A PLACE FOR (ALMOST) EVERY THING AND EVERYTHING IN ITS PLACE:

PHONOTACTIC EFFECTS ON PHONOLOGICAL DEVELOPMENT IN ITALIAN

by
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Abstract

In learning their first language(s), children must acquire a phonemic inventory, a syllable shape (e.g., CV, CVC, CCV), and an understanding of which phonemes can occupy which positions within the syllable or word. In hierarchical representations, this can be accounted for through constraints on dependency relationships, where the specification of segmental features in dependent positions captures marked options. This thesis examines the phonological development of four Italian-learning children, whose overall behaviour aligns with implicational relationships proposed in the literature. I account for their behaviour through hierarchically organized prosodic and segmental representations which reflect claims based on the notion of markedness. These representations incorporate the prediction that early stages of acquisition and typologically ubiquitous syllable shapes represent unmarked options, while syllable shapes learned relatively late and those only allowed in typologically rare languages constitute more marked options. By investigating prosodic development alongside segmental development in Italian, this thesis contributes novel observations concerning the markedness of prosodic dependency in reference to sonority and place or articulation, for example: liquid+consonant, strident+consonant coda-onset clusters and consonant+liquid onset clusters all imply homorganic nasal+consonant coda-onset clusters, which also means that complex onsets imply coda-onset clusters, both in child grammars and in the typology of adult grammars.

General Summary

In learning their first language(s), children must build an inventory of sounds, and a set of positions in which each sound is available. This thesis describes the language development of four Italian-learning children, focusing on the development of consonants neighbouring other consonants within words (clusters). Italian allows two cluster types: those spanning syllable boundaries (e.g., *pa**n.d**a*, *a**l.t**o*, *la**r.g**o*, *ve**s.p**a*), and those within syllables (e.g., ***pl**asma*, ***br**occoli*). This thesis illustrates complexity through hierarchically-organized representations, and shows how children elaborate these representations throughout developmental stages, adding complexity. Hierarchies in these representations are proposed to be valid across all human languages: early stages of development and widely available clusters represent simple/unmarked options; clusters learned later and available in rare languages are evidence of more complex/marked options. Assuming children produce simpler clusters earlier, and complex clusters later, this thesis supports, among others, claims that clusters across syllable boundaries are simpler than those within syllables.

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Table of Contents

List of Tables and Figures

Chapter 1: Introduction

In this chapter, I lay out the goals of this thesis and their relevance to the literature on phonology and phonological acquisition. I begin in §1.1 with the motivations for studying language development in terms of markedness, and illustrate this discussion with a parallel between Dutch syllable shape acquisition and typological evidence. In §1.2 I motivate addressing this goal with an investigation of Italian. In §2 I state the trajectory of this thesis.

1 Scope and objectives

In this section, I discuss the goals of representational phonology relevant to the current study. I briefly discuss markedness and its importance in studying both phonological acquisition and phonology more generally. I also motivate the choice to study Italian development in striving to satisfy the goals of representational phonology.

1.1 Why study phonological acquisition?

During the process of learning their first languages, children must acquire the speech sounds and sound combinations relevant to these languages. This entails that children build an inventory of sounds, an inventory of available sound positions, and a mapping between sounds and positions. For example, while /pla/ forms a phonotactically licit syllable in many languages, including English and Italian, as illustrated in (1), it is not well formed in languages like Quechua or Desano (Chomsky & Halle 1968; Fudge 1969; Kaye & Lowenstamm 1981; Itô & Mester 1994; Zeč 1995; Kager, Pater & Zonneveld 2004). This is often accounted for through constraints on relationships between sounds and their positions within the word or the syllable. Theories which assume the syllable as a phonological unit describe these relationships by placing restrictions on syllabic constituents (e.g., onsets, nuclei, codas).

Kaye & Lowenstamm (1981) propose a typology of syllable shapes in adult languages. They first observe that all languages have Consonant+Vowel (CV) syllables, represented by /pa.la/ in (1). Therefore, all languages allowing for CVC syllables also allow for CV (e.g., Quechua). They also observe that every language which allows for CCV syllables (e.g., English, Italian, Spanish), exemplified by /pla/ in (1) below, also allows for CVC, e.g., /pal/. Importantly, there seem to be no languages that allow for CCV but not for CVC.[1]

(1) Legal syllabifications across languages

	/pala/	/pal/	/pla/
English, Dutch	✓	✓	✓
Italian, Spanish	✓	✓	✓
Quechua	✓	✓	×
Desano	✓	×	×

Kager, Pater & Zonneveld (2004) draw a parallel between the above typology of syllable shapes and the acquisition of Dutch syllable shapes summarized by Levelt *et al.* (2000), building on Fikkert's (1994) study of 12 children. Levelt *et al.* (2000) note the consistent developmental path for syllable structure among Dutch-learning children shown in (2) below. As we can see, Dutch not only allows for CVC and CCV, but also for CVCC and CCVCC. Where the two groups of children diverge is in the relative development of tri-positional rhymes and complex onsets. What this path suggests is that, while CCV always implies the presence of CVC, there is no implicational relationship between CCV and VCC, leading to the divergent behaviour. However

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[1] In fact, Blevins (1995) has since reported Mazateco as a counter-example to Kaye & Lowenstamm's (1981) proposal. While this warrants further research, the strong typological trend reported by Kaye & Lowenstamm is still worth formalizing within a phonological framework.

this path confirms that no child displays CCV syllables before CVC. Kager *et al.* attribute parallels like these to universal markedness, or linguistic complexity/unnaturalness, where early stages of acquisition and typologically ubiquitous syllable shapes represent unmarked options, while syllables only allowed in typologically rare languages and those learned relatively late by children are evidence of more marked options.

(2) Syllable structure acquisition in Dutch-learning children

$$\begin{tikzcd}
 & & & & \text{CVCC} \arrow[r] & \text{VCC} \arrow[r] & \text{CCV} \arrow[r] & \text{CCVC} \arrow[dr] & \\
\text{CV} \arrow[r] & \text{CVC} \arrow[r] & \text{V} \arrow[r] & \text{VC} \arrow[ur] \arrow[dr] & & & & & \text{CCVCC} \\
 & & & & \text{CCV} \arrow[r] & \text{CCVC} \arrow[r] & \text{CVCC} \arrow[r] & \text{VCC} \arrow[ur] &
\end{tikzcd}$$

Child language acquisition therefore offers a perspective on phonological systems with which we can test typological claims, and investigate developmental predictions made by universal markedness (Jakobson 1941; McCarthy & Prince 1986; Fikkert 1994; de Lacy 2002; Hume 2003). An added goal, specifically in the context of representational phonology, is to capture these markedness relationships within hierarchically organized prosodic and segmental representations. Pursuing these combined goals, I investigate the development of Italian, a language which allows for both CVC and CCV syllables, although with stringent restrictions on what portion of the segmental inventory is available in each syllable position. I elaborate briefly on the constraints of Italian in the next section.

1.2 Why study Italian?

Italian provides a clear and robust set of asymmetrical constraints on legal segmental and prosodic combinations, from this we can make claims about syllable/segmental structure in terms of dependency relationships within phonological representations. I describe these phonotactics in depth in Chapter 3.

Among other details, Italian does not allow for word-final consonants and, implicationally, does not allow for word-final clusters. Given these facts, we can strip away the syllable shapes from the Dutch developmental path given in (2) and arrive at general predictions for the developmental trajectory of Italian-learning children. This is shown in (3).

(3) Predicted developmental path for Italian syllable structure
CV → CVC → CCV

This prediction, however, is too broad in that it fails to account for the fact that Italian does not allow all, or even most, of its consonantal inventory in the coda of CVC syllables, and allows an even more restricted set of consonants in the second position of the CCV syllable shape. Such asymmetries are attested across many of the languages of the world. From an acquisition standpoint, this poses a challenge for the child who must not only figure out which are the sounds of Italian, for example, but also the distributions of these sounds within words and syllables. In turn, asymmetries in sound distributions, both in adult language as well as in children's early productions, can give clues about how speakers represent these structures as part of their lexical representations (Spencer 1986; Fikkert 1994).

Since linguists generally assume that adults' phonological representations incorporate prosodic units (e.g., syllable, onset, nucleus; e.g., Golston 1995; Rose 2000; Goad & Rose 2004), children must either have access to them through some innate device (e.g., Chomsky 1957; Pinker 1984), or they must build representations over time through learning. Many researchers claim that children build prosodic units as they develop phonological representations for the words they acquire (Fikkert 1994; 2005; Levelt 1994; Freitas 1997; Goad & Rose 2004; Rose 2003; Fikkert & Freitas 2004; Levelt & van Oostendorp 2007; Fikkert & Levelt 2008; McAllister

Byun, Inkelas & Rose 2016). In a similar vein, researchers have analyzed segmental development by building nodes on a segmental structure (Rice 1992, Rose 1997).

Under this view, phonological errors observed in child speech can be taken as evidence for underdeveloped lexical representations of the children's developing vocabulary. In order to fully understand the contexts in which errors in production occur, researchers must come up with a thorough understanding of both the child's level of development of prosodic structure and how individual segments are represented within this structure at the given stage. This is the option I entertain throughout this thesis, through a systematic investigation of the development of Italian phonology.

2 Roadmap

This thesis is organized as follows. In Chapter 2, I discuss background research relevant to the current thesis. In Chapter 3, I describe relevant aspects of the phonology of Italian. In Chapter 4, I lay out the research questions and the methods with which I carry out the investigation. In Chapter 5, I describe the developmental behaviours of Italian-learning children, which I analyze in Chapter 6. I conclude with a discussion in Chapter 7.

Chapter 2: Background research

Phonology as a system comprises both segmental and prosodic levels of representation, among others. The study of these levels has largely been undertaken separately, leading to independent observations about markedness in segmental and prosodic phenomena. Within the acquisition literature, the study of segmental development predates that of prosodic development (Jakobson 1941), which has resulted in a focus on purely segmental descriptions of phonological behaviours, mainly in the form of sonority and place of articulation (henceforth PoA). The study of prosodic development began in earnest after the incorporation within phonological theory of prosodic constituents such as the syllable and the foot as domains of analysis (Fudge 1969; Selkirk 1982; Steriade 1982; McCarthy & Prince 1986). The incorporation of these constituents have allowed for a discussion of relative sonority across sequences of segments, and the relative markedness of different syllabifications of these consonant sequences. This provides a metric through which we can compare the typology of adult languages and patterns of development in child language acquisition. In this chapter, I discuss how universal markedness has been incorporated into structural representations, and the path along which these representations are observed to be acquired. Throughout this discussion, I focus on how prosodic development interacts with segmental structure in the speech of young children, and the parallels these patterns have with the typology of adult phonological systems.

1 Prosodic structure

This section reviews developmental studies of prosodic positions available in Italian, namely codas and complex onsets. Since the study of Italian phonological acquisition to date has focused on clinical investigations, it has not been incorporated within the mainstream formal literature on phonological development (however see e.g., Bortolini *et al.* 1990; Bortolini, Zmarich & Bonifacio 1991; Bortolini *et al.* 1992; Bortolini 1993; Zmarich, Hulstijn & Bernardini 2002; Zmarich & Miotti 2003; Zmarich *et al.* 2005; Zmarich *et al.* 2007; Costamagna & Marotta 2008; Giulivi, Vayra & Zmarich 2010; Giulivi *et al.* 2011; Zmarich *et al.* 2014; Vayra, Avesani & Tamburini 2015). Therefore, the studies reviewed in this thesis come from other languages, which do not necessarily have the same prosodic structure. These differences are addressed as well. I begin with syllable codas in the next section.

1.1 Codas

1.1.1 Revisiting Dutch prosodic development

Recall from Chapter 1 the parallel suggested by Kager, Pater & Zonneveld (2004: 16) between the typology of syllable shapes in adult languages proposed by Kaye & Lowenstamm (1981) and Fikkert's (1994) observations about the prosodic development of Dutch-learning children highlighted by Levelt *et al*. (2000). Fikkert argues for the acquisition of increasingly complex syllable 'templates' through a series of developmental stages. Each of these stages resembles a type of language in Kaye & Lowenstamm's typology. Fikkert also makes use of segmental labels that restrict which sounds can appear in given syllabic positions, which aim to capture distributional asymmetries within her corpus data. I begin with a summary of Fikkert's analysis, and then address the labels and the behaviours they capture.

In (4), we see data from Dutch-learning Jarmo, who systematically deleted word-final consonants and reduced branching onsets to single consonants during his initial stage of phonological development, between 1;4 and 1;7. Fikkert accounts for behaviours like this by positing child representations similar to those hypothesized by Spencer (1986) to be discussed below in §1.2.2. In addition, Fikkert (1994: 56–57) points out that syllable onsets are obligatory, and that only plosives can occupy the onset position at this early stage. This grammatical conditioning is such that, even in his attempts at words that are vowel-initial, Jarmo produces a plosive onset, as shown in (4b).

(4) Jarmo’s Dutch development: Stage 1 (adapted from Fikkert 1994)

	Orthography	Adult target	Child form	Age	Gloss
a) consonant-initial	*daar*	/daːr/	[daː], [dɑ]	1;04.18	‘there’
	klaar	/klaːr/	[ka], [kaː]	1;05.02	‘ready’
	poes	/puːs/	[puː]	1;05.02	‘puss’
	tok	/tɔk/	[kɔ], [kaː]	1;05.27	‘cluck’
b) vowel-initial	*auto*	/ˈoːtoː/	[ˈ**t**aːtoː], [ˈ**t**oːtɔ]	1;06.27	‘car’
	apie	/ˈaːpiː/	[ˈ**t**aːpiː]	1;07.15	‘monkey’

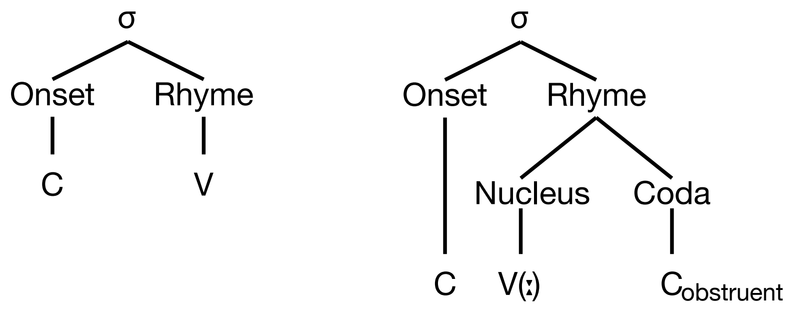
Jarmo’s stage 2 began at around age 1;7 when, as illustrated in (5a), onsets become optional, although they are still limited to plosives; when Jarmo was attempting a sonorant-initial word, he produced an obstruent onset, exemplified in (5b). As we can see, Jarmo produced word-final consonants at this stage, which are, in parallel with onsets, restricted to obstruents. At this stage, Jarmo could produce final consonants while he still reduced branching onsets to singletons, as shown in his production of *vliegtuig*. This is consistent with Kaye & Lowenstamm’s (1981) prediction that there are grammars with CVC that do not allow CCV, as Jarmo’s appears to have been at this stage, while the reverse is unattested. We also see no relation between the size of the nucleus (heavy or light) and the presence of a word-final segment (see §1.1.2).

(5) Jarmo’s Dutch development: Stage 2 (adapted from Fikkert 1994)

	Orthography	Adult target	Child form	Age	Gloss
a) obstruent-initial	*deze*	/ˈdeːzə/	[tɛiʃ]	1;06.13	‘these’
	poes	/puːs/	[puːs]	1;07.29	‘puss’
vowel-initial	*aap*	/aːp/	[ɑp], [aːp]	1;07.15	‘monkey’
	eend	/eːnt/	[aːt]	1;07.15	‘duck’
b) sonorant-initial	*wap*	/**ʋ**ɑp/	[**p**aː]	1;07.15	‘seesaw’
	wipwap	/**ʋ**ɪpˈ**ʋ**ɑp/	[ˈ**piːb**aː]	1;08.26	‘seesaw’
	vliegtuig	/ˈvliːχˌtœyχ/	[**tiːt**ɑ]	1;07.29	‘plane’

Fikkert interprets cluster reductions in child speech as a result of incomplete, or underspecified, child representations. Building on the behavioural stages summarized above, Fikkert proposes the unmarked syllable shape for stage 1 consisting solely of an (obligatory) onset and a rhyme, as shown in (6a) below. To account for the emergence of word-final consonants in stage 2, Fikkert proposes the syllable template in (6b). Finally, in order to account for the segmental restrictions on syllabic positions, she uses the ‘obstruent’ label to denote these restrictions. Fikkert thus appends the label ‘obstruent’ to the coda’s terminal node to capture the observation that the only consonants appearing in this position at stage 2 are obstruents. The nucleus shows optional length, as mentioned above, with no concrete relationship between vowel length and the presence of post-vocalic segments.

(6) Syllable shape acquisition (adapted from Fikkert 1994)



a) Stage 1

b) Stage 2

Rose (1997) points out, however, that Fikkert's analysis falls short in two ways. From a theoretical standpoint, Rose argues that labels are arbitrary constraints on syllables and therefore provide no principled explanation for why children acquire, for example, obstruents before sonorants in word-final position. Rose also argues that Fikkert's analysis fails to explain why word-final and word-initial consonants are subject to the same sonority constraint upon appearing in Jarmo's productions (i.e., that they must be obstruents). In addition to the points made by Rose (1997), since sonorants are the typologically unmarked codas (Zeč 1995), the Dutch developmental data above seem contradictory, as Jarmo's unmarked consonants in word-final position are restricted to obstruents. Piggott (1999) discusses typological evidence for asymmetrical behaviour at the right edge of words that capture this apparent contradiction. I summarize this typology next.

1.1.2 Excursus on representation at the right edge

Piggott (1999) compares restrictions on the types of consonants that can appear word-finally within given languages to those that can appear word-initially and in word-medial codas, highlighting structural similarities and differences between these positions. Piggott argues that languages like Selayarese, which have the same restrictions on word-final consonants as on word-medial codas, syllabify both positions in the same way, as true syllable codas. In contrast, languages like Diola-Fogny restrict the segments that can appear in word-medial codas while leaving word-final consonants relatively unrestricted, parallel to the relative lack of restrictions on syllable onsets we observe cross-linguistically. Piggott hypothesizes that Diola-Fogny, and languages with a similar lack of restrictions at the right edge of words, allow codas word-medially but syllabify word-final consonants as 'onsets of empty-headed syllables' (henceforth OEHS), that is, syllable onsets followed by empty nuclear positions. Further support for word-final OEHS comes from languages like Yapese, which have no restrictions on word-final consonants but yet do not allow for any type of word-medial codas. Piggott contends that Yapese-like languages syllabify word-final consonants as OEHSs, and that these languages have no true codas. In addition to these languages, there are also languages with no final consonants, which either have medial codas (e.g., Italian), or do not allow codas at all (e.g., Senufo). However, languages with word-final codas and no word-medial codas are unattested. This typology is summarized in (7) below.

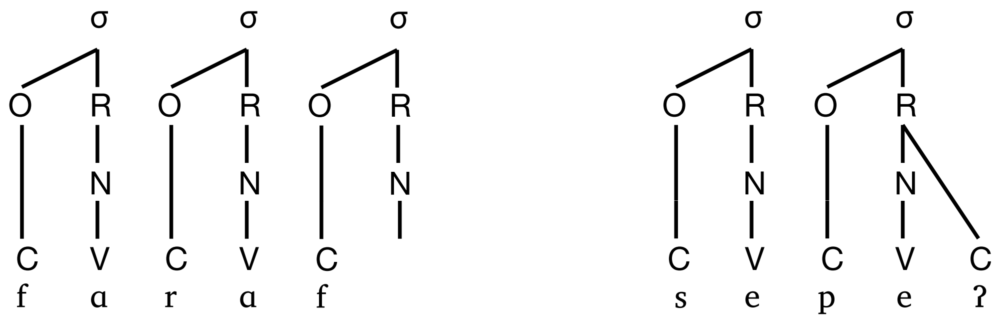
(7) Post-vocalic consonant typology (expanded from Piggott 1999)

	Codas	
	Allowed	Not Allowed
No final Cs	Italian	Senufo
Final onsets	Diola-Fogny	Yapese
Final codas	Selayarese	*Unattested

The representations in (8) show the syllabification of final consonants, where only relevant structure is shown. (8a) illustrates final consonants in languages where this position is not restricted, representing these consonants as OEHSs. (8b) exemplifies final consonants in languages with restrictions parallel to those on medial codas, syllabifying them as true codas.

(8) Syllabification of word-final consonants

a) word-final Onset (e.g., Yapese, Diola-Fogny) b) word-final Coda (e.g., Selayarese)



The adoption of onsets at the right-edge of words enables a straightforward account of Jarmo’s early behaviours described above. Jarmo’s final consonants share the same profile as onsets (i.e., they are restricted to obstruents), do not correlate with rhyme size (heavy and light nuclei can precede these consonants), and appear at a time when there are no word-medial codas. These final consonants thus suggest Jarmo has syllabified them as OEHSs.

Fikkert’s analysis does not entertain the theoretical possibility of OEHSs. The parallel adult typology proposed by Kaye & Lowenstamm (1981) also makes no reference to final onsets. Therefore we cannot be certain that the typology, and the developmental path it sets up for syllable shapes is in fact valid. Rather, we must look at word-medial syllables and coda-onset clusters to validate whether the claims of Kager *et al.* (2004) and Kaye & Lowenstamm (1981) are borne out for syllables, and not just word shapes.

1.2 Left-edge clusters

Researchers studying phonological development generally assume relationships between surface (phonetic) and lexical (phonological) representations, with phonological features either fully specified at the lexical level (Smith 1973; Rose 2000), or with feature specification emerging as an outcome of the developmental process (Levelt 1994; Fikkert 1994; Mielke 2008; Rose & Inkelas 2011; Rose 2014; McAllister Byun, Inkelas & Rose 2016). Studies falling into the former category treat child phonological patterns as the grammatical outcomes of constraints or limitations on children’s developing systems (e.g., Smith 1973; Rose 2000): the full (adult-like) input undergoes phonological processes to abide by the restrictions of the particular phonological rules or constraints of the child’s developing system (see also Barlow 1997; Freitas 1997; Pater 1997). In contrast to this, studies in the latter category allow for segments or other positions within a word to be unspecified or partially specified for particular segmental or prosodic dimensions (e.g., Levelt 1994; Fikkert 1994; Goad & Rose 2001, 2004; Fikkert & Levelt 2008). The contrast between these perspectives leads to different understandings of child phonological productions. I begin by reviewing the study of prosodic development and how it has influenced analyses of segmental patterning in child phonology. I then move to the discussion of prosodic asymmetries and how they may interact with developing segmental representations.

1.2.1 Sonority

Many researchers have endeavoured to explain children's reduction patterns observed in their early left-edge cluster as the preservation of the least sonorous element of the target cluster, without any explicit reference to syllable structure. Indeed, attempts to classify consonants in terms of 'sonority' date back to Sievers (1881) and Jespersen (1904). Other researchers account for these patterns using structured representations of the syllable, and capture this observed link between preserved elements and relative sonority by assuming that syllabification is heavily constrained by sonority. Both of these accounts make use of a sonority hierarchy, represented by sonority scales, as in (9) below. The scale in (9) represents relatively uncontroversial sonority relationships among the major natural classes of consonants. In addition to the distinctions made here, liquids are often separated by sonority into laterals and rhotics, where rhotics are taken to be more sonorous than laterals. This last sonority distinction will be discussed further in §2.1.

(9) Sonority Scale (adapted from Clements (1990))

Obstruents	<	Nasals	<	Liquids	<	Glides	<	Vowels

Many researchers use scales similar to these to make generalizations about syllabification, formalized through the Sonority Sequencing Principle (henceforth SSP), often citing Clements (1990), as shown in (10).

(10) Sonority Sequencing Principle (Clements 1990)
Between any member of a syllable and the syllable peak, only sounds of higher sonority rank are permitted.

The consequence of the SSP in onset clusters is that they optimally rise in sonority, as onsets are the pre-nucleic constituent of a syllable. However, while one might assume that a maximal rise in sonority in an onset cluster is optimal (i.e., C+Glide), this would result in a shallower rise in sonority between the glide and the following nuclear vowel. Instead, sonority optimally rises steadily within and following the onset, making liquids the optimal dependent in an onset cluster as they are equidistant in sonority, according to the scale in (9), from the left edge and the peak of the syllable. Thus, the unmarked onset cluster is obstruent+liquid, as exhibited by Italian. There are, however, other types of initial clusters, namely sC clusters (discussed in §1.2.4), which do not conform to the generalizations about sonority relationships in onset clusters mentioned above. Smith (1973) studies the development of both types of clusters in English. I discuss his analysis next.

