2	2	2	1	0	3	0	0	33
Cl ↔ Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	4	1	0	2	0	1	1	0	2	1	2	21
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	58	100	100	---	40	0	25	50	---	40	100	67	

|pr/br|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	5
pr/br ↔ p/b	0	0	0	0	0	0	1	0	2	12	27	12	30	13	9	33	14	14	7	8	14	17	17	17	6	7	0	4	1	11	276
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	7
pr/br ↔ pl/bl	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	4	3	12
pr/br ↔ pr/br	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	23	6	33	68
Accuracy Rate	---	---	---	---	---	---	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	100	77	55	69	

|tr/dr|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	1	0	0	5	1	0	0	0	0	3	0	0	2	0	1	0	0	2	0	1	2	3	21
tr ↔ ∅	0	0	0	0	1	0	0	0	0	0	2	1	0	0	1	1	0	2	0	2	0	0	0	1	0	1	0	0	0	0	12
tr/dr ↔ t/d	0	0	0	0	0	0	0	0	8	19	13	32	11	15	14	17	2	27	13	10	27	21	15	32	22	11	3	3	10	5	330
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	1	7
tr/dr ↔ tr/dr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	8	17	23	30	80
Accuracy Rate	---	---	---	---	0	---	---	---	0	0	0	0	0	0	0	0	0	0	0	7.7	0	0	0	0	0	6.3	73	77	66	77	

|kr/gr|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
kr/gr ↔ ∅	0	0	0	0	0	0	0	0	2	0	0	3	2	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	11
kr/gr ↔ t/d	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	2	0	0	0	0	0	8
kr/gr ↔ k/g/ɣ	0	0	0	0	0	17	0	2	0	8	7	22	9	1	6	2	1	2	3	0	7	0	2	1	7	0	0	0	0	0	97
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	0	0	0	5
gr ↔ gl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
kr/gr ↔ kr/gr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	7	11	3	3	26
Accuracy Rate	---	---	---	---	---	0	---	0	0	0	0	0	0	0	0	0	0	0	0	---	0	0	0	20	0	33	100	92	60	100	

|fr/vr|	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
Other	0	0	0	0	1	0	0	0	1	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	9
fr/vr ↔ t/d	0	0	0	0	0	0	0	0	0	1	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
fr/vr ↔ p/b	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
fr/vr ↔ f/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	5	0	2	6	6	0	0	1	4	4	33
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
fr/vr ↔ fr/vr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13	8	27
Accuracy Rate	---	---	---	0	0	---	---	---	0	0	0	0	0	---	0	0	0	0	0	---	0	---	0	0	0	---	---	86	72	53	

|pl/bl|	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
pl/bl ↔ pVl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	4
pl/bl ↔ pl/bl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0	---	---	---	---	---	---	---	---	0	---	---	---	33	100	---	

|kl|	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
kl ↔ k	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7
kl ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
kl ↔ kVr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5
kl ↔ kVl	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	1	0	0	0	0	1	1	0	0	0	0	0	7
kl ↔ kl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	1	8
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	---	0	0	0	0	---	---	64	---	---	---	---	0	0	---	---	---	---	100	

|fl|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
fl ↔ f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
fl ↔ t/tj/d	0	0	0	0	0	0	0	0	3	0	4	3	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	2	1	1	1	0	0	0	2	0	1	1	0	1	0	0	17
fl ↔ fr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
fl ↔ fl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	2	0	1	1	0	1	0	1	11
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	0	100	100	---	40	---	33	50	---	50	---	50	

|kw/gw|, excluding in *água*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
kw/gw ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
kw/gw ↔ k/g/ɣ	0	0	0	4	0	0	0	0	2	1	0	5	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	1	0	4	21
kw/gw ↔ kw/gw	0	0	0	0	0	0	0	0	0	0	0	1	9	1	1	0	0	9	2	1	1	6	6	18	13	6	5	4	8	13	104
Accuracy Rate	---	---	---	0	---	---	---	---	0	0	---	17	90	100	100	---	0	100	100	50	100	75	100	100	93	100	100	80	100	72	

|kw/gw|, in *água*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
gw ↔ ∅	0	0	4	0	0	8	0	10	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34
gw ↔ β	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
gw ↔ w	0	0	0	0	0	0	0	2	0	25	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	35
gw ↔ ɣ	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
gw ↔ gw	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	9	0	0	1	0	1	0	0	0	1	0	0	1	0	1	18
Accuracy Rate	---	---	0	---	---	0	---	0	0	0	0	---	0	100	100	100	---	---	50	---	100	---	---	---	100	---	---	100	---	100	

2.1 First Position of Branching Onsets

|p/b|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
p/b ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
p/b ↔ β/v	0	0	0	0	0	0	0	0	0	3	3	0	1	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	11
p/b ↔ p/b	0	0	0	0	0	0	1	0	2	9	24	13	30	13	10	33	14	14	7	8	14	17	17	18	6	15	3	33	12	48	361
Accuracy Rate	---	---	---	---	---	---	100	---	100	75	89	100	94	100	100	97	100	93	100	100	100	100	100	100	100	79	100	100	100	100	

|t/d|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
t/d ↔ ∅	0	0	0	0	1	0	0	0	0	0	2	4	0	0	1	1	0	3	0	2	0	0	0	1	0	1	0	1	1	0	18
t/d ↔ k	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
t/d ↔ t/d	0	0	0	0	0	0	0	0	8	19	13	32	11	17	14	17	2	29	13	11	30	22	16	32	26	13	11	22	34	41	433
Accuracy Rate	---	---	---	---	0	---	---	---	89	100	87	84	92	100	93	94	100	91	100	85	100	100	100	97	100	81	100	96	97	100	

|k/g|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
k/g ↔ ∅	0	0	0	0	0	0	0	0	2	1	0	3	2	0	4	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	15
k/g ↔ t/d	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	2	0	0	0	0	0	7
k/g ↔ ɣ	0	0	0	0	0	0	0	0	0	4	0	6	6	0	1	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	22
k/g ↔ k/g	0	0	0	0	0	17	0	2	0	4	9	16	4	4	6	7	0	2	10	0	7	0	2	6	9	3	7	12	5	4	136
Accuracy Rate	---	---	---	---	---	100	---	100	0	44	90	64	31	100	50	78	0	67	71	---	100	0	67	86	82	100	100	100	100	100	

|f/v|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
f/v ↔ ∅	0	0	0	0	1	0	0	0	1	1	1	2	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	10
f/v ↔ t/d	0	0	0	0	0	0	0	0	3	1	4	16	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
f/v ↔ p/b	0	0	0	1	0	0	0	0	0	0	0	0	0	0	11	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
f/v ↔ f/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	2	4	6	0	7	6	9	2	0	9	18	17	87
Accuracy Rate	---	---	---	0	0	---	---	---	0	0	0	0	0	0	0	0	100	100	100	100	100	---	100	100	90	100	---	100	100	100	

2.2 Second Position of Branching Onsets

|ɾ|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	1	0	5	0	2	0	1	0	3	0	0	4	0	2	1	1	4	0	1	2	3	30
ɾ ↔ ∅	0	0	0	1	2	17	1	2	14	40	52	85	60	29	40	67	18	50	24	20	52	39	36	58	43	19	3	8	15	20	815
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	7	6	19
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	14	18	59	45	76	216
Accuracy Rate	---	---	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.8	0	0	0	3.3	2.2	37	86	83	65	72	

|l|	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
l ↔ ∅	0	0	0	0	0	0	0	0	4	1	6	3	1	3	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	23
l ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4
l ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	1	0	0	0	0	0	0	0	0	1	0	1	9
l ↔ ʎ	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
l ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	3	1	0	11	4	1	0	4	2	3	2	0	4	1	2	43
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	25	0	44	33	100	0	92	100	100	---	80	67	75	100	---	80	100	67	

