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The Structure of Branching Onsets and Rising Diphthongs:

Evidence from the Acquisition of French and Spanish

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Consonant-glide-vowel (CGV) sequences are represented differently across languages. In some languages, the CG sequence is represented as a branching onset; in other languages, the GV sequence is represented as a rising diphthong. Given variable syllabification across languages, this study examines how young children represent CGV sequences. In particular, we evaluate Rose's (2000) proposal, based on French acquisition data, that CGV sequences are initially represented as rising diphthongs. To do this we examined children's acquisition of CGV sequences in cross-sectional data from 14 French-speaking children (aged 1;10 – 2;10 years) and longitudinal data from five Spanish-speaking children (aged 1;3 – 3;0 years). Across several different measures (order of acquisition, style of acquisition, positional faithfulness, error patterns), children's production of rising diphthongs and branching onsets patterned similarly. The results suggest that, at least for these children, CGV sequences are represented as branching onsets during the early stages of acquisition.

1. INTRODUCTION

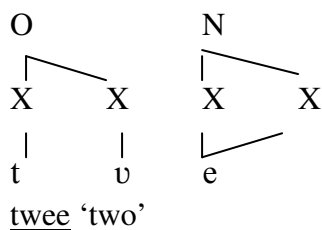
Languages differ as to how consonant + sonorant + vowel sequences are represented.

Whereas the most common pattern in consonant + liquid + vowel sequences (CLV) is that the liquid forms part of the syllable onset,¹ several patterns are possible in consonant + glide + vowel (CGV) sequences: the glide may form part of a branching onset or it may form part of a rising diphthong with the following vowel. Dutch is an example of a language in which CG sequences pattern as branching onsets (e.g., twee [tʰe:] ‘two’) as in (1a) (Booij, 1983);

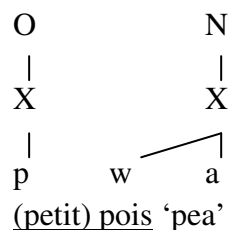
French is an example of a language in which the glide forms part of a rising diphthong in the nucleus (e.g., (petit) pois [pwa] ‘pea’) as in (1b) (Kaye, 1985). The glide may also be secondarily articulated to the onset, thus forming a complex segment (e.g., C^jV, C^wV) as in some analyses of CGV sequences in Portuguese (d’Andrade & Viana, 1993) (1c). Finally, the glide may be multiply linked to the onset and to the nucleus as in (1d). Such a proposal has been made for the CjV sequence (e.g., pew [pju:] in English but not for the CwV (e.g., twin [twin]) sequence, which patterns as a branching onset (Giegerich, 1992). In all cases an X represents a timing unit (see discussion in section 2.2).

(1) Structural representation of CGV sequences

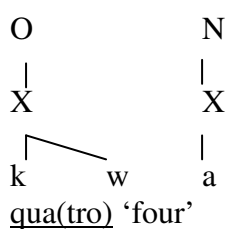
a. Dutch



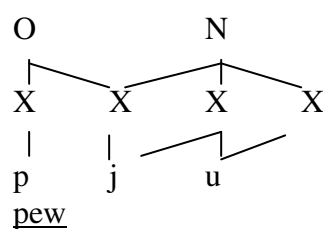
b. French



c. Portuguese



d. English



If CGV sequences are represented differently across languages, how do children learn these language-specific representations? Do they represent them initially as branching onsets, as rising diphthongs, as complex segments with secondary articulations or as something in-between? The primary aim of the study is, thus, to examine the structure of CGV sequences in early child language. In particular, we wish to evaluate proposals made by Rose (2000), based on French acquisition data, that the unmarked representation for CGV sequences is that of a rising diphthong. Specifically, Rose observed different patterning between CLV and CGV sequences, consistent with the representation of CLV sequences as branching onsets and CGV sequences as rising diphthongs.² To examine the representation of CGV sequences, we employ acquisition data from French and another language in which CLV and CGV sequences pattern differently, namely, Spanish. We contrast the behavior of rising diphthongs and branching onsets on a variety of measures inspired by Rose (2000) and other researchers (Barlow, 1997a; Paradis and B eland, 2002): 1. Order of acquisition; 2. Style of acquisition - whether acquisition is categorical or gradual; 3. Positional faithfulness effects (i.e., influence of stress); and 4. Error patterns.

The article is organized as follows: In section 2, we present background information on branching onsets and rising diphthongs in French and Spanish and consider relevant literature on the acquisition of these segmental sequences; in section 3, we present the database; in section 4, we analyze the data; in section 5, we consider the implications of the findings on the representation of CGV sequences in early child French and Spanish.

2. EMPIRICAL AND THEORETICAL BACKGROUND

2.1. The Structure of Branching Onsets and Rising Diphthongs in French and Spanish

Examples of branching onsets in French and Spanish are given in (2).³ They consist of plosive + liquid, and /f/ + liquid sequences (and /vr/ sequences in French), whereby the liquid is either an alveolar lateral /l/ or /r/. In French, the /r/ is a uvular approximant ([ʁ]) whereas

in Spanish, it is an alveolar tap ([ɾ]). Examples of rising diphthongs are given in (3). In addition to the palatal and labial-velar diphthongs (/jV/ & /wV/) found in both French and Spanish, French also contains the labial-palatal diphthong (/ɥV/).

(2) Branching onsets in French and Spanish

plosive + liquid

	French	Spanish
/p/	<u>pl</u> age [plaʒ] ‘beach’	<u>pl</u> ato [ˈplato] ‘plate’
/pr/	<u>pr</u> ésent [pʁeˈzɑ̃] ‘present’	<u>pr</u> onto [ˈpronto] ‘quick’
/b/	<u>b</u> leu [blø] ‘blue’	<u>b</u> lanco [ˈblanko] ‘white’
/br/	<u>br</u> osse [bʁos] ‘brush’	<u>br</u> uja [ˈbruxa] ‘witch’
/tr/, */t/	<u>tr</u> ain [tʁɛ̃] ‘train’	<u>tr</u> en [tren] ‘train’
/dr/, */d/	<u>dr</u> ap [dʁa] ‘bed sheet’	<u>dr</u> agon [draˈɣon] ‘dragon’
/k/	<u>k</u> lé [kle] ‘key’	<u>k</u> laro [ˈklaro] ‘clear’
/kr/	<u>kr</u> êpe [kʁep] ‘pancake’	<u>kr</u> ema [ˈkrema] ‘cream’
/g/	<u>g</u> lace [glas] ‘ice’	<u>g</u> lobo [ˈgloβo] ‘balloon’
/gr/	<u>gr</u> and [gʁɑ̃] ‘big, tall’	<u>gr</u> ande [ˈgrande] ‘big, tall’
/f/ + liquid		
/fl/	<u>fl</u> eur [flœʁ] ‘flower’	<u>fl</u> or [flor] ‘flower’
/fr/	<u>fr</u> omage [fʁɔˈmaʒ] ‘cheese’	<u>fr</u> ío [ˈfri.o] ‘cold’
/v/ + liquid		
/vr/	<u>vr</u> ai [vʁɛ] ‘true, real’	

(3) Rising diphthongs in French and Spanish

	French	Spanish
/jV/	<u>camion</u> [ka'mjɔ̃] 'truck'	<u>camión</u> [ka'mjon] 'truck'
/wV/	<u>voiture</u> [vwa'tyʁ] 'car'	<u>bueno</u> ['bweno] 'good'
/ɥV/	<u>cuillère</u> [kɥi'jɛʁ] 'spoon'	

Several phonotactic facts in French and Spanish are consistent with the analysis of GV sequences as rising diphthongs. First, both French and Spanish allow segmental sequences consisting of sonorant + glide + vowel. In many languages, however, there are constraints on two sonorants appearing in the onsets of syllables. For example, English does not allow onset sonorant sequences such as */ml/, */mr/, */nl/, */nr/, */rl/ and */lr/ nor does it allow sonorants to precede /w/ in CwV sequences (e.g., */nwV/, */lwV/, */rwV/). In French and Spanish, sonorant sequences such as /ml/, /mr/, /nl/ and /nr/ do not occur, but sonorant sequences containing glides do (e.g., /nwV/, /lwV/, /njV/, /ljV/), suggesting that the glide is not associated to the onset but rather to the nucleus of the syllable.

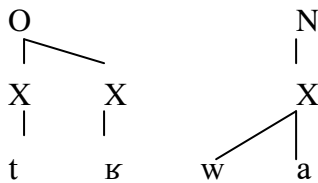
Second, both French and Spanish have no constraints on homorganicity in CGV sequences. Consonant + glide sequences may consist of two labials (e.g., /mw/, /pw/, /bw/, /fw/, /vw/) or two coronals (e.g., /nj/, /tj/, /dj/, /sj/). In contrast, many languages do not allow syllable onsets to contain two consonants of the same place of articulation. For example, English does not allow homorganic sequences in the case of the glide /w/ (e.g., */mw/, */bw/, */pw/). It behaves like other sonorants (e.g. /l/ as in */tl/, */dl/) in requiring that a preceding tautosyllabic consonant belong to a different place of articulation (Davis & Hammond, 1995). In French and Spanish, however, constraints on homorganicity apply in the case of the liquid /l/ (*/tl/ and */dl/ sequences are not allowed) but not in the case of glides. This fact is consistent with an analysis of the glide as part of the nucleus and not as part of the onset.