Smith (1973) studies the development of phonological productions made by his English-learning child Amahl. His analysis is based on a diary study consisting of phonetically-transcribed attestations made periodically by Smith between Amahl's ages of 2;2 and 3;9. Addressing word-initial consonant cluster reductions such as those in (11) below, Smith notes that Amahl reduced stop+sonorant clusters to maintain only the stop in his speech productions (Smith 1973: 166). Smith mentions that this pattern represents the norm, whether the stop is the first or the second member of the adult cluster.

(11) Amahl’s word-initial cluster reductions (Smith 1973; adapted from Goad & Rose 2004)

	Orthography	Adult target	Child form
Stop-initial	*plate*	/**p**leit/	[**b̥**eːt]
	trail	/**t**reil/	[**d̥**ei]
	clock	/**k**lɔk/	[**g**ɔk]
Stop-second	*spider*	/s**p**aidə/	[**b̥**aidə]
	stiff	/s**t**if/	[**d̥**if]
	skip	/s**k**ip/	[**g̊**ip]
Stop-medial	*stroke*	/s**t**rəuk/	[**g̊**oːk]
	spring	/s**p**riŋ/	[**b̥**iŋ]

Smith, using the linear, rule-based view of phonology of the time (Chomsky & Halle 1968; Fudge 1969), proposes that Amahl’s phonology obeys a rule that maintains the least sonorous element of the target (adult) cluster in his productions of word-initial consonant clusters. Following Smith, many scholars have since sought to explain reduction patterns through formal references to the relative sonority of the consonants present in the target cluster (e.g., Barlow 1997; Bernhardt & Stemberger 1998; Gnanadesikan 2004). However, other reduction patterns are also attested, such as in (12) below, which in fact contradict Smith’s basic analysis, leading him to claim that Amahl always deletes /s/ “despite its inherent prominence” (1973: 166). Smith, however, does not discuss these examples further.

(12) Amahl’s word-initial /s/+sonorant cluster reductions (Smith 1973)

	Orthography	Adult target	Child form
/s/+liquid	*slug*	/s**l**ʌg/	[**l**ʌg]
/s/+nasal	*small*	/s**m**ɔː/	[**m**ɔː]
/s/+nasal	*sneezed*	/s**n**iːzd/	[**n**iːd]

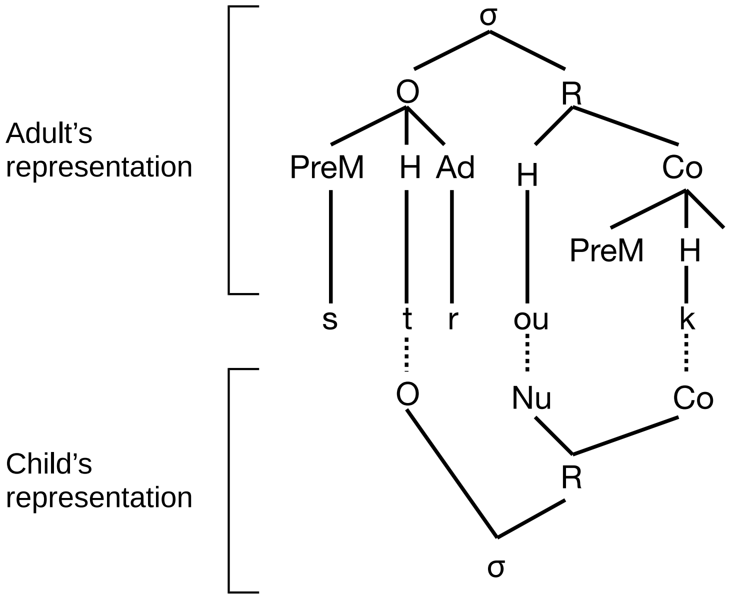
Smith’s (1973) analysis is, in many respects, a product of its time, which predates the incorporation of multiple levels of analysis in phonological theory, for example within prosodic phonology (e.g., Goldsmith 1976; Kahn 1976; Goldsmith 1979). Within prosodic phonology, phonological representations are organized across autonomous yet interacting ‘tiers’, or levels, of representation. Smith, who frames his analysis within Standard Generative Phonology (*Sound Pattern of English*; Chomsky & Halle 1968), could only refer to the segmental tier, given that *SPE* offered no apparatus to encode prosodic domains or relations between different phonological tiers. Spencer (1986), whose analysis is formulated within prosodic phonology, builds on Smith’s descriptions above. I discuss his proposal next.

1.2.2 Headedness

Spencer (1986) revisits the case of Amahl’s cluster reductions, with an emphasis on highly-articulated, hierarchical, syllable-level representations. Spencer’s analysis, which builds on Cairns & Feinstein’s (1982) theory of markedness and syllable structure, makes reference to structural ‘heads’ within the syllable, and predicts that these positions are what children preserve, and therefore produce, in early spoken forms.

In the structure in (13) below, Spencer posits a hierarchical structure for the adult representation of a syllable, in which he labels structural heads as ‘H’, adjuncts as ‘Ad’ and another optional position, the pre-margin, as ‘PreM’. While pre-margins and adjuncts are both optional, heads are obligatory constituents of the syllable. Pursuing a markedness-based view of acquisition, Spencer claims that the child’s early representation is inherently unmarked, in that it can only hold the amount of segmental detail which structural heads allow. Thus, according to his analysis, *stroke* /strouk/ produced in child speech as [touk] involves the deletion of both optional constituents, resulting in the unmarked syllable structure representation.

(13) Structural preservation in a developmental grammar (adapted from Spencer 1986: 13)[2]



stroke /strouk/ → [touk]

The child's representation in (13) accounts for the forms in both (11) and (12) above, if we assume stop-initial clusters to be Head+Adjunct clusters, and /s/+stop clusters to be PreMargin+Head clusters. Spencer's analysis can also account for the data in (12) above, if we assume /s/+sonorant clusters to have the same structure as /s/+stop clusters, given their parallel distribution. Recall that Smith's (1973) analysis under *SPE* conventions was unable to fully account for these /s/+sonorant cluster reduction patterns.

Spencer, via prosodic phonology, thus provides a framework to formalize syllable structure reductions observed in child language. However, Spencer provides no mechanism by which children label constituents (e.g., heads, adjuncts, pre-margins) or come to acquire the relevant structures. Goad & Rose (2001, 2004), whose analysis I discuss next, address this topic.

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[2] Spencer (1986) uses a toy example in the above structure. However, Amahl has the form [ɡ̥oːk] for stroke, which is structurally comparable but avoids the extra complication posed by Amahl's well-documented pattern of velar harmony (see e.g., Goad 1997, 2001; Rose 2000; Rose & Inkelas 2011).

1.2.3 Building representations

Building on Spencer's (1986) groundwork, Goad & Rose (2001, 2004) discuss children's reduction patterns of sC clusters at the left-edge of words in West Germanic languages (English, German, and Dutch).[3] As mentioned above, a sonority-based account is sufficient in explaining most patterns of cluster reduction in child language, without any need to appeal to syllabic constituency (Barlow 1997; Bernhardt & Stemberger 1998; Gnanadesikan 2004). The sonority-based analysis, however, cannot account for reduction patterns affecting /s/+sonorant clusters which maintain the sonorant in the produced forms, as those of Amahl in (12) above. The rising sonority profile of these clusters is different from that of other sC clusters, but similar to that of obstruent+sonorant clusters. However children often do not treat /s/+sonorant clusters the same as obstruent+sonorant clusters, even within the same language. That is, not all children reduce /s/+sonorant clusters to the least sonorous element of the target cluster, nor do all children delete all word-initial /s/ as Amahl did.

Goad & Rose (2001, 2004) highlight two specific behaviours in word-initial sC cluster reduction: the 'sonority' pattern, shown by Gitanjali in (14), and the 'head' pattern, shown by Amahl in (12) above. These two patterns diverge in the production of /s/+sonorant clusters, which Gitanjali reduced to the least sonorous segment [s], shown in (14c), while Amahl maintained the sonorant in his productions.

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[3] The 's' in sC refers to [s] in English and Dutch, and to [ʃ] in German. sC clusters denote any word-initial string consisting of [s]/[ʃ] followed by another consonant. When relevant, I distinguish between the C portion of the cluster as obstruent or sonorant.

(14) Gitanjali’s word-initial cluster reductions (data from Gnanadesikan 2004)

	Orthography	Adult target	Child form	
a) Stop-initial	*please*	/**p**liz/	[**p**iz]	
	draw	/**d**ɹɒ/	[**d**ɒ]	
	clean	/**k**lin/	[**k**in]	
b) Stop-second	*spoon*	/s**p**un/	[**b**un]	
	star	/s**t**ɑː/	[**d**ɑː]	
	sky	/s**k**aj/	[**ɡ**aj]	
c) /s/+sonorant	*sleep*	/s**l**ip/	[**s**ip]	cf. Amahl’s [**l**iːp]
	smoke	/s**m**ok/	[**f**ok]	cf. Amahl’s [**m**uːk]
	snow	/s**n**o/	[**s**o]	cf. Amahl’s [**n**uː]

Goad & Rose posit that children build, or elaborate, their phonological representations of words based on the distributions of sounds in their target language. In line with Spencer (1986), they argue that, in the adult representations of the forms in (14), /s/ is syllabified in an appendix position (i.e., Spencer’s pre-margin), and that the head of the cluster is the sonorant. At stage 1 of sC cluster development, Goad & Rose propose that children have made the (simpler, more encompassing) generalization that syllables rise in sonority from the left-edge, and therefore analyze /s/, the least sonorous member of /s/+sonorant clusters, as the structural head. This accounts for children displaying the sonority pattern, as in (14) above. Moving to stage 2, children have by then come to fully understand the distribution of /s/ in English (or other languages with similar distributions), and built the (more complex) structure to allow for the appendix position, thereby syllabifying the sonorant within the head of the onset constituent. Goad & Rose predict that children at this later stage represent all /s/+consonant clusters as appendix+onset, a structure that formally differs from the representation of obstruent+sonorant clusters as branching onsets.

Positing a hierarchically-organized syllable structure thus makes testable predictions about how children develop the sound system of their language. In this case, Goad & Rose posit that a child’s analysis of the segmental distributions allowed within his/her target language may lead to the generalization that a class of sounds behaves in a particular way in the target language (as /s/ does in the analysis above), which may in turn cause children to treat these segments asymmetrically, as Amahl did in his productions in (11) versus (12). Under this view, children’s phonological development consists of a series of stages in which they elaborate their lexical representations based on distributional evidence available from the target language, incorporating as many syllable positions (e.g., syllable coda, appendix) as their grammar allows to syllabify each vowel and consonant. This view also entails that children syllabify segments based, at least in part, on their sonority. I summarize the relevant observations about such asymmetries in §2. While Goad & Rose assume that /s/ in adult West Germanic languages is syllabified as an appendix, evidence from Portuguese (d’Andrade & Rodrigues 1998; Mateus & d’Andrade 2000) and typological evidence (Goad 2012, 2015) suggests otherwise. I discuss this latter proposal in the next section.

1.2.4 Representation of sC clusters

As discussed above, the representation of left-edge sC clusters is controversial. These clusters do not abide by the otherwise unviolated constraint against place identity in onsets, such that tautosyllabic /*pw/ and /*tl/ are ungrammatical in English but /sl/ and /st/ are perfectly acceptable word-initially. Furthermore, sC clusters do not abide by the typical rising sonority pattern required of onsets, according to the SSP in (10) (Clements 1990). These facts point to an analysis where the /s/ of an sC cluster is syllabified outside of the onset. For these reasons, among others, researchers (e.g., Hulst 1984; Davis 1990; Goldsmith 1990) argue that the /s/ in sC clusters is represented as an appendix of the syllable, as exemplified in Goad & Rose’s (2004) analysis. The appendix, by virtue of being outside the onset, allows the /s/ to avoid both a rising sonority profile, and conforming to the constraint against homorganicity in onsets.

In addition to not obeying a rising sonority profile, sC clusters display the reverse of what we would expect from an onset cluster: as the sonority profile of the sC cluster flattens, the more the cluster is preferred cross-linguistically (Goad 2011). A similar observation is formalized in the Syllable Contact Law (henceforth SCL), which describes cross-linguistic preferences about syllabification and sonority across syllable boundaries. The SCL is formulated in (15) below, where '\$' represents a syllable boundary.

(15) Syllable Contact Law (Clements 1990; there attributed to Murray & Vennemann 1983)
In any sequence C_a \$ C_b there is a preference for C_a to exceed C_b in sonority.

A body of literature proposes that initial sC clusters are never tautosyllabic and are instead coda-onset clusters, with /s/ syllabified as a coda of an empty-headed syllable (Kaye 1992; d'Andrade & Rodrigues 1998; Mateus & d'Andrade 2000; Goad 2012, Goad 2015). If sC clusters are syllabified as coda-onset sequences word-initially, their accordance with the SCL and their exemption from place identity constraints are both predicted. With the incorporation of empty-headed syllables at the left and right edges, we can observe prosodic development in a formally principled way. Moving now to the internal structure of individual segments, and its impact on syllabification, I discuss segmental representation in the next section.

2 Segmental structure

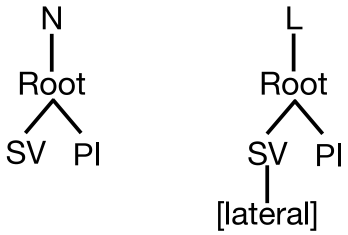
Recall that the goal of a hierarchical phonological representation is to reflect cross-linguistic facts about markedness into the structure itself. Segmental markedness is often captured in terms of sonority, as in the sonority scale used in the SSP and SCL in (10) and (15), respectively. Another cross-linguistic observation about markedness lies in the relationship between two adjacent segments, which optimally match along certain featural dimensions.

2.1 Sonority in structure

Rice (1992) proposes the segmental structures in (16), couched within Feature Geometry (Clements 1985; Sagey 1986; McCarthy 1988), to account for the cross-linguistic behaviour of nasals, in (16a), and liquids, in (16b). Rice uses the monovalent Sonorant Voice (henceforth SV) node to encode the feature [sonorant]. These structures reflect the markedness of these natural classes, where nasals have less structure and are therefore the unmarked sonorants, and liquids have more structure and are therefore relatively more marked.

(16) Segmental structure of sonorants (Rice 1992)

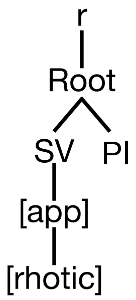
a) Nasal b) Liquid



While Rice notes that some languages display a sonority difference between laterals and rhotics, she does not propose a separate structure for the latter class. For a language such as Italian where, as we will see in Chapter 5§1.2, /l/ is acquired earlier than, and acts a substitute for /r/, while the reverse is never true, the markedness of /r/ can be captured in line with Rice's proposal, as in the structure in (17) below. The first node dominated by the SV node must indicate the class of liquids, [approximant] in (17), where laterals are unmarked compared to rhotics. The feature [rhotic] further specifies the segment, also making rhotics representationally more marked.[4]

(17) Proposed segmental structure of rhotics

Rhotic



Rice also proposes that obstruents are similarly structured to reflect the relative markedness of their subclasses. The Air Flow (henceforth AF) node, for our purposes, replaces the SV node in the structure of obstruents.[5] This bare AF node denotes oral stops, shown in (18a), with fricatives having an additional [continuant] feature, shown in (18b).

(18) Segmental structure of obstruents


a) Stops b) Fricatives

Observations as early as those made by Jakobson (1941) show that the first classes of consonants acquired by children are oral and nasal stops. These are, accordingly, the least marked consonant structures, according to Rice's analysis, also in line with the goal of representational

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[4] Glides would require a further node, however glides are not analyzed to be consonants in Italian (see Chapter 3 §1), and are therefore outside the scope of this investigation.

[5] Rice's proposal includes the AF node for sonorants as well, however it is unmarked for all voiced sonorants, and therefore does not play a role in this investigation.

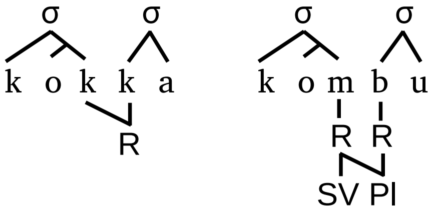
phonology to capture the parallels in adult typology and child language acquisition through structural markedness. In addition to encoding the relative markedness of individual segments, formal aspects of phonological structure also play a role in constraining relationships between adjacent consonants. I discuss this type of markedness in the next section.

2.2 Feature sharing

'Prince-languages' (as coined by Goldsmith 1989) suggest a preference in heterosyllabic cluster relationships. The hallmark of these languages is an extremely constrained set of medial coda-onset clusters: geminates (long consonants) and/or homorganic nasal-obstruent (henceforth NC) clusters. These languages have been accounted for by a preference for segments to 'share' features across syllable boundaries, where the head of the cluster, located in the syllable onset position, is responsible for some or all of the features expressed in coda. This relationship is shown in (19), where 'R' stands for Root, and 'Pl' stands for Place features. Only relevant structure is shown.

(19) Structure of feature sharing (adapted from Ota 2001)[6]

a) Geminate b) NC cluster



'nation' 'kelp'

These structures come from Japanese, which is an example of a Prince-language, whose L1 phonological acquisition is studied by Ota (1999, 2001). As we see in (19a), geminates are

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[6] Ota's (2001) analysis is framed within Moraic Theory (Hyman 1985; McCarthy & Prince 1986; Archangeli 1989; Hayes 1989; Itô 1989), where the sharing takes place between the moraic and the segmental tiers. For our purposes, this is not crucially different from what is represented here.

represented as two segments which share the root node, itself dominating all segmental features. In (19b), we see that NC clusters have separate root nodes, but share the place features. Ota observes that geminates are acquired at a time when NC clusters are not, which suggests that the geminates are the least marked heterosyllabic sequence. This is reflected in (19a) and (19b), and capture both the adult typological observations as well as the developmental order.

In this section, we have discussed segmental markedness, along both sonority and feature-sharing dimensions, and incorporated the relevant observations into structural representations. These form the basis for the formal aspects of all discussion throughout the remainder of the thesis.

3 Interim discussion

The structures assumed in the current investigation should account for the following observations: the preference for feature-sharing relationships across syllable boundaries discussed in §2.2 above, sonority patterns discussed throughout this chapter, namely those formulated in the SSP and SCL, and the fact that geminates, in languages which allow for them, are representationally the least marked heterosyllabic sequences.

Similarly, observations about prosodic structure and syllabification are an inherent component of the discussion to follow. In a nutshell, Piggott's (1999) proposal concerning syllabification at the right edge of words calls for a reconsideration of the apparent parallel between Levelt *et al.*'s (2000) observations of Dutch syllable acquisition and the adult typology of syllable shapes proposed by Kaye & Lowenstamm. Also, evidence suggests a parallel between the syllabification of word-medial sC clusters and that of word-initial sC clusters (Freitas 1997;

d’Andrade & Rodrigues 1998; Mateus & d’Andrade 2000; Fikkert & Freitas 2004; Goad 2012, 2015).

To investigate the validity of these theoretical proposals concerning segmental and prosodic structure, I examine the development of Italian phonology. I motivate the use of Italian data for an investigation of the issues mentioned above through a description of the phonology of Italian, in the next chapter.

Chapter 3: Italian phonological system

In the previous chapter I introduced the general hypothesis that hierarchically-organized phonological structure can capture, and motivate, markedness relationships, both in the typology of adult phonological systems and in phonological development. These articulated structures account for prosodic relationships between constituents as well as relations between segments and their positions within the syllable or as part of segmental sequences (e.g., geminates, clusters). I describe the types of clusters available in Italian below in order to make predictions about the developmental paths we should expect given the structures posited in the preceding chapter.

I propose to work on Italian for three reasons. First, Italian offers a clear case of phonotactic restrictions, allowing for virtually no word-final consonants.[7] This implies that all Italian codas are part of coda-onset sequences. In order to study the acquisition of codas, it is optimal to observe them in medial position, where they do not have alternate syllabification options (see a discussion of Piggott 1999 in §1.1.2). Secondly, Italian displays a variety of coda-onset clusters that include both sonorant and obstruent codas. This allows for the observation of different classes of codas within heterosyllabic clusters, and a comparison of the development of the different types of coda-onset clusters they form, alongside the following onset. Lastly, Italian has initial clusters, which allow for a comparison of the acquisition of different types of dependency relationships that take place within these clusters (i.e., coda-onset, complex onset). To investigate these dependency relationships, an inventory of both hetero- and tautosyllabic

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[7] Final consonants appear only in clitics and prepositions, and are further restricted to the coronal sonorants /l, n, r/. These function words which allow final consonants have been argued to be clitics within the prosodic word (Monachesi 1996), as they are always followed by a lexical word.

clusters is necessary. I discuss Italian's consonants in §1, and its syllable structure and related phonotactic restrictions in §2.

1 Consonant inventory

This description focuses on consonants and consonantal clusters, given that vowels are immaterial in the topic at hand. The consonantal inventory of Italian is listed in (20). All consonants are allowed in singleton onsets. With the exception of palatals, all consonants show a contrast in duration (i.e., between singletons and geminates), however only as part of coda+onset sequences; there are no phonemic word-initial or -final geminates.[8] The geminate counterpart of most singleton consonants in the inventory below consists only of a durational difference, except for /r/, which is a tap in singletons and a trill in geminates, as well as affricates, which have a lengthened closure portion rather than a repeated or extended release. The geminate contrast is not phonemic in certain dialects, notably in the Northern Italian dialects (Loporcaro 1996; Bertinetto & Loporcaro 2005).

I follow Chierchia (1983) in analyzing vocalic on-glides (in CGV sequences like *Siena* [sjena]) as part of a rising (light) diphthong (possibly the unmarked option cross-linguistically; Rose 1999), and thus part of the syllable nucleus. This is why there are no glides in the inventory in (20) (see footnote 4). Finally, palatals always appear as short word-initially, and as geminates intervocalically. Palatal affricates, which additionally appear in medial clusters, can be preceded only by sonorants. In the description below and the investigation that follows, I ignore palatals, with the exception of affricates, as they differ from the rest of the inventory and thus involve their own set of constraints or restrictions.

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[8] This description excludes the post-lexical word-initial gemination process *Raddoppiamento Sintattico*, whereby word-initial onsets are lengthened when preceded by a stressed light syllable within the same phrase (Borrelli 2013).

(20) Phonemic consonants of Italian (adapted from Krämer 2009: 50)

	Labial	Dental	Alveolar	Palatal	Velar
Stop	p, b	t, d	ʦ, ʣ	ʧ, ʤ	k, g
Fricative	f, v		s	ʃ	
Nasal	m		n	ɲ	
Lateral			l	ʎ	
Rhotic			r		

Moving to a description of legal segment combinations in Italian, I describe the constraints in terms of both manner and place of articulation.

2 Phonotactics

In my description of the types of clusters which are allowed in Italian, I begin with initial clusters, and then move to the restrictions that hold across syllable boundaries. At the level of syllable structure, Italian displays maximally $(C_1)(C_2)(C_3)V(C_4)$ phonetic syllables (Bertinetto & Loporcaro 2005; Krämer 2009), where C_4 stands for a set of consonants constrained by the head of the following onset. This is markedly different from the syllable structure of many of the languages whose acquisition has been studied before, specifically concerning the right edge of words, where many languages such as Dutch, English, French, and German, all allow for post-vocalic clusters, with almost no restrictions on singleton consonants in what would be the comparable C_4 position (while Portuguese and Spanish have similar restrictions, neither allows geminates).

There are virtually no restrictions on singleton onsets (C_2), although some phonemes are much less common than others in those onsets (Krämer 2009). As children must acquire all attested clusters, not just the most common clusters, and given the nature of my inquiry as well as the data available, I will not discuss issues related to usage frequency.

For clusters at the left edge of words, Italian allows for the manner sequences listed in table (21) below. As we can see from this table, Italian generally displays obstruent+approximant onsets. Stops and fricatives can precede the coronal liquids /l, r/. Except when the first member of the cluster is /s/, Italian disallows obstruent+obstruent clusters and those involving a nasal. Given the sonority scale in (9), and the SSP in (10), we can state that Italian requires a minimal sonority distance of two for an onset cluster to be well-formed.