3. Codas

|ʃ/ʒ|, excluding in *Inês* and cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	2	0	9	4	8	5	2	4	3	6	3	10	4	5	5	1	1	2	0	4	1	4	83
ʃ/ʒ ↔ ∅	0	0	4	2	1	24	8	10	59	27	35	75	64	70	53	69	45	105	47	47	36	24	11	14	6	12	9	25	14	29	925
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	1	0	0	1	7	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	14
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	5	21	2	2	0	3	4	0	3	2	11	6	17	2	3	6	1	6	5	4	7	110
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	2	25	35	65	52	34	25	24	23	72	18	21	31	117	84	144	80	140	89	166	130	204	1581
Accuracy Rate	---	---	0	0	0	0	0	0	3.1	44	35	44	39	31	30	24	32	39	25	23	40	72	82	89	86	90	86	83	87	84	

|ʃ/ʒ| in *Inês*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
ʃ/ʒ ↔ ∅	3	1	17	20	12	39	26	14	11	23	30	39	24	21	0	3	0	1	0	0	0	0	0	2	0	0	0	0	0	0	286
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	3	0	0	1	0	0	3	0	0	2	3	0	0	14
Accuracy Rate	0	0	0	0	0	0	0	0	0	0	0	2.5	0	4.5	---	0	---	75	---	---	50	---	---	60	---	---	100	100	---	---	

|ʃ/ʒ|, cases of resyl-labification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	3	0	0	0	0	1	0	0	0	0	0	0	0	7
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	0	1	0	4	7	2	5	6	2	6	2	0	0	0	1	0	0	1	0	2	0	0	39
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	3	1	5	1	2	4	1	1	0	25
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	3	0	7	12	12	15	35	16	18	15	31	16	32	217
Accuracy Rate, [s/z]	---	---	---	---	---	---	---	---	---	80	0	0	0	0	0	0	33	25	0	100	67	80	83	88	94	86	79	91	94	100	

|ʃ/ʒ|, utterance-final, excluding in *Inês*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	1	0	3	2	0	0	1	1	2	2	0	1	0	1	3	1	0	0	0	0	1	0	19
ʃ/ʒ ↔ ∅	0	0	4	2	0	16	6	6	9	2	3	5	3	2	2	3	1	4	0	3	1	4	2	4	2	5	4	3	5	6	107
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	5	12	2	2	0	3	4	0	2	2	10	2	7	0	0	0	1	0	1	1	2	56
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	2	21	30	59	46	30	21	22	17	69	15	12	21	32	25	44	14	36	21	43	30	47	657
Accuracy Rate	---	---	0	0	---	0	0	0	15	75	63	87	90	94	78	73	85	90	88	46	88	73	83	90	88	86	84	91	81	85	

|ʃ/ʒ|, utterance-medial, excluding in *Inês* and cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	6	1	1	5	1	3	1	3	2	8	4	4	1	0	1	2	0	3	0	4	50
ʃ/ʒ ↔ ∅	0	0	0	0	1	8	2	4	50	25	32	70	61	68	51	66	44	101	47	44	35	20	9	10	4	7	5	22	8	23	817
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	13
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	1	4	10	2	4	6	0	6	4	3	5	55
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	4	5	6	6	4	4	2	6	3	3	9	10	85	59	100	66	104	68	123	100	157	924
Accuracy Rate	---	---	---	---	0	0	0	0	0	14	9.6	7.7	8	5.2	7.1	2.8	12	2.8	5.7	14	19	71	82	88	86	92	86	80	90	83	

|ʃ/ʒ|, utterance-medial word-final, excluding in *Inês* and cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	5	1	1	5	0	2	1	3	2	8	4	3	1	0	1	2	0	3	0	4	46
ʃ/ʒ ↔ ∅	0	0	0	0	0	6	2	1	2	4	7	30	16	14	20	21	12	43	7	13	13	5	8	9	3	6	4	20	4	18	288
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	3	9	2	3	3	0	5	1	3	3	41
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	2	4	6	6	4	4	2	6	3	3	9	10	49	30	49	29	43	32	78	42	74	485
Accuracy Rate	---	---	---	---	---	0	0	0	0	33	17	16	26	17	17	8	32	5.9	25	30	33	74	73	80	81	84	78	76	86	75	

|ʃ/ʒ|, word-medial, excluding cases of resyllabification	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
Other	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4
ʃ/ʒ ↔ ∅	0	0	0	0	1	2	0	3	48	21	25	40	45	54	31	45	32	58	40	31	22	15	1	1	1	1	1	2	4	5	529
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	11
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	3	0	1	3	0	2	14
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	36	29	51	37	61	36	45	58	83	439
Accuracy Rate	---	---	---	---	0	0	---	0	0	8.7	3.6	0	0	0	0	0	0	0	0	0	0	68	94	96	90	98	95	90	94	92	

|ɾ|, excluding cases of resyllabification	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
Other	0	0	0	0	0	0	1	1	1	2	3	4	8	4	2	6	0	4	5	3	6	2	8	1	6	5	0	4	6	5	87
ɾ ↔ ∅	1	1	0	1	4	15	23	13	14	17	16	41	41	41	43	57	41	44	25	26	56	46	34	51	21	25	26	25	17	37	802
ɾ ↔ l	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	2	1	1	0	0	3	3	0	0	1	1	0	1	0	17
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0	0	1	0	2	1	1	2	3	3	0	2	4	2	1	26
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	4	1	3	2	11	1	10	4	3	3	11	8	35	16	47	27	50	29	60	325
Accuracy Rate	0	0	---	0	0	0	0	0	0	0	0	8	1.9	6.1	4.2	15	2.3	17	11	8.8	4.5	17	15	39	35	60	48	60	53	58	

|ɾ|, cases of resyl-labification	**0_11_13**	**1_00_25**	**1_01_29**	**1_03_06**	**1_04_09**	**1_05_11**	**1_06_11**	**1_07_02**	**1_08_02**	**1_09_18**	**1_10_29**	**2_00_11**	**2_01_10**	**2_02_01**	**2_03_08**	**2_04_18**	**2_05_24**	**2_07_16**	**2_08_22**	**2_10_20**	**2_11_21**	**3_00_15**	**3_02_03**	**3_04_06**	**3_05_28**	**3_07_29**	**3_10_01**	**3_11_12**	**4_01_00**	**4_02_17**	
Other	0	0	0	0	0	0	0	0	2	1	4	3	4	1	2	6	4	1	2	0	3	0	2	0	2	0	1	1	0	0	39
ɾ ↔ l	0	0	0	0	0	0	0	0	0	3	14	6	18	22	18	7	12	30	13	6	17	15	9	29	10	9	4	12	4	7	265
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	3	15	2	12	2	6	9	6	2	6	2	4	0	6	7	3	5	13	12	13	14	142
Accuracy Rate	---	---	---	---	---	---	---	---	0	43	45	18	35	8	23	41	27	6.1	29	25	17	0	35	19	20	36	72	48	76	67	

|ɾ|, utterance-final, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	1	0	0	0	1	4	3	0	5	0	2	1	3	6	1	4	0	3	3	0	2	4	1	44
ɾ ↔ ∅	0	0	0	0	0	7	5	1	3	0	0	1	2	4	2	6	5	2	4	4	4	9	1	0	4	6	3	4	3	6	86
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	1	1	0	1	7
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	2	0	1	1	1	2	2	8	5	4	3	6	38
Accuracy Rate	---	---	---	---	---	0	0	0	0	---	---	0	0	22	0	8.3	0	0	29	0	9.1	8.3	17	67	20	47	56	36	30	43	

|ɾ|, utterance-medial, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	1	0	1	2	3	3	4	1	2	1	0	2	6	0	0	1	4	1	3	2	0	2	2	4	45
ɾ ↔ ∅	1	1	0	1	4	8	18	12	11	17	16	40	39	37	41	51	36	42	19	22	52	37	33	51	17	19	23	21	14	31	714
ɾ ↔ l	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	2	1	1	0	0	2	3	0	0	1	1	0	1	0	16
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0	0	0	0	1	1	1	2	2	2	0	1	3	2	0	19
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	4	1	1	2	10	1	10	2	3	2	10	7	33	14	39	22	46	26	54	287
Accuracy Rate	0	0	---	0	0	0	0	0	0	0	0	8.3	2.2	2.5	4.3	16	2.6	18	7.1	12	3.6	20	14	38	39	64	47	64	58	61	