Third, both French and Spanish contain CLGV sequences (e.g., French trois [tʁwa]

‘three’; bruit [bʁɥi] ‘noise’; Spanish grieta [ˈgrjeta] ‘crack’; trueno [ˈtrweno] ‘thunder’).

Many languages do not allow onsets containing three consonants, with the exception of /s/ clusters. For example, English does not contain sequences such as */plw/ and */flj/. The constraint against three elements in onsets can be maintained in French and Spanish if the glide is analyzed as part of a rising diphthong and not as part of the onset, as shown in (4).

(4) Representation of CLGV sequences (trois [tʁwa] ‘three’) in French



Additional support for a rising diphthong representation in Spanish comes from the existence of /s/ + glide sequences (e.g., siesta [ˈsjesta] ‘nap’; suerte [ˈswerte] ‘luck’). All other initial /s/ + consonant sequences are preceded by an epenthetic vowel [e] (e.g., esfera [esˈfera] ‘sphere’; esclavo [esˈlaβo] ‘slave’), allowing the /s/ to close the preceding syllable and preventing a complex onset containing /s/. The fact that /s/ + glide sequences occur means that the glide does not form part of the syllable onset (Carreira, 1992).

In sum, all of the phonotactic factors mentioned above are consistent with a separate analysis of CLV and CGV sequences in French and Spanish: the liquid forms part of the syllable onset whereas the glide forms part of the nucleus. Note, we have not discussed two other possible representations of CGV sequences, namely that they are secondarily articulated consonants (1c) or that the glide is dually associated with the onset and nucleus (1d). A secondary articulation analysis typically entails place and sonority restrictions between C and G, restrictions that we have already shown not to occur in the case of French and Spanish. For example, labialized labials and labialized coronals are dispreferred as secondary articulations (Ladefoged & Maddieson, 1996; see Goad, 2006) whereas they readily occur in

French and Spanish (e.g., French: boire [bwaʁ] ‘to drink’, doigt [dwa] ‘finger’; Spanish: bueno [ˈbweno] ‘good’, duele [ˈdwele] ‘(it) hurts’). Thus, a secondary articulation analysis does not seem viable for these languages. Concerning the latter representation (1d), to our knowledge a dual representation of complex onset and rising diphthong has not been proposed for CGV sequences in French and Spanish, but has been proposed to explain the complex behavior of CjV sequences in English (see Section 2.4.1).

2.2. Rising Diphthongs: One Timing Unit or Two?

The representations of branching onsets and rising diphthongs differ not only with respect to the affiliation of the approximant (onset or nucleus) but also with respect to the number of timing units they contain. Whereas branching onsets consist of two timing units, several works support the representation of rising diphthongs as complex segments consisting of a single timing unit in the nucleus (Everett, 1996; Hyman, 1985; Kaye, 1985; Shane, 1987). Evidence stems from the stress facts and phonotactics of the language. For example, in Spanish, while word-final syllables containing VG rhymes always attract stress (e.g., convoy [konˈboi] ‘convoy’) and word-final syllables containing VC rhymes generally attract stress (e.g., virtud [birˈtuð] ‘virtue’), final GV rhymes are not stressed (e.g., limpio [ˈlimpio] ‘clean’) suggesting that syllables containing rising diphthongs behave like light syllables. Rising diphthongs are also the only syllables in Spanish that permit three segments in the rhyme. Thus, forms like muerte ([ˈmwerte] ‘death’) and siesta ([ˈsjesta] ‘nap’) are possible but forms like *dewrso and *artna are not (examples are taken from Carreira, 1992: 22). Again, these facts are consistent with the structure of rising diphthongs as being that of light diphthongs.

Most authors argue that rising diphthongs are universally light or monoperpositional (Schane, 1987; Rose, 1999; Senturia, 1998); however occasional references to bipositional

rising diphthongs have been reported in the literature (Kenstowicz & Rubach, 1987; Rosenthal, 1994; see later discussion).

2.3. Additional Issues about Rising Diphthongs in French and Spanish

Some additional comments should be included about rising diphthongs in Spanish since their analysis is not without controversy. First it should be noted that alternate pronunciations of words containing rising diphthongs are possible in Spanish. Hualde (1991) points out that a hiatus pronunciation is possible in certain Spanish words assumed to contain rising diphthongs. For example, the vocalic sequences in Column A of (5) may be pronounced as rising diphthongs or as hiatus sequences (piano ‘piano’ may be pronounced as either [ˈpjano] or [pi.ano]) whereas the vocalic sequences in Column B can only be pronounced as diphthongs. Pronunciation differences appear to vary across dialect and speaker but not within speaker as Hualde (1991) reported that speakers’ intuitions about which words allow hiatus were “generally very strong and clear” (p. 476).

(5)	Column A		Column B
	vowel-vowel (bisyllabic)		glide-vowel (monosyllabic diphthong)
	pi.á.no ‘piano’		li.viá.no ‘light’
	di.á.blo ‘devil’		a.ciá.go ‘fateful’
	cli.én.te ‘client’		dién.te ‘tooth’
	du.é.to ‘duet’		bué.no ‘good’

(adapted from Senturia, 1998: 203)

Second, the way in which stress, syllabification and vowel-glide sequences (GV or VG) interact in Spanish is extremely complex (Carreira, 1992; Rosenthal, 1994, Senturia, 1998). Although rising diphthongs may pattern as light for the purposes of stress (as mentioned above), they may also pattern as heavy. Like VC and VG rhymes, they block antepenultimate stress when in penultimate position (*as.tró.n[aw].ta; *cá.ram.ba; *Dá.n[je].la); Rhymes

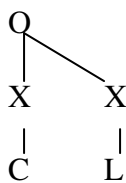
containing a simple V allow antepenultimate stress (sá.ba.na ‘sheet’). Furthermore, although they don’t attract stress when in final position, they block antepenultimate stress (*té.ra.p[ja], *cón.ti.n[wo]). Light syllables do not behave in this way (nú.me.ro ‘number’). The complex behavior of rising diphthongs in Spanish has led certain authors to propose that, in certain cases, a GV sequence is underlyingly bipositional. Some accounts allow for bipositional rising diphthongs (Dunlap, 1991, Harris, 1983, Nouveau, 1993) whereas others propose that rising diphthongs behave like two separate light syllables (Carreira, 1992; Hualde, 1991, Senturia, 1998). In either case, the representation of rising diphthongs is not simply assumed to be a monopositional form.

These two above-mentioned factors, the alternate pronunciations of rising diphthongs and the complex behavior of rising diphthongs with respect to stress, may be an important issue when examining children’s acquisition of these structures. How do children determine the representation of rising diphthongs (monopositional or bipositional) in Spanish given ambiguity of the surface forms – some forms produced as rising diphthongs and others as vowels in hiatus? In addition, do these factors apply to French? The second factor, the complex behavior of rising diphthongs with respect to stress, should not be an issue in French because stress is word-final regardless of the quantity of the syllable.⁴ Thus, stress will neither hinder nor help children in sorting out the representation of rising diphthongs. The first factor may play a role, however. We have observed rising diphthongs in French being pronounced as hiatus sequences (e.g., pieux [pjø] ‘pious’ > [pi.ø]; émotion [emo'sjõ] ‘emotion’ > [emosi.õ]; suave [sqɑ:v] ‘sweet/ bland’ > [su.avə]).⁵ This observation is consistent with reports in the French literature noting that hiatus pronunciation is possible in certain dialects of French (Klein, 1993; Martinet, 1933). This leads us to posit that similar bipositional structures may also be present for French.

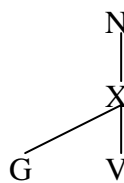
The preceding discussion suggests that there are two possible representations of rising diphthongs: one in which GV sequences are associated with one timing unit and the other in which they are associated with two timing units.⁶ Branching onsets are associated with two timing units. As mentioned, the first representation of rising diphthongs (Rising Diphthongs 1) is the one universally accepted; the second has been proposed by a small number of researchers to account for dialectal variation and the complex stress facts of Spanish. As we noted, such variation has also been attested in French. Their different representations are shown in (6).

(6) Structure of branching onsets versus rising diphthongs

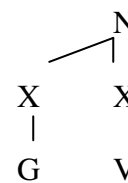
a. Branching Onset



b. Rising Diphthong 1



c. Rising Diphthong 2



In the next section, we consider studies which have directly compared the acquisition of branching onsets and rising diphthongs. These have been conducted in English (Barlow, 1997a), French (Rose, 2000; Paradis & Béland, 2002) and Spanish (Anderson, 2002; Barlow, 2005).

2.4. The Acquisition of Branching Onsets and Rising Diphthongs

2.4.1. English

In English, as mentioned above, CwV sequences pattern differently from CjV sequences (Davis & Hammond, 1995; Giegerich, 1992). Whereas CwV sequences pattern like CLV sequences, CjV sequences pattern as if the glide belongs to both the onset and to the nucleus (Anderson, 1986; Giegerich, 1992). For example, unlike /w/, /j/ can occur in onsets after sonorants (/mj/ mule; /nj/ new; /lj/ lewd vs. */mw/, */nw/, */lw/), consistent with an analysis of /jV/ as a rising diphthong. However, like /w/, it cannot occur after consonant + liquid

sequences (forms such as /flju/ and /plju/ do not occur), suggesting that /j/ also takes up a slot in the onset. Additional evidence for the hybrid status of /j/ comes from American English, in which /j/ is deleted from coronal + [j] sequences – clusters of the form /tj, dj, nj, lj, sj, zj/ are not allowed. The fact that GV sequences are sensitive to constraints on homorganicity suggests that /j/ must also be associated with the onset of the syllable.