(21) Manner combinations in word-initial clusters in Italian (adapted from Krämer 2009)

	Stop	Fricative	Nasal	Lateral	Rhotic
/s/	**st**a **zb**aʎʎa	**sf**orʦa **zv**eʎʎa	**zn**ɛllo	**zl**itta	**zr**adika
Stop	*pt	*tf	*kn	**kl**asse	**kr**edo
Fricative	*ft	*fs	*fn	**fl**auto	**fr**aele
Nasal	*nt	*nf	*mn	*ml	*mr
Lateral	*lp	*lf	*lm	*lʎ	*lr
Rhotic	*rp	*rf	*rn	*rl	*rr

In addition to these clusters, /s/ can form a two-consonant cluster with any licit singleton onset except the palatal sonorants /ɲ, ʎ/, and the sibilants /s, ʃ, ʦ, ʣ, ʧ, ʤ/. In the clusters in (21), [z] results as a voice-assimilated alternant of underlying /s/, which parallels the behaviour of the same string, syllabified as coda+onset, word-internally (*fantasma* /fan.tas.ma/ [fan.taz.ma]). In word-initial tri-consonantal clusters, Krämer (2009) states that /s/ can precede almost any licit branching onset. The table in (22) shows the inventory of Italian initial clusters. The consonants in (22) are organized in line with analyses which assume that /s/ is not part of an onset when it appears in an initial cluster.

(22) Segmental restrictions on initial clusters in Italian

	C_1	C_2	C_3
a) C_1C_2	/s/ +	/p, t, k, f, b, d, g, v, m, n, l, r/	
b) C_2C_3		/p, t, k, f, b, d, g/	+ /l, r/
c) $C_1C_2C_3$	/s/ +	/p, t, k, f, b, d, g/	+ /l, r/

The distribution of consonants in (22a) differs clearly from (22b). In (22a), the second consonant is much less constrained, as the cluster does not need to rise in sonority, while in (22b) the initial consonant is the less constrained member of the cluster but consistently enters in a rising sonority profile with the following liquid. (22c) shows how the sequences in (22a) and (22b) fully concatenate into tri-consonantal sequences. Another asymmetry in these cluster types is that while tautosyllabic obstruent+liquid clusters occur word-medially, sC strings word-internally are always analyzed as heterosyllabic coda+onset clusters; furthermore, nouns beginning in sC clusters are preceded by vowel-final articles (Davis 1990, among others). Given these two profiles of clusters, I refer to sC clusters, in (22a), separately from CL clusters, in (22b). Table (23) below shows the combinatorial possibilities of the clusters more clearly. CL clusters are grouped by whether the initial obstruent is followed by /l/, which can pair with labial and velar stops, and or by /r/, which can pair with labial, coronal, or velar stops. While /l/ and /r/ constitute a single sonority class (liquid, henceforth L), it is clear that there are asymmetries between these sounds as well.

(23) Initial cluster types in Italian

CL	C+/l/	pl, bl, kl, gl, fl
	C+/r/	pr, br, tr, dr, kr, gr, fr
sC		sp(l, r), sb(l, r), st(r), sd(r), sk(l, r), sg(r), sf(r), sv, sm, sn, sl, sr

Moving now to the right edge of syllables, as summarized in (24) below, we find that word-medial codas in Italian are restricted to coronal continuants /l, r, s/, homorganic nasals, and the first half of geminates. The coronal continuants can co-occur in heterorganic clusters (e.g., a**lp**i 'Alps', ve**sp**a 'wasp'), as well as in homorganic (place-sharing) contexts (e.g., a**lt**o 'high', pa**st**a 'pasta'), where the following (onset) consonant is unconstrained. /r/+coronal clusters are also attested in both heterorganic (e.g., co**rp**o 'pig') and homorganic environments (e.g., po**rt**o 'port'), however, as we will see, /r/ shows no place advantage in Italian development.[9] As their label indicates, homorganic nasals always share place with the following onset, and this place sharing is the only constraint imposed on this cluster type (i.e., any onset can be preceded by a homorganic nasal). Finally, geminates only occur word-internally, they are therefore commonly analyzed as coda-onset sequences (Loporcaro 1996).

(24) Segmental restrictions on syllable codas in Italian

	Allowed coda-onset sequences
a) sonorants	/C_iC_i, NC, lC, rC,/
b) obstruents	/C_iC_i, sC/

Now that the relevant facts of Italian are laid out, I turn to predictions that can be made for phonological development in this language in light of the literature covered in chapter 2.

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[9] Because of the distribution of /r/ cross-linguistically and within languages, as well as facts about its development, /r/ has been argued to be cross-linguistically placeless (Rice 1992; Rose 2000; Goad & Rose 2004).

3 Predictions for acquisition

In this section I discuss predictions for the acquisition of Italian clusters described above, based on structural theories of sonority and markedness (Rice 1992), place sharing (Goldsmith 1989), and the syllable structure representations involved in geminates (Ota 2001) and sC clusters (Kaye 1992; d'Andrade & Rodrigues 1998; Mateus & d'Andrade 2000; Goad 2011, 2012).

The first half of a geminate (i.e., the coda of heterosyllabic C_iC_i sequence) is analyzed as a position whose features are completely supplied by the following onset, as illustrated in (19a) above. In this view, geminates are the unmarked coda-onset sequence and, as such, we might expect them to be acquired first among child learners, as Ota (2001) observes in the acquisition of Japanese. That is, under this analysis, geminates are predicted to be acquired before NC, LC, and sC clusters in Italian, as formulated in (25a) below.

Building on this structural representation for geminates, homorganic (or place-sharing) nasals in NC clusters are analyzed as positions which license their own nasal feature, but whose place features are licensed by the following consonant, as illustrated in (19b). This analysis also attributes a less marked structure to NC clusters than to coda+onset clusters, whose codas must be responsible for their own place features (e.g., heterorganic LC clusters), as stated in (25b) below.

Recall that Zeč (1995) states that the unmarked coda is a sonorant. Structural theories of the syllable have captured this by formulating a constraint on consonants at the end of a syllable to be greater than the sonority of the following segment, as per the SCL in (15). While this seems to suggest that all sonorants in codas are less marked than all obstruents, it also indicates that the least marked sonorant is the least marked coda (laryngeals aside, as there are none in Italian).

Also recall that Rice's (1992) proposed structure for stops, in (18a) above, is less marked than that for continuants, where the latter have an additional [continuant] feature dominated by the AF node. From these observations, one would expect stops to be less marked than continuants in codas. It is intriguing, then, that Italian allows /s/ while prohibiting any other non-geminate stop, or indeed any other obstruent, in coda. Instead, only /s/ is allowed, which indicates that it is some property of this consonant itself which affords it this distributional possibility. Goad (2016) examines /s/ and other strident fricatives across languages where its distribution varies and concludes that, due to their robust perceptual cues, stridents often pattern outside the sonority class of obstruents (see, also, Rose & Demuth 2006 for evidence from loanword adaptation). If this is the cause of the distributional freedom of /s/ in Italian, then the question remains concerning the sonority class that /s/ patterns with. As NC clusters are the unmarked coda-onset cluster, we will compare sC clusters to LC. This competition between the relative acquisition of LC and sC clusters is formulated in (25c).

From a structural standpoint, researchers analyze word-medial coda consonants to be structurally dependent on following onsets (McCarthy & Prince 1986; McCarthy 1988; Goldsmith 1990; Kaye 1990; Rice 1992; Piggott 1999). Similarly, the second consonant in complex onsets (i.e., liquids in Italian) is dependent on the head of the onset constituent (McCarthy & Prince 1986). Looking back at the inventories of sounds which Italian allows in these positions, shown in (22), onsets display all available contrasts in the language, while codas allow only a subset of these (/l, r, n, s, C_1/), and the second member of complex onsets allow for a more restricted subset (/l, r/). Recall the typology suggested by Kaye & Lowenstamm, and specifically the prediction that all grammars with complex onsets will have final consonants. If these final consonants refer to codas, we should expect the least marked coda-onset cluster (NC) before the first CL cluster. The contrast between the opposing evidence summarized here is formulated in (25d) below. As liquids are the only class of sounds available in both types of dependent structures, we can also make the comparison between CL clusters and LC clusters.

As discussed in chapter 2, §1.2.4, there are three main possibilities in the syllabification of word-initial sC clusters entertained in the literature. Many researchers analyze these clusters, in parallel with other left-edge clusters, as complex onsets. Others (Hulst 1984; Goldsmith 1990; Goad & Rose 2004) propose that /s/ in sC clusters is syllabified as an appendix, licensed by some higher prosodic unit (e.g., syllable, prosodic word), while yet others (Kaye 1992; d'Andrade & Rodrigues 1998; Mateus & d'Andrade 2000; Goad 2012, 2016a) propose that the /s/ is syllabified as the coda of an empty-headed syllable. The branching onset analysis predicts parallels with other branching onsets (CL), which does not hold true of the distribution of consonants in sC clusters, as schematized in (22). The appendix analysis draws no parallel between word-initial and word-medial sC clusters. A coda-onset analysis of word-initial sC clusters predicts parallels in the acquisition of word-initial and word-medial sC clusters, and has been reported for Portuguese (Freitas 1997). This position is expressed in the prediction in (25e) below.

(25) Predictions for Italian cluster acquisition
a) We will observe geminates emerge before other coda+onset clusters.
b) We will observe NC clusters emerge before LC clusters.
c) We will observe LC clusters before medial sC clusters.
d) We will observe CL clusters emerge after NC clusters.
e) We will observe word-initial sC clusters emerge at the same time as word-medial sC clusters.

In sum, Italian offers a constrained inventory of syllable codas, as well as complex onsets, as best summarized through a comparison between the inventories in (23) and (24). It is in light of this central observation that I formulate my research questions next.

Chapter 4: Research questions and methods

I propose to study a corpus of Italian-learning children, which I describe below, in order to show how phonotactics and the structural relations they suggest contribute to the developmental trajectories of children's phonological grammars.

I state my research questions, below in (26). These are formulated to test the predictions of a structural theory on the development of clusters for Italian-learning children, made above in (25).

(26) Research questions
a) Do we observe geminates emerge before other coda-onset clusters?
b) Do we observe NC clusters emerge before LC clusters?
c) Do we observe LC clusters before medial sC clusters?
d) Do we observe NC clusters emerge before CL clusters?
e) Do we observe word-initial sC clusters emerge at the same time as word-medial sC clusters?

1 Materials

The data come from a corpus documenting 4 children (VL (female), BS (male), CN (female), and TA (female)) learning Italian as their first language, who were recorded in Trieste, Italy (Zmarich *et al.* 2012). This corpus has been processed for online publication through the PhonBank database (Rose & MacWhinney 2014). I have received personal permission from Dr. Claudio Zmarich to use these data for my research. The children are typically-developing monolingual Italian children from northern Italy. Recall that the varieties of Italian spoken in northern Italy typically do not maintain the geminate contrast, which will have consequences on the results in this investigation.

The children were first recorded at 18 months (1;6), and every third month from then until they reached four years of age (i.e., 11 recordings per child; the child CN was recorded at 1;11 instead of 2;0). Recordings made at 1;6 are significantly shorter than later recordings. The contributors, who are trained linguists and speak Italian as their native language transcribed the first four sessions (1;6-2;3) orthographically and using IPA transcriptions, and have deemed these sessions to be representative of the children's early stages of development. These transcribed sessions are what I analyze as part of my thesis. The digitized recordings consist of WAV files encoded at a sample rate of 44.1kHz, with a 16-bit sample size. These transcribed recordings last an average of 35 minutes, for a total of approximately 8 hours of transcribed audio. While segments were checked for inter-transcriber reliability, stress was not, and is inconsistently transcribed across different sessions. As a result, any investigation involving stress patterns would require a systematic re-transcription of stress annotations.

The recording sessions took place between a speech therapist and the child, sitting in front of toys while playing with and naming them, as illustrated in (27) below. As can be seen from these examples, articles are used variably by children.[10]

(27) Investigator-child interactions in Italian

Speaker	Orthography	Translation	Age
Serena	E questo come si chiama ?	And this one, what is it called?	
VL	treno	Train	1;6
	[teno] for |treno|		
Serena	Chi c'é? La rana, come si chiama ?	Who is it? The frog, what's its name?	
VL	La rana	The frog	1;6
	[ke lana] for |la rana|		

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[10] The development of articles is a topic I do not discuss further, as it is beyond the scope of this thesis.

Serena	Dove nuota il pesce? Nell’acqua. Come si chiama?	Where does the fish swim? In the water. What is it called?	
VL	l’acqua [lakwa] for |ˈlak̚kwa|	The water	1:6

The toys were chosen from a word list compiled by parents based on the MacArthur CDI list (Caselli & Casadio 1995). The researchers verified that, for each child, the sessions at ages 1;6 and 1;9 included at least 50% of the words from each child’s word list compiled by their parents, in order to provide a representative assessment of their early phonological abilities based on a sufficient amount of known words. In addition to this, a set of nonce words used as the names of various toy animals were elicited by the speech therapist. The toy names were the following minimal-pair pseudo-words, contrasting labial, dental and velar voiced and voiceless stops: ‘papa’, ‘baba’, ‘pipi’, ‘bibi’, ‘tata’,‘dada’, ‘titi’, ‘didi’, ‘kaka’, ‘gaga’, ‘kiki’, ‘gigi’.

I analyzed the phonological productions of these Italian children using a specialized software program called Phon (Hedlund & Rose 2019; Rose & MacWhinney 2014), designed specifically for the building and analysis of phonological corpora. I used Phon’s query and reporting functions to extract the behavioural data for each child’s initial and medial clusters, at each recorded age. This allowed for the systematic extraction of both qualitative and quantitative data on the children’s developing systems over the documented time period.

2 Methods

I investigated the questions formulated above in (26) by observing the corpus of the four Italian-learning children described above. To investigate these questions, I needed to account for behaviours in both segmental and prosodic development. I frame my interpretation of these results within the sub-theories summarized below.

Throughout the ensuing data descriptions, I refer to two time points. Mastery of prosodic structure (or prosodic mastery) is defined as when the child begins to produce at least 50% of targeted clusters with outputs matching the prosodic structure of the input (i.e., when there is one-to-one correspondence between segments in the input and the output at least 50% of the time). I refer to segmental mastery as the period when a child achieves 75% segmental accuracy within a single recording, or shows a substantial increase in accurate productions as compared to the previous recording. Acquisition refers to the process of achieving mastery along both prosodic and segmental dimensions. I ignore data from recordings with fewer than four tokens unless they show a single behaviour 100% of the time.

I also note certain behaviours in addition to prosodic reduction and segmental substitution. Fusion is a process whereby two segments (consonants, in our discussion) are represented within a single prosodic position. Fusion is distinct from a prosodic reduction in that the output incorporates segmental features from both members of the target cluster. Epenthesis is the addition of a segment (pertinently, a vowel) between the two consonants of the target cluster in the output. These will be discussed in more detail when relevant to the observations.

In formalizing prosodic and segmental development, I assume that children elaborate structural representations node by node, in the spirit of Fikkert’s (1994) analysis of Dutch syllable acquisition, and in accordance with Goad & Rose (2001, 2004) in positing that children do this through their analysis of the segmental distributions relevant to the input language. This analysis incorporates the research on prosodic representation detailed above in chapter 2 §1.2, and specifically work on syllabification of sC clusters at the left edge of words (Kaye 1992; d’Andrade & Rodrigues 1998; Goad 2012). I frame the analysis of segmental development with monovalent, hierarchically-organized features in line with Rice’s (1992) proposed structural representation of sonority, within the SV node, illustrated in (16)-(18). I also account for the preference for feature-sharing by incorporating structures like those illustrated in (19).

Chapter 5: Observations

In this chapter I detail the developmental trajectories of segments across prosodic positions for the four Italian-learning children considered in the current study (VL, BS, CN, and TA), focusing on the initial and word-medial clusters in (23) and (24) respectively. I also compare the relevant segments in clusters to their singleton counterparts in order to separate purely segmental behaviours from those likely to be structurally motivated. I compare the structural and segmental development of segments for each child, and also report on prominent substitution patterns. I then form generalizations about the behaviour of segments in clusters, which I will analyze in Chapter 6, based on representational properties of these clusters.

To address the research questions above in (26), I begin, in §1, with the development of medial clusters, as I describe the timelines of each cluster type and the most prominent substitution patterns they involve. In §2, I discuss initial clusters (i.e., word-initial sC clusters, as well as word-initial and word-medial CL clusters) including timelines and substitutions. In §3, I summarize the findings to be analyzed in the following chapter.

1 Medial clusters

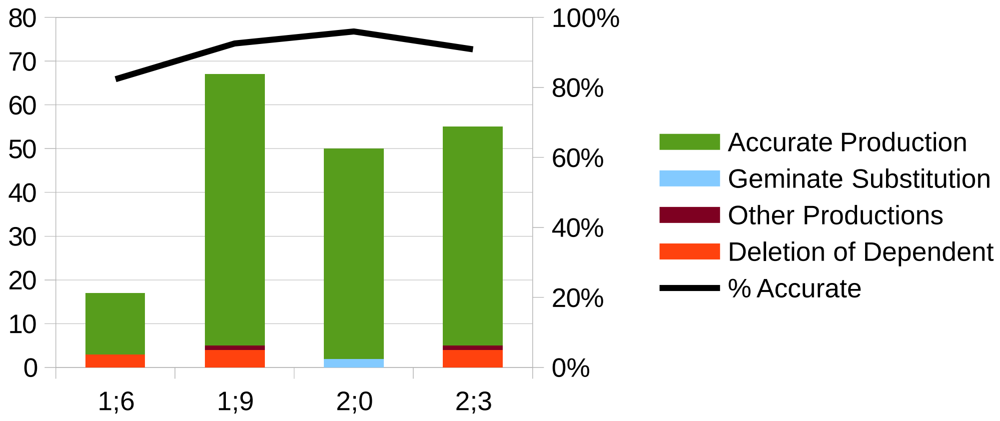
In this section, I describe the development of medial clusters, as in (24) above, unambiguously syllabified as coda-onset clusters. As we will see, many cluster types show implicational relationships, in which acquisition timelines and substitution patterns converge on a single developmental trajectory.

1.1 NC clusters

1.1.1 VL

The data in (28) show VL's behaviour in producing NC clusters throughout the recorded period, where green bars represent accurate productions (whose overall proportion is represented by the black line), red bars represent reductions that maintain the prosodic head (the C of NC clusters), and light blue represents geminate substitution (illustrated in (32) below). All other productions are classed as 'other' in brown, unless otherwise specified. Tokens are counted along the left Y-axis, while percentages (the black line) is measured along the right margin. At 1;6, VL produced NC clusters with 86% accuracy (n=14). From 1;9 onward, VL performed accurate productions of NC clusters at above 91% consistency (n≥50). We see that VL produced NC clusters with a high level of accuracy from the earliest recordings, across all PoA. VL also showed little variation throughout the recorded period (< 10% of total productions), with no prominent substitution patterns. Based on these observations, I consider VL's NC clusters to be structurally and segmentally mastered at 1;6.

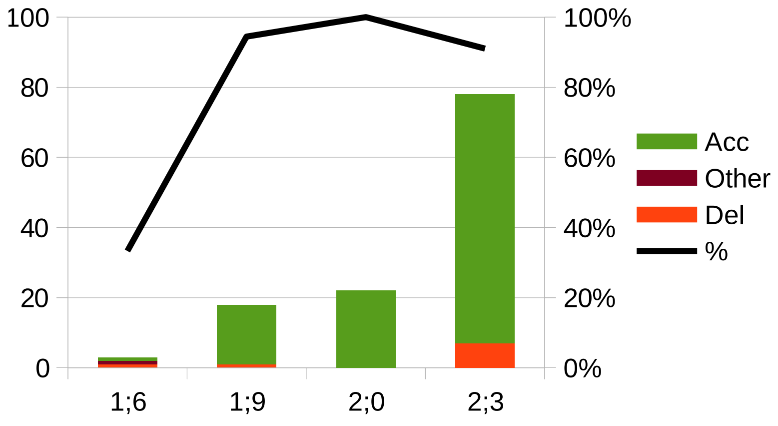
(28) VL's production of NC clusters



1.1.2 BS

In (29), we see that BS targeted too few NC clusters at 1;6 to evidence degrees of structural or segmental development. At 1;9, he produced NC clusters with above 90% accuracy, showing mastery of both structure and segmental content. This mastery-level accuracy continued throughout the remainder of the recorded period. There are no prominent substitutions for BS's NC clusters, similar to VL.

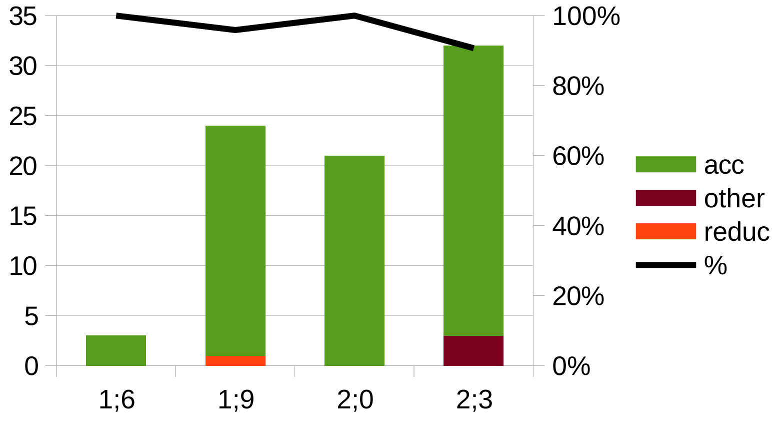
(29) BS's production of NC clusters



1.1.3 TA

(30) shows TA's productions of NC clusters, which are 100% accurate in the earliest recording at 1;6 (n=3), and continue with mastery-level accuracy from 1;9 onward (96%, n=24). Inaccurate productions of TA's NC clusters account for 5% of her total productions over the recorded period, with no single recording displaying more than 9% inaccuracy, also with no noticeable error pattern to report. Accordingly, I consider 1;6 to be the age when TA has mastered both the structure and the segmental content of NC clusters.

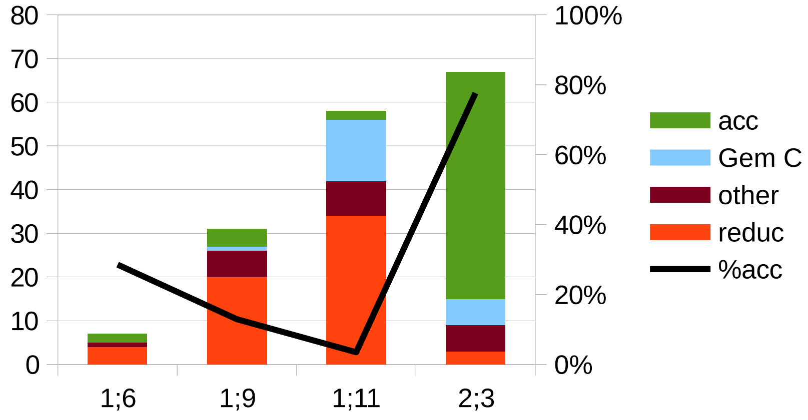
(30) TA’s production of NC clusters



1.1.4 CN

(31) shows CN’s production of NC clusters. In contrast to the previous children, CN did not display any mastery of the cluster early on. She mainly reduced NC clusters to geminates or deleted the entire cluster at both 1;6 and 1;9, while also showing marginal accuracy, and no preference for any PoA. At 1;11, she produced geminates in place of NC clusters at a rate of 24% (n=58), as exemplified in (32). These geminated clusters occurred across all PoAs. At 2;3, however, CN displayed noticeable development as she produced NC clusters with 78% accuracy.

(31) CN’s production of NC clusters



The data from 2;3 meets the criteria for both prosodic and segmental mastery. The only prominent pre-mastery pattern is geminate substitution, where NC_i clusters are produced as C_iC_i, as shown in (32) below. As we can see, geminate substitution occurs in labial, coronal, and velar environments.

(32) Geminate substitution in CN’s NC clusters

Orthography	Adult form	Child form	Gloss	Age
zampa	/ˈʦa**mp**a/	[ˈa**p̚p**ʰa]	‘paw’	1;11
denti	/ˈdɛ**nt**i/	[ˈje**t̚t**i]	‘teeth’	1;11
attenti	/at̚ˈtɛ**nt**i/	[attɛ̃**t̚t**i]	‘attention’	2;3
anche	/ˈa**ŋk**e/	[ˈa**kk**æ]	‘also’	2;3

1.1.5 Summary of NC clusters

The developmental timeline for all children is shown in (33) below, where ‘pro’ stands for prosodic mastery, and ‘seg’ stands for segmental mastery. As we can see, all children mastered the prosodic and segmental content of NC clusters within the recorded period. Many children mastered both at the same age, however this may be due to a generalized floor effect, as this cluster appears to be acquired early for most children.

(33) Child production of NC clusters[11]

	Type	1;6	1;9	1;11/2;0	2;3
VL	pro	✓			
	seg	✓			
BS	pro		✓		
	seg		✓		
TA	pro	✓			
	seg	✓			
CN	pro				✓
	seg				✓

---

[11] CN was recorded at 1;11, and not at 2;0. I collapse these two ages in the table (33) for parsimony.

The only pre-mastery substitution pattern was exhibited by CN, who produced NC clusters as geminates prominently at 1;11, and marginally at both 1;9 and 2;3.