|ɾ|, utterance-medial word-final, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	2	3	3	4	1	2	1	0	1	6	0	0	1	1	0	2	0	0	2	0	3	32
ɾ ↔ ∅	0	0	0	0	0	2	2	0	1	3	6	12	14	9	14	32	20	15	4	7	20	15	11	27	7	12	17	14	12	25	301
ɾ ↔ l	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	2	1	1	0	0	2	2	0	0	1	0	0	0	0	13
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	1	1	1	2	1	1	0	0	2	0	0	12
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	4	1	1	2	10	1	10	1	2	2	10	3	17	2	12	10	15	2	31	136
Accuracy Rate	---	---	---	---	---	0	0	---	0	0	0	21	4.8	8.3	11	23	4.3	37	8.3	20	8.7	34	16	38	17	48	37	45	14	53	

|ɾ|, word-medial, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	3	1	1	2	0	0	2	1	13
ɾ ↔ ∅	1	1	0	1	4	6	16	12	10	14	10	28	25	28	27	19	16	27	15	15	32	22	22	24	10	7	6	7	2	6	413
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	3
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2	0	7
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	4	16	12	27	12	31	24	23	151
Accuracy Rate	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.3	6.3	0	0	13	38	50	75	60	79	77	77	

|ɫ|, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	1	0	0	0	1	3	2	0	3	4	3	0	0	3	1	3	1	2	2	3	1	6	0	39
ɫ ↔ ∅	0	0	17	1	0	0	4	2	8	3	3	10	5	6	9	12	0	13	10	2	5	4	1	6	2	2	3	0	5	1	134
ɫ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	8	1	11	6	32
ɫ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	5	3	4	10	2	6	7	39
Accuracy Rate	---	---	0	0	---	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	17	0	38	38	33	42	50	21	50	

|ɫ|, cases of resyl-labification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2	4
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
ɫ ↔ l	0	0	0	0	0	0	0	1	0	0	0	1	4	8	2	1	5	6	5	4	0	2	2	8	4	1	1	0	3	2	60
Accuracy Rate, [l]	---	---	---	---	---	---	---	100	---	---	0	100	100	100	100	100	100	100	100	100	---	67	100	100	100	100	50	0	100	50	

|ɫ|, utterance-final, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	1	0	0	0	1	3	2	0	3	2	2	0	0	0	2	3	0	1	1	0	0	2	0	23
ɫ ↔ ∅	0	0	9	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	1	0	0	0	1	0	0	1	0	2	0	19
ɫ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
ɫ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	3	0	0	1	10
Accuracy Rate	---	---	0	---	---	---	---	0	---	---	---	0	0	0	---	0	0	0	---	0	---	0	0	75	75	0	75	---	0	50	

|ɫ|, utterance-medial, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3	0	0	1	1	1	3	1	4	0	17
ɫ ↔ ∅	0	0	8	1	0	0	4	0	8	3	3	9	5	6	9	10	0	13	9	1	5	4	1	5	2	2	2	0	3	1	114
ɫ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	8	1	10	5	30
ɫ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	4	7	2	6	6	29
Accuracy Rate	---	---	0	0	---	---	0	---	0	0	0	0	0	0	0	0	0	0	0	0	11	20	0	22	0	36	35	50	26	50	

|ɫ|, utterance-medial word-final, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	1	0	1	0	7
ɫ ↔ ∅	0	0	7	0	0	0	0	0	0	0	1	3	1	1	0	1	0	4	1	0	0	1	0	2	1	0	1	0	0	0	24
ɫ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ɫ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	3
Accuracy Rate	---	---	0	---	---	---	---	---	---	---	0	0	0	0	---	0	0	0	0	---	50	0	---	25	0	0	0	---	0	100	

|ɫ|, word-medial, excluding cases of resyllabification	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	1	0	2	1	3	0	10
ɫ ↔ ∅	0	0	1	1	0	0	4	0	8	3	2	6	4	5	9	9	0	9	8	1	5	3	1	3	1	2	1	0	3	1	90
ɫ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	8	1	10	5	30
ɫ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	4	7	2	6	5	26
Accuracy Rate	---	---	0	0	---	---	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	20	0	40	39	50	27	45	

/ʃ/, utterance-final	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	2	0	3	2	0	0	1	1	2	2	0	1	0	1	3	1	0	0	0	0	1	0	20
ʃ ↔ ∅	0	0	4	2	0	16	6	6	9	2	3	5	3	2	2	3	1	4	0	3	1	4	2	4	2	5	4	3	5	6	107
ʃ ↔ s	0	0	0	0	0	0	0	0	0	5	12	2	2	0	3	4	0	2	2	9	2	5	0	0	0	1	0	1	1	2	53
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	3
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	2	21	29	59	45	30	21	22	17	69	15	12	21	32	25	44	14	36	21	42	30	46	653
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4
Accuracy Rate, [ʃ]	---	---	0	0	---	0	0	0	15	75	60	87	88	94	78	73	85	90	88	46	88	73	83	90	88	86	84	89	81	84	

/ʃ/ before voiceless consonants	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	2	0	8	3	0	0	0	2	1	2	3	2	0	0	0	0	0	0	0	1	24
ʃ ↔ ∅	0	0	0	0	0	2	1	2	43	21	26	40	45	55	35	46	35	65	45	35	25	17	1	1	3	2	1	2	5	7	560
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	5	0	1	4	0	1	2	0	3	20
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	1	2	1	4	1	0	0	1	2	1	3	5	50	49	72	43	70	52	81	74	110	622
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	1	5
Accuracy Rate, [ʃ]	---	---	---	---	---	0	0	0	0	4.5	6.3	2.4	7	1.7	0	0	2.8	2.9	2.1	7.3	15	68	96	96	86	97	95	93	94	90	

/ʃ/ before voiced consonants	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	1	0	2	0	5	1	2	2	0	1	1	0	2	0	2	22
ʃ ↔ ∅	0	0	0	0	0	5	1	1	4	2	3	14	7	9	12	13	7	28	1	8	6	2	1	2	0	1	1	4	1	7	140
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	6
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	0	3	0	4	2	0	1	17
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	0	3	0	0	2	0	7	2	3	2	4	0	6	3	6	44
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	12	7	14	15	24	11	23	15	29	153
Accuracy Rate, [ʒ]	---	---	---	---	---	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	17	44	54	70	71	80	69	61	75	64	

/ʃ/ before vowels	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	3	0	3	2	0	1	0	3	1	1	0	0	1	0	0	0	0	0	0	0	15
ʃ ↔ ∅	0	0	0	0	0	0	0	0	2	1	2	8	4	2	1	2	0	2	1	0	1	0	1	0	0	1	0	2	1	1	32
ʃ ↔ d	0	0	0	0	0	0	0	0	0	1	0	4	4	2	5	6	2	6	2	0	0	0	1	0	0	1	0	2	0	0	36
ʃ ↔ s	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	4
ʃ ↔ z	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	3	0	6	12	12	15	34	15	18	15	30	15	31	210
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	1	0	3	0	2	0	0	0	0	1	1	5	7	1	2	3	2	2	4	3	1	38
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	3	2	0	5	0	2	1	1	1	1	18
Accuracy Rate, [z]	---	---	---	---	---	---	---	---	0	38	0	0	0	0	0	0	33	21	0	67	57	55	79	83	83	75	83	77	71	91	

4. Codas of Empty-headed Syllables

|ʃ/ʒ|, excluding *estar*	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	2	2	4	11	4	0	5	8	3	15	2	12	9	7	3	4	9	4	0	1	0	1	106
ʃ ↔ d	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	2	6
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	2	15	12	12	6	23	12	37	123
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	11	0	0	0	0	0	30	40	79	57	75	100	96	86	93	

|ʃ|, in *estar* and related words	0_11_13	1_00_25	1_01_29	1_03_06	1_04_09	1_05_11	1_06_11	1_07_02	1_08_02	1_09_18	1_10_29	2_00_11	2_01_10	2_02_01	2_03_08	2_04_18	2_05_24	2_07_16	2_08_22	2_10_20	2_11_21	3_00_15	3_02_03	3_04_06	3_05_28	3_07_29	3_10_01	3_11_12	4_01_00	4_02_17	
Other	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ʃ ↔ ∅	0	5	1	1	0	2	2	2	13	16	28	69	41	65	23	38	30	31	22	11	20	31	15	31	11	19	11	11	15	29	593
ʃ ↔ t	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
ʃ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	3	7	0	5	1	21
Accuracy Rate	---	0	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.1	6.3	0	21	13	39	0	25	3.3	