Note that for Giegerich (1992), the /j/ is associated with its own timing unit which is dually attached to the onset and to the nucleus; the following vowel /u/ is also associated to two timing units (see 1d). In contrast, Davis and Hammond (1995) conclude that /j/ is not associated with its own timing unit but is co-moraic with the following vowels (they work within a moraic system of syllable structure). According to these authors, stress facts support a monomoraic analysis for jV sequences since nouns with three or more syllables containing a jV sequence in an open penultimate syllable generally receive antepenultimate stress (e.g., áccuracy, currículum, binóculars, Drácula). Thus, the rising diphthong does not appear to add weight to the penultimate syllable. Under Davis and Hammond's (1995) account, CwV sequences are branching onsets and CjV sequences are rising diphthongs.

Barlow (1996, 1997a, 1997b) observed that the ambiguous behavior of CjV sequences in the adult grammar was also reflected in children's acquisition. Within and across children, /j/ sometimes patterned as part of the nucleus and sometimes as part of the onset. Her findings are based on the performance of CGV and CLV sequences in a group of phonologically disordered children. In the case of Subject 13 (aged 5;2), CjV sequences patterned differently from branching onsets, consistent with an analysis as rising diphthong. CjV sequences were produced correctly whereas CwV and CLV sequences were reduced to a single consonant, as shown in (7a). In the case of JS (age 3;10), CjV sequences behaved similarly to other consonant clusters, consistent with an analysis as complex onset. For example, JS tended to

epenthesize a vowel between the two segments of an onset cluster in both Cj and Cl sequences, as in (7b).

(7) Productions of CLV and CGV sequences in phonologically disordered English-speaking children (adapted from Barlow, 1996: 41, 44)

a. Subject 13 (age 5;2)

Target CjV	Target CwV	Target CIV and CrV
<u>pew</u> [pju]	<u>twin</u> [tɪn]	<u>play</u> [peɪ]
<u>cute</u> [kjuʔ]	<u>queen</u> [kiŋ]	<u>drum</u> [dʌmi]

b. JS (age 3;10)

Target CjV	Target CIV
<u>cute</u> [kəjut]	<u>play</u> [pəleɪ]
<u>few</u> [fəju]	<u>blowing</u> [bəlouwiŋ]

Barlow's (1996, 1997a) findings, thus, show that there is variation in how CjV sequences pattern in child English, a finding consistent with the ambiguous status of CjV sequences in the adult English grammar. We now turn to French, a language in which CLV and CGV sequences are represented differently.

2.4.2. French

Rose (1999, 2000) proposes that the unmarked representation of CGV sequences is that of consonant followed by rising diphthong. His proposal stems from two sources. The first is a cross-linguistic survey of the syllabification of CGV sequences in languages that permit CLV sequences, in which he observed that languages most frequently syllabify CGV sequences as rising diphthongs (C.GV) rather than as onset clusters (CG.V).⁷ The second is developmental data, in which he observed that two French-speaking children (Clara and Théo), studied from the onset of word production through to 2;7/4;0 years, acquired rising diphthongs differently from branching onsets. This finding is consistent with there being structural differences

between the two sets of target sequences. We focus in more detail on his developmental findings.

Rose (2000) observed that CLV and CGV sequences behaved differently in two important respects: mastery time and their relation with stress. Concerning the first point, rising diphthongs were fully mastered before branching onsets (although the trajectory of acquisition in the case of branching onsets was complicated by the presence of stress -- see second point). Associated with mastery time, Rose (2000) observed that rising diphthongs emerged progressively (at different times), whereas branching onsets emerged categorically (at the same time). The gradual emergence of rising diphthongs, according to Rose (2000), could be explained by the fact that their mastery was “affected by segmental – rather than prosodic - constraints governing the feature combinations involved in each diphthong” (p.148). That is, the acquisition of rising diphthongs was influenced by the segmental make-up of the individual root nodes, whereas the acquisition of branching onsets was determined by the branching of prosodic constituents.

Concerning the second point, stress played a significant role in the realization of branching onsets but an unimportant one in the realization of rising diphthongs: rising diphthongs were mastered independently of stress. For example, Clara mastered branching onsets in stressed syllables several months before she mastered them in unstressed syllables (8a). In contrast, she produced rising diphthongs in stressed and unstressed syllables at the same time (8b).

(8) Effect of stress on branching onsets and rising diphthongs (Rose, 2000)

a.	<u>glisse</u>	[glis]	[klis]	‘(s/he) slides’	Clara 1;10,04
	<u>glissade</u>	[gli'sad]	[ka'sæd]	‘a slide’	Clara 1;10.04
b.	<u>bois</u>	[bwa]	[bwa]	‘wood’	Clara 1;09,01
	<u>poisson</u>	[pwa'sõ]	[pwe'sõ]	‘fish’	Clara 1;10,04

Rose (2000) accounted for the contrasting behaviors of the two segmental sequences by positing a high-ranking prosodically-conditioned faithfulness constraint (MaxHead(Foot)). This constraint demands faithfulness to timing units in stressed syllables but not to the melodic content of the individual root nodes in stressed syllables. Therefore, this constraint would contribute to the reduction patterns of branching onsets, which involve two timing units but not to the patterns of rising diphthongs which involve a single unit.

As for error patterns, Rose (2000) did not observe any differences between rising diphthongs as compared to branching onsets. Children, when dealing with these segmental sequences, deleted the approximant; they selected the head element in both cases, resulting in similar types of output patterns. For example, the head element of the branching onset /bʁ/ is the initial consonant /b/, and the head element of the rising diphthong /wa/ is the syllabic element /a/. Reduction of the two French words bras [bʁa] ‘arm’ and (petit) pois [pwa] ‘pea’ would result in very similar productions, namely, [ba] and [pa] respectively, thus, not providing any information as to the underlying structure of these segmental sequences.

Differences in error patterns between branching onsets and rising diphthongs have been reported, however, with older French children (aged 6 years) using novel words. Paradis and Béland (2002) observed a higher proportion of epenthesis in rising diphthongs compared with branching onsets (see (9)). Epenthesis involved insertion of a vowel nucleus, as in the example [avi.ɔ̃] for avion [avjɔ̃] ‘plane’ or the insertion of a consonant onset as in [lijɔ̃] for lion [ljɔ̃] ‘lion’. From now on we refer to these patterns as nuclear and onset epenthesis respectively.⁸

(9) Differences in error patterns between branching onsets and rising diphthongs (adapted from Paradis & Béland, 2002: 220)

Epenthesis

Deletions

Branching Onsets	4%	96%
Rising Diphthongs	33%	67%

Although Paradis and Béland's (2002) findings indicate different patterning between branching onsets and rising diphthongs, they don't necessarily offer any information as to the structure of rising diphthongs. Epenthesis is a pattern that is often suggestive of two separate input segments (Barlow & Dinnsen, 1998; Barton, Miller, & Macken, 1980). This pattern would then argue against a complex segment analysis for CGV sequences. Nuclear epenthesis has also been reported in children's acquisition of complex onsets (e.g., brush > [bəɪʌʃ]) and is said to signify the point at which children acquire the segmental representation of the input sequence but not the requisite prosodic one involving branching structure in the onset (Freitas, 2003). We return to this issue in the discussion.

2.4.3. Spanish

Turning finally to Spanish, Barlow (2005) provides support for the different structural representations of CLV and CGV sequences on the basis of a phonological treatment study of a Spanish child (aged 3;9). Barlow (2005) examined whether phonological training on a complex onset (/fr/) would generalize to other CLV sequences, as well as to CGV sequences; the inference being that if CGV sequences are structurally related to CLV sequences then generalization is likely to occur. She found that the child's performance on CLV sequences improved following treatment but the child's performance on CGV sequences remained unaffected, thus, suggesting that CGV sequences were not patterning as complex onsets in this child's system. Interestingly, Barlow's (2005) findings differ from an earlier study by Anderson (2002) who documented improvement on both CLV and CGV sequences following training on two rising diphthongs (/lw/ and /lj/) for one Spanish-speaking child. In trying to integrate the two sets of findings, Barlow (2005) acknowledges that children may differ in their early structural representations of CGV sequences. In the phonology of the child in

Anderson's (2002) study, the glide may form part of a complex onset, whereas, in the phonology of the child in her study, the glide may form part of a complex nucleus.

In sum, a review of the studies comparing the acquisition of rising diphthongs and branching onsets shows differing results across languages. The findings in English and, to some extent, in Spanish are equivocal: rising diphthongs sometimes pattern differently from branching onsets and sometimes not. The findings in French are more straightforward: rising diphthongs pattern differently from branching onsets. We turn to the aims of the current study.