1.2 LC clusters

In this section, I describe patterns in the development of liquid+consonant clusters, consisting of both lC and rC types. As we will see, /l/ and /r/ do not behave as a monolithic class; rather they appear to show implicational relationships involving both their age of mastery, and related substitution patterns.

1.2.1 VL

As shown in (34), VL deleted the /l/ in lC clusters, producing only the C at 1;6. At 1;9, she accurately produced lC clusters at 27% (n=11), as her accurate productions were limited to place-sharing (lT) contexts. VL only deleted /l/ in place-sharing environments where the following consonant was an affricate. Also at this stage, she produced /l/ as a nasal (shown in yellow) in two place-sharing environments, and [rtr][12] for the cluster /ltr/ (shown in dark green), as exemplified in (35). At 2;0, VL produced lC clusters 77% of the time, including in /l/+labial (lP) contexts (n=13). She did not attempt /l/+velar (lK) clusters at this age. At 2;3, VL produced lK clusters, acquiring the cluster across all PoAs.

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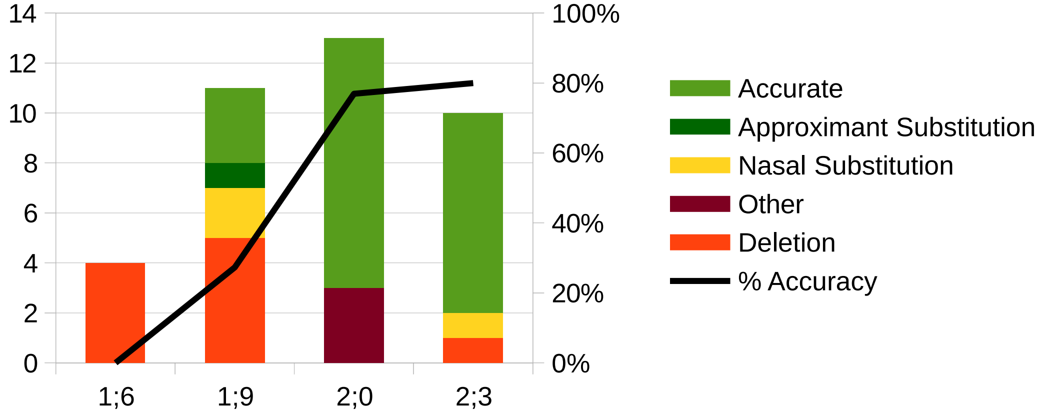
[12] This coda [r] sounds quite different from VL's later productions of /r/, and is produced at a stage when /r/ is rarely produced accurately. It is likely that this substitution is actually a spectrally-deficient [l], which sounds [r]-like because of the [r] in the following complex onset.

(34) VL’s production of lC clusters



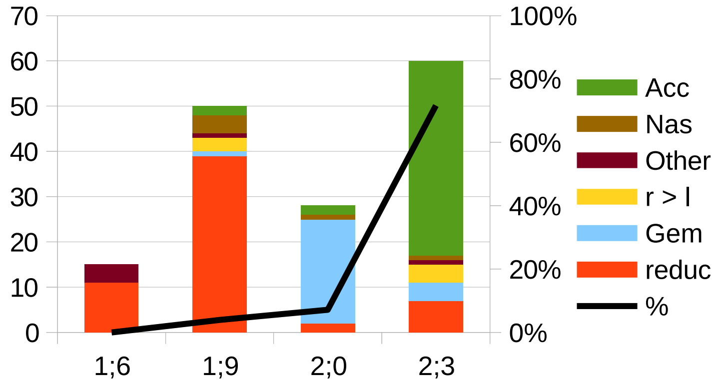
VL’s productions at 1;9 show mastery of lT clusters, with the exception of affricates, as mentioned above. I also consider her lC structure to be mastered at this age, given that over 50% of her productions were not reduced, and therefore faithful to the coda+onset structure. From 1;9 to 2;0, the notable increase in VL’s segmental accuracy of lC clusters indicates she had mastered the segmental content of this cluster by 2;0.

(35) Sonorant substitutions in VL’s lC clusters

Orthography	Adult form	Child form	Gloss	Age
salti	/ˈsa**lt**i/	[sã**nt**ĩʰ]	‘s/he jumps’	1;9
poltrona	/po**l**ˈ**t**rona/	[po**rt**rɔnã]	‘armchair’	1;9

As a point of reference, VL produced /l/ accurately in 61% of singleton onsets (n=28) at 1;6, and 80% of the time (n=156) at 1;9. This suggests that the cluster environment was constraining her development of /l/ syllable codas at least by 1;9, if not before.

(36) VL’s production of rC clusters



VL’s rC cluster productions, in (36), show that at 1;6 she reduced most clusters to the C. At 1;9, she still reduced most clusters. She also exhibited a number of marginal patterns, including substituting /r/ by a homorganic nasal, substituting /r/ for [l], as well as substituting the cluster for a geminate, as shown in (37).

(37) Geminate substitution in VL’s rC clusters

Orthography	Adult form	Child form	Gloss	Age
barca	/ˈba**rk**a/	[ˈbḁ**kˌk**ɜ̥]	‘boat’	2;0
barba	/ˈba**rb**a/	[ˈḅa**ḅḅ**a]	‘beard’	2;0

Two targeted rC clusters at 1;9 were accurately produced, /rs/ and /rk/, spanning different places and manners of articulation, out of 50 tokens. At 2;0, the vast majority of productions (82%, n=28) resulted in substituting the cluster with a geminate, yet VL also accurately produced both [rm] and [rf] clusters at this age. At 2;3, VL produced the majority of target rC clusters accurately (72%, n=60), across all PoAs and MoAs. VL substituted geminates for rC clusters less frequently at this age (7%), and also exhibited a marginal amount of [l] substitution (only before stops; 7%).

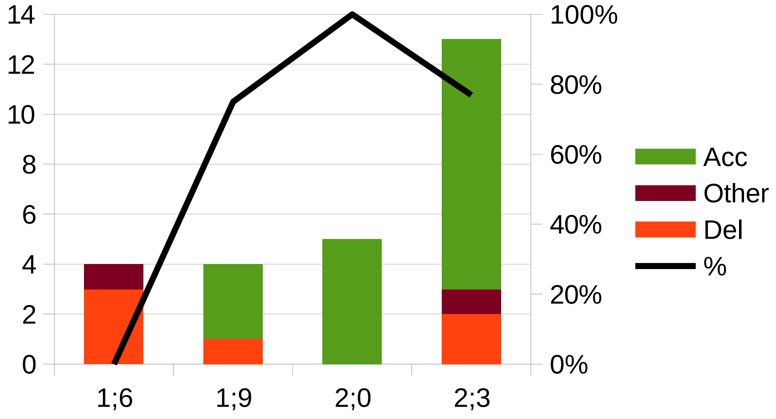
As a comparison, VL produced singleton onset /r/ as [l] 52% of the time (n=27) at 1;6, and 84% (n=63) at 1;9. At 2;0, she produced /r/ accurately 45% of the time (n=47). These results are in stark contrast to the behaviour of /r/ in rC clusters, where she exhibits neither a prominent /l/ substitution pattern, nor early mastery. VL's rC clusters were structurally mastered at 2;0, a stage when singletons were produced at chance. However her productions do not show segmental mastery until 2;3.

In comparing (34) and (36), it is clear that there is not a uniform timeline for VL's acquisition of liquids. At 1;9, VL produced /l/ at a much higher accuracy than /r/ (27% vs. 4%, respectively). At 2;0, when VL began to accurately produce lC clusters the majority of the time, she also began to substitute geminates for almost all rC clusters. At 2;3, when VL began to reliably produce lC clusters across all PoAs, she also began to accurately produce rC clusters in similarly high proportions. The two liquids also differ in that, upon first appearing in VL's productions, lC clusters were clearly constrained by place, while rC clusters do not show the same pattern. Additionally, lC clusters did not undergo a stage of geminate substitution.

1.2.2 BS

Similar to VL, as we see in (38), BS mainly reduced lC clusters at 1;6. At 1;9, he accurately produced all lC clusters in lT environments, but still reduced the lP clusters. At 2;0, BS began producing lC clusters accurately in all PoA, however he attempted only /l/+stop clusters at this age. At 2;3, BS maintained accuracy in all but one /l/+stop production. Also at this age, BS began attempting /l/ before fricatives (/ls/ and /lv/), reducing each of these clusters.

(38) BS’s production of lC clusters



In isolating the structural effects from the purely segmental, I compare BS’s production of lC cluster with his singleton /l/. In singletons, BS produced an accurate [l] and two deletions at 1;6. In contrast to this, at 1;9, BS produced singleton /l/ with 77% accuracy, showing mastery of the consonant. As BS took until 2;0 to master lC clusters, constraints on the production of this cluster are likely the reason for the delay. BS shows mastery of both segmental content and the prosodic structure of lT clusters at 1;9. At 2;0, he shows segmental mastery of lC clusters across all PoA.

In (39) we see that BS reduced most rC clusters. At 1;9, BS mainly reduced rC clusters, however he also substituted the cluster for a geminate in three attempted clusters. At 2;0, BS produced /r/ as [l] in 45% of his attempts at the cluster (n=22); these all took the shape [l]+stop.[13] BS exhibited these substitutions in /r/+coronal and /r/+labial environments, revealing no place-sharing preference. He reduced an additional 41% to a singleton C at 2;0. At 2;3, [l] substitution accounted for 69% of BS’s productions. These included /r/+stop and /r/+fricative

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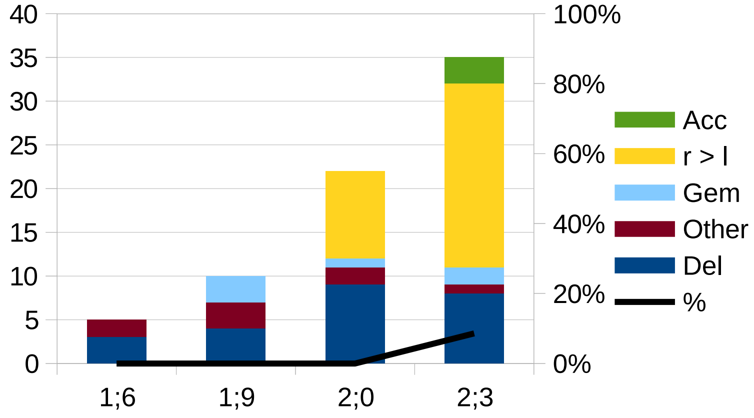
[13] The word *sberla* /zberla/ was produced as [belda]. While the underlying environment is not /r/+stop, the output is [l]+stop.

clusters. His accurate productions of rC at this age consisted of two [rm] clusters, and one case of [rs].

(39) BS’s production of rC clusters



In singletons, BS produced /r/ as [l] in no more than 20% of his attempts at this consonant at any given stage. This suggests that the substitution to [l] in clusters has to do with pressures arising from the cluster itself. At 2;0, BS’s rC structure was mastered at the structural level. However, BS did not master the segmental content of rC clusters during the recorded period.

(40) Lateralization in BS’s rC clusters

Orthography	Adult form	Child form	Gloss	Age
torta	/ˈtɔ**rt**a/	[ˈto**lt**a]	‘pie’	2;3
barca	/ˈba**rk**a/	[ˈba**l̥k**a]	‘boat’	2;3

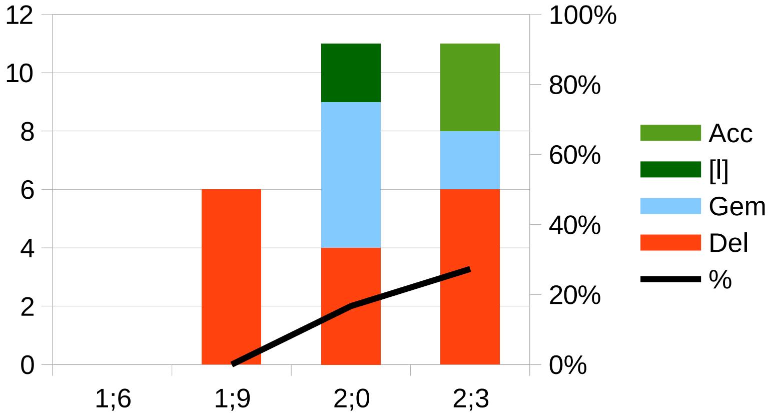
The data in (38)-(39) show that, similar to VL’s, BS’s liquids exhibit distinct timelines. At 1;6, we see parallels across lC and rC clusters, in that they were reduced across-the-board. At 1;9, BS produced /l/ in place-sharing environments, while his productions of rC clusters show mostly reductions. At 2;0, BS began to accurately produce lC clusters in all place environments, while his rC clusters display [l] substitution. At 2;3, BS reduced all /l/+fricative clusters (/lv/ as [v], and /ls/ as [s]), while he produced [lv] and [ls] in place of /rv/ and /rs/ clusters respectively.

That is to say, BS’s outputs of [l]+fricative at 2;3 are all and only for target rC clusters, while all /l/+fricative clusters are reduced to a singleton C.

1.2.3 TA

Moving now to the children that did not master LC clusters in the recorded period, we begin with TA. TA first attempted lC at 1;9, as shown in (41), reducing all clusters. At 2;0, TA substituted /l/ +stop clusters five times with geminates, and reduced the cluster four times to a single C. She also produced /lv/ clusters as [l] singleton onsets in the word *salvagente* /salvaˈʤɛnte/, producing [alʊaʤenːte], and [hɛləˈgɛntɛ].[14] At 2;3, TA reduced eight lC clusters, including /lv/ to [v]. She also substituted lC clusters for geminates in two attempts. At this age, TA produced /lt/ and /ld/ accurately, as [lθ] and [l̥ð] respectively. At this stage /t, d/ are produced as [θ, ð].

(41) TA’s production of lC clusters



For reference, TA was producing singleton onset /l/ accurately at 2;0. This indicates that TA’s production of /l/ in clusters is affected by the cluster environment. Her productions at 2;0 are indicative of prosodic mastery. TA’s behaviour in lT clusters does indicate segmental mastery

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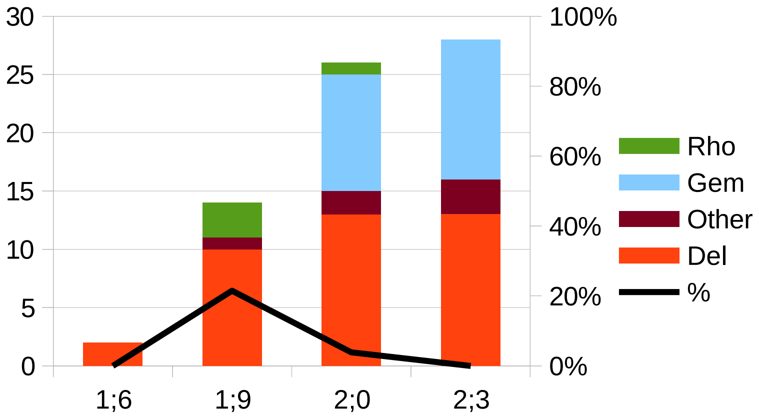
[14] It appears TA has misinterpreted /v/ as the onglide of a light diphthong, which would suggest her /l/ became an onset due to syllabification markedness. Later at 2;3, she has reanalyzed /v/ as consonantal, reflected in her reduction of /lv/ clusters to [v].

at 2;3, at least in homorganic environments, however she did not reach segmental mastery of the cluster across PoA.

In (42) we see that TA produced no fully accurate attempts at rC clusters during the recorded period. She attempted few rC clusters at 1;6, reducing all of them. At 1;9, she produced [ɹ] in /r/+labial targets. She also produced [nd] in place of /rn/ at this age. At 2;0, TA reduced rC clusters to geminates in 38% of her productions (n=26). We also see a single rhotic production in an /r/+coronal cluster. At 2;3, we see the same geminate substitution occurs 43% of the time (n=28). TA produced no rhotics at this age.

(42) TA's production of rC clusters



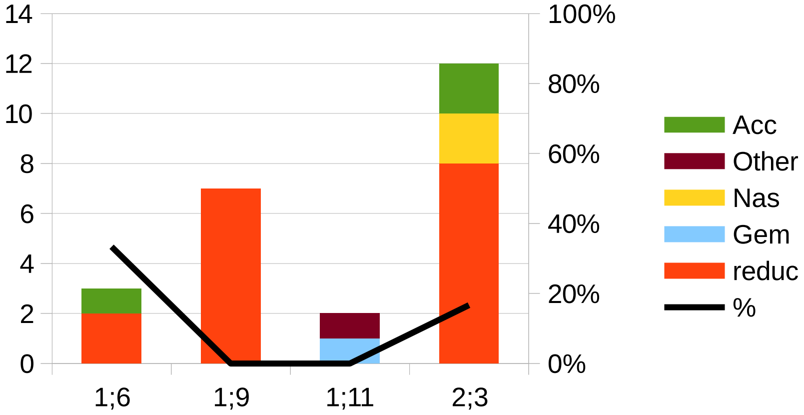
Comparing again to singletons, TA never produced /r/ with more than 4% accuracy in any recording. We can see that TA's cluster behaviour at 2;0, by nature of achieving 50% unreduced clusters, is indicative of prosodic mastery. From her behaviour in singletons as well as in rC clusters, TA shows no evidence of segmental mastery.

Comparing (41) and (42), we see parallel trajectories. TA reduced both lC and rC clusters in early recordings. While she produced some rhotics in rC clusters from 1;9 onward, the majority of her productions consisted of cluster reductions and geminate substitutions. Similarly, while she produced /l/ with some accuracy at 2;0 and 2;3, TA primarily substituted geminates for the clusters. Her accurate /l/ productions at 2;3 were exclusively place-sharing clusters.

1.2.4 CN

Shown in (43), CN's production of lC clusters are sparse, with very few accurate productions. She produced a single accurate token of [lt] at 1;6, reducing the other lC clusters at this age. At 1;9, she reduced all clusters, including /lt/ clusters. At 1;11, CN substituted /lt/ for [tt]. She also produced /ld/ as [j]. At 2;3, CN reduced most lC clusters, however she also produced accurate [l] in two lT clusters. At the same age, she produced lT as [n]+coronal.

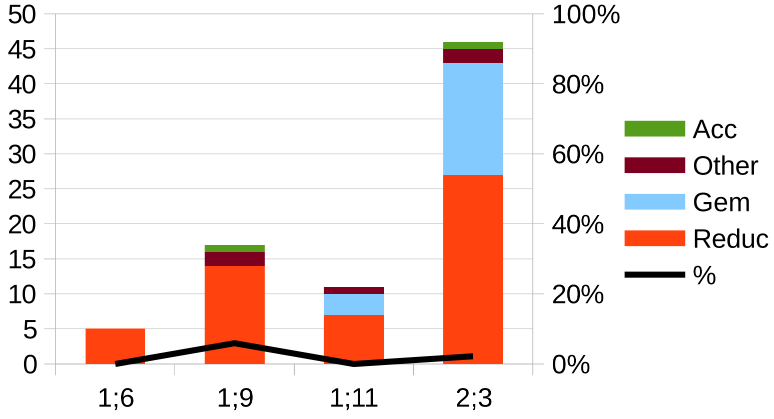
(43) CN's production of lC clusters



Looking to singletons as a comparison, CN produced /l/ accurately only 63% of the time (n=105) at 2;3. This potentially accounts for her lack of segmental mastery in lC clusters. However, CN shows no prosodic mastery of lC clusters either.

The figure in (44) shows that CN's productions of rC clusters are primarily reduced from 1;6 to 1;9. Also at 1;9, CN reduced /rb/ to a singleton [r]. At 1;11, CN began substituting rC clusters for geminates. This pattern continued at 2;3, when CN substituted rC clusters to geminates in 35% of attempts (n=46). At this age, she also produced a single accurate /rp/ cluster. This last observation shows that CN exhibits no preference for coronals in rC clusters, similar to the other children. Looking at singletons, CN produced a single accurate token of [r] throughout the recordings. Given this, we would expect no segmental mastery in CN's rC productions.

(44) CN's production of rC clusters



In comparing (43) and (44), we see that CN mainly reduced both lC and rC clusters at 1;6 and 1;9. She also produced a single accurate token of each cluster at this stage; an lT cluster and an /r/+labial cluster. CN targeted fewer lC clusters overall, however 2;3 marks a notable change in patterning. At this age, CN produced both accurate lT clusters, while producing other lT as NC clusters. CN began producing rC clusters as geminates at 1;11, a pattern that became more robust at 2;3.

1.2.5 Summary of LC clusters

Children's mastery timelines are summarized in (45) below. This table shows that place-sharing lC clusters are acquired earlier for all children who did acquire the cluster during the observation period. Only VL segmentally mastered rC clusters, displaying no such preference for place sharing. While all of the children show a clear preference for place-sharing lC clusters, this is not the case for rC clusters, for any child. We return to this observation in the next chapter.

(45) Child production of Italian lC and rC clusters

		lT	lP/lK	rC
VL	pro	1;9	1;9	2;0
	seg	1;9	2;0	2;3
BS	pro	1;9	1;9	2;0
	seg	1;9	2;0	-
TA	pro	2;0	2;0	2;0
	seg	2;3	-	-

All children except BS show prominent geminate substitution for rC clusters. Instead, BS predominantly substitutes /rC/ for [lC]. In addition, although appearing more marginally, lC clusters are produced as NC clusters by VL at 1;9 and 2;3, as well as by CN at 2;3. This concludes the discussion of sonorants in medial clusters. In the next section, I discuss the only obstruent-initial medial cluster, namely sC clusters.

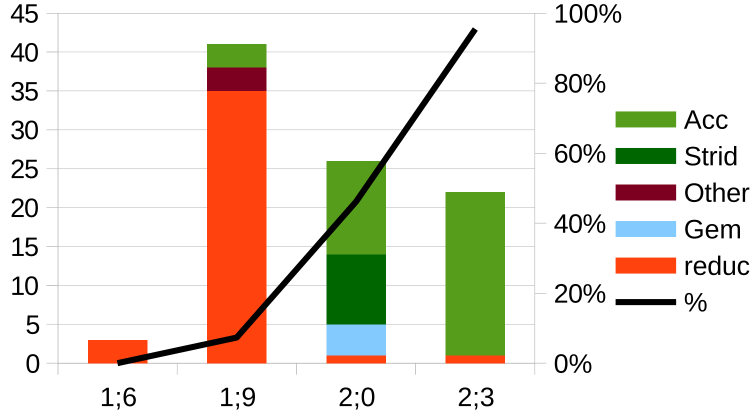
1.3 Medial sC clusters

In this section, I describe the children’s development of word-medial sC clusters. Recall from (24) that these are the only obstruent+consonant clusters in Italian, excluding geminates. I begin with VL’s acquisition of sC clusters below.

1.3.1 VL

In (46), we see that VL targeted few sC clusters at 1;6, and reduced all of them to a singleton C. At 1;9, VL also reduced the majority of her sC clusters (85%), but also produced three sC clusters accurately, two sT and one sK cluster.[15] At 2;0, VL did not reduce any sC clusters.[16] She produced 46% accurately across all PoA, and produced [ç] in place of /s/ in another 31% of attempted sC clusters (n=26), in both coronal and velar environments, for which she also substituted four sC clusters by geminates. At 2;3, VL produced 95% of sC clusters accurately (n=22), reducing only one /sk/ cluster to [k].

(46) VL’s production of medial sC clusters



In comparison to clusters, VL produced /s/ as [ç] in singleton onsets at 2;0 at a rate of 29% (n=34). The fact that this substitution occurs independently in singletons suggests that this same substitution is not due to an assimilatory process in clusters. Accordingly, I interpret this behaviour as target-like. Given this interpretation, VL’s sC clusters emerged at a high rate (77%) at 2;0. I consider this her age of prosodic and segmental mastery of sC clusters.

(47) Geminate substitution in VL’s medial sC clusters

Orthography	Adult form	Child form	Gloss	Age
bosco	/ˈbɔ**sk**o/	[ˈbɔ**kk**ọ]	‘wood’	2;0
questo	/ˈkwe**st**o/	[ˌkwe**tt**ɛ]	‘this’	2;0

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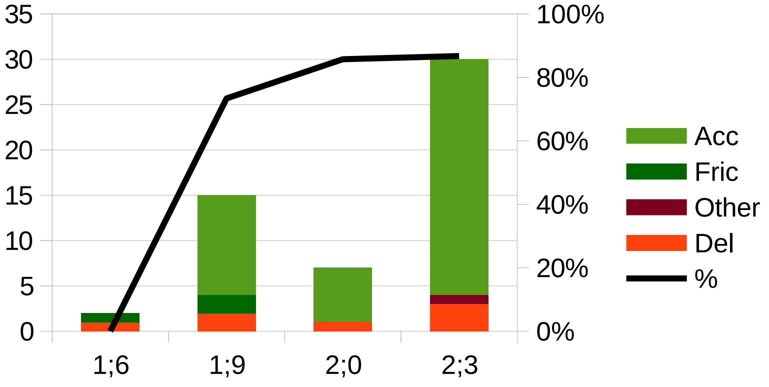
[15] VL also substituted two sC clusters for homorganic nasal clusters, however these were both in phrases that had preceding nasals, with *finestre* resulting in [finente] and *in tasca* as [in tãŋkaʰ]. These behaviours are beyond the scope of the this thesis, but see (Piggott 1995) for a discussion of adult nasal harmony.