Appendix B: Aggregated Inventories of Joana's Consonantal Development

1. Singleton Onsets

|p/b|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	1	0	1	2	2	2	0	2	3	0	2	2	7	0	4	1	5	1	2	1	2	2	0	0	1	0	1	0	1	0	45
p/b ↔ ∅	0	0	0	1	0	1	12	1	4	2	6	8	8	4	4	3	1	0	2	3	3	0	0	1	12	4	0	0	1	4	0	2	4	91
p/b ↔ m	0	0	0	0	0	0	0	0	0	0	13	3	5	1	2	1	1	0	3	4	1	0	0	3	8	7	1	6	0	2	0	1	2	64
p ↔ β/ɸ/v	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	2	1	1	1	1	3	1	1	2	0	4	0	2	0	1	1	0	4	30
p/b ↔ p/b	0	0	0	3	0	0	18	3	33	24	40	47	36	107	71	122	164	79	93	122	104	114	52	126	168	165	127	109	59	138	77	78	72	2351
Accuracy Rate	---	---	---	50	---	0	55	50	85	89	65	77	73	94	89	90	98	94	93	90	93	97	96	94	88	92	99	92	98	95	99	95	88	

|t/d|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	1	0	1	2	10	10	4	2	1	10	3	10	4	16	8	5	3	7	1	2	1	1	1	12	0	7	1	123
t/d ↔ ∅	0	0	1	0	0	0	1	1	4	4	20	13	7	23	7	11	19	11	27	26	14	23	9	18	41	37	17	11	2	11	6	16	9	389
t/d ↔ k/g/ɣ	0	0	0	0	0	0	0	0	2	0	8	8	4	3	2	13	3	10	21	42	13	1	7	11	4	5	3	1	2	6	0	1	1	171
t ↔ ð	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	0	2	2	2	3	1	0	1	2	0	1	0	2	0	1	21
t/d ↔ t/d	0	0	0	0	0	0	0	0	1	4	10	46	41	122	71	171	185	74	129	167	166	211	87	169	295	304	244	213	115	182	117	215	144	3483
Accuracy Rate	---	---	0	---	---	---	0	0	13	40	21	60	72	81	88	83	88	69	71	66	82	87	80	82	87	87	91	94	95	86	94	90	92	

|k/g|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	1	0	2	0	5	1	1	2	2	3	0	1	0	7	4	2	10	4	0	5	0	2	1	1	2	9	1	66
k/g ↔ ∅	0	0	0	0	0	0	1	3	2	7	11	11	16	12	2	9	6	2	3	10	3	2	7	6	6	8	3	3	3	2	1	5	1	145
k/g ↔ t/d	0	0	0	0	0	0	1	0	0	0	0	7	0	4	4	4	1	0	1	2	1	1	2	1	0	0	1	1	0	0	0	0	0	31
k/g ↔ ɣ	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	0	0	7
k/g ↔ k/g	0	0	0	0	0	0	1	4	23	16	39	29	48	103	71	140	157	87	140	153	152	143	68	148	243	195	132	142	104	144	111	98	103	2794
Accuracy Rate	---	---	---	---	---	---	25	57	85	70	71	60	74	84	90	90	96	97	97	89	95	97	78	93	98	94	96	95	96	98	95	88	98	

|f/v|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	2	3	3	2	1	3	2	5	4	1	1	7	2	2	2	2	1	0	2	0	1	0	2	1	0	49
f/v ↔ ∅	0	0	0	0	0	0	0	1	2	5	1	7	2	1	9	4	2	2	3	6	1	1	0	0	3	0	0	3	3	0	1	7	2	66
f/v ↔ p/b/β	0	0	0	0	0	0	1	0	2	6	0	0	0	0	0	2	0	0	1	0	2	1	1	1	0	0	0	0	0	1	0	3	0	21
f/v ↔ f/v	0	0	0	0	0	0	0	0	0	2	17	24	19	41	27	58	53	43	71	87	80	90	37	75	139	96	71	70	49	83	53	85	47	1417
Accuracy Rate	---	---	---	---	---	---	0	0	0	13	81	73	86	91	71	84	90	93	93	87	94	96	93	96	97	100	97	96	92	99	95	89	96	

|s/z|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	2	2	8	3	1	19	8	4	10	4	7	8	11	3	7	1	3	4	4	0	1	1	2	8	2	123
s/z ↔ ∅	0	0	0	0	0	0	0	0	0	2	11	6	8	8	1	4	3	3	4	2	2	2	2	3	5	0	4	4	4	1	1	5	2	87
s/z ↔ t/d	0	0	0	0	0	0	0	0	0	0	5	5	1	5	2	4	0	1	2	3	0	2	0	1	1	2	2	2	0	0	0	1	0	39
s/z ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	4	7	12	27	8	31	21	10	18	17	14	13	23	21	38	19	10	4	1	3	0	12	3	316
s/z ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	1	6	29	21	36	49	34	68	58	53	86	25	56	101	112	111	96	60	86	67	86	79	1320
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	4.5	21	33	53	46	59	65	69	66	66	81	44	68	68	82	85	91	91	95	96	77	92	

|ʃ/ʒ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	0	5	1	2	7	10	5	4	5	4	6	3	1	2	4	2	3	0	2	0	0	1	0	1	69
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	3	3	5	3	10	2	4	1	0	1	0	1	1	1	0	4	2	2	1	0	0	0	1	0	0	45
ʃ/ʒ ↔ t/d	0	0	0	0	0	0	0	1	2	2	3	1	3	2	2	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	21
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	2	4	8	7	10	6	4	13	10	28	1	17	13	24	3	2	12	2	3	3	0	172
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	5	8	9	15	5	25	17	18	25	20	19	21	15	18	39	49	31	35	31	26	14	23	39	507
Accuracy Rate	---	---	---	---	---	---	---	0	0	0	28	62	35	50	17	66	53	60	76	49	58	40	83	42	70	62	86	90	72	93	74	88	98	

|ʀ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	2	0	2	1	1	5	2	2	3	5	6	4	9	14	6	6	9	3	2	7	3	2	2	0	1	97
ʀ ↔ ∅	0	0	0	0	0	0	0	0	5	2	3	12	5	10	4	9	13	7	17	16	12	11	5	10	3	1	2	4	2	0	1	1	1	156
ʀ ↔ k/g/ɣ	0	0	0	0	0	0	0	0	5	1	3	0	0	5	0	1	0	2	0	3	1	2	5	6	7	6	5	2	4	2	1	0	1	62
ʀ ↔ r	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	4	1	3	1	3	0	1	0	0	0	0	0	17
ʀ ↔ ʀ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	7	11	4	12	4	6	49
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1	31	33	55	50	75	80	67	

|m|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	1	0	0	0	0	0	0	2	2	1	0	1	1	3	1	1	1	3	1	0	1	5	1	0	0	0	1	0	1	1	1	29
m ↔ ∅	1	3	1	1	0	0	0	0	0	2	4	5	3	7	3	3	3	9	1	3	1	2	3	2	0	0	0	3	0	0	0	2	0	62
m ↔ p/b	0	0	0	0	0	0	0	0	1	9	5	0	2	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	1	1	0	22
m ↔ m	0	5	6	1	0	0	0	1	5	23	28	11	34	72	37	65	106	40	58	113	68	106	68	83	141	135	114	92	57	97	64	87	56	1773
Accuracy Rate	0	63	75	50	---	---	---	100	83	64	72	65	87	90	90	92	96	80	97	94	97	98	92	92	99	100	100	97	98	100	97	96	98	

|n|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	1	0	2	0	0	1	0	0	3	4	2	4	5	3	6	3	2	1	5	0	2	10	2	1	1	1	0	0	1	1	1	2	64
n ↔ ∅	0	0	0	0	0	0	1	1	2	3	7	9	9	10	3	6	7	1	1	4	1	5	1	0	2	1	0	2	0	1	2	4	4	87
n ↔ ɲ	0	0	0	0	1	0	1	1	2	5	20	30	16	50	13	16	30	5	9	6	19	2	4	2	8	5	3	1	2	1	3	0	1	256
n ↔ n	1	0	0	0	0	1	0	0	1	2	15	21	13	42	18	84	75	41	52	89	77	96	45	59	145	121	84	106	32	58	60	92	65	1495
Accuracy Rate	100	0	---	0	0	100	0	0	20	15	33	34	31	39	49	75	65	84	83	86	79	91	75	94	93	95	95	97	94	95	91	95	90	