2.5. Research Aims

The aim of this study is to examine in detail French- and Spanish-speaking children's acquisition of CLV and CGV sequences. The goal is to determine if these sequences are represented similarly or differently. In order to determine whether CLV sequences are represented as complex onsets, and CGV sequences as rising diphthongs, we examine these sequences with respect to: 1. Order of acquisition; 2. Style of acquisition - whether acquisition is categorical versus gradual; 3. Positional faithfulness effects (influence of stress); and 4. Error patterns. Given the similar structure of branching onsets and rising diphthongs in the adult grammars of French and Spanish, our predictions for child French and Spanish are the same. A summary of the predictions, based on the literature review, is given in Table 1.

INSERT TABLE 1 ABOUT HERE

The prediction that rising diphthongs as a group should be acquired before branching onsets is consistent with Rose's (2000) findings and also with other findings in the literature pointing to the developmental sequence of complex segments being acquired before complex syllable structure. For example, affricates which are complex segments are acquired before branching onsets in English, German, and Spanish (Gierut & Champion, 1999; Lleó & Prinz,

1997). Similarly, Freitas (2003) reports that complex segments, such as segments containing secondary articulations (e.g., [k^w]), are acquired before branching onsets (e.g., [tr]) in European Portuguese. One concern with this prediction, however, is that CGV sequences may emerge before CLV sequences even if they are represented as branching onsets due to factors relating to sonority sequencing: the sonority distance is greater in CG than CL sequences. However, certain patterns are also predicted not to occur, such as similar acquisition times for branching onsets and rising diphthongs or split patterns in which different types of rising diphthongs or branching onsets behave differently. Such findings should therefore offer potential information on the structure of CGV and CLV sequences.

The second prediction that syllabic constituents emerge categorically (i.e., at similar time points) is inherent in Rose's findings and in the work of other investigators in child phonology (Fikkert, 1994; Freitas, 2001, 2003). For example, Portuguese children acquire syllable-final liquids considerably later than syllable-final fricatives. This different timeline led Freitas (2001) to propose that final liquids do not belong to the same part of the syllable as final fricatives: final fricatives are codas but final liquids are part of a branching nucleus. One concern with this prediction, however, is that segmental factors may interact with syllable structure such that sequences with similar syllable structure may not always be acquired categorically. This may lead some readers to question its usefulness as a measure to distinguish branching onsets from rising diphthongs. We include this parameter, nevertheless, because it is one of the measures proposed by Rose (2000) that clearly revealed differences between the two types of segmental sequences.

The third prediction, the presence of positional faithfulness effects in branching onsets but not in rising diphthongs, comes from Rose's (2000) findings. He observed that branching onsets were produced in stressed syllables before unstressed syllables, consistent with a high ranking constraint demanding faithfulness to the input segments (i.e., timing units) of stressed

syllables. One concern with this prediction, however, is that positional faithfulness effects have been observed at the melodic level as well (Beckman, 1997), suggesting that they may also apply to rising diphthongs, thereby putting into question the value of this measure in distinguishing the two types of structures. What is important, nevertheless, is that the two structures pattern differently in terms of positional faithfulness effects.

The fourth prediction stems from Paradis and B eland's (2002) findings that branching onsets and rising diphthongs differed in terms of error patterns: branching onsets were mainly subject to deletion errors whereas rising diphthongs were subject to both epenthesis and deletion errors. Our analysis will not only focus on deletions and epenthesis, but will consider all types of errors with the general aim of determining whether the two types of sequences pattern differently.

Before proceeding to a discussion of methodology, some important features of the study relating to the database and its adherence to Rose (2000) should be pointed out. The database consists of experimental cross-sectional data from French-speaking children and longitudinal spontaneous data from Spanish-speaking children. We include the two types of data-sets because they provide complementary information on phonological development. The cross-sectional data, by testing a greater number of subjects, provides a perspective on typologies of syllable and segmental structure, whereas the longitudinal data, by following subjects over a period of time, provides direct developmental information similar to that used in Rose's (2000) study. The two data-sets also contain different advantages and disadvantages. The cross-sectional experimental study allows for a more complete set of productions across all conditions, since the target stimuli were elicited in a semi-formal set-up. The longitudinal study does not yield a complete set of stimuli since the focus was on collecting spontaneous productions. Nevertheless in answering certain questions such as order of acquisition, the longitudinal data will provide more conclusive information than the cross-sectional data. It

should be pointed out that our longitudinal data-base contains not only data from monolingual Spanish-speaking children but also data from bilingual Spanish-German children, in which only the Spanish productions are analyzed. The justification for using data from bilingual children is provided in section 3.2.5.

Our choice of the four measures largely follows Rose's (2000) study. However, we acknowledge that there are several differences between Rose's study and the current one which make direct comparisons between the two studies difficult. First, Rose's (2000) study consisted of longitudinal data on two subjects whereas the current study contains cross-sectional and longitudinal data on a greater number of subjects. As noted above, cross-sectional data may not be ideal for addressing all research questions, such as those related to developmental information. Furthermore, an analysis of a larger group of subjects will naturally yield more variable patterns than one conducted on a smaller group of subjects. Second, there may be other differences in methodology between the two studies which have an impact on the test findings. For example, different things were counted as errors in the two studies. We counted glide/ liquid substitutions (CLV > CGV; CGV > CLV) as errors in the current study (see Method section) whereas Rose did not. Third, Rose (2000) analyzed his two subjects' productions of CLV and CGV sequences in light of their overall phonological development, whereas we are unable to provide a detailed analysis of each child's phonological patterns, due to the larger number of subjects. Where possible, we focus on individual differences but it is possible that we may miss some important segmental trends that bear on the acquisition of CLV and CGV sequences. We believe the advantages of making generalizations on a larger data-set should outweigh some of these disadvantages.

3. METHOD

3.1. French Cross-sectional Data

3.1.1. Subjects

Subjects include 14 French-speaking children aged 1;10 to 2;9 years growing up in Lyon, France (mean age = 2;4.0). Seven children were boys and seven were girls. These children formed a subset of a larger experimental study which focused on other aspects of phonological development (e.g., development of codas). Eight children from the larger study did not participate in the current study because they did not produce sufficient numbers of words.

3.1.2. Procedure

Children were engaged in semi-formal word elicitation tasks in two sessions of 30 minutes, recorded in the children's homes. The children played with an experimenter and, on occasions, with a parent. Tasks involved naming pictures in a book or picking objects out of a bag. Standard phrases used to elicit responses included Qu'est-ce que c'est? 'What is this?', Peux-tu me dire ce que tu vois? 'Can you tell me what you see?', Qu'est-ce qu'il y a dans le sac? 'What is there in the bag?' The children were both audio and video-recorded using a digital camera and a FM transmitter/receiver set-up.

3.1.3. Stimuli

The stimuli consisted of real words (predominantly monosyllabic and disyllabic) containing branching onsets and rising diphthongs in stressed and unstressed syllables. Every attempt was made to choose "picturable" words which would be familiar to two-year-old children. Children were encouraged to produce the designated stimulus items, but any word, containing a branching onset or rising diphthong, spontaneously produced during a test session could be included in the final data-set. A list of potential stimulus items is given in Appendix 1 and examples are shown in (10). Words featured with an asterisk in the appendix are those that were not targeted as stimuli.

(10) Examples of French stimulus words

a. Branching Onsets

/Cl/ clé [kle] ‘key’, tableau [ta'blo] ‘blackboard’

/Cɤ/ bras [bɤa] ‘arm’, bracelet [bɤas'lɛ] ‘bracelet’

b. Rising Diphthongs

/CjV/ pied [pje] ‘foot’, piano [pja'no] ‘piano’

/CwV/ poire [pwaɤ] ‘pear’, poisson [pwa'sɔ̃] ‘fish’

/CɥV/ cuillère [kɥi'jɛɤ] ‘spoon’, biscuit [bis'kɥi] ‘biscuit’

3.1.4. Data-base and Data Coding

The recorded sessions were downloaded onto a computer and transcribed using CHAT conventions (MacWhinney, 2000). All productions of stimulus words were transcribed by two native speakers. Differences in transcription were resolved via consensus. If the two transcribers failed to agree, the production was excluded. This occurred for two items in the entire database. Multiple repetitions of the same stimulus item were included. Productions which were inaudible or masked by noise were excluded. Productions were classified as to whether they were spontaneous or imitated (followed an adult production of the target word). Imitated utterances constituted 30% of the total number of utterances. Paired t-tests revealed that children produced branching onsets and rising diphthongs with significantly greater percent accuracy ($t(11)=-2.74, p<0.05$) in their imitated than in their spontaneous productions (compare 67% vs. 59%), suggesting a mild (ameliorative) effect of imitation on children’s productions. Additional analyses did not show that children were more likely to imitate branching onsets as opposed to rising diphthongs or vice versa. Thus, we do not believe that the imitation effect influenced the overall conclusions in any way. Consequently, imitated and spontaneous productions were analyzed together.

Productions were finally coded according to whether the target form contained a branching onset (ClV or CɤV) or a rising diphthong (CjV or CwV or CɥV) and whether the

sequence occurred in a stressed or unstressed syllable. For the first part of the initial analysis, Order of acquisition, the rising diphthongs wV and ɥV were coded separately. Later, they were grouped into a single category (referred to as WV). Our decision to group these two diphthongs was based on methodological factors: (1) French transcribers reported difficulty perceiving the difference between these two diphthongs and (2) children often substituted target ɥV with wV diphthongs. The grouping of the two diphthongs in the French data also ensured some symmetry of presentation with that of the Spanish data. In grouping wV and ɥV together, our methodology differs from Rose (2000) who analyzed these two diphthongs separately.