[16] VL truncated the final two syllables in the word *finestra* /fiˈnestra/, producing [fin], utterance-finally.

1.3.2 BS

In (48) we see BS's sC clusters. The data show that BS attempted few sC clusters at 1;6. The only targeted cluster was /st/, which was pronounced [ðd].[17] At 1;9, BS accurately produced 73% of targeted sC clusters (n=15), all involving coronal stops. He also produced [χk] for /sk/ at this age, shown in (49). At 2;0, BS produced /s/ accurately across all sT (n=4) and sK (n=2) clusters, however he produced one sK clusters as [st]. He also truncated one /st/ cluster at 2;0. BS attempted no sP clusters at this age. At 2;3, BS produced 87% of attempted sC clusters accurately, including one sP cluster. BS's only reduced clusters at this age were /sp/ produced as [p], and /str/ produced as [tr].

(48) BS's production of medial sC clusters



By comparison, in singleton onsets, BS never produced /s/ as any of the substituted fricatives reported above, mastering the consonant at the first stage for which there is evidence (he attempted no singleton /s/ at 1;6). From 1;6 to 1;9, BS assimilated coda /s/ to the following onset, resulting in coronal fricatives [ð, θ, s] before coronals and the uvular fricative [χ] before velars. This behaviour is indicative of prosodic mastery, with control over just enough segmental

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[17] BS produced voiceless stops with variable voicing at this age.

content to produce place-sharing sC clusters.[18] At 2;0, BS produced [s] correctly in these coronal and velar contexts, indicating full segmental mastery. BS did not attempt any clusters involving labials until 2;3, at which point he reduced the only targeted cluster.

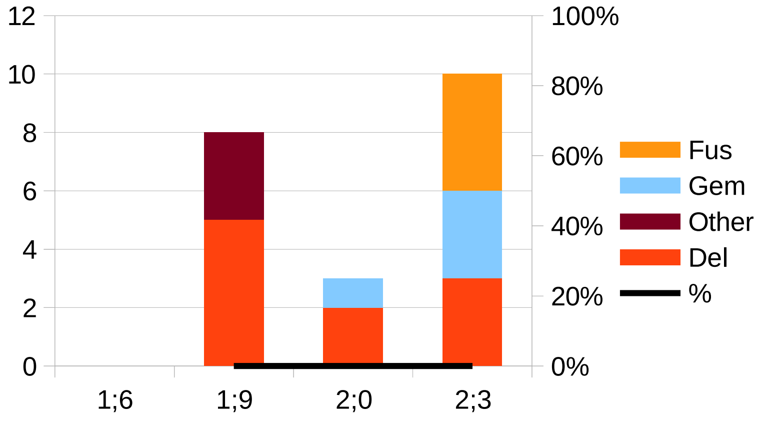
(49) Assimilation in BS’s medial sC clusters

Orthography	Adult form	Child form	Gloss	Age
questo	/ˈkwe**st**o/	[ˈe**ðd**o]	‘this’	1;6
questa	/ˈkwe**st**a/	[ˈkwe**θ̪t**a]	‘this’	1;9
casco	/ˈka**sk**o/	[ˈka**χk**o]	‘helmet’	1;9

1.3.3 TA

(50) shows TA’s behaviour in acquiring sC clusters. She targeted no sC clusters at 1;6. At 1;9, TA reduced many sT and sK clusters to singletons. At 2;0, TA reduced /st/ and /sk/ to [t] and [k] respectively. She also substituted a geminate [tt] for /st/. At 2;3, TA continued producing /sk/ as singleton [k], while she began producing all /st/ clusters as [tt] geminates. Also at this age, she produced /sk/ clusters as [k^x], while also producing /st/ as [ʦ]. These substitutions are illustrated in (51) below.

(50) TA’s production of medial sC clusters



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[18] While [χ] is uvular instead of velar, place-sharing refers to the Dorsal feature, responsible for both velar and uvular PoAs.

While TA's production of [ʦ] for /st/ clearly involves a reduction of prosodic structure, it is not immediately clear which member of the input cluster corresponds to the resultant affricate, since it is both a stop, like /t/, and a strident, like /s/. The same holds true of [kˣ] for /sk/.[19]

(51) Gemination and apparent fusion in TA's medial sC clusters

Orthography	Adult form	Child form	Gloss	Age
questa	/ˈkwe**st**a/	[ˈkwe**tt**a]	'this'	2;3
posto	/ˈpo**st**o/	[ˈpo**ʦ**æ]	'place'	2;3
vasca	/ˈva**sk**a/	[ˈva**kˣ**ə]	'tub'	2;3

In singleton onsets, TA rarely produced [ʦ] for /s/ (4% overall, n=74), and never produced velars in its place. It is therefore unlikely that TA's output affricate singletons correspond to the /s/ of the sC cluster in the input. At 2;3, when the affricate substitutions took place, TA did not substitute [kˣ] for /k/, nor [ʦ] for /t/ in singleton onsets. It is similarly unlikely that these affricate outputs correspond solely to the input /k/ or /t/ respectively. TA's singleton affricate substitutions for sT and sK clusters, then, suggest fusion of manner of articulation (henceforth MoA) from the coda and PoA from the onset of the cluster. However, TA does not show evidence that she has mastered the segmental content or prosodic structure of sC clusters within the observed period. In fact, the fused segments imply a lack of prosodic structure, while the gemination implies a lack of segmental mastery. This indicates that TA is unable to produce the clusters in a target-like way, she is able to innovate in finding ways to represent the clusters in production.

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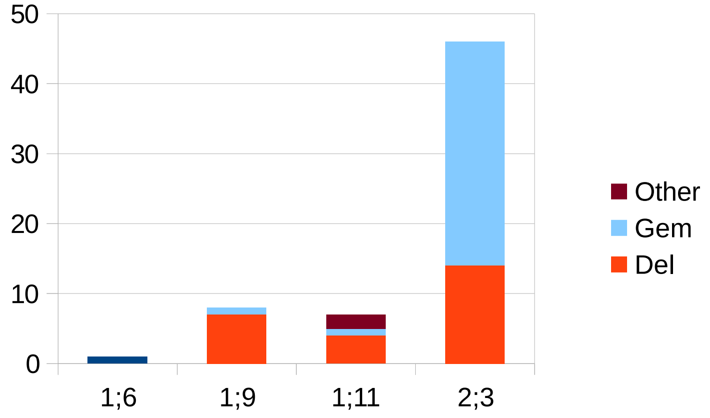
[19] While [kˣ] is not considered a strident, a high-frequency aperiodic release (the hallmark of stridents) with a Dorsal feature in consistent with this transcription.

1.3.4 CN

As we can see in (52), CN reduced her only attempted sC cluster at 1;6. At 1;9, one /sk/ cluster was substituted for a geminate, resulting in [kk]. The remainder of CN's sC clusters at this age were reduced to a singleton C. At 1;11, CN continued to reduce coronal and velar sC clusters to C. She also produced /st/ as geminate [tt]. At 2;3, CN reduced some sC clusters across all PoAs. She substituted /s/ for a geminate in 70% of sC clusters at this age (n=46), however all sP clusters were reduced to P.

(52) CN's production of medial sC clusters



In singleton onsets, CN produced /s/ with 76% accuracy at 2;3. Her behaviour in clusters at 2;3 therefore indicates prosodic mastery, but no segmental mastery.

1.3.5 Summary of medial sC clusters

The table in (53) summarizes the timelines of the children's mastery of sC clusters. BS shows preference for place sharing, acquiring sT clusters at 1;9 , while VL does not. Neither of the other children shows enough development to determine whether place sharing plays a role.

(53) Child production of Italian medial sC clusters

		1;6	1;9	2;0	2;3
VL	pro			✓	
	seg			✓	
BS	pro		✓		
	seg		☑	✓	
CN	pro				✓
	seg				

VL, TA and CN substitute sC clusters for geminates, while BS displays place assimilation (represented in the table with a boxed checkmark). TA exhibited fusion in coronal and velar clusters, resulting in affricates.

1.4 Geminates

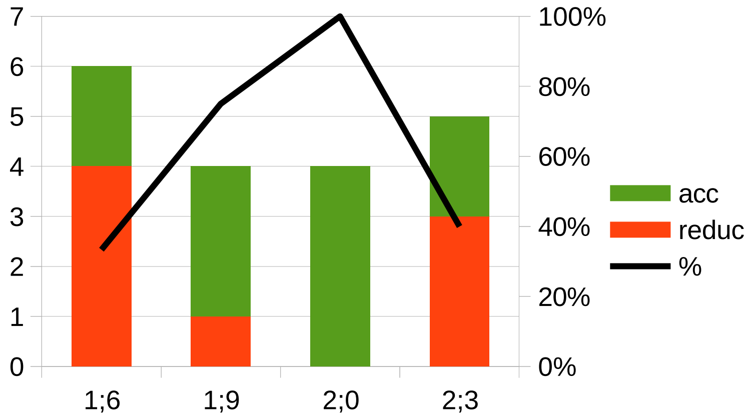
In this section, I describe the four children's productions of target geminates. As we will see, the children did not produce geminates with enough frequency to draw proper conclusions. However, some observations remain relevant, which I detail in this section. Recall the segmental structure in (19a), where both prosodic positions of a geminate share the Root node of the onset. Therefore, only prosodic mastery is necessary in acquiring geminates. Nonetheless, CN is the only child to achieve mastery.

1.4.1 VL

VL attempted labial nasal geminates sparsely throughout the recorded period (n=12). VL reduced all /mm/ geminates at 1;6 (n=4). She produced all attempts at the cluster accurately at 1;9 and 2;0 (n=3, n=1 respectively). At 2;3 she produced one full length geminate, but reduced the other three. VL attempted coronal geminates even more sparsely (n=7), however she only reduced one of these at 1;9, while she produced full-length geminates in all other recordings (1;6, 2;0, and

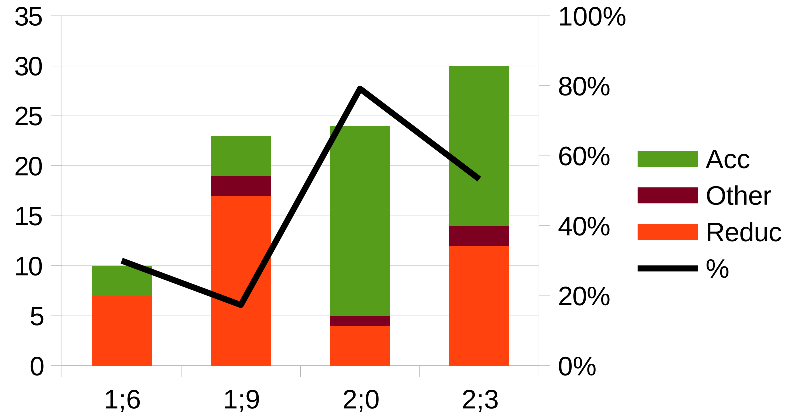
2;3). Labial and coronal nasal geminates together, shown in (54), thus suggest early, accurate production, but with reductions persisting in a noticeable fashion throughout the observed period.

(54) VL’s production of geminate nasals



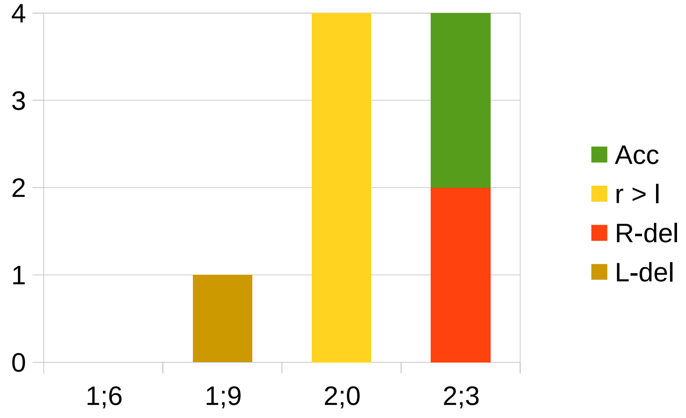
(55) shows VL’s production of /ll/ interludes. Of VL’s 10 attempts at /ll/ at 1;6, three were accurate, while she reduced the remainder to singletons. At 1;9, VL attempted the geminate 23 times and produced four of these accurately. Of the remaining 19 attempts, VL deleted two entirely (full syllable deletions), and reduced the rest to singleton [l]. Both of these recordings show at least 70% reduction rates. At 2;0, VL produced geminates with an accuracy of 79%, reducing the majority of the remainder to a reduced singleton. At 2;3, VL produced geminates with 53% accuracy, and a 40% reduction rate. In other words, while the first three recordings appear to show a consistent progressive trend in development, the final recording contradicts this observation. As a point of reference, VL produced /l/ accurately in 61% of singleton onsets (n=28) at 1;6, and 80% of the time (n=156) at 1;9. This suggests that the geminate context is what is constraining her development of /l/ at these ages.

(55) VL's production of geminate /ll/



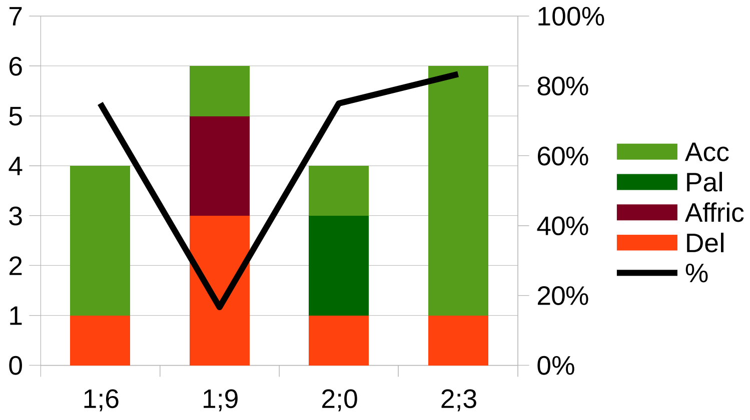
As shown in (56) below, VL did not attempt any rhotic geminates at 1;6. At 1;9, she produced the word *terra* /ˈtɛrra/ as [teːla]. Recall VL's /r/ development, whereby she produced over 80% of /r/ as [l] at 1;9. This parallel behaviour in geminates is thus not surprising. At 2;0, VL produced geminate /rr/ as the lateral geminate [ll], illustrated in her production of *terra* at this stage, [ˈtʰella]. In word-medial singleton onsets, she produced /r/ accurately or as a rhotic at a rate of 60% (n=43), which suggests that VL's geminate /rr/ produced as [ll] resulted from something other than purely segmental factors. At 2;3, she attempted the geminate four times, producing two singleton [r] and two geminate [rr], lagging behind her singletons which are produced as [r] in 76% of medial environments at this age (n=55).

(56) VL's production of geminate /rr/



In (57) we see that VL produced geminate /ss/ at 1;6 accurately, with one reduction. At 1;9, she reduced the geminate in three occurrences, and produced it accurately once. She also produced /ss/ as [ʦ]. At 2;0, VL produced /ss/ as [çç] twice, and as [ss] once, in addition to one reduced singleton. Recall VL's singleton /s/, which she produced variably as [s] and [ç], mirroring the behaviour we see in geminates. At 2;3, she reduced one geminate, producing geminates accurately the other 5 times.

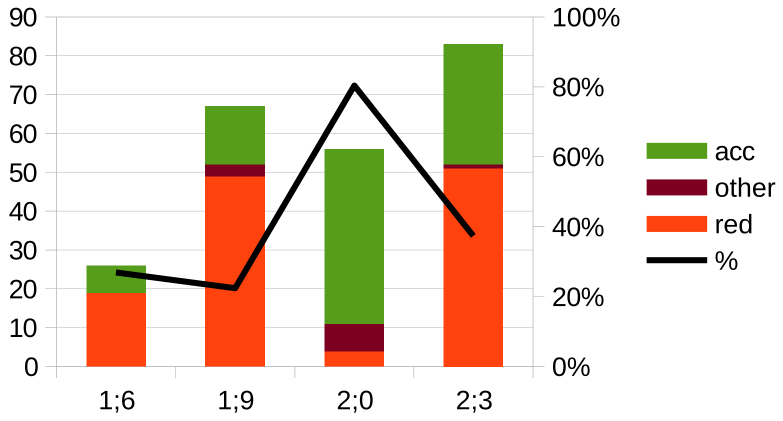
(57) VL's production of geminate /ss/



(58) shows VL's production of geminate stops, which have considerably higher token counts. From this data, VL's development of geminate stops began with 27% accuracy at 1;6

(n=26) and 22% at 1;9 (n=67). Her accuracy improved at 2;0 to 80% (n=56), and then lowered back to 37% accuracy (n=83) at 2;3. This pattern is also seen in VL's geminate /ll/.

(58) VL's production of geminate stops

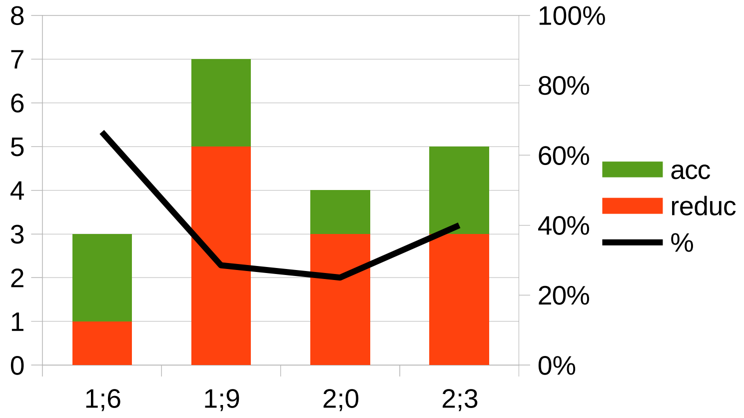


In sum, all geminates were produced accurately by VL in some of her early attempts, with the exception of /rr/; however no geminate type can be considered mastered by the end of the recorded period. Geminates are also not substituted by any consonant cluster.

1.4.2 BS

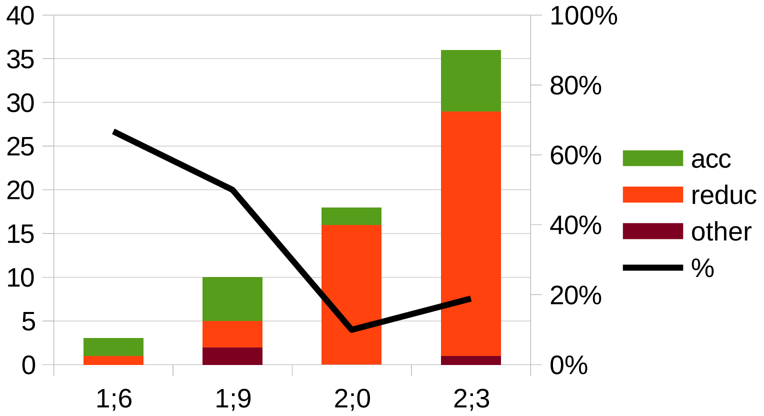
In (59) we see that BS produced some geminate nasals as early as 1;6, but from there, reduced them throughout the recorded period.

(59) BS's production of nasal geminates



In (60) we see that BS produced geminate /ll/ accurately in the earliest recording at 1;6. However, he reduced geminates significantly throughout the recordings, showing that he had not mastered the geminate structure before 2;3.

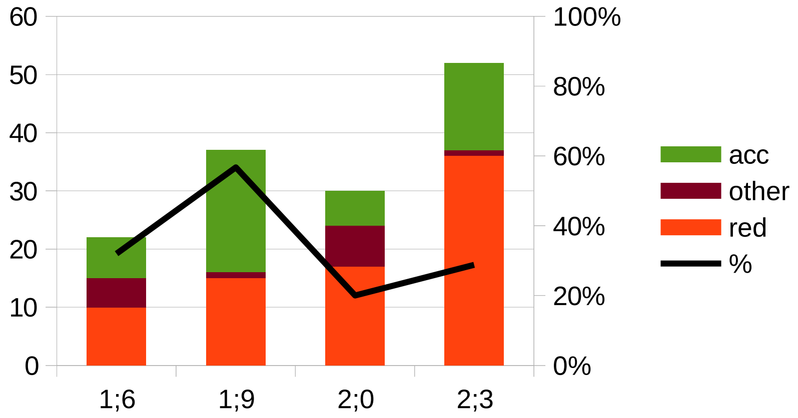
(60) BS's production of geminate /ll/



BS did not attempt any geminate /rr/ until 2;0, at which point he deleted the only occurrence he attempted. At 2;3, BS produced [ɹ] in place of the two geminates he attempted. BS also attempted three geminate /ss/ during the observed period. He reduced two of them at 1;9, and accurately produced [ss] at 2;3.

In (61) we see BS's production of geminate stops. His productions are trending toward accuracy at 1;9 (57%, n=37), and then decline at 2;0 (20%, n=30) and 2;3 (29%, n=52).

(61) BS's production of geminate stops

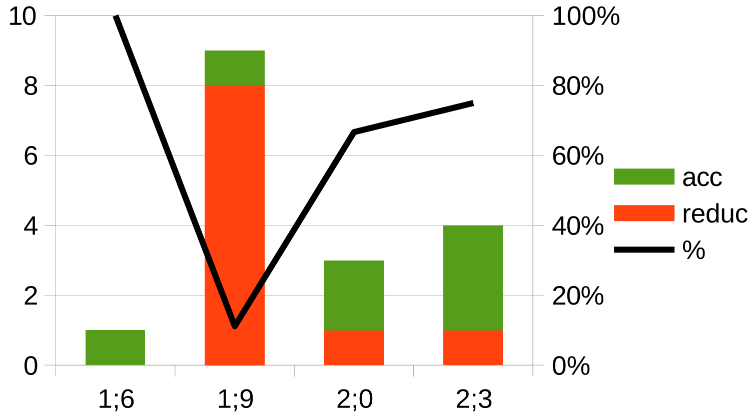


Overall, BS's productions show no evidence of mastery for any geminate, however they suggest that he was sporadically able to produce geminates early in development. BS shows no substitution patterns replacing geminates. All of these observations match those for VL above.

1.4.3 TA

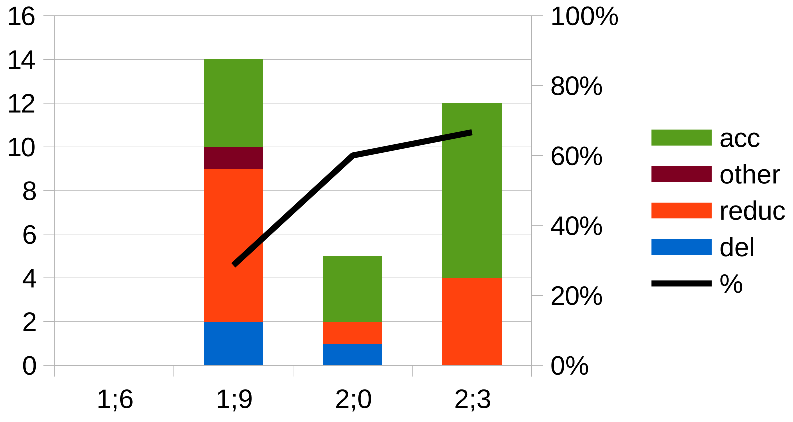
From (62), we see that TA accurately produced geminate nasals as early as 1;6. We also see reductions persisting until 2;3.

(62) TA's production of geminate nasals



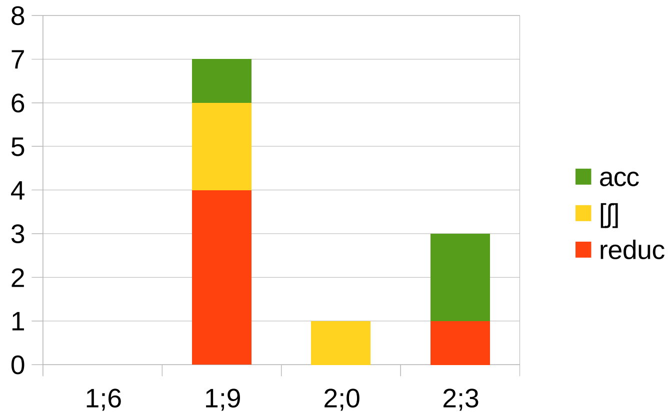
In (63), we see that TA produced geminate /ll/ starting at 1;9, but that reductions persisted into the final recording.