|ɲ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	3	1	0	0	1	2	2	1	2	0	1	0	1	0	19
ɲ ↔ ∅	0	0	0	0	0	0	0	0	1	0	1	2	1	2	0	1	1	0	0	1	0	1	1	2	0	2	1	1	0	2	0	0	0	20
ɲ ↔ n	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	8
ɲ ↔ ɲ	0	0	0	0	0	0	0	0	0	1	9	6	4	25	20	23	14	12	20	26	28	21	9	21	48	49	34	26	9	26	18	25	14	488
Accuracy Rate	---	---	---	---	---	---	---	0	0	100	90	67	80	86	95	92	88	86	100	87	97	95	82	84	94	92	94	90	100	90	100	93	100	

|l|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	3	18	4	1	10	8	13	8	3	8	15	9	20	8	15	15	7	9	12	7	23	4	7	9	237
l ↔ ∅	0	0	0	0	0	0	2	4	2	11	15	24	9	18	13	19	16	10	12	12	12	18	7	16	29	16	15	22	10	15	4	7	4	342
l ↔ k/g/ɣ	0	0	0	0	0	0	0	0	3	2	4	1	1	0	0	3	3	0	0	1	1	5	4	8	11	13	6	7	5	6	4	2	1	91
l ↔ w	0	0	0	0	0	0	0	0	0	0	1	9	10	13	6	19	20	8	11	10	25	30	7	10	29	12	10	0	0	3	1	5	0	239
l ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	2	6	3	7	14	5	6	13	13	10	0	9	13	6	14	24	24	21	26	11	31	258
Accuracy Rate	---	---	---	---	---	---	0	0	0	0	0	0	8.7	13	10	11	23	19	16	25	22	12	0	16	13	11	26	37	52	31	67	34	69	

|ʎ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	1	3	3	0	2	2	1	4	1	2	1	4	1	0	1	1	3	1	2	0	2	2	1	1	39
ʎ ↔ ∅	0	0	0	0	0	0	0	0	0	2	0	2	0	1	5	1	0	0	2	4	4	5	2	0	1	3	1	1	0	0	0	1	5	40
ʎ ↔ j	0	0	0	0	0	0	0	0	0	0	0	4	3	18	5	8	21	10	10	15	12	10	7	19	9	31	19	16	12	15	11	8	8	271
ʎ ↔ ʎ	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0	0	0	3	0	0	0	0	1	0	0	0	9
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	4.5	0	9.1	3.8	0	0	4.8	4.8	0	0	0	21	0	0	0	0	5.6	0	0	0	

|j|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
j ↔ ∅	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5
j ↔ j	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	8	4	5	1	5	1	3	3	3	10	4	7	16	2	2	4	6	1	89
Accuracy Rate	---	---	0	---	---	---	---	---	---	---	100	33	100	---	---	89	80	100	100	100	100	100	100	100	100	100	88	100	100	100	80	100	100	

|ɾ|, excluding in *para*	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	1	1	2	1	4	2	5	1	7	2	11	6	9	11	13	14	4	11	3	6	8	6	12	1	142
ɾ ↔ ∅	0	0	0	0	0	0	0	1	4	2	9	8	4	35	15	31	29	35	23	17	23	20	16	22	38	29	18	26	12	21	11	14	7	470
ɾ ↔ k/g/ɣ	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	6	8	4	6	8	4	6	1	0	1	2	1	52
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	13	13	3	2	4	3	0	0	1	0	1	1	1	0	2	0	1	0	52
ɾ ↔ w	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	5	5	3	1	0	1	1	1	1	1	0	1	2	0	0	26
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	2	0	1	13	3	6	4	7	4	12	5	0	3	4	5	73
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	11	10	3	4	3	12	18	22	25	24	10	38	22	39	32	277
Accuracy Rate	---	---	---	---	---	---	---	0	0	0	0	8.3	0	0	0	1.9	4.3	0	24	21	7.5	7.5	7.3	20	22	31	39	33	29	54	49	54	70	

|ɾ| in *para*	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	2	1	0	0	0	1	0	0	0	1	0	0	0	8
ɾ ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	1	0	2	9	16	14	11	9	8	16	8	3	9	13	9	6	7	7	5	4	4	1	162
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	1	0	0	0	0	0	0	5
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	0	1	2	4	2	0	16
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	0	---	0	0	0	0	0	0	0	0	0	0	0	5.9	23	30	0	13	25	50	33	0	

2. Branching Onsets

C|r|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	0	2	0	0	4	1	4	2	0	6	12	4	1	5	7	0	7	4	7	4	5	3	6	2	87
Cr ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	5	3	1	6	2	1	1	1	2	0	0	0	1	2	0	0	0	2	0	0	2	2	32
Cr ↔ C	0	0	0	0	0	0	0	0	0	0	4	14	18	23	17	26	32	22	38	44	39	37	24	37	85	57	45	24	25	29	19	43	13	715
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11	5	12	1	9	49
Cr ↔ Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	14	8	14	10	11	26	86
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	1.1	0	2	25	16	26	23	17	50	

C|l|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	3	1	1	0	0	1	0	1	11
Cl ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Cl ↔ C	0	0	0	0	0	0	0	0	0	0	2	2	1	4	2	3	1	3	1	2	1	4	1	3	1	0	3	1	0	0	0	1	2	38
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	2	0	2	1	1	4	1	4	2	3	1	2	27
Cl ↔ Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	4
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	33	0	25	0	0	0	0	0	

|pr/br|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	2	0	1	1	0	3	0	4	1	5	2	1	0	1	0	24
pr/br ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	0	2	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7
pr/br ↔ p/b	0	0	0	0	0	0	0	0	0	0	0	2	8	9	5	11	8	10	20	18	22	14	8	6	49	28	19	7	10	5	5	13	4	281
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	4	1	2	1	2	18
pr/br ↔ pr/br	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	14	5	11	5	10	12	58
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	4.3	0	0	0	0	0	0	0	0	41	24	61	42	40	67	

|tr/dɾ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1	2	0	0	1	0	0	2	3	2	1	2	2	3	1	23
tr/dɾ ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1	2	0	0	0	1	1	0	0	0	0	0	0	1	0	10
tr/dɾ ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	11	4	6	6	11	14	4	9	15	13	16	9	23	21	19	21	14	12	19	13	26	7	293
tr/dɾ ↔ k/g	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	3	8	1	0	3	3	0	1	0	0	1	1	0	1	0	26
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	2	8	0	6	22
tr/dɾ ↔ tr/dɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	2	1	10	16
Accuracy Rate	---	---	---	---	---	---	---	---	0	---	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	5	4	8	3.1	42	

|kɾ/gɾ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	1	1	0	0	0	0	0	1	0	1	0	8
kɾ/gɾ ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	2	11
kɾ/gɾ ↔ k/g/ɣ	0	0	0	0	0	0	0	0	0	0	2	0	4	1	5	0	8	5	7	11	2	5	2	7	13	8	3	3	2	4	0	2	0	94
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	1	5
kɾ/gɾ ↔ kɾ/gɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	2	6
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	0	0	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	33	0	100	0	40	

|fɾ/vɾ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	6
fɾ/vɾ ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
fɾ/vɾ ↔ f/v	0	0	0	0	0	0	0	0	0	0	2	1	2	7	1	4	2	3	2	0	2	2	5	1	2	2	2	0	1	1	1	2	2	47
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	4
fɾ/vɾ ↔ fɾ/vɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	2	6
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	---	0	0	0	0	33	0	0	---	0	67	20	0	40	

|pl/bl|

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
pl/bl ↔ p/b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	0	0	1	0	0	0	0	2	9
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	0	0	0	1	0	0	6
pl/bl ↔ pl/bl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0	33	0	0	0	0	0	0	---	---	0	---	0	

|kl|

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	5
kl ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
kl ↔ k	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0	1	0	10
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	2	0	1	0	0	2	1	1	1	0	1	2	14
kl ↔ kl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	---	---	0	0	---	0	---	0	0	0	---	0	---	0	---	100	0	0	0	0	0	0	0	

|fl|

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	4
fl/vl ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
fl/vl ↔ f/v	0	0	0	0	0	0	0	0	0	0	2	2	1	1	2	3	1	2	0	1	0	1	0	1	0	0	2	0	0	0	0	0	0	19
Epenthesis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	1	2	0	0	7
fl/vl ↔ fl/vl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	0	---	0	---	0	---	50	0	100	0	0	0	---	---	

|kw/gw|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	6
kw/gw ↔ ∅	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	8
kw/gw ↔ k/g	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	1	0	0	0	1	0	1	3	4	2	0	1	0	0	2	3	22
kw/gw ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3
kw/gw ↔ kw/gw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	7	7	2	7	4	2	1	7	9	19	12	4	11	9	6	5	10	128
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	75	100	100	78	100	78	100	50	50	88	75	79	86	100	92	100	100	63	77	