Productions were considered correct if the child produced CLV and CGV sequences for branching onsets and rising diphthongs respectively. Deletions (bras -> [ba]; pois -> [pa]) and epenthesis (bras -> [bɛʁa]; pois -> [pu.a]) were considered errors. Substitutions of the initial consonant were not considered errors (bras -> [pʁa]; pois -> [bwa]) but substitutions of glides for liquids or vice versa were considered as errors (bras -> [bja] ; pois -> [pla]). Substitutions within a class were also counted as errors (e.g., bras -> [bla]). The final database consisted of 1032 target productions, that is, an average of 74 productions (range 22-104) per child.

3.2. Spanish Longitudinal Data

3.2.1. Subjects

Subjects include two monolingual Spanish children (María and Miguel), growing up in Madrid, Spain, and three bilingual German-Spanish children (Nils, Simon, and Jens) growing up in Germany. The bilingual children were children of Spanish-speaking mothers (in two cases, Spanish; in one case, Chilean) and German-speaking fathers. The main care person during the first two years of life for the bilingual children was the Spanish-speaking mother.

Information based on the percentage of German and Spanish utterances produced in the recording sessions and Mean Length of Utterances (MLUs) suggested that Simon and Jens were balanced bilinguals, whereas Nils was dominant in German (see Kehoe, Lleó, & Rakow, 2004).⁹

3.2.2. Procedure

The bilingual children were audio- and video-recorded fortnightly from the beginning of word production (1;0 to 1;3) through to approximately 2;6 – 3;0 years. The monolingual children were audio-recorded monthly. Both sets of children were recorded in their homes in unstructured play situations, in sessions of approximately 40 minutes, while interacting with one of the parents and an investigator. The bilingual children were visited by two separate teams: a German- and a Spanish-speaking team. If one of the parents was present, he/she had to be a native speaker of the language in which the recording was taking place. Only Spanish words spoken in Spanish sessions were included in the study.

3.2.3. Stimuli

All words containing branching onsets and rising diphthongs (in stressed and unstressed syllables) produced in the recording sessions were included in the final data set. A list of potential stimulus items is given in Appendix 1 and examples are shown in (11).

(11) Examples of Spanish stimulus words

a. Branching Onsets

/Cl/ plato ['plato] 'plate', iglesia [i'ylesja] 'church'

/Cr/ fruta ['fruta] 'fruit', libro ['libro] 'book'

b. Rising Diphthongs

/CjV/ pie [pje] 'foot', serpiente [ser'pjente] 'snake'

/CwV/ agua ['aywa] 'water', cuánto ['kwanto] 'how much'

3.2.4. Data-base and Data Coding

Following testing, all sessions were glossed and phonetically transcribed by native Spanish speakers. The majority of utterances included in the study were spontaneous productions. Data were coded similarly to the French data. Deletions (tres -> [tes]; pierna -> ['pena]) and epenthesis (flor -> [fu'lor]; camión -> [kami.'on]) were considered errors. Substitutions of the initial consonant were not considered errors (globos -> ['klobos]; ciervo -> ['tjevo]) but substitutions of glides or liquids were considered as errors (dragon -> [dja'ʔɔn] ; columpio-> [ku'lɔmplo]).

Reliability between transcribers for the syllable structure parameters of interest (e.g., agreement in terms of whether a segment was deleted or inserted) was over 90%. The final database consisted of 1846 target productions (Miguel = 472; Maria = 286; Jens = 247; Nils = 407; Simon = 434).

3.2.5. Bilingual vs. Monolingual Subjects

It should be emphasized here that the bilingual data are being used alongside the monolingual data to provide information on Spanish phonological development. It is, of course, appropriate to ask whether we should include bilingual children in the study because their phonological development may be different from that of monolingual children. Spanish contains both branching onsets and rising diphthongs; however, German, the other target language of the bilingual children, contains only branching onsets (e.g., klein 'small'; krank 'sick'). This asymmetry may influence the bilingual children's phonological development. One possible prediction is that the predominance of branching onsets in the input (branching onsets being in German and Spanish; rising diphthongs being only in Spanish) may lead bilingual Spanish children to also analyze rising diphthongs as branching onsets. An aspect of the current analysis will be to compare the patterning of CLV and CGV sequences in monolingual and bilingual children in order to exclude the possibility of cross-linguistic

interaction. As will be seen, the two groups of children behave similarly in their developmental patterns justifying, the inclusion of the bilingual subjects.

4. RESULTS

4.1. Comparison between CGV Sequences

Before we contrast the behaviors of CGV and CLV sequences across the four measures outlined above, we examine whether children treat all types of CGV sequences similarly. In French and Spanish, the segmental make-up of CGV sequences varies. They may be obstruent-initial (e.g., cuillère [kɥi'jɛʁ] ‘spoon’, agua [ˈaɣwa] ‘water’) or sonorant-initial (e.g., noir [nwaʁ] ‘black’, nieve [ˈnjeβe] ‘snow’); the consonant and glide may share place of articulation (e.g., poisson [pwa'sɔ̃] ‘fish’, bueno [ˈbweno] ‘good’) or may not (e.g., piéd [pje] ‘foot’, piedra [ˈpjeðra] ‘stone’). As discussed in section 2.1, phonotactic facts such as the presence of sonorant-initial sequences and the absence of constraints on homorganicity are particularly revelatory of the status of CGV sequences as rising diphthongs. Obstruent-initial sequences, which differ in place of articulation (e.g., cuillère [kɥi'jɛʁ] ‘spoon’, cuatro [ˈkwatro] ‘four’), resemble for all intents and purposes CGV sequences which pattern as branching onsets in other languages.

In this analysis, we examine whether children treat the two types of CGV sequences differently. It is possible that children treat CGV sequences, in which the first segment is a sonorant or in which the consonant and glide share place of articulation, as rising diphthongs, and treat other types of CGV sequences as branching onsets. To test this in the French data, CGV sequences were divided into two groups: Group 1 consisted of sonorant-initial sequences, and obstruent-initial sequences in which the obstruent and glide share place of articulation (i.e., noir and poisson type words) and Group 2 consisted of obstruent-initial sequences in which the obstruent and glide differ in terms of place of articulation (i.e.,

cuillère type words).¹⁰ Table 2 presents the percent correct scores according to group for individual French-speaking children. The findings show slightly higher percent correct scores for Group 1 as opposed to Group 2 words (Mean scores of 66% vs 54 %) and paired t-tests indicated that these differences were marginally significant ($t(13)=2.08$, $p=0.06$). Note in particular the performances of several children (Je, Ta, Qu, Mr) who scored higher on the Group 1 versus the Group 2 words.

INSERT TABLE 2 ABOUT HERE

In a similar way, Spanish CGV sequences were divided into two groups: Group 1 (e.g., nieve, bueno) vs. Group 2 (e.g., cuatro). The analysis focuses on time periods 1;9 - 2;0, 2;0 - 2;3, 2;3 - 2;6, and 2;6 - 2;9, the periods in which the majority of productions were recorded. The only exception was for Jens where productions from the period 2;9 - 3;0 were also included due to his low verbal output. Table 3 presents the percent correct scores according to group for individual Spanish-speaking children. The mean percent scores for Group 2 words were slightly higher than for Group 1 words (Mean scores of 49% vs. 41%), a trend different to that of the French children; however, paired t-tests indicated that this difference was not significant ($t(4)=-2.30$, $p>0.05$).

INSERT TABLE 3 ABOUT HERE

In sum, the results indicate a mild tendency for the French children to treat the two groups of words differently but none for the Spanish children. Given that the effect is only marginally significant in the French data and not present in the Spanish data, we justify our decision to group all CGV sequences together for the remaining analyses. We will return to the French findings when we discuss individual differences across children.

4.2. Order and Style of Acquisition

In the following sections, we present acquisition patterns for target branching onsets and rising diphthongs. We analyze the two branching onsets (Cl, Cr) and the three rising

diphthongs (CwV, CWV, CjV) separately because, as will be seen, grouping the results together would distort the main findings.

The findings in this section address the first two measures: 1. Order of acquisition and 2. Style of acquisition. We predict that rising diphthongs as a group should be acquired before branching onsets, and that rising diphthongs should be subject to gradual development, whereas branching onsets should be subject to categorical development. Note that, because we are using cross-sectional data in the case of French, Order of acquisition is inferred from overall percent correct scores.

4.2.1. French Cross-sectional Data

The means and standard deviations of percent correct scores for all the French-speaking children for the three rising diphthongs (jV, ɥV, wV) and the two branching onsets (Cɪ, Cɛ) are shown in Table 4. These results indicate superior performance for CwV as compared to CɥV and CjV sequences, and for CɪV as compared to CɛV sequences. Statistical tests (1-way repeated measures ANOVA and paired t-test) revealed that the differences between the three rising diphthongs, however, were not significant ($F(2, 26)=0.66, p>0.05$) whereas the ones between branching onsets were ($t(13)=3.74, p<0.01$). That is, the French children experienced less difficulty producing Cɪ than Cɛ branching onsets.