(63) TA’s production of geminate /ll/



TA attempted only one geminate /rr/ throughout the recorded period, at 2;0, which she produced as [ʁ̝]. In (64) we see that TA first attempted geminate /s/ at 1;9, when she reduced over half of her attempts. The other productions at this age include the fricative [ʃ] and one accurate production.

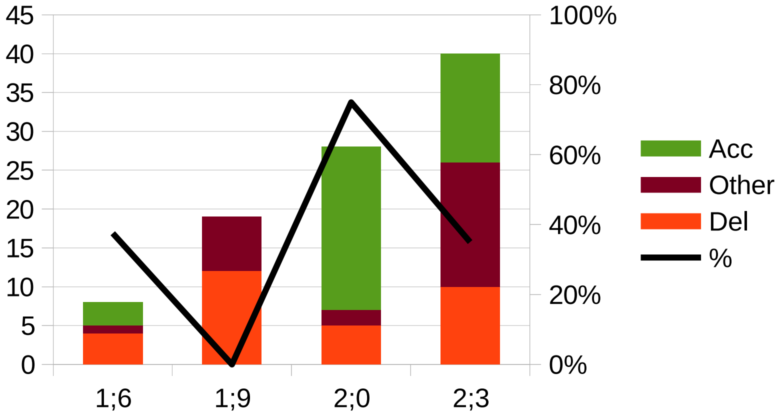
(64) TA’s production of geminate /ss/



At 2;0, she only produced the geminate as [ʃ]. At 2;3, TA produced two accurate geminates and reduced another. By comparison, during the same period, in singletons, TA produced [ʃ] for /s/, which indicates these productions in geminates are essentially reductions of the geminate’s prosodic structure.

(65) shows that TA produced geminate stops inconsistently throughout the recorded period. At 1;6, TA produced geminates accurately 38% if the time (n=8). At 1;9, she produced no accurate geminates out of 19 attempts. At 2;0, TA produced geminates accurately 75% of the time (n=28), while at 2;3, she produced only 35% of target geminates accurately (n=40).

(65) TA's production of geminate stops

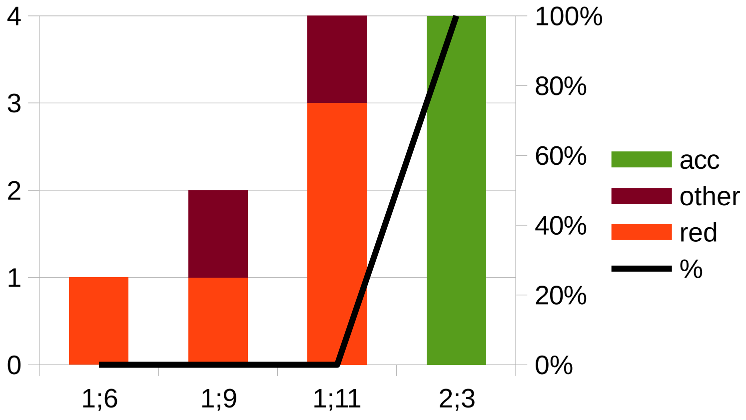


Overall, similar to both VL and BS, TA's productions show no evidence of mastery, but that she was able to produce geminates early in development. Also like the previous children, TA shows no substitution patterns for target geminates.

1.4.4 CN

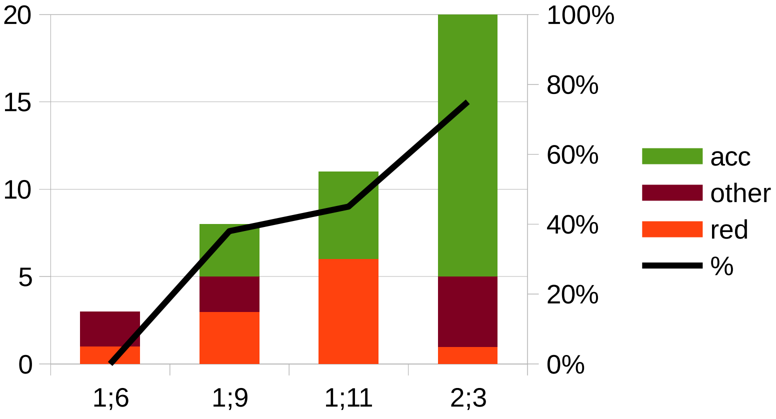
In (66) we see that CN produced no accurate geminate nasals out of seven attempts recorded between 1;6 and 1;11, until 2;3, when she produced all four attempts accurately. She primarily reduced geminates before then.

(66) CN's production of geminate nasals



(67) shows CN's production of geminate /ll/. At 1;9, she produced /ll/ accurately 38% of the time (n=8), and at 1;11 45% of the time (n=11). At 2;3, CN produced [ll] 75% of the time (n=20).

(67) CN's production of geminate /ll/

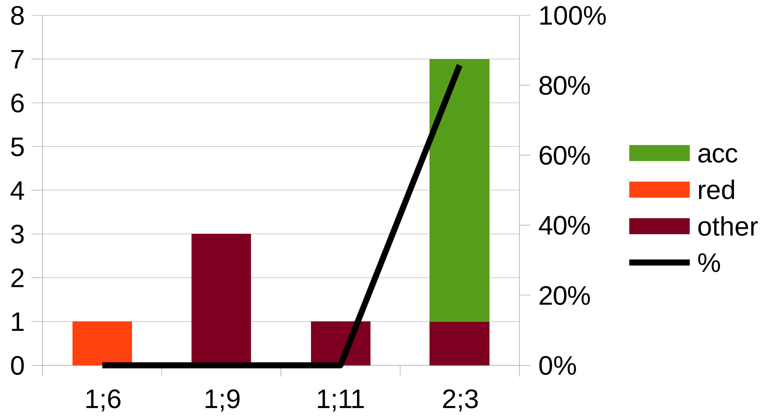


CN attempted geminate /rr/ beginning at 1;11, when she produced two target /rr/ as [r] and [j], respectively. At 2;3 she produced one reduced geminate, and another as [t] in *arrivato* /arriˈvato/, producing [hɛˈtoˈvattɔ].

(68) shows that, out of 5 attempts from 1;6 to 1;11, CN produced no accurate geminate /ss/. At 2;3, she produced /ss/ with 75% accuracy (n=7). Before that, CN either reduced or

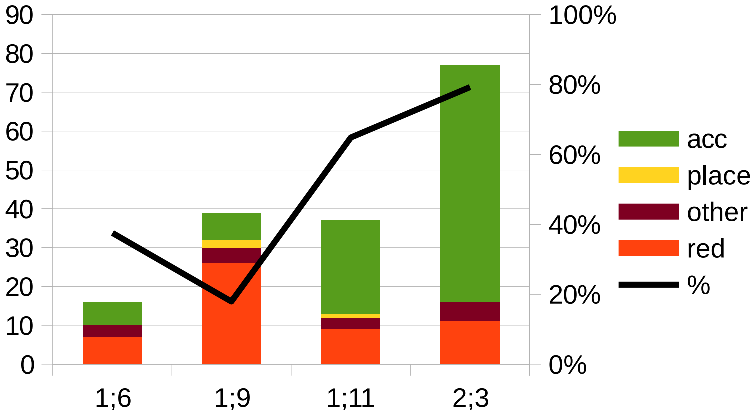
substituted geminate /ss/ for an affricate. CN produced singleton /s/ as an affricate throughout the recordings, implying these same substitutions in geminates are reductions of the target prosodic structure.

(68) CN's production of geminate /ss/



(69) shows CN's development of geminate stops. At 1;6, she produced these geminates accurately 38% of the time (n=16) however falling to 18% at 1;9 (n=39). At 2;0, CN produced accurate geminates 65% of the time (n=37), and increased her performance to 79% at 2;3 (n=77).

(69) CN's production of geminate stops



Overall, CN shows evidence of mastery at 2;3 across all geminate types. This is in stark contrast to the lack of evidence for mastery we saw in the other three children.

1.4.5 Summary of geminates

In summary, no child shows any substitution of geminates by any type of cluster. Only CN shows evidence of consistent geminate development, and she masters geminates of all types at the same age. Every other child shows either productions too sparse to serve as evidence, or a path too inconsistent to fit the definition of mastery used in this thesis. This variability, and CN’s consistent path, will be addressed in chapter 6. I move now to discuss word-initial clusters.

2 Initial clusters

In this section I describe the trajectories of initial clusters, comprising sC clusters that appear at the left edge of words, as well as CL clusters, both word-initially and word-medially. These are sC and CL clusters, however, as we have seen, it is formally warranted to analyze the structure of the two clusters differently (Hulst 1984; Davis 1990; Kaye 1992; d’Andrade & Rodrigues 1998; Goad 2011). As we will see, children’s productions of these clusters diverge noticeably as well.

2.1 CL clusters

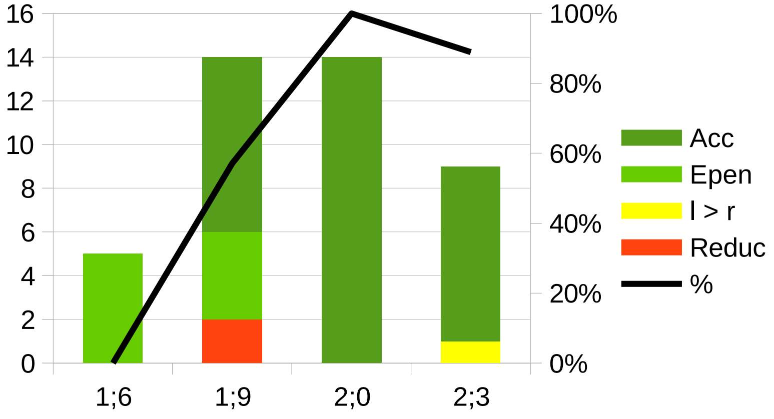
In this section I describe the children’s development of CL onset clusters. Recall from §1.2 that onset clusters are head-initial while coda-onset clusters, described throughout §1, are head-final. Recall, as well that, while coda-onset clusters may be homorganic, grammars forbid this in onset clusters (Rice 1992; Goad & Rose 2004). As a result, there are no /tl/ onset clusters in Italian (as well as in most languages of the world), leaving only labial+/l/ and velar+/l/ clusters. This same restriction does not apply to Cr clusters, allowing labial+/r/, coronal+/r/, and velar+/r/.

2.1.1 VL

As we can see in (70), during her acquisition of these onsets, VL epenthesized a vowel, breaking up all Cl clusters at 1;6. This was true for all 5 attempts of /l/ in this position, in both labial+/l/

and velar+/l/ clusters. At 1;9, VL continued to epenthesize in velar+/l/ clusters (29%, n=14), however she also produced these accurately in about half of her attempts (53%). Similarly, VL produced labial+/l/ accurately in three tokens at this age, and reduced the clusters to singleton labials in two tokens. At 2;0, VL produced all Cl onset clusters accurately (n=14). At 2;3, VL produced most Cl onset clusters accurately (89%, n=9), while the other attempt resulted in [brː] for /bl/.

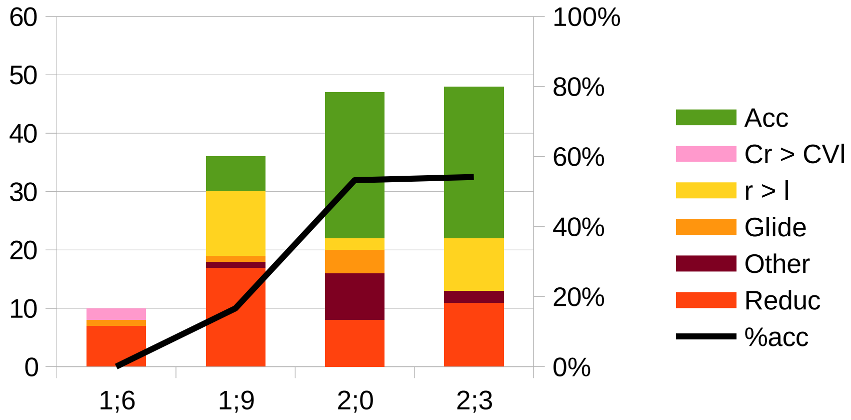
(70) VL's production of Cl clusters



Based on these observations, I claim that VL mastered the prosodic structure of a branching onset by 1;9 and achieved segmental mastery by 2;0.

(71) shows that VL mainly reduced Cr clusters at 1;6, producing just the consonant. Also at this age, VL produced [gəl] and [gel] for /gr/ clusters, substituting [l] for /r/ and epenthesizing in these two tokens, exemplified in (72) below.

(71) VL’s production of Cr clusters



At 1;9, she replaced Cr with [Cl] in 31% of tokens, across all PoAs, also illustrated in (72). She also produced accurate Cr clusters 17% of the time. At 2;0, VL produced accurate Cr clusters 53% of the time. Her productions at 1;9 are indicative of prosodic mastery. VL did not achieve segmental mastery within the recorded period.

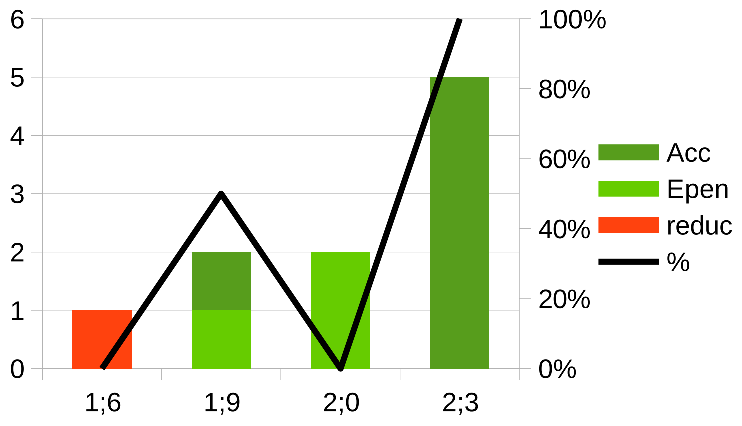
(72) Substitutions in VL’s CL clusters

Orthography	Adult form	Child form	Gloss	Age
triciclo	/triˈʧi**kl**o/	[ʧi**kəl**ɔ]	‘tricycle’	1;6
blù	/ˈ**bl**u/	[**brː**u]	‘blue’	2;3
tigre	/ˈti**gr**e/	[tiː**gel**e]	‘tiger’	1;6
zebra	/ˈʥɛ**br**a/	[ʥe**bl**aʰ]	‘zebra’	1;9
finestra	/fiˈnɛs**tr**a/	[finẽ**tl**a]	‘window’	1;9
crema	/ˈ**kr**ɛma/	[**kl**eːmã]	‘cream’	2;3

2.1.2 BS

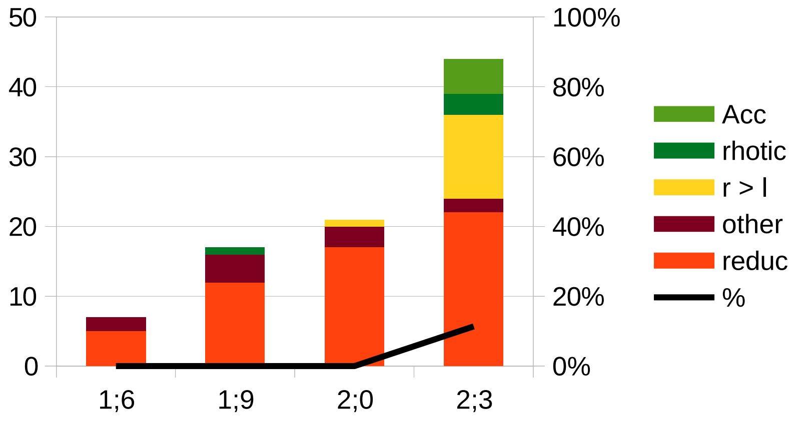
In (73) we see that BS first accurately produced Cl clusters at 1;9, reducing his single earlier attempt. He also epenthesized a vowel in another production at the same age, shown in (75) below. At 2;0, BS epenthesized both of the Cl clusters he attempted. At 2;3, he produced the complex onset accurately in all attempts (n=5). BS's productions at 2;3 are suggestive of both prosodic and segmental mastery, however there are too few tokens to determine this conclusively.

(73) BS's production of Cl clusters



(74) shows BS's production of Cr clusters. From 1;6 to 2;0, BS mainly reduced Cr clusters to a singleton C. At 2;3, he mainly deleted /r/ (50%), but also produced a few accurate [Cr] clusters (11%), and substituted /r/ for [l] in 27% of attempted clusters (n=44). His productions at 2;3 have a consistent structure 50% of the time (n=44), indicating prosodic mastery. No segmental mastery is observed during the recorded period.

(74) BS's production of Cr clusters



As a comparison, recall from §1.2.2 that BS did not master singleton /r/ during the recorded period. He also did not prominently substitute [l] for /r/ until 2;3, when he did so at a rate of 21% (n=39), which shows a parallel to his productions in these Cr cluster environments.

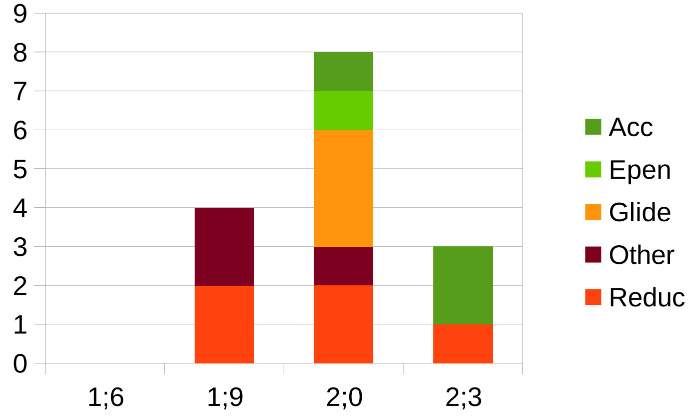
(75) Substitutions in BS's CL clusters

Orthography	Adult form	Child form	Gloss	Age
triciclo	/triˈtʃi**kl**o/	[teˈtʃi**kˣəl**ɔʰ]	'tricycle'	2;0
treno	/ˈ**tr**ɛno/	[ˈ**tel**eo]	'train'	1;9
fragole	/ˈ**fr**agole/	[ˈ**fl**agolɛʰ]	'strawberries'	2;3
maestra	/maˈɛs**tr**a/	[mãˈes**tl**aʰ]	'teacher'	2;3

2.1.3 TA

In (76), we can see that TA began attempting Cl clusters at 1;9, when she reduced /bl/ to a singleton twice. Also at 1;9, TA employed metathesis and prosodic reduction in /kl/ clusters in the word *triciclo*, producing [ˈkiʦ̻o].

(76) TA's production of Cl clusters



At 2;0, labial+/l/ and velar+/l/ clusters diverge once again. TA did not reduce any labial+/l/ cluster at this age, instead epenthesizing a back vowel, or metathesizing liquids /l/ and

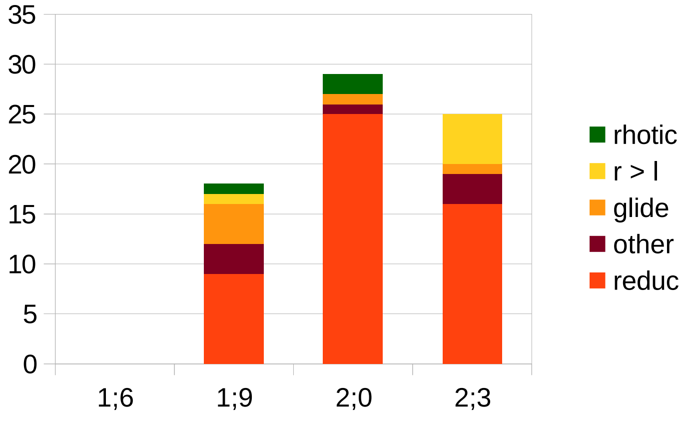
/r/ in the word *aeroplano*. In light of these variable patterns, in combination with the paucity of data (at 2;3, n=3), TA’s behaviour does not allow evidence for prosodic or segmental mastery at any point throughout the recorded period.

(77) Substitutions in TA’s CL clusters

Word form	Target form	Child form	Gloss	Age	Process
aeroplano	/aero ˈ**pl**ano/	[alleoˈ**pʁ̝**aːno] [ʰ̲a**po**ˈ**l**aːnʌ]	‘airplane’	2;0 2;0	metathesis epenthesis
triciclo	/triˈʧi**kl**o/	[tiˈxi**kj**o]	‘tricycle’	2;0	/l/ gliding
zebra	/ˈʥɛ**br**a/	[ˈʔeᵇ**vj**a]	‘zebra’	2;0	/r/ gliding

(78) shows TA began targeting Cr clusters at 1;9. At this age, she reduced the majority of these clusters to a singleton C. Focusing on place, TA reduced or glided the /r/ in /br/ clusters, as shown in (77). She deleted three coronal+/r/ clusters entirely, reduced one other to a singleton, and produced /tr/ as [tʴ] at this age. TA also produced /tr/ as [ʦ] and [ʦl] in the same recording. As a comparison, at this age TA produced singleton /t/ as [ʦ] less than 10% of the time (n=31), however her /r/ was produced even more rarely. This suggests that her productions [ʦ] and [ʦl] for target /tr/ is attributable to the onset /t/, therefore constituting a prosodic reduction, rather than to a fusion of both segments in the cluster. TA reduced all velar+/r/ clusters to singletons at this age. At 2;0, TA showed mainly /r/-deletion, as well as /r/-gliding, and some productions resulting in rhotics. At 2;3, TA began producing Cr as Cl in higher volume, but deletion persisted as the primary pattern. TA shows neither segmental nor prosodic mastery in the recorded period.

(78) TA's production of Cr



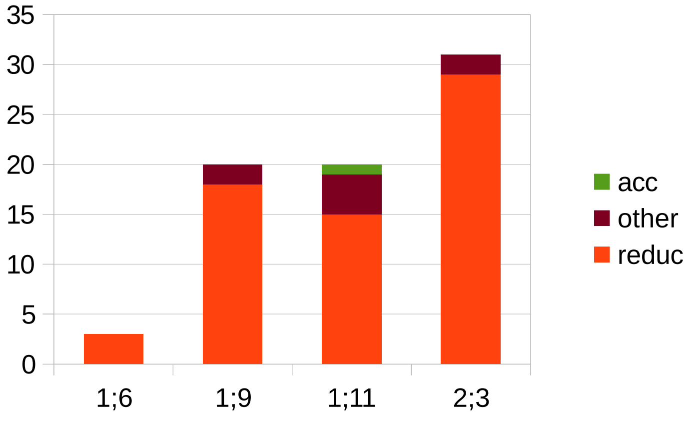
TA reduced or glided all labial+/r/ clusters throughout the recorded period. Velar and coronal clusters showed /r/ → [l] substitutions marginally, while reductions make up the majority of TA's attempts throughout the recorded period. TA showed no evidence of prosodic or segmental mastery.

2.1.4 CN

CN only produced 5 target Cl clusters during the observation period, four at 1;9 and one at 2;3. At 1;9, she deleted /l/ in half of the tokens, accurately produced one, and epenthesized a vowel in producing [bəˈluʰ] for /ˈblu/. She also reduced the cluster to a singleton C at 2;3. These behaviours are not indicative of either prosodic or segmental mastery.

As shown in (79), CN targeted Cr with much higher frequency. She deleted nearly all target /r/ in this context, ranging from 100% to 75% throughout the recordings. This behaviour is also not indicative of segmental or prosodic mastery.

(79) CN’s production of Cr clusters



2.1.5 Summary of CL clusters

This completes my description of the children’s development of CL onset clusters. The table in (80) summarizes the children’s developmental paths for initial Cl and Cr clusters, where ‘Ø’ represents deleted targets and a dash indicates the absence of targets for that period. VL and BS acquired Cl clusters. No child mastered Cr clusters, however VL displayed relatively high accuracy in her later productions of Cr.

(80) Child production of Italian CL clusters

		1;6	1;9	2;0	2;3
/Cl/	VL	CVl	Cl	Cl	Cl
	BS	Ø	CVl	CVl	Cl
	TA	-	-	CG	Cl
	CN	-	Ø	-	Ø
/Cr/	VL	ø	Cl	Cl/Cr	Cl/Cr
	BS	ø	CVl	C(V)l	Cl
	TA	-	Ø	Ø	Ø
	CN	Ø	Ø	Ø	Ø

All children showed at least marginal epenthesis in Cl clusters, breaking up the target cluster. Concerning Cr clusters, VL, BS and TA showed epenthesis in conjunction with /r/

substitution to [l]. TA also showed gliding in both Cl and Cr clusters. I turn now to the other type of initial clusters, sC clusters.