2.1 First Position of Branching Onsets

|p/b|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	0	0	0	1	1	1	0	0	0	8
p/b ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	0	2	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7
p/b ↔ m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
p/b ↔ β	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	1	0	1	0	0	0	0	6
p/b ↔ p/b	0	0	0	0	0	0	0	0	0	0	2	2	8	9	5	11	8	10	21	17	24	17	8	8	51	33	21	33	19	17	13	25	20	382
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	100	100	80	100	63	100	89	100	91	94	100	94	89	73	98	94	95	94	90	94	100	100	100	

|t/d|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1	2	0	0	1	0	0	1	3	1	0	2	1	3	0	18
t/d ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1	2	0	0	0	1	1	0	0	0	0	0	0	1	0	10
t/d ↔ k/g	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	0	0	3	8	1	0	3	3	0	1	0	0	1	1	0	1	0	27
t/d ↔ ð	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	4
t/d ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	11	4	6	7	11	16	4	9	14	12	16	8	23	21	20	22	16	19	22	24	26	24	335
Accuracy Rate	---	---	---	---	---	---	---	---	0	---	---	100	80	60	78	79	100	80	64	52	86	100	62	85	95	91	88	94	95	88	96	81	100	

|k/g|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	1	1	1	0	7
k/g ↔ ∅	0	0	0	0	0	0	0	0	0	0	0	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	2	16
k/g ↔ t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
k/g ↔ ɣ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
k/g ↔ k/g	0	0	0	0	0	0	0	0	0	0	1	0	4	4	5	1	8	6	10	12	2	8	2	9	13	9	6	6	5	7	2	3	6	129
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	50	0	57	80	83	100	89	100	100	86	67	100	67	90	100	100	100	86	71	88	67	50	75	

|f/v|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
f/v ↔ ∅	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
f/v ↔ p/b	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
f/v ↔ f/v	0	0	0	0	0	0	0	0	0	0	3	3	3	7	3	7	4	5	3	1	3	4	5	2	3	4	5	1	6	4	7	2	5	90
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	75	100	100	78	60	70	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	

2.2 Second Position of Branching Onsets

|ɾ|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	2	0	0	1	1	2	1	3	1	2	2	5	2	26
ɾ ↔ ∅	0	0	0	0	0	0	0	0	1	1	4	19	21	27	23	32	35	23	43	57	41	38	29	44	86	60	45	25	29	31	19	47	15	795
ɾ ↔ k/g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
ɾ ↔ t/d	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	1	2	1	0	1	13
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	0	6
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	23	19	18	19	11	34	127
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	1.1	0	2	41	38	34	43	17	65	

|l|	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	3	0	3	0	1	2	0	2	0	1	2	0	0	1	1	0	0	22
l ↔ ∅	0	0	0	0	0	0	0	0	0	1	2	2	2	4	2	0	1	3	0	2	0	3	1	2	1	0	2	1	0	0	1	1	1	32
l ↔ g/ɣ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	3	1	0	0	2	1	0	11
l ↔ w/u	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	6
l ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1	2	1	2	4	1	0	0	2	16
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	0	0	25	0	0	25	0	0	50	33	13	50	100	50	0	0	40	

3. Codas

|ʃ/ʒ|, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	7	3	24	8	31	18	8	13	27	11	7	4	6	6	5	2	4	0	17	2	11	2	218
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	1	5	23	20	7	32	11	42	21	14	13	27	16	8	15	11	15	34	28	11	4	15	10	24	6	413
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	8	5	10	15	12	12	7	7	37	16	33	10	18	25	23	8	7	14	27	12	16	5	327
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	5	18	15	38	26	91	88	37	61	67	74	48	49	72	155	160	125	81	48	109	64	79	92	1602
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	17	34	50	37	43	52	63	56	65	42	63	50	63	67	77	72	77	79	73	65	73	61	88	

|ʃ/ʒ|, cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	1	0	0	1	0	4	0	0	0	1	0	0	1	0	0	0	0	0	12
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	9	4	13	7	0	14	1	15	20	22	22	23	7	18	6	6	8	203
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	8	1	1	5	10	0	4	0	3	3	4	2	1	4	1	0	2	53
Accuracy Rate, [s/z]	---	---	---	---	---	---	---	---	---	---	0	0	---	75	100	50	53	80	87	58	0	100	20	100	83	88	85	88	88	82	86	100	80	

|ʃ/ʒ|, utterance-final, excluding cases of resyllabification

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	2	2	8	5	16	7	4	5	13	7	5	3	4	4	1	1	3	0	10	2	8	1	113
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	0	4	14	2	1	7	3	10	6	4	4	4	5	1	6	5	0	4	4	3	1	4	6	11	4	113
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	8	5	8	12	2	3	4	4	11	5	17	6	7	2	7	1	1	5	4	5	3	2	122
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	5	15	14	27	14	24	27	18	23	22	18	16	23	20	35	36	42	25	34	29	25	23	23	538
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	24	56	64	54	41	46	63	60	64	44	51	41	61	56	85	75	88	78	85	62	66	51	77	

|ʃ/ʒ|, utterance-medial, excluding cases of resyllabification

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	5	1	16	3	15	11	4	8	14	4	2	1	2	2	4	1	1	0	7	0	3	1	105
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	1	1	9	18	6	25	8	32	15	10	9	23	11	7	9	6	15	30	24	8	3	11	4	13	2	300
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	10	9	3	3	26	11	16	4	11	23	16	7	6	9	23	7	13	3	205
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	3	1	11	12	66	61	19	38	45	56	32	26	52	120	124	82	56	14	80	39	55	69	1061
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	12	13	20	46	54	64	53	66	42	68	56	65	73	75	71	72	79	54	66	78	65	92	

|ʃ/ʒ|, utterance-medial word-final, excluding cases of resyllabification

	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	7	7	3	8	7	3	2	0	1	2	3	1	0	0	5	0	3	1	58
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	0	0	3	2	1	6	5	21	9	7	8	17	9	4	7	5	13	26	21	8	3	10	2	11	2	200
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	2	0	13	6	6	1	6	18	8	2	4	5	12	5	7	1	106
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	3	0	8	1	29	34	13	26	30	33	23	15	32	93	70	59	33	9	45	28	42	40	666
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	43	0	50	10	48	63	52	62	45	65	66	65	73	74	65	71	73	53	63	80	67	91	

|ʃ/ʒ|, word-medial, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	3	1	15	1	8	4	1	0	7	1	0	1	1	0	1	0	1	0	2	0	0	0	47
ʃ/ʒ ↔ ∅	0	0	0	0	0	0	0	0	1	1	6	16	5	19	3	11	6	3	1	6	2	3	2	1	2	4	3	0	0	1	2	2	0	100
ʃ/ʒ ↔ s/z	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	7	5	1	3	13	5	10	3	5	5	8	5	2	4	11	2	6	2	99
ʃ/ʒ ↔ ʃ/ʒ	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	37	27	6	12	15	23	9	11	20	27	54	23	23	5	35	11	13	29	395
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	14	7.9	69	59	64	55	75	37	74	41	65	74	79	81	74	88	56	71	73	62	94	