INSERT TABLE 4 ABOUT HERE

Interestingly, Rose (2000) observed that the children in his study acquired rising diphthongs in the following order: Cj > Cw > Cɥ with the later acquisition of Cɥ diphthongs being explained by the fact that, in contrast to j and w, the glide ɥ contains two articulators (labial and palatal) underneath the place node.¹¹ The order of acquisition in the current study was: Cw > Cɥ > Cj. Like Rose (2000), we found that Cw sequences tended to be acquired more easily than Cɥ sequences; however, unlike Rose (2000), Cj sequences were acquired

less easily than the other sequences.¹² Given that the differences were not statistically significant, it is difficult to interpret these percent scores in terms of segmental complexity (i.e., number of articulators underneath the place node). For the methodological reasons stated above (see section 3.1.4), we collapse diphthongs Cw and Cɥ into a single category (referred to as CW) for the remaining analyses.

The mean percent scores for the two rising diphthongs (CjV, CWV) and the two branching onsets (CIV vs. CɛV) for the individual French-speaking children are displayed in Figures 1 and 2 respectively. The raw scores for individual children are also given in Table A of Appendix 2. Several of the children performed better with CWV as compared to CjV diphthongs, consistent with a mild segmental effect (Figure 1). However the segmental effect appeared even greater in the case of branching onsets (CIV vs. CɛV), as seen in Figure 2.

INSERT FIGURES 1 AND 2 ABOUT HERE

In order to obtain an approximate index of order of acquisition, we grouped segmental sequences together in terms of similar percent correct scores. A segmental sequence was noted as being acquired before another segmental sequence when the percent difference between the two segmental sequences was reasonably large (in two cases this difference was 10% but in the majority of cases (11/14), the percent score difference was in the order of 30 to 40%). The grouping together of segmental sequences revealed three main patterns in the data as summarized in (12). An arrowhead indicates a difference in percent accuracy of at least 10%; a comma indicates no difference or a difference of less than 10% in percent accuracy.

(12) Summary of French acquisition patterns

a. Pattern 1: CIV > CɛV

Mr CIV > CWV, CjV, CɛV

Ar	CIV > CWV, CjV > C _B V
El	CIV, CWV > CjV, C _B V
My	CIV, CWV > CjV, C _B V
Ba	CIV, CWV > CjV > C _B V
Pa	CIV, CWV, CjV > C _B V
Qu	CIV, CWV, CjV > C _B V
Ta	CIV, CjV > C _B V > CWV
*Cl	CWV > CIV, CjV > C _B V

b. Pattern 2: Branching Onsets > Rising Diphthongs

Lo	CIV, C _B V > CWV, CjV
Ag	CIV, C _B V > CWV > CjV
Im	CIV, C _B V, CWV > CjV

c. Pattern 3: Rising Diphthongs > Branching Onsets

Le	CjV > CWV, CIV, C _B V
Je	CWV > CjV > C _B V > CIV

The first pattern, followed by the majority of children (n=9), was that CIV branching onsets were acquired before C_BV onsets with rising diphthongs falling somewhere in between, either being acquired at the same time as CIV onsets or afterwards. Subject “Cl” is noted with an asterisk because her patterns were slightly different from the other children in this group in that the rising diphthong CW received superior percent correct scores to the branching onset Cl. Nevertheless, the percent correct score for Cl sequences was superior to C_B sequences consistent with the other children in this group. The second pattern, followed

by three of the children was that branching onsets were acquired before rising diphthongs, and the third pattern followed by two of the children was the opposite one: rising diphthongs were acquired before branching onsets.

The third pattern is the only one consistent with our prediction that rising diphthongs should be acquired before branching onsets. Many of the French-speaking children showed a split pattern with CIV and CGV sequences being acquired before CɤV sequences.

Nevertheless, as noted above, interpretation of percent accuracy in cross-sectional data is not a foolproof way to determine order of acquisition. Another way to test this would be to examine whether there is any evidence that a child produces CLV sequences to the exclusion of CGV sequences or vice versa. Here, the findings are equivocal since both patterns were present in the data. Le and Je produced some CGV sequences (Le – CjV sequences only; Je – CjV & CWV) but very few CLV sequences. In contrast, Mr produced some CLV sequences (CIV sequences only) but very few CGV sequences. Thus, we turn to the longitudinal data. If similar results are observed in the Spanish data as in the French ones, we have stronger confirmation of the French findings.

4.2.2. Spanish Longitudinal Data

The acquisition profiles of the two monolingual (Miguel and María) and the three bilingual (Simon, Jens, and Nils) Spanish-speaking children are presented in Figures 3 and 4 respectively. Each profile displays the percent correct scores for the two rising diphthongs (CjV, CwV) and the two branching onsets (CIV, CrV) for the analysis period studied. Sessions are grouped into three-month intervals. The end point of testing varies from child to child depending upon the data available. In the case of Miguel, data were available until 3;1 (period 3;0 - 3;3), whereas in the case of Simon, only until 2;7 (period 2;6 - 2;9). The time points indicated in the figures mark the end of a given three-month interval. For example,

time point 1;9 for Miguel (see Figure 3) refers to the results obtained during the three-month interval 1;6 – 1;9.

INSERT FIGURES 3 AND 4 ABOUT HERE

The order of acquisition of rising diphthongs and branching onsets for the Spanish children is summarized in (13). Here, we considered the acquisition profiles of each child and focused on the earliest time point in which a clear order of acquisition could be determined from overall percent scores. In general, this time point was 2;3 - 2;6 or 2;6 - 2;9 following the stabilization of a relatively steep acquisition curve. Using criteria similar to the cross-sectional data, a segmental sequence was noted as being acquired before another segmental sequence when the percent difference between the two segmental sequences was reasonably large (in general, 30% or greater). The only exception is María, one of the monolingual children, whose acquisition profile is less clear (see Figure 3). It could be possible to identify María as belonging to a different pattern (time point: 2;3 - 2;6), namely, one in which rising diphthongs are acquired before branching onsets; however, C_iV sequences pattern with rising diphthongs in showing some development (albeit erratic), whereas C_rV sequences show no development (percent correct score less than 10% during the entire testing period). Therefore, for the sake of simplicity we group her pattern together with those of the other children. Note that Miguel displays inconsistent production of C_jV sequences around 3;0 years of age, which may relate to reduced sampling at this age. The raw scores for individual children are also given in Table B of Appendix 2. Percent correct scores which were based on fewer than three items were not plotted in Figures 3 and 4.

(13) Summary of Spanish acquisition patterns

Pattern 1: Rising Diphthongs, C_iV > C_rV

Miguel C_iV, C_jV, C_wV > C_rV

María C_wV, C_jV, C_iV > C_rV

Simon CjV, CwV, CIV > CrV

Jens CIV > CwV, CjV > CrV

Nils CIV > CwV, CjV > CrV

Returning to the issue of whether we should include bilingual data in the study, we observe that the patterns of the three bilingual children are not qualitatively different from the patterns of Miguel and (with the provisos mentioned above) María, the two monolingual children. If the bilingual children's acquisition of rising diphthongs were being influenced by their other language, German, we would need to explain why their results didn't pattern differently from the monolingual children's. On theoretical grounds, we might have predicted that the predominance of branching onsets in the input (German and Spanish combined) may have led the bilingual children into interpreting rising diphthongs as having the same structure as branching onsets. This would have resulted in similar acquisition patterns for all segmental sequences. This was not found to be the case. Rather, we saw CIV and CGV sequences being acquired before CrV sequences, a pattern found in all the Spanish-speaking children, and consequently, one that does not appear to be related to the bilingual input.

Therefore, it seems that the bilingual children's patterns do not differ significantly from those of the monolingual children. Obviously the sample size of both groups is small and findings will need to be verified in future studies. We also acknowledge that there may be subtle differences between the monolingual and bilingual children's acquisition of branching onsets and rising diphthongs, but these differences do not concern the main questions of this study. Critically, the Spanish-speaking children's later acquisition of CrV sequences compared with CIV and CGV sequences is the same as that found in most of the French-speaking children.

In sum, the French and Spanish results of our study did not support our predictions concerning either Order or Style of acquisition: Rising diphthongs were not acquired before branching onsets, nor were they subject to gradual development in contrast to branching

onsets which should have been subject to categorical development. Instead, branching onsets were subject to gradual development, with earlier acquisition of Cl than Cr clusters.

4.3. Positional Faithfulness Effects

In this section, we examine the data for positional faithfulness effects by comparing the accuracy scores of rising diphthongs and branching onsets in stressed versus unstressed syllables. The prediction is that branching onsets should pattern differently to rising diphthongs in terms of positional effects. If the findings parallel those of Rose (2000), we should expect branching onsets to be produced more accurately in stressed compared to unstressed syllables, consistent with a high ranking faithfulness constraint which is sensitive to the timing units of heads of feet (i.e., MaxHead(Foot)). It is difficult to fully address this question with the data under consideration because many of the elicited words and spontaneous productions were monosyllabic. We therefore consider a subset of the data (French data $n=607$ items; Spanish data $n=737$ items), focusing on the rising diphthong CWV/CwV and the branching onset $CɤV/CrV$, for which balanced numbers of productions existed across stressed and unstressed syllables.

4.3.1. French Cross-sectional Data

Table 5 shows the influence of stress on the means and standard deviations of percent correct scores of rising diphthongs (CWV) and branching onsets (CɤV) for all the French children. Paired t-tests revealed that French children produced rising diphthongs significantly more often in stressed versus unstressed syllables ($t(13)=-3.11$, $p<0.01$). They also produced branching onsets more often in stressed versus unstressed syllables but this difference was not significant ($t(13)=-0.67$, $p>0.05$). Note that there was no effect of word length (1 vs. 2 syllables) on percent correct performance, when stress was controlled ($t(11)=0.52$, $p>0.05$).