2.2 Initial sC clusters

In this section, I describe the development of four children's initial sC clusters. As we will see, the substitutions in these data clearly differ from those we observe in CL clusters, on two accounts: sC substitutions clearly show a preference for place-sharing sT clusters, and epenthesis patterns before the /s/ result in a coda-onset syllabification for the target string, similar to those reported by Freitas (1997; Fikkert & Freitas 2004).

2.2.1 VL

In (81) we see VL's attempts at word-initial sC clusters. At 1;6 and 1;9, VL reduced nearly all clusters to a singleton C (83% and 91% respectively). Recall from §1.2.4 that the C in an sC cluster is uncontroversially the head, whether the /s/ is a coda (Kaye 1992; d'Andrade & Rodrigues 1998; Goad 2012), or an appendix (Hulst 1984; Davis 1990; Goad & Rose 2004). At 2;0, she produced the cluster accurately across all PoA, in addition to palatal fricatives before velar and labial consonants. Because VL also substituted singleton onset /s/ for the palatal fricative at this age, I consider these productions to be accurate. At 2;3, VL produced nearly all initial sC clusters accurately (83%), with reductions accounting for only 14% of attempts (n=29), all affecting sK clusters. VL's productions at 2;0 are indicative of both prosodic and segmental mastery.[20]

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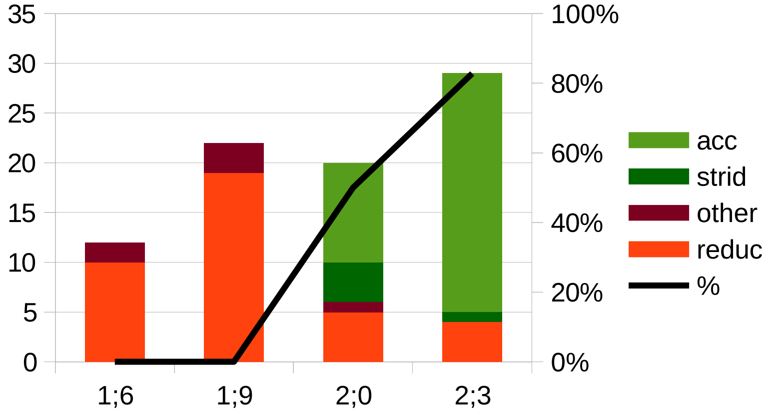
[20] Counting palatal productions in place of evidence for /s/, VL still only reaches 70% accuracy; however given the categorical change from the previous age, this constitutes mastery.

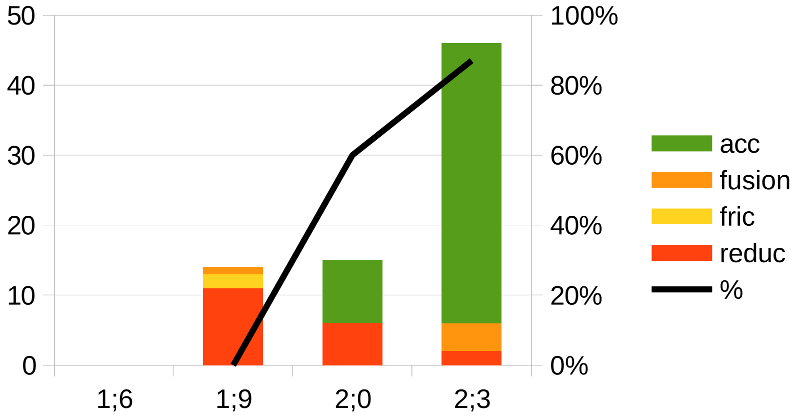
(81) VL’s production of initial sC clusters



2.2.2 BS

(82) shows BS’s production of initial sC clusters. BS targeted no initial sC clusters at 1;6. At 1;9, he reduced 85% of his attempted clusters (n=13) to singletons. Also at this age in sK clusters, as exemplified in (83), BS place-assimilated in one cluster and produced a [x] in place of another. At 2;0, BS produced 60% of sC clusters accurately for coronal and velar clusters, but reduced all sP clusters. At 2;3, BS produced 87% of initial sC clusters accurately, across all PoA. Also at this age, BS reduced four /st/ clusters to [s]. This last observation, as well as the reduction (substitution) to [x] at 1;9, must be explored further to distinguish whether these outputs are simply prosodic reductions, or whether they are segmentally/featurally representative of both members of the underlying cluster.

(82) BS’s production of initial sC clusters



Comparing to singleton onsets, at 1;9, BS did not produce /k/ as [x], however at 2;0, he did this 26% of the time (n=57). I take the output [x] to be a case of fusion as there is no evidence of BS producing /k/ as [x] in the same time period. The reduction to [s] at 2;3 was only affecting target sT clusters, in which a fusion of MoA and PoA would result in an output identical to a simple prosodic reduction. Looking instead to distributional evidence, the reduction to [s] only occurs as an output for sT clusters. If this behaviour were due to a difficulty with the prosodic structure of the cluster, or with /s/ itself, we would expect this same output for sP and sK clusters as well, however they are produced accurately at this age. I therefore suggest that the output [s] is a fusion of the segmental content of both members of the cluster, and not simply a prosodic reduction. BS’s attempts at 2;0 are reduced to singletons less than half of the time, which is indicative of prosodic mastery. Finally, BS shows evidence of segmental mastery at 2;3.

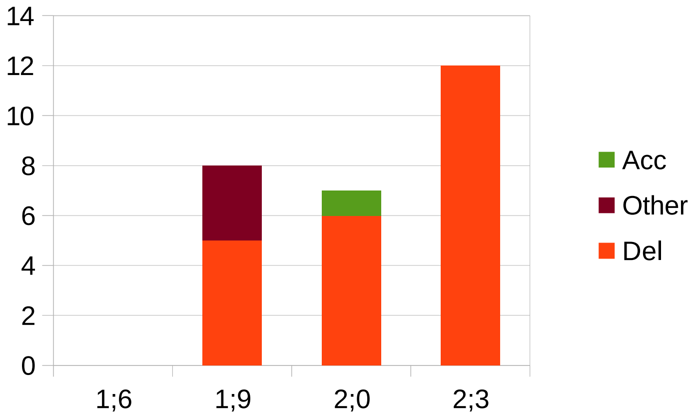
(83) Assimilation in BS’s initial sC clusters

Orthography	Adult form	Child form	Gloss	Age
scopa	/ˈ**sk**opa/	[**xoː**ʋaː]	‘broom’	1;9
schiena	/ˈ**sk**jɛna/	[ˈ**χːk**ẹᵗna]	‘back’	1;9
sta	/ˈ**st**a/	[**s**ə]	‘(it) is’	2;3

2.2.3 TA

From (84), we can see that TA primarily deleted /s/ in sC clusters throughout the recordings. At 2;0, she produced one sT token accurately, and at 2;3 she produced four tokens with the MoA of /s/ (fricative) and the PoA of the following segment. The coronal clusters were produced as [θ], while the velars resulted in [x, xˁ], as shown in (85).

(84) TA's production of initial sC clusters



TA substituted /k/ with [x] in 40% of her attempts at word-initial singleton onsets at the same age (2;3, n=30). Similarly, TA substituted /t/ by [θ] in 14% of her attempts at word-initial singleton onsets at the same age (2;3, n=22). Thus, both behaviours can be captured by positing /s/-deletion, with /k/ and /t/ independently produced as [x] and [θ], respectively. TA's productions therefore do not involve fusion, nor do they indicate mastery.

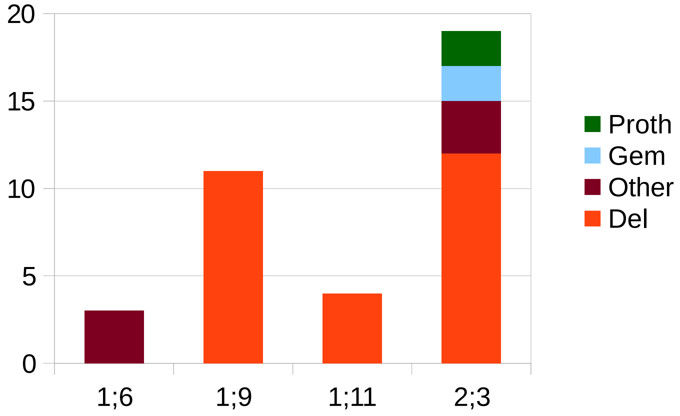
(85) Apparent fusion in TA's initial sC clusters

Orthography	Adult form	Child form	Gloss	Age
scopa	/ˈ**sk**opa/	[ˈ**xˁ**oːppa]	'broom'	2;3
stira	/ˈ**st**ira/	[ˈə**θ**irə]	'(s/he) irons'	2;3

2.2.4 CN

(86) shows CN’s productions of sC clusters consisted mainly of reductions to a singleton C throughout the recordings. At 2;3, however, two non-deletion patterns took place. In sT and sP clusters, CN epenthesized a vowel word-initially and produced the cluster as a geminate. She also epenthesized a word-initial vowel in two place-sharing contexts, in which she produced the cluster accurately. That is, CN produces two tokens of initial sC clusters with prothesis, and two tokens with both prothesis and geminate substitution. Examples of these patterns are shown in (87) below. CN shows no evidence of mastery.

(86) CN’s production of initial sC clusters



(87) Prothetic behaviours in CN’s initial sC clusters

Orthography	Adult form	Child form	Gloss	Age
spegne	/ˈ**sp**ɛɲɲe/	[a**p**ˈ**p**ɛ̃nnjɛ̃]	‘s/he turns (smth) off’	2;3
stira	/ˈ**st**ira/	[ɪ**s**ˈ**t**ytʲa]	‘s/he irons (smth)’	2;3

2.2.5 Summary of initial sC clusters

The table in (88) summarizes the mastery timelines and substitution patterns of sC clusters, where XC represents place-assimilated cluster substitution, sC indicates prosodic mastery, ‘Ø’ represents deletion, and a dash represents no targeted clusters at that age. We can see that VL and BS acquired sC clusters prosodically at 2;0. VL also achieved segmental mastery at 2;0, while BS showed place assimilation at 1;9, achieving mastery at 2;3.

(88) Timeline of initial sC mastery and substitutions in Italian children

	1;6	1;9	2;0	2;3
VL	Ø	Ø	√	√
BS	-	XC	sC	√
TA	-	Ø	Ø	Ø
CN	Ø	Ø	Ø	VsT & VXC

Prominent substitution patterns were shown by BS and CN. BS showed both place assimilation and fusion in sK clusters at 1;9. At 2;3, when he segmentally mastered sC clusters, BS showed fusion with sT clusters. At 2;3, CN showed two patterns of prothesis. Epenthesis in the sP cluster coincided with geminate substitution, syllabified as /Vp.pV/, while epenthesis in the sT cluster showed a target-like production, syllabified as /Vs.tV/. Notably, the epenthesis patterns we witnessed in sC clusters is prothetic in nature: the vowel is always inserted before the consonants. This contrasts with CL clusters, whose epenthetic vowel is always inserted between the consonants. This will be addressed in the following chapter.

3 Summary

In this section, I summarize the behaviours of the cluster types to be analyzed in the next chapter. Beginning with medial clusters, NC clusters are acquired for all children. Children show only one type of substitution: CN substitutes NC clusters for C_iC_i sequences, referred to as geminate substitution.

Liquid+consonant clusters pattern asymmetrically between /l/ and /r/, where /l/ is always acquired earlier than /r/, and [l] acts as a substitute for /r/ while the reverse is not true. These facts should be reflected in the representation of each liquid. Additionally, lT clusters are always produced earlier than lP and lK, while rC clusters show no place asymmetry. Finally, both lC and rC are substituted for C_iC_i, while VL also showed a marginal substitution pattern, turning lC and rC into NC clusters.

sC clusters are mastered prosodically and segmentally by both VL and BS, while CN only mastered the structure of sC clusters. TA showed neither prosodic nor segmental mastery, while VL and TA showed geminate substitution for sC clusters. BS shows a preference for place dependency in acquiring sT clusters before sP and sK, while at the same stage assimilating the /s/ to a velar in sK clusters.

In contrast to most patterns described above, geminates are only acquired by a single child, CN, who mastered them across all places and manners of articulation at the same age. No other child showed mastery of geminates and no child showed any prominent substitution patterns. The general behaviour is one of geminate reduction to singletons Cs, the rate of which varies across children.

Moving to initial clusters, again we see a close relationship between /l/ and /r/, where Cl is acquired earlier than Cr, and Cl acts as a substitute for Cr. VL and BS both show mastery of Cl clusters, while only VL shows mastery of Cr clusters. Both these children also show epenthesis where the Cl cluster is split up by the epenthetic vowel; they also display this same [CVl] output as a substitute for Cr clusters. TA also shows gliding in both Cl and Cr clusters. VL shows a marginal gliding pattern in Cr clusters, but not in Cl.

VL and BS prosodically and segmentally mastered initial sC clusters within the observed period. BS shows place assimilation in initial sC clusters before mastery, as well as marginal fusion. CN displays prothesis in sC clusters, both with accurate sC cluster production as well as with geminate substitution. In the next chapter, I turn to an analysis of these patterns.

Chapter 6: Analysis

In this chapter I lay out the representations for each cluster type. I describe these representations briefly in §1, building on research reviewed in Chapter 2. In §2, I compare the cluster types relevant to answering the research questions in (26). In §3, I demonstrate the proposed stages of cluster development, capturing the developmental behaviours exhibited by Italian-learning children, as described in Chapter 5.

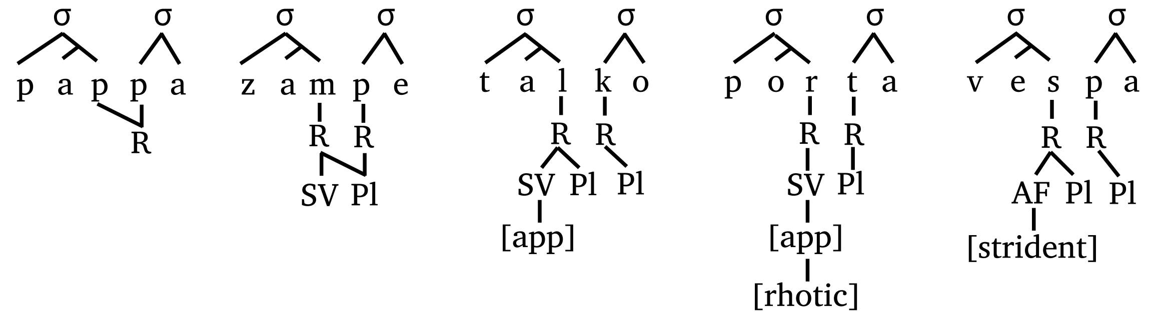
1 Representations

As I will show throughout this chapter, the representations below in (89)-(92) capture the developmental behaviours of Italian consonant cluster acquisition described in Chapter 5. Putting aside the issue of geminate mastery, which, as I will discuss in §2.1, may be an artefact of the children's exposure to their local variety of Italian, all of the evidence assembled in this thesis is compatible with a structure regarding medial sonorant+C and sC clusters and complex onsets in line with those proposed by Rice (1992). Segmental representations for the adult grammar are shown in (89)-(91), and prosodic structure of initial sC clusters is shown in (92), where only relevant structure is shown.

To review, the first half of geminates is represented by a featurally-empty position linked to the following consonant's root node, as shown in (89a). NC clusters are represented with a bare SV node under the root, denoting the feature [nasal], and whose place node is shared with the following C, yielding homorganicity, as illustrated in (89b). The representation for lC clusters in (89c) shows the feature [approximant] beneath the SV node, and by supporting its own place node. The representation of rC, in (89d), further builds on the SV node, with the feature [rhotic] dominated by [approximant], as well as having no place node. For sC clusters, shown in (89e), the root node dominates both a place node, capturing the fact that sC clusters do not require homorganicity, and an AF node, further dominating the feature [strident].

(89) Segmental representations for medial clusters in Italian

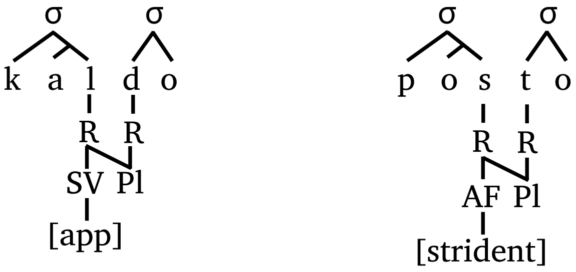
a) Geminate b) NC cluster c) lC cluster d) rC cluster e) sC cluster



Elaborating on the structural representations in (89), I account for place-sharing preferences within lC and sC clusters with the representations in (90). These representations differ from those in (89c) and (89e) by virtue of the coda's root node sharing the place node of the following onset, implying that these are less marked than their place-independent counterparts.

(90) Segmental representations for place-sharing clusters in Italian-learning

a) place-sharing lC b) place-sharing sC

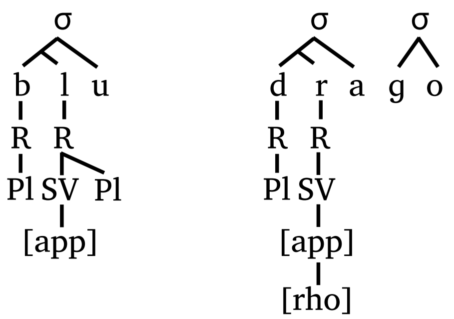


Moving to initial clusters, it is uncontroversial to analyze obstruent+liquid clusters as tautosyllabic complex onsets, illustrated in (91). The liquids available in complex onsets of

Italian are /l/ and /r/, whose segmental structure consists of an SV node, an [approximant] feature (/l/), and a [rhotic] feature (/r/). While /l/ bears a place node, /r/ does not. This captures the availability of /r/ in complex onsets involving a coronal, in which an /l/ would be prohibited. The placelessness of /r/ is discussed further in §2.2.

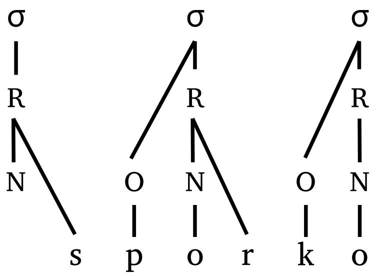
(91) Structure of CL clusters in Italian

a) Cl b) Cr



The representation of initial sC clusters is more widely debated. In the prosodic representation in (92) below, we see that /s/ is syllabified as the coda of an empty-headed syllable (Kaye 1992; d'Andrade & Rodrigues 1998; Mateus & d'Andrade 2000; Goad 2012). This captures parallels between medial and initial sC clusters restrictions, behaviours, and developmental trajectories, as reported by Freitas (1997; Fikkert & Freitas 2004). These will be discussed further in §2.5.

(92) A coda-onset representation of initial sC clusters



I discuss in the next section how the behaviour of the Italian learning children can be captured by the representations above.

2 Analysis

In comparing the behaviours of the various clusters across children, two types of evidence will be accounted for through direct reference to the structural markedness of each cluster's representation. I account for the developmental timelines discussed in the previous chapter by showing that less marked cluster types are acquired earlier than more marked clusters. Secondly, I account for a number of substitutions as a reduction in the segmental structure, or the 'unmarking' of levels of structure. I account for other substitutions patterns, namely place assimilation, and fusion, also by showing that these processes lead to less marked outputs. I address in turn the research questions initially formulated in (26). In §2.1, I assess the relative markedness of geminates in relation to coda-onset clusters in addressing the question in (26a). In §2.2, I investigate the relative markedness of NC clusters versus LC clusters, in addressing the question in (26b). In §2.3, I assess the parallel between LC and sC clusters in addressing the question (26c). In §2.4, I compare CL and NC clusters in addressing the question in (26d). In §2.5, I draw parallels between initial and medial sC clusters in addressing the question in (26e).

2.1 Geminates vs. medial clusters

In this section, I detail the observations for the relative acquisition of geminates and coda-onset clusters. Recall from chapter 5, §1.4, that all children show accurate geminate productions earlier than, or concurrently with, the comparable C_iC_j cluster (e.g., /ll/ before /lC/, /ss/ before /sC/). However, while CN's behaviour at 2;3 marks a notable exception, no other child exhibits geminate mastery within the recorded period.

From the children's substitutions summarized in (93), we see that geminates were not substituted by any other cluster type, while all cluster types show geminate substitution. This asymmetry is captured by the representation above in (89a), where a geminate structure can be arrived at by removing all features from the coda, and sharing the root node of the following onset.

(93) Substitution patterns in medial cluster acquisition in Italian

	Child	Age
NC → C_iC_i	CN	1;11
lC → C_iC_i	TA	2;0
rC → C_iC_i	VL	2;0
	CN	2;3
sC → C_iC_i	VL	2;0
	TA	2;3
	CN	2;3

Both the substitution patterns and CN's timeline suggest that geminates are less marked than all coda-onset clusters. However, the fact that the other children fail to acquire geminates along the expected timeline must be addressed. I discuss this below.

While it is possible the children are producing a contrast between these sounds that is not identical to the typical adult contrast (e.g., a subtler duration contrast than that of adults'; a non-temporal contrast; see Scobbie *et al.* 1996; Scobbie 1998 on covert contrasts), work is currently being done on the acoustics of these consonants to confirm or refute the presence of covert contrast in these data, and transcribers were given training in hopes of avoiding such perceptual neutralizations (C. Zmarich, personal communication, 17 February 2020).

It is well documented that the Northern dialects of Italian are subject to degemination, a loss in the geminate contrast (Loporcaro 1996; Chang 2000; Bertinetto & Loporcaro 2005, among others). While the children, by nature of living in Italy, are exposed to geminates at least some of the time (e.g., formal settings like the hospital where the recordings took place), the most prominent influence on them will be the variety spoken by their parents and family members. As these children were recorded in Trieste, where a Northern variety is spoken, most children's families would speak this variety, and thus account for the majority of the children's input. This lack of temporal contrast in the Italian of Trieste could be the reason that geminates do not behave as expected in the children's acquisition timelines.[21]

2.2 NC vs. LC clusters

Turning now to the acquisition of sonorant+obstruent clusters, I begin with the timelines in (94), where we can see, first, that NC clusters are acquired earlier than lC clusters for all children who acquired both. BS appears to master NC clusters at the same age as he acquires place-sharing lC, however this is likely due to the low token count for his NC clusters at 1;6 (n=2; indicated in the table by '*'), which would have otherwise been considered the age of NC mastery. Importantly, the children who do not acquire both cluster types within the recorded period acquire only NC clusters. As well, lC clusters are invariably acquired before rC clusters. This suggests that NC clusters are the least marked, with lC clusters being relatively more marked, and rC clusters the most marked sonorant+C clusters, as they are either acquired last, or not at all within the observed period. All of these observations are accounted for in the structures for NC, lC, and rC clusters in (89b-d).

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[21] CN, whose behaviour is indicative of geminate mastery along the timeline we expect, may have had more exposure to geminating dialects. This, however, cannot be verified based on available information.

(94) Timeline of NC and LC cluster acquisition in Italian

	place sharing		no place sharing	
	NC	lT	lP, lK	rC
VL	1;6	1;9	2;0	2;3
BS	1;6*/1;9	1;9	2;0	
TA	1;6	2;3		
CN	2;3			

Place sharing also clearly plays a role in the development of clusters, as also reflected in the table in (94). NC clusters, which necessarily share place, are acquired first. Within lC clusters, all children were able to produce lT clusters before lP or lK clusters; this holds true even for CN, who mastered the cluster only in lT contexts, not across all PoAs. /rC/ clusters show no such advantage, as no children showed mastery in place-sharing clusters earlier than clusters with contrastive place. In fact, CN's first accurate rC production was [rp]. These facts, coupled with /r/'s availability in coronal onsets, are accounted for by the place-sharing representation for lC in (90a), and the lack of a place node for rC in (89d).

Additional evidence that NC clusters are less marked than LC clusters comes from the substitutions exhibited throughout development, shown in (95). VL and CN substituted the /l/ in by dropping the feature [approximant], leaving a bare SV node, producing NC clusters. In showing similar asymmetries between /l/ and /r/, BS prominently substituted /r/ with [l] in rC clusters for a significant period of time, extending to the end of the recorded period, while showing no such substitution in singletons. VL also showed marginal /r/ substitution to [l] in clusters. These can be accounted for in the same fashion, where, by failing to incorporate the feature [rhotic], the children arrive at the structure for /l/, instead of /r/.

(95) Substitutions in NC and LC cluster acquisition in Italian

Behaviour			Child	Age
lC	→	NC	VL	1;9, 2;3
			CN	2;3
rC	→	lC	BS	2;0, 2;3
			VL	1;9, 2;3

VL also prominently replaces /r/ for [l] in singletons, while BS marginally shows the same pattern, suggesting the segments themselves reflect a markedness relationship. The observations regarding the relative markedness of NC and LC clusters are formulated in (96).