|ɾ|, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	12	8	4	3	7	3	9	4	8	10	9	8	6	2	4	5	11	5	120
ɾ ↔ ∅	0	0	0	0	0	0	1	1	1	5	25	13	7	33	24	62	59	29	60	62	67	61	25	68	78	47	40	44	21	25	12	22	24	916
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	2	2	4	14	9	11	0	3	4	1	1	0	1	1	3	4	5	0	2	1	0	0	68
ɾ ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	1	0	6
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	4
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	3	1	0	3	1	0	0	3	1	2	0	0	20
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	3	5	5	2	10	19	28	20	20	24	38	34	32	21	265
Accuracy Rate	---	---	---	---	---	---	0	0	0	0	0	0	10	0	0	1.2	1.2	0	1.5	3.7	6.6	6.3	6.3	11	17	32	27	27	47	54	63	48	42	

|ɾ|, cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	1	1	1	0	0	1	2	0	2	0	1	0	0	1	13
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
ɾ ↔ w	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	3	3	2	1	3	1	0	1	17
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	0	0	2	3	8	8	5	4	3	2	5	0	49
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	---	---	---	0	0	0	0	---	---	75	75	0	---	67	75	62	73	56	80	43	67	100	0	

|ɾ|, utterance-final, excluding cases of resyllabification	**0_11_23**	**1_00_25**	**1_02_07**	**1_02_28**	**1_04_06**	**1_05_05**	**1_06_23**	**1_08_04**	**1_09_24**	**1_10_22**	**2_00_09**	**2_02_18**	**2_04_01**	**2_06_23**	**2_08_05**	**2_10_08**	**2_11_02**	**3_00_26**	**3_02_12**	**3_03_23**	**3_04_25**	**3_06_19**	**3_08_00**	**3_10_04**	**3_11_11**	**4_00_13**	**4_02_11**	**4_03_24**	**4_04_29**	**4_06_00**	**4_07_07**	**4_08_11**	**4_10_07**	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	5	2	2	3	2	4	3	4	3	3	3	2	1	3	1	5	1	54
ɾ ↔ ∅	0	0	0	0	0	0	0	0	0	2	12	2	1	2	3	5	2	1	4	10	1	4	2	6	3	8	3	9	6	4	6	7	2	105
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	2	2	2	12	2	4	0	2	2	0	0	0	1	0	1	1	3	0	0	1	0	0	35
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	2	1	0	0	1	0	0	0	0	0	0	0	8
ɾ ↔ r	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	0	4	4	5	3	2	5	1	1	5	1	35
Accuracy Rate	---	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	7.1	0	0	0	40	8.3	0	27	40	28	30	13	42	13	11	29	25	

|ɾ|, utterance-medial, excluding cases of resyllabification	**0_11_23**	**1_00_25**	**1_02_07**	**1_02_28**	**1_04_06**	**1_05_05**	**1_06_23**	**1_08_04**	**1_09_24**	**1_10_22**	**2_00_09**	**2_02_18**	**2_04_01**	**2_06_23**	**2_08_05**	**2_10_08**	**2_11_02**	**3_00_26**	**3_02_12**	**3_03_23**	**3_04_25**	**3_06_19**	**3_08_00**	**3_10_04**	**3_11_11**	**4_00_13**	**4_02_11**	**4_03_24**	**4_04_29**	**4_06_00**	**4_07_07**	**4_08_11**	**4_10_07**	
Other	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	5	3	2	1	4	1	5	1	4	7	6	5	4	1	1	4	6	4	66
ɾ ↔ ∅	0	0	0	0	0	0	1	1	1	3	13	11	6	31	21	57	57	28	56	52	66	57	23	62	75	39	37	35	15	21	6	15	22	811
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	7	7	0	1	2	1	1	0	0	1	2	3	2	0	2	0	0	0	33
ɾ ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	1	0	6
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	3
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	3	0	0	0	3	1	2	0	0	12
ɾ ↔ r	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	3	3	4	2	6	15	23	17	18	19	37	33	27	20	230
Accuracy Rate	---	---	---	---	---	---	0	0	0	0	0	0	14	0	0	1.4	0	0	1.7	4.6	4.2	5.9	7.7	8.3	15	33	27	31	49	60	73	55	43	

|ɾ|, utterance-medial word-final, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	1	2	1	1	0	3	4	4	4	2	0	1	1	2	0	32
ɾ ↔ ∅	0	0	0	0	0	0	0	0	0	0	2	0	1	4	4	14	13	5	15	21	18	17	10	20	36	16	16	13	10	12	3	8	11	269
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	5	7	0	1	2	1	0	0	0	0	1	2	0	0	1	0	0	0	24
ɾ ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	1	1	0	0	6
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	1	4	11	17	11	5	6	16	6	10	2	97
Accuracy Rate	---	---	---	---	---	---	---	---	---	---	0	---	0	0	0	0	0	0	0	7.1	9.1	17	9.1	15	20	45	32	25	38	52	55	50	15	

|ɾ|, word-medial, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	2	0	2	0	4	1	1	3	2	1	2	1	0	3	4	4	34
ɾ ↔ ∅	0	0	0	0	0	0	1	1	1	3	11	11	5	27	17	43	44	23	41	31	48	40	13	42	39	23	21	22	5	9	3	7	11	542
ɾ ↔ j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	1	1	1	2	0	1	0	0	0	9
ɾ ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	4
ɾ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
ɾ ↔ ɫ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3	0	1	0	0	6
ɾ ↔ ɾ	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	1	2	4	6	6	13	13	21	27	17	18	133
Accuracy Rate	---	---	---	---	---	---	0	0	0	0	0	0	17	0	0	2.1	0	0	2.4	2.7	2	0	6.7	4.4	8.3	19	21	33	57	68	79	59	55	

|ɬ|, excluding cases of resyllabification	**0_11_23**	**1_00_25**	**1_02_07**	**1_02_28**	**1_04_06**	**1_05_05**	**1_06_23**	**1_08_04**	**1_09_24**	**1_10_22**	**2_00_09**	**2_02_18**	**2_04_01**	**2_06_23**	**2_08_05**	**2_10_08**	**2_11_02**	**3_00_26**	**3_02_12**	**3_03_23**	**3_04_25**	**3_06_19**	**3_08_00**	**3_10_04**	**3_11_11**	**4_00_13**	**4_02_11**	**4_03_24**	**4_04_29**	**4_06_00**	**4_07_07**	**4_08_11**	**4_10_07**	
Other	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0	0	0	1	0	3	0	3	0	0	0	3	2	1	0	4	1	9	1	35
ɬ ↔ ∅	0	0	0	0	0	0	0	0	14	2	9	2	1	12	2	4	12	4	4	6	0	14	7	6	14	20	10	10	3	4	7	8	6	181
ɬ ↔ w	0	0	0	0	0	0	0	0	0	0	4	3	1	3	1	8	4	5	5	5	14	10	0	6	8	6	2	0	1	2	1	1	0	90
ɬ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
ɬ ↔ ɬ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	0	4	3	0	0	0	0	1	0	8	4	2	3	3	12	46
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	25	14	11	9.1	0	22	18	0	0	0	0	3.3	0	38	50	15	25	14	63	

|ɬ|, cases of resyllabification	**0_11_23**	**1_00_25**	**1_02_07**	**1_02_28**	**1_04_06**	**1_05_05**	**1_06_23**	**1_08_04**	**1_09_24**	**1_10_22**	**2_00_09**	**2_02_18**	**2_04_01**	**2_06_23**	**2_08_05**	**2_10_08**	**2_11_02**	**3_00_26**	**3_02_12**	**3_03_23**	**3_04_25**	**3_06_19**	**3_08_00**	**3_10_04**	**3_11_11**	**4_00_13**	**4_02_11**	**4_03_24**	**4_04_29**	**4_06_00**	**4_07_07**	**4_08_11**	**4_10_07**	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2
ɬ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	2	0	3	1	0	4	13
Accuracy Rate, [l]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	100	---	---	---	---	100	0	---	---	---	---	100	100	---	75	100	---	100	