INSERT TABLE 5 ABOUT HERE

Table 6 presents the individual results for rising diphthongs and branching onsets. First, we focus on the findings for rising diphthongs. Two children (Ta and Le) did not produce rising diphthongs in either stressed or unstressed syllables. Of the remaining 12 children, seven displayed positional faithfulness effects (i.e., percent scores differences of 10% or more in favor of stressed syllables), whereas five displayed no difference between stressed and unstressed syllables (percent score differences of less than 10% between stressed and unstressed syllables). Even in the latter case, percent score differences were all consistent with an ameliorative effect of stress on rising diphthongs. That is, there were no cases in which percent scores were higher in unstressed as compared to stressed syllables. In particular, note the patterns of Ar and Ag who produced rising diphthongs 100% of the time in stressed syllables and less than 20% of the time in unstressed syllables. Examples of Ar's productions are given in (14).

INSERT TABLE 6 ABOUT HERE

(14) Effect of stress on rising diphthongs in one French-speaking child's productions

a. stressed syllables

<u>poire</u>	[pwa]	[pwa]	'pear'	Ar 2;6.0
<u>quoi</u>	[kwa]	[kwa]	'what?'	Ar 2;6.0
<u>baig'noire</u>	[bɛ'ɲwa:ʁ]	[be'mwaʁ]	'bath'	Ar 2;6.0

b. unstressed syllables

<u>poi'sson</u>	[pwa'sɔ̃]	[pa'sõ]	'fish'	Ar 2;6.0
<u>coi'ffer</u>	[kwa'fe]	[ka'fe]	'to arrange hair'	Ar 2;6.0
<u>voi'ture</u>	[vwa'ty:ʁ]	[ba'ty:ʁ]	'car'	Ar 2;6.0

In contrast, the individual results for branching onsets revealed more varied results. One child (Le) did not produce branching onsets in either stressed or unstressed syllables. Of the

remaining 13 children, five children displayed positional faithfulness effects, three children displayed reverse effects (superior performance in unstressed syllables) and five children showed no difference between stressed and unstressed syllables. Thus, positional faithfulness effects were observed in rising diphthongs more than in branching onsets, a finding different to that reported by Rose (2000).

4.3.2. Spanish Longitudinal Data

Table 7 shows the influence of stress on the means and standard deviations of percent correct score for the rising diphthong (CwV) and branching onset (CrV) in the Spanish data. The two monolingual children (Miguel and María) are not included in the group results because they attempted insufficient numbers of rising diphthongs in unstressed syllables. In the case of the three bilingual children (Simon, Jens, and Nils), analyses concentrated on those time periods in which there were balanced numbers of productions across stressed versus unstressed syllables. These periods were: Simon (1;10-2;6); Jens (2;3-2;10); Nils (2;0-2;7). The group results show very little effect of stress on branching onsets or on rising diphthongs. Low percent correct scores for the branching onset Cr were observed in both stressed and unstressed syllables, whereas the opposite effect was recorded for rising diphthongs: Children produced rising diphthongs more often in unstressed compared to stressed syllables, but this difference was not significant ($t(2)=-0.64, p>0.05$).¹³

INSERT TABLE 7 ABOUT HERE

In sum, neither the French nor the Spanish data replicated Rose's (2000) finding that positional faithfulness effects were present in branching onsets but not in rising diphthongs. Positional faithfulness effects were more strongly present in rising diphthongs than in branching onsets in the French data, whereas findings were inconclusive in the Spanish data, possibly due to floor effects resulting from the low percent accuracy of Cr clusters. As noted above, it is possible that positional faithfulness effects may refer to melodic units (e.g.,

Beckman, 1997), in which case the fact that rising diphthongs patterned differently to branching onsets in French could offer support for the two sets of sequences being represented differently. Given the ambiguous results, we turn to an analysis of error patterns in an attempt to find more definitive findings on the representation of CGV and CLV sequences.

4.4. Analysis of Error Patterns

In this section, we examine whether rising diphthongs as a group display different types of error patterns to branching onsets. As noted in the introduction, differences in error patterns were not discussed by Rose (2000) but have been reported by Paradis and Béland (2002). They found that rising diphthongs display more epenthesis errors than branching onsets. For the sake of simplicity, we categorized error patterns into three main groups, as shown in (15). Patterns that were difficult to categorize were excluded. This represented 16% and 12% of the total number of error patterns for the French and Spanish data respectively. Patterns that were excluded included deletions, in which it was not clear which consonant was being preserved (e.g., Spanish: grande [ˈgrande] -> [ˈnande] ‘big’; tigre [ˈtiɣre] -> [ˈtije] ‘tiger’) and productions involving metatheses (e.g., Spanish libro [ˈliβro] -> [ˈbilo] ‘book’). Productions in which the entire consonant + sonorant sequence was deleted (e.g., French: brosse [bʁɔs] -> [ɔs] ‘brush’; voiture [vwaˈtyʁ] -> [atyʁ] ‘car’) were also excluded.¹⁴

(15) Main error patterns in the data

	French	Spanish
a. Reduction to C ₁ V	<u>bras</u> -> [ba] ‘arm’	<u>grande</u> -> [gande] ‘big’
	<u>pois</u> -> [pa] ‘pea’	<u>cuento</u> -> [kento] ‘story’
b. Reduction to C ₂ V	<u>bras</u> -> [ʁa] ‘arm’	<u>grande</u> -> [rande] ‘big’

	<u>pois</u> -> [wa] 'pea'	<u>cuento</u> -> [wento] 'story'
c. Epenthesis	<u>bras</u> -> [bɛʁa] 'arm'	<u>grande</u> ->[gɛrande] 'big'
	<u>pois</u> -> [puwa] 'pea'	<u>cuento</u> -> [ku.eto] 'story'

4.4.1. Main Errors: French Cross-sectional Data

The distribution of error patterns for rising diphthongs (CjV, CWV) and branching onsets (CIV, CɤV) in the French data is shown in Figure 5. The results show that the rising diphthong CjV patterned differently from the other three segmental sequences by having more reductions to C₂ (e.g., avion [a'vjɔ̃] 'airplane' -> [a'jɔ̃]) and by having more epenthesis (e.g., avion [a'vjɔ̃] 'airplane' -> [avi.'ɔ̃]). The rising diphthong CWV behaved similarly to the branching onsets, however, being characterized predominantly by reduction to C₁. Thus, there was no consistent patterning of behavior that distinguished the two groups of consonant sequences.

INSERT FIGURE 5 ABOUT HERE

4.4.2. Main Errors: Spanish Longitudinal Data

The distribution of error patterns for rising diphthongs (CjV, CwV) and for branching onsets (CIV, CrV) in the Spanish data is shown in Figure 6. The Spanish findings are different from the French ones. The two rising diphthongs and the branching onset CIV patterned together in showing a high proportion of reduction to C₂. In contrast, the branching onset CrV was characterized predominantly by reduction to C₁. Only the rising diphthong CjV was subject to a substantial number of epenthesis errors (i.e., 12%). This finding was similar to the French one in that the CjV sequence as opposed to the CWV sequence was also subject to epenthesis errors. Like the French results, there were no error patterns that distinguished CLV and CGV sequences, providing little support for structural differences between the two sets of sequences.

INSERT FIGURE 6 ABOUT HERE

4.4.3. Further Discussion of Error Patterns

In this section, we focus on error patterns in the data which potentially provide information on the child's representation of CLV and CGV sequences. These error patterns include glide/liquid substitutions, reduction to C₂, coalescence, and epenthesis errors. We consider the French and Spanish data-sets together.

Substitution Errors

Children occasionally substituted CGV sequences with CLV sequences or vice versa. For example, they produced piano ([pja'no] 'piano') as [pla'no] or dragon ([dra'ʝon] 'dragon') as [dja'gon]. If there were a structural difference between branching onsets and rising diphthongs, we might have expected to observe substitutions only within groups, that is, between the two rising diphthongs (CjV <-> CwV) or between the two branching onsets (CIV <-> CrV).¹⁵ However, this was not the case. In particular, children showed a preference for the segmental sequence Cl, substituting it not only for Cr sequences but also for CG sequences, as shown in (16).

(16) Cl substitutions in branching onsets and rising diphthongs

a. French Data

C _ɤ V	<u>brosse</u>	[bɤɔs]	[blos]	'brush'	Mr 2;0.04
	<u>trompette</u>	[tɤʃ'pɛt]	[tlɔ'pɛt]	'trumpet'	Ta 2;0.10
CjV	<u>viande</u>	[vjãd]	[plãd]	'meat'	Mr 2;0.04
	<u>tiens</u>	[tjɛ̃]	[tlɛ̃]	'hold!'	Ta 2;0.10
CWV	<u>poire</u>	[pwa:ɤ]	[pla]	'pear'	Mr 2;0.04
	<u>etoile</u>	[e'twal]	[e'tlal]	'star'	Ta 2;0.10

b. Spanish Data

CrV	<u>tigre</u>	[ˈtiɣre]	[ˈtiple]	‘tiger’	Simon 1;10.0
	<u>libro</u>	[ˈliβro]	[ˈliklo]	‘book’	Simon 2;0.04
CjV	<u>pendientes</u>	[penˈdjentes]	[vɛɾˈdlæɪdə]	‘hill’	Maria 2;3.11
	<u>columpio</u>	[koˈlumpjo]	[kʊˈlumplo]	‘swing’	Maria 2;7.17
CwV	<u>pingüino</u>	[piŋˈgwino]	[ˈmliŋo]	‘penguin’	Simon 2;0.04
	<u>suelo</u>	[ˈswelo]	[ˈflel:o]	‘floor’	Nils 2;1.26

Reduction to C₂

In the Spanish data, a common error pattern for CGV and CIV sequences was omission of the initial consonant leading to production of the glide or liquid as onset; in the French data, this error pattern was also observed for CjV sequences. Examples are given in (17).