(96) Relative markedness of sonorants in Italian
NC << lT << lP, lK << rC

The relationship in (96) is captured by a hierarchical representation where each level of markedness is expressed by a feature dominated by less marked features, as illustrated in (89b-d), with the relatively unmarked status of lT compared to lP/lK is captured by the place-sharing shown in (90a). Having captured the generalizations of sonorant+C cluster behaviour in the representations described here, I move to discussing the only obstruent+C cluster in Italian.

2.3 LC vs. sC clusters

In this section I discuss the differences between the acquisition of word-medial LC versus that of sC clusters, highlighting the asymmetries between the cluster types. As discussed above in Chapter 5 §1, lC and rC clusters do not form a uniform developmental timeline for all children, as rC clusters are invariably acquired later than lC. As mentioned above, this is captured by the marking of the feature [rhotic] as the third node in the representation in (89d). Here I specifically compare sC against lC clusters to determine what parallels may exist across their behaviour. I then capture the relevant asymmetries in the representation of sC clusters. As I showed in the previous section, lC clusters are mastered first in place-sharing environments. I will show evidence that suggests this is the case for sC clusters as well. Given that not all children mastered sC clusters during the recorded period, the discussion will focus on the children that did display mastery, namely VL and BS.

VL first accurately produced sC clusters at 1;9, in a small amount of sT and sK environments, although not enough to evidence mastery. At 2;0, she produced the majority of sC clusters accurately, mastering the cluster across all PoA. The fact that accurate production of sC clusters occurs at 1;9 in both coronals and velars seems to defy a place-sharing advantage for VL's sC clusters. However, it is possible that in the unrecorded period between 1;6 and 1;9, VL produced only coronal clusters and later added velars in time to see evidence of both in the recording at 1;9. Speculations aside, the reason why we do not observe a period in which VL produced only sT may also have to do with her overall production of /s/ throughout the recorded period. As we saw in §1.3.1 of chapter 5, she produced both coronal and velar fricatives for singleton /s/, which suggests her place specification for /s/ was not yet fully developed. The observation that VL's initial sC clusters were first produced in coronal and velar environments then dovetails with the fact that her /s/ was place-compatible with both these PoAs in her early sC cluster productions.

BS began producing sC clusters in place-sharing environments first; at 1;9 BS produced only sT clusters. Also, at this age BS produced /sk/ as [χk], also showing place assimilation with the following C. At 2;0, he began producing sC clusters across all PoA, fully mastering the cluster.

Building on the place-sharing advantage I incorporated in the structure of lC clusters above, a similar structural advantage is motivated for sC clusters given the data for VL and, particularly, for BS, who clearly displayed place sharing in coronal and velar sC clusters. These observations suggest that sT >> sP, sK, captured in the place-sharing structure in (90b) versus the place-independent representation in (89e).

Beyond these two children, I note that TA produced target-like lC clusters in place-sharing environments at 2;3, while she did not produce any accurate sC clusters at this age. This suggests that the parallel in the timeline of VL and BS's acquisition of sC and lC clusters is not required, and therefore should not be implied by the phonological representations. TA also exhibits fusion in sC clusters. Because the current study focuses on how segmental features and their structure are incorporated and acquired in dependent prosodic positions, and the fused singleton segments are uncontroversially analyzed as onsets, fusion does not contribute to the analysis. However, the fact that TA exhibited both fusion and geminate substitution at the same age suggests the contemporaneous, yet separate, development of segmental and prosodic structure, where the markedness of one may be produced at the cost of the other.

The structures in (89c) and (89e) account for why lC and sC clusters are acquired in parallel for VL and BS. The structures of both cluster types are composed of a root node dominating two further levels of structure. NC clusters require one node fewer, and are acquired earlier without exception, while rC clusters, which require one more node than either lC or sC, are acquired later than each of these cluster types.[22] Indeed, as shown by TA, either of lC or sC can be acquired before the other, based on which features the child acquires earlier. Instead of SV, which denotes

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[22] However it is conceivable, and permitted according to the proposed structures, that rC clusters could be acquired earlier than sC clusters if any of the features incorporated in the representations were to cause particular difficulties to a given learner. It is unattested in the limited data presented here.

sonorants, I use AF, or the airflow node, to distinguish fricatives from oral stops. To distinguish stridents from non-stridents, I use the feature [strident]. This also captures that it is the stridency of /s/ that allows it a freer distribution than other obstruents.[23]

The structures proposed to capture lC and sC cluster behaviours, by virtue of having no features in common, also capture the relative lack of substitutions between sC clusters and son+C clusters. Instead, sC substitutions consist mainly of BS's place assimilations, captured by the place-sharing structure in (90b).

2.4 CL vs. NC clusters

In this section I show the observations of each child's productions of CL complex onsets and coda-onset clusters, in which we will focus on NC clusters, because as we have seen they involve the first codas acquired (outside of the first half of geminates, in the dialects that display them). This will help us understand the universal trajectory suggested by Kaye & Lowenstamm (1981), and whether it truly indicates that grammars with complex onsets are a subset of those with codas.

The timelines of cluster acquisition are summarized in (97) below. As we can see, VL acquired NC at 1;6, three months before mastering Cl. BS acquired NC clusters at least six months before Cl clusters. TA produced accurate Cl clusters at 2;3, nine months after she mastered NC clusters. CN mastered NC clusters at 2;3, and never showed mastery of any Cl or Cr clusters. All Cr clusters are acquired even later than Cl, which, as described here, were all clearly acquired later than NC.

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[23] Why some languages exhibit multiple strident fricatives while restricting the coda position of an empty-headed syllable to a single member of this inventory is beyond the scope of this paper.

(97) Child production of Italian CL vs. NC clusters

		1;6	1;9	2;0	2;3
Cl	VL	NC	Cl	Cl	Cl
	BS		NC		Cl
	TA	NC		CG	Cl
	CN				NC
Cr	VL	NC	Cl	Cl/Cr	Cl/Cr
	BS		NC	Cl	Cl
	TA	NC			
	CN				NC

All children thus mastered NC clusters before Cl or Cr clusters, which means that CVC syllables were acquired before CCV syllables. This suggests that Kaye & Lowenstamm's (1981) generalization holds true in word-internal contexts, i.e., branching onsets imply codas.[24] This is captured in the prosodic structure of these syllable types and relative prominence of onsets versus rhymes; codas are rhymal dependents, and rhymes are the head of a syllable, while the second member of a complex onset is a dependent of the onset. The formal implication is that allowing two levels of dependency (i.e., C2 of a complex onset) is more marked than allowing a dependent within a constituent head. Any segmental structure allowed in the coda is therefore in a more privileged position relative to that in the second position of a complex onset. This claim is also supported by the larger inventory of segments allowed in codas than in the C2 position of a complex onset. However, as a comparison between Cl and lC clusters reveals, this does not indicate a given segment in a coda is necessarily acquired before the same segment in C2 of a complex onset. I briefly summarize the relevant observations next.

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[24] Whether this trajectory holds true for final syllables remains to be seen, as further complications might arise from the additional syllabification possibilities at the right edge (Piggott 1999; Rose 2003).
Additionally, why CVC appears before CCV may be due to the fact that nasals are the representationally simpler class, and are only available in the former syllable shape, to the exclusion of the latter. I leave this to future research.

VL acquired Cl clusters at 1;9, and lC clusters three months later at 2;0. She also prominently produced Cr clusters at 2;0, three months earlier than her prominent target-like rC clusters. In contrast, BS acquired lC at 1;9 and Cl six months later at 2;3. TA exhibits prominent target-like production of both lC and Cl clusters starting at 2;3, while CN does not show prominent accurate productions of either Cl or lC clusters (lT clusters aside). The four children show every possible permutation of orders of acquisition, and so I draw no correlation between these two cluster types. Instead, the only formal implication is that the mastery of CL implies that of NC. The final research question, on the prosodic structure of sC clusters, is addressed next.

2.5 Initial sC vs. medial sC clusters

In this section, I compare initial sC clusters, described in §2.2, to medial sC coda-onset clusters, described in §1.3. I also contrast initial sC cluster development with that of CL clusters discussed in the previous section. As we will see, initial sC clusters show almost all conceivable parallels with medial sC clusters across the children's developmental patterns, while they share no parallels with CL clusters, and in fact differ from them in many equally revealing ways.

VL shows a temporal parallel between the acquisition of initial and medial sC clusters. She reduced both cluster types at 1;6 and 1;9, showed a significant increase in accuracy at 2;0, and finally mastered them both at 2;3. This parallel in timeline strongly suggests a parallel in VL's analysis of these clusters.

BS shows a place sharing parallel in both initial and medial sC clusters. At 1;9, BS began producing accurate place-sharing medial sC clusters while also producing place-assimilated clusters. At the left edge, BS place-assimilated /s/ in /sk/ clusters, resulting in velar fricatives at 1;9. He produced both sT and sK clusters word-medially in the following recording, at 2;0, however it is possible that he began producing sT clusters earlier than sK within the three-month gap between recordings. More importantly for the current discussion, this place sharing is not consistent with a branching onset analysis of initial sC clusters, where place sharing is unattested cross-linguistically, and has no parallel in CL cluster behaviour. I return to this after addressing CN's behaviour.

CN provides evidence of two patterns that are inconsistent with a branching onset analysis of initial sC clusters, and instead show strong parallels with patterns of medial sC cluster development. At 2;3, CN produced initial sC clusters with prothesis, inserting a vowel before the /s/, making it a medial cluster. Within this prothetic context, she produced two target sT clusters accurately, and produced two other sC clusters with geminate substitution, a pattern strongly attested in medial sC clusters and entirely absent from CL behaviours. The place sharing pattern displayed for initial sC clusters is not compatible with a branching onset analysis, as the two consonants of complex onsets appear, in the unmarked case, to contrast in place (recall this from §1.2.4 of chapter 2). Additionally, the epenthesis displayed for sC clusters is qualitatively different from that displayed for CL branching onset clusters; while children epenthesize a vowel to split up the CL clusters, the epenthetic vowel in sC clusters is prothetic, and maintains the dependency relationship in the cluster. This latter prothesis pattern effectively creates a medial sC cluster out of an initial sC cluster. This evidence lends further support to the analysis that sC clusters, at least in Italian, are represented as coda-onset clusters (Kaye 1992; d'Andrade & Rodrigues 1998; Goad 2012), in which the coda is in an empty-headed syllable, as shown in (92) above.

All children do not show identical parallels, however due to the nature of the coda of an empty-headed syllable. Because an empty-headed syllable is more marked than a syllable with an audible head (i.e., specified for segmental material), initial sC clusters may be acquired later than their medial counterparts. Children show different substitution patterns (e.g., assimilation, geminate substitution) in medial clusters, so the different initial sC cluster substitutions are expected, and demonstrated, to show this same variability. The parallels within individual systems, however, remain stark: BS produced place-assimilated sC clusters both initially and medially; CN produced geminates in place of both initial and medial sC clusters; and VL mastered initial and medial sC clusters during the same period.

3 Summary in stages

A timeline of all children’s medial cluster acquisition is summarized in (98), where, for each cell, the cluster in its row is mastered before the cluster in its column. In (98a) we see that NC clusters are acquired earlier than all other sonorant+C cluster types; this was found for all children in this study. Next, lT clusters are acquired, followed by heterorganic lC clusters. While not all children acquired lC in the recorded period, all children showed lT production at a time when they did not show lP or lK production. Finally, rC is acquired, if at all, after heterorganic lC clusters, as exemplified by VL. Turning to the obstruent+C clusters in (98b), we see that sT clusters are acquired before heterorganic sC clusters, as exemplified by BS. No child shows sP or sK acquired at a stage when sT is not.

(98) Timeline of medial cluster mastery

a) Sonorants

	NC	lT	lP, lK	rC
NC		✓	✓	✓
lT	×		✓	✓
lP, lK	×	×		✓
rC	×	×	×	

b) Obstruents

	sT	sP, sK
sT		✓
sP, sK	×	

Substitution patterns also evidence the relations expressed in (99) where, for each cell, the cluster in its row acts as a substitute for the cluster in its column. Geminates act as a substitute for all clusters, while NC acts as a substitute only for sonorant+C clusters, namely lC and marginally for rC. The lP and lK clusters are never substituted by lT, however their relative markedness is due to place sharing, and not SV markedness. In obstruents we see that sC clusters of all PoAs are substituted for geminates. Place-sharing clusters, similar to with lC, are not substituted by sP and sK.

(99) Substitution patterns in medial cluster acquisition

a) Sonorants

	C_iC_i	NC	lT	lP, lK	rC
C_iC_i		✓	✓	✓	✓
NC	×		✓	✓	✓
lT	×	×		×	✓
lP, lK	×	×	×		✓
rC	×	×	×	×	

b) Obstruents

	C_iC_i	sT	sP, sK
C_iC_i		✓	✓
sT	×		×
sP, sK	×	×	

The summaries in (98) and (99) reflect the markedness relationships shown below in (100). The alignment of place-sharing sC and lC clusters above it reflects the observation that sC clusters, even in place-sharing environments, do not emerge until NC clusters are mastered. This is not reflected in a structural relationship, but rather by the observation that the unmarked post-vocalic consonants are sonorants (Zeč 1995), represented by the SV node.

(100) Relative markedness of medial clusters in Italian

a) Sonorants: C_iC_i >> NC >> lT >> lP, lK >> rC
b) Obstruents: C_iC_i >> sT >> sP, sK

Concerning initial clusters, while Cr clusters are acquired later than Cl, and Cl are acquired later than NC, no correlation seems to exist between Cl and lC clusters, or Cr and rC clusters.

This markedness relationship, along with the others described in this chapter, is represented in the proposed developmental path in (101) below. I illustrate this path with a summary of the results discussed throughout this chapter.[25]

(101) Path of acquisition of Italian consonant clusters

Stages:	1	2	3	4	5
CCV			Cl	Cr	
VC.CV	C_iC_i	NC	lT	lP, lK	rC
			sT	sP, sK	

The acquisition of consonant clusters begins, at stage 1, when coda production begins. Unfortunately we do not have data when a child reduces all clusters, so we cannot make generalizations beyond this. At stage 1, codas can be produced, but cannot specify their own segmental material (or distinctive features), and therefore look like the geminate structure in (89a). This accounts for CN's accurate production of geminates at 2;3 before any other cluster, as well as for all children's substitutions to geminates affecting each medial cluster type throughout development. Geminates are not in fact acquired along this path for children other than CN, probably due to the lack of geminates in the local variety of Italian, as discussed in §2.1; I leave this question to future research.

Stage 2 is achieved when the child can produce a coda supplying its own SV node, illustrated in (89b), resulting in the production of a homorganic nasal. Substitutions at this stage, exemplified by CN, consist of NC clusters being reduced to C_iC_i clusters, implying the latter has a subset of the NC structure.

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[25] Note that NC must precede all other types of coda-onset clusters, as well as complex onsets. However, this is not meant to imply anything about the relative acquisition of sub-types of complex onsets and coda-onset clusters. For example, while rC is shown in stage 5, it need not be acquired later than Cr, only later than lC.

Stage 3 is characterized by three separate developments that need not occur simultaneously: children acquiring place-sharing codas that independently supply a feature at a level below the SV node (i.e., the [approximant] feature) as shown in (90a), or codas that supply a feature below the AF node (i.e., the [strident] feature) in (90b), or complex onsets (Cl) as in (91a). Thus, stage 3 is achieved when the child has acquired lT (stage 3a), sT (stage 3b), or Cl (stage 3c).

The structure for lC clusters is motivated by the fact that they are consistently acquired later than NC clusters, for all children, and that when substituted, lT clusters often become either NC clusters or geminates. This implies that both NC clusters and geminates have a subset of the structure required for lC. For sC clusters, the structure is motivated by the fact that sC is always acquired later than NC. Substitutions for the sC cluster marginally present as NC clusters, however these productions, mentioned in footnote 15, have other likely explanations. The lack of independent place features is motivated by the fact that lT clusters are the first accurate lC clusters produced. The same representation is less motivated for sC clusters, as these do not show as consistent a pattern, however no child's behaviour contradicts this representation. Branching onsets are invariably produced and acquired later than NC clusters, lending support to Kaye & Lowenstamm's (1981) typology, at least for word-medial codas.

Stage 4 is attained when children can license their own place in codas, allowing the production of lP, lK (stage 4a, as shown in (89c)), as well as sP and sK (stage 4b, as shown in (89e)). Stage 4c is achieved when the child is able to produce Cr, and therefore able to support two levels of specification under the SV node in complex onsets, shown in (91b).

Stage 5 is achieved when the child can license the feature [rhotic] under the feature [approximant], dominated by the SV node, resulting in accurate productions of /r/. This is motivated by the fact that no children acquired /r/ before /l/, and that /r/ is often substituted by [l] for many children. The acquisition of initial Cl and Cr clusters parallels that of lC and rC clusters, where the features of the /r/ exist as a superset of those of /l/, which is motivated by Cl being consistently acquired before, and acting as a substitute for, Cr.

Lastly, initial sC clusters are analyzed in the same way as medial sC clusters, which is motivated by the parallels in the two clusters, concerning when they are acquired, the pre-mastery place sharing, and the epenthesis and the geminate substitutions. The difference between initial and medial sC clusters is that initial clusters involve a coda of an empty-headed syllable: empty headed syllables are more marked than head-specified syllables, by virtue of the empty head, which adds an element of abstraction to the structure. However, while it should not formally constitute its own developmental stage, homorganic initial sC production could begin once the same has happened word-medially. Further investigation is necessary to understand the process of acquiring empty-headed syllables.

Chapter 7: Discussion

In §1, I reflect on the results of the current investigation, in light of the goal of representing markedness in a hierarchically organized structure. In §2, I summarize the thesis and conclude.

1 Markedness

In this thesis, I have discussed markedness in the form of sonority generalizations, place-sharing, and prosodic structure. I summarize below the contributions of this thesis to our understanding of each of these facets of markedness.

Markedness in sonority has been discussed in terms of the Sonority Sequencing Principle (SSP) in (10), the Syllable Contact Law (SCL) in (15), and Sonorant Voice (SV) structure (Rice 1992), incorporated in representations like those in (89). All of these proposals crucially rely on a sonority scale, similar to the one in (9). These guiding principles have helped uncover supporting evidence for a coda-onset syllabification of word-initial sC clusters. Sonority, as represented with Rice's (1992) SV structure, also helped unveil that the contrast between /l/ and /r/ may in fact be one of sonority, which would suggest some bifurcation for the liquid category in the sonority scale in (9). Similarly, sonority was also found to potentially encode the contrast allowing for the distributional freedom of /s/ compared to all other obstruents (Goad 2016b). However, it is not represented as such in this thesis (as the feature [strident] would be necessarily dominated by at least the SV node, and not the AF node). I leave the link between stridency, sonority, and the SV node to future work.

We also saw that place-sharing across heterosyllabic consonant clusters is unmarked relative to independent place specification.[26] This observation strengthens the support for a coda-onset syllabification of initial sC clusters, while the lack of this effect in rC clusters, which dovetails with the relative distributional freedom in coronal onset clusters, reinforces the claim that /r/ is cross-linguistically placeless (Rice 1992; Rose 2000; Goad & Rose 2004).

2 Conclusion

I set out to describe the facts of Italian consonant cluster acquisition, and account for them in light of the adult language typologies of medial clusters and syllable shapes with a structural representation composed of monovalent, hierarchically-organized features. This is in line with the overall goal of representational phonology, which is to account for markedness, or universal linguistic tendencies, through structured representations. More broadly, I aimed to describe Italian cluster acquisition in a manner that makes testable predictions, without depending solely on theory-internal interpretations.

Elaborating on the discussion of Dutch prosodic development in Chapter 1, I uncovered the presence of a relationship between segmental and prosodic development by examining a typology of consonants at the right-edge (Piggott 1999). I also emphasized the explanatory power of forming generalizations about development based around the syllable and its relation to sonority (Smith 1973; Clements 1990; Zeč 1995; Gnanadesikan 2004; Goad & Rose 2004). As languages with word-medial codas but no final consonants, like Italian, are underrepresented in the literature on phonological acquisition, the dataset observed in this thesis presented a useful test

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[26] This is likely part of a more general feature-sharing markedness across different domains of segments, suggested by the various geminate substitution patterns employed by all children. Due to the variability of geminates, place-sharing played the most prominent role in this investigation.

case to study the affects of relatively strict constraints on consonant distributions across different segmental relationships and cluster syllabifications.

I briefly examined the phonology of Italian, focusing on the combinatorial options for consonant clusters, both across and within syllables. In doing so, I established the consonants available as the dependents of the clusters: namely /N, l, r, s, C_i/ in codas, where N represents a nasal place-dependent on the following onset, and C_i represents the first half of a geminate; and /l, r/ as the second member of a complex onset.

From the constraints on Italian syllable and segmental structure, and assuming monovalent, hierarchically-organized features and nodes, I formed predictions, and then research questions, to investigate the markedness relationships between (sonority) and within (place-sharing) cluster types. I then explored these cluster types for each child in a corpus of four typically-developing Italian-learning children, and organized the data to answer the research questions formulated.

Sonorants in clusters show development consistent with the hierarchically structured monovalent features and nodes proposed by Rice (1992), whereby nasals are the least marked sonorants, represented as a bare SV node. Additionally, the place-sharing requirement on NC clusters affords it a further element of unmarkedness within its representation. lC clusters show this same SV node and place sharing as in NC clusters, with the added feature [approximant], indicating these consonants are segmentally more marked. Homorganic rC clusters show no preference compared to heterorganic clusters, while the feature [rhotic] added along the SV continuum assigns rC clusters a marked status compared to the other sonorant+C clusters.

The only non-geminate obstruent codas in Italian are found in sC clusters, which appear both word-initially and word-medially. The parallels across these clusters are clear: place sharing shows a facilitative effect in medial clusters and initial clusters; both clusters exhibit geminate substitution, although word-initial clusters also involve prothesis; and finally the two clusters may be acquired during the same period.

CL clusters are invariably produced, and then acquired, later than NC clusters, suggesting that Kaye & Lowenstamm's (1981) typology does indeed fit in word-internal syllables. CL clusters show epenthesis, where the inserted vowel breaks up the cluster, contrary to the behaviour of sC clusters, further supporting the distinct syllabifications that these two clusters involve.

While geminates are predicted to have the least marked structure, implying that they would be acquired first out of all medial coda-onset interludes, they did not behave this way for three out of the four children. This is likely due to the lack of geminate contrast in the ambient language variety these children were exposed to during their first years of development. CN, however, behaved exactly as predicted, which may indicate a dialectal difference in her input. Also in support of the simple root-sharing representation for geminates, all children showed geminate substitutions for all cluster types. Geminates behaviours include only reductions or accurate productions, as predicted by its representation.

The analysis is formulated in terms of stages, which capture each child's timeline of cluster mastery, as well as substitution behaviours. The first stage allows for geminates, which share all features with the following onset. At stage 2, the coda independently supplies its own SV node, while sharing the place node of the following onset, resulting in accurate NC clusters. Stage 3a involves the further marking of the feature [approximant], which results in place-sharing lT clusters. Stage 3b involves the development of the AF node dominating the feature [strident], resulting in place-sharing sT clusters. Stage 3c is achieved when children can produce complex onsets, which optimally consist of Cl clusters. Stage 4a and 4b result when children's representations of lT and sT incorporate their own place feature in codas, resulting in lP/lK and sP/sK respectively. Children reach stage 4c when their complex onset representations can supply the SV node, dominating the feature [approximant], further dominating the feature [rhotic], resulting in Cr clusters. Finally, stage 5 is achieved when children's representations can support the three levels of SV structure in codas, i.e., SV dominating [approximant], in turn dominating [rhotic], resulting in rC clusters. Overall, the stages summarized here all share that the representations underlying the children's behaviours become increasingly marked through the addition of segmental nodes or features in dependent positions of syllabic constituents.

By investigating prosodic development in tandem with segmental development in Italian, this thesis contributes novel observations concerning the markedness relationships between sonority, place, and dependency relations in prosodic structure. This study also contributes to the currently underrepresented literature on Italian phonological acquisition within formal phonology, which to date has been mostly the focus of clinical research (Rose, Almeida & Freitas to appear).

In future research, it would be useful to design perceptual tests to investigate if, at the stage when children are not producing geminates, they are able to perceive the geminate contrast in their target language. Additionally, a cross-dialectal study of Italy's geminating and non-geminating dialects would be useful in discerning if the predictions of this thesis, supported only by CN's development concerning geminates, are borne out in the development of children in a region where geminates are contrastive. Recording Italian-learning children more frequently would allow an elaboration of more detailed timelines than those reported in this thesis.

Similarly, shorter time intervals between recordings would potentially allow for the observation of the hypothesized stage where CN mastered geminates before mastering NC clusters. Finally, reliable stress transcription across all participants may reveal a facilitative role for stressed syllables in the development of clusters and geminates.

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