|ɬ|, utterance-final, excluding cases of resyllabification	**0_11_23**	**1_00_25**	**1_02_07**	**1_02_28**	**1_04_06**	**1_05_05**	**1_06_23**	**1_08_04**	**1_09_24**	**1_10_22**	**2_00_09**	**2_02_18**	**2_04_01**	**2_06_23**	**2_08_05**	**2_10_08**	**2_11_02**	**3_00_26**	**3_02_12**	**3_03_23**	**3_04_25**	**3_06_19**	**3_08_00**	**3_10_04**	**3_11_11**	**4_00_13**	**4_02_11**	**4_03_24**	**4_04_29**	**4_06_00**	**4_07_07**	**4_08_11**	**4_10_07**	
Other	0	0	0	0	0	0	0	0	0	1	0	0	1	4	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	2	0	6	0	17
ɬ ↔ ∅	0	0	0	0	0	0	0	0	9	1	4	0	0	1	0	2	7	0	3	2	0	7	1	1	2	5	0	1	2	1	2	2	3	56
ɬ ↔ w	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	1	1	3	1	0	4	1	0	1	1	2	0	0	1	1	0	0	0	21
ɬ ↔ l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
ɬ ↔ ɬ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	3	0	0	0	0	0	0	2	2	2	2	0	4	20
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	100	0	0	0	0	57	43	0	0	0	0	0	---	33	40	29	50	0	57	

|ɨ|, utterance-medial, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0	3	0	0	0	2	2	0	0	2	1	3	1	18
ɨ ↔ ∅	0	0	0	0	0	0	0	0	5	1	5	2	1	11	2	2	5	4	1	4	0	7	6	5	12	15	10	9	1	3	5	6	3	125
ɨ ↔ w	0	0	0	0	0	0	0	0	0	0	4	1	1	1	1	7	3	2	4	5	10	9	0	5	7	4	2	0	0	1	1	1	0	69
ɨ ↔ ɨ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	1	0	6	2	0	1	3	8	26
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	18	20	13	0	0	0	0	0	0	0	4.5	0	40	67	0	13	23	67	

|ɨ|, utterance-medial word-final, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	1	6
ɨ ↔ ∅	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	1	1	1	0	1	4	2	5	9	1	1	0	1	2	1	3	36
ɨ ↔ w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	5	0	0	0	1	2	0	0	0	0	0	0	0	12
ɨ ↔ ɨ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	1	6	12
Accuracy Rate	---	---	---	---	---	---	---	---	0	---	---	---	---	0	---	---	0	0	0	0	0	0	0	0	0	7.7	0	80	---	0	0	33	60	

|ɨ|, word-medial, excluding cases of resyllabification	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	2	0	0	0	1	2	0	0	1	1	2	0	12
ɨ ↔ ∅	0	0	0	0	0	0	0	0	3	1	5	2	1	11	2	2	4	3	0	3	0	6	2	3	7	6	9	8	1	2	3	5	0	89
ɨ ↔ w	0	0	0	0	0	0	0	0	0	0	4	1	1	1	1	7	2	2	2	4	5	9	0	5	6	2	2	0	0	1	1	1	0	57
ɨ ↔ ɨ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	2	2	0	1	2	2	14
Accuracy Rate	---	---	---	---	---	---	---	---	0	0	0	0	0	0	0	18	25	14	0	0	0	0	0	0	0	0	0	20	67	0	17	20	100	

/ʃ/, utterance-final	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	2	2	2	8	5	15	7	4	5	13	8	5	3	4	4	1	1	3	0	10	2	8	1	113
ʃ ↔ ∅	0	0	0	0	0	0	0	0	0	4	14	2	1	7	3	10	6	3	4	4	5	1	6	5	0	4	4	3	1	4	6	11	4	112
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	8	5	8	12	1	3	4	4	11	5	14	6	4	2	6	1	1	4	4	3	2	0	108
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	1	0	0	1	0	2	1	2	12
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	5	14	13	27	14	20	27	17	23	21	19	15	27	19	34	36	43	23	34	28	25	20	23	527
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	2	0	0	0	3	0	9
Accuracy Rate, [ʃ]	---	---	---	---	---	---	---	---	---	0	24	54	62	54	41	43	63	61	64	42	51	39	64	53	83	75	88	72	85	61	66	44	77	

/ʃ/ before voiceless consonants	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	15	1	8	5	2	2	9	2	1	1	0	1	2	1	0	0	5	0	0	0	55
ʃ ↔ ∅	0	0	0	0	0	0	0	0	0	1	5	15	4	19	5	11	8	5	3	6	3	6	4	0	2	8	5	1	0	2	2	4	0	119
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	7	6	1	4	16	7	9	4	4	9	8	5	2	6	13	3	9	2	120
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	3	2	0	0	0	0	0	1	0	8
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	0	2	1	3	10	41	34	9	21	21	30	15	19	25	50	78	41	25	8	51	23	21	46	574
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	4	1	0	0	0	1	2	1	0	2	0	2	1	2	0	18
Accuracy Rate, [ʃ]	---	---	---	---	---	---	---	---	---	0	0	12	20	7.5	53	60	63	53	62	40	71	47	68	83	75	79	79	83	57	70	79	57	96	

/ʃ/ before voiced con-sonants	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	3	0	1	2	0	4	0	0	1	1	0	0	0	0	0	0	2	0	17
ʃ ↔ ∅	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0	8	2	1	0	3	2	0	1	0	5	3	4	2	1	3	0	7	1	48
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	3	4	2	0	0	1	1	0	1	0	16
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	1	0	1	4	2	0	2	2	3	2	1	0	27
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	4	8	0	4	4	5	4	1	6	13	7	6	7	0	6	0	10	3	91
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	3	4	5	9	8	2	6	22	20	17	17	3	9	6	18	4	168
Accuracy Rate, [ʒ]	---	---	---	---	---	---	---	---	---	---	0	0	---	0	25	24	45	43	31	33	41	57	50	35	45	59	63	61	43	41	75	46	50	

/ʃ/ before vowels	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	12
ʃ ↔ ∅	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	5	0	0	1	1	1	0	0	3	1	3	1	2	1	1	1	0	0	25
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	1	2	2	0	1	1	4	1	0	0	2	0	1	2	21
ʃ ↔ z	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	8	4	11	9	0	15	1	15	19	17	23	24	6	17	6	6	7	196
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	8	6	3	5	4	10	1	2	0	10	3	7	2	0	3	0	0	2	69
ʃ ↔ ʒ	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	6	3	1	7	5	2	1	3	10	9	5	0	1	3	0	0	1	61
Accuracy Rate, [z]	---	---	---	---	---	---	---	---	---	---	0	0	---	30	100	17	32	36	58	39	0	71	25	68	45	47	62	83	75	63	86	86	58	

4. Codas of Empty-headed Syllables

|ʃ/ʒ|, excluding *estar*	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	7
ʃ ↔ ∅	0	0	0	0	0	0	0	1	4	6	2	2	3	3	7	4	0	0	1	0	1	0	0	2	1	0	8	4	0	0	1	5	1	56
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	1	0	0	0	5	4	2	1	0	2	0	1	0	20
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	7	8	1	3	9	2	1	2	9	13	14	12	7	8	1	6	1	6	114
Accuracy Rate	---	---	---	---	---	---	---	0	0	0	0	0	0	33	17	58	89	100	75	82	40	100	100	82	65	74	55	58	100	33	86	14	86	

|ʃ|, in *estar* and related words	0_11_23	1_00_25	1_02_07	1_02_28	1_04_06	1_05_05	1_06_23	1_08_04	1_09_24	1_10_22	2_00_09	2_02_18	2_04_01	2_06_23	2_08_05	2_10_08	2_11_02	3_00_26	3_02_12	3_03_23	3_04_25	3_06_19	3_08_00	3_10_04	3_11_11	4_00_13	4_02_11	4_03_24	4_04_29	4_06_00	4_07_07	4_08_11	4_10_07	
Other	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	4
ʃ ↔ ∅	0	0	1	0	0	0	0	0	0	0	2	0	3	9	1	3	5	1	2	12	18	13	2	7	14	20	11	6	5	4	1	8	4	152
ʃ ↔ s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	8
ʃ ↔ ʃ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	16	3	3	1	3	0	0	0	0	0	0	0	0	0	0	0	1	33
Accuracy Rate	---	---	0	---	---	---	---	---	---	---	0	---	0	0	50	63	62	75	50	6.7	14	0	0	0	0	0	0	0	0	0	0	0	17	