(17) Examples of reduction to C₂

a. Spanish Data

<u>iglesia</u>	[iˈɣlesja]	[ˈlesa]	‘church’	Simon 2;0.04
<u>avión</u>	[aˈβjon]	[aˈjon]	‘aeroplane’	Simon 2;0.25
<u>guapo</u>	[ˈgwapo]	[ˈwapo]	‘good-looking’	Simon 2;4.15
<u>abuelas</u>	[aˈβwelas]	[ʔaˈwoles]	‘grandmothers’	Nils 2;0.01
<u>agua</u>	[ˈaɣwa]	[ˈawa]	‘water’	Nils 2;1.12
<u>vueltas</u>	[ˈbwelta]	[ˈwelta]	‘turn’	Miguel 1;10.18
<u>globos</u>	[ˈgloβo]	[ˈloβo]	‘balloon’	Miguel 1;10.18

b. French Data

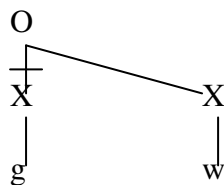
<u>avion</u>	[aˈvjɔ̃]	[ɛ̃jɔ̃]	‘airplane’	Qui 2;0.13
<u>camion</u>	[kaˈmjɔ̃]	[kaˈjɔ̃]	‘truck’	Pab 2;4.18
<u>serviette</u>	[sɛʁˈvjɛt]	[sɛˈjɛt]	‘towel’	Pab 2;4.18

chien [ʃjɛ̃] [jɛ̃] ‘dog’ Je 2;6,00

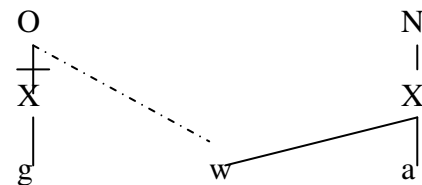
If CGV sequences are represented as branching onsets, this error pattern involves deletion of the head segment of the branching onset. If GV sequences are represented as rising diphthongs, this error pattern involves deletion of a simple onset. The second type of deletion may be followed by some form of restructuring such that the glide becomes onset of the syllable. The two possible representational accounts of C₁ deletion in CGV sequences are given in (18).

(18) Representational account of C deletion in CGV sequences

(a) Represented as Branching Onset



(b) Represented as Rising Diphthong



Is either of these representations consistent with the data? First, it should be noted that there were very few examples of simple onset deletion in the data. In the case of monopositional onsets, only when the onset was followed by a rising diphthong, did children tend to delete the onset. Thus, Simon produced vueltas ([¹bweltas] ‘turns’) as [¹weltas] but produced barco ([¹barko] ‘boat’) as [¹bako] not as [¹ako]. This suggests that C₁ deletion was influenced by the presence of the glide, a finding inconsistent with the glide belonging only to the nucleus of the syllable.

Second, we observed that it was not only CGV but also CIV sequences in the Spanish data that were subject to this error pattern. The latter observation is at odds with other literature accounts that report that the most frequent reduction pattern in clusters is the preservation of the first consonant. Both a structural account (preservation of head elements, see Goad & Rose, 2002, 2004; Rose, 2000) and a sonority account (preservation of the least sonorous segment, see Fikkert, 1994; Gnanadesikan, 1995/2004; Pater & Barlow, 2001,

2003) would predict the preservation of C_1 over C_2 . Nevertheless, Lleó and Prinz (1996), when comparing cluster reduction patterns in Spanish and German, observed a greater tendency by Spanish children to select the second consonant. They attributed this finding to differences in the directionality of syllabification in the two populations: Spanish children syllabify from right to left leading them to prefer the second consonant; German children syllabify from left to right leading them to prefer the first consonant. This is one explanation for the findings but other explanations are also possible.

We draw the readers' attention to the fact that in the Spanish data, voiced obstruent + glide/liquid sequences (e.g., /gl/, /gw/, /bw/, /bj/ etc.) were frequent in the data and were particularly susceptible to reduction to a C_2 pattern: Over 80% of errors occurred in sequences involving a voiced obstruent (particularly dorsal) + glide/liquid sequence (see Langer, 2002, for similar observations). Pater and Barlow (2001) also note that English-speaking children may deviate from the sonority pattern when conflicting constraints outrank onset sonority constraints. They identified constraints such as *Fricative, *Dorsal, and MaxLabial as being responsible for a non-sonority pattern in the English data. We posit that constraints such as *VoicedObstruent and *Dorsal may underlie the Spanish children's reduction patterns in both CGV and CIV sequences.¹⁶ In addition, MaxLabial may be highly ranked in the Spanish children's grammar since CwV sequences were the sequences most frequently reduced to a C_2 pattern (see Figure 6).^{17, 18} Alternatively, constraints that demand preservation of contiguous elements may also explain the high preservation rate of C_2 in CGV and CIV sequences (see van der Pas, 2004).

The aim of this study is not to provide a formal account of reduction patterns in CLV and CGV sequences; hence, we leave a more detailed discussion of these error patterns for future research and return to the issue at stake. Do these error patterns provide any information on the representation of CLV and CGV sequences? The fact that C_1 deletion was observed in

both CGV and CIV sequences alike, and the fact that the mechanisms underlying reduction appeared to be very similar in both types of segmental sequences (relating to the presence of dorsal segments or voiced obstruents) does not support there being a structural difference in the child's representations.

Coalescence

Apart from reduction to C_1 or C_2 , another type of error pattern in CGV sequences was coalescence, in which the output segment appeared to be a fusion of two input segments. Two types of coalescence patterns were observed: 1. Consonant coalescence, in which the output segment was a fusion of $C_1 + G$ and 2. Vowel coalescence, in which the output segment was a fusion of $G + V$. These two patterns are schematized in (19) and additional examples are given in (20).

(19) Coalescence in C + w sequences

Consonant Coalescence	<u>cuento</u> ->	[pento]
	k_1w_2ento ->	$p_{12}ento$
Vowel Coalescence	<u>cuento</u> ->	[konto]
	kw_1e_2nto ->	$ko_{12}nto$

(20) Examples of coalescence in the Spanish data

a. Consonant Coalescence

<u>agua</u>	[$'a\gamma wa$]	[$'a\beta a$]	'water'	Nils 1;06.21
<u>guapo</u>	[$'gwapo$]	[$'pato$]	'good-looking'	Simon 2;00.04

b. Vowel Coalescence

<u>cuánto</u>	[$'kwanto$]	[$'kunto$]	'how much'	Nils 2;00.15
<u>luego</u>	[$'lwe\gamma o$]	[$'l\theta\gamma o$]	'next, later'	María 2;03.11

Coalescence patterns may provide insight into the nature of the child's representation. If the glide aligns with the onset as part of a complex onset, consonant coalescence may occur. This error pattern has been reported in English-speaking children's acquisition of onset clusters (Barlow, 1997b). If the glide aligns with the vowel as part of a complex nucleus, vowel coalescence may occur. Rose (2000) reported some examples of vowel coalescence in French children's acquisition of rising diphthongs (footnote 25:150). In the current study, there were few examples of coalescence in the French data and also few examples in the case of CjV sequences.¹⁹ Therefore, our analysis focuses on CwV target structures in the Spanish data, in which the first consonant was either dorsal or alveolar. Results for individual children are given in Table 8.

INSERT TABLE 8 ABOUT HERE

As the table indicates, four of the five children displayed more examples of consonant than vowel coalescence. The overall percentage of consonant coalescence (16%) was significantly higher than that of vowel coalescence (4%) on the basis of a chi-square analysis ($\chi^2(1)=22.564$, $p<0.001$) suggesting that the labial glide aligns more often with the consonant than with the vowel. This supports the representation of CGV sequences as branching onsets. It is interesting that we did not observe examples of coalescence in the case of CLV sequences, given that they should also be represented as branching onsets. Independent properties of /r/ (see later discussion on the placelessness of /r/) and the coronal place of /l/ may make coalescence difficult to detect in CLV sequences. Note that four children displayed examples of both consonant and vowel coalescence, and one child displayed more examples of vowel than consonant coalescence suggesting some variability in patterning. We will return to this observation later in the discussion.

Epenthesis Errors

The final type of error pattern that we consider is epenthesis errors. They did not distinguish rising diphthongs as a group from branching onsets but, nevertheless, they were present 12-16% of the time for target CjV sequences in both the French and Spanish data.

Examples are given in (21).

(21) Epenthesis errors in CjV sequences

a. Spanish

camión [ka'mjon] [kami.'on] 'truck' Simon 2;6.10

avión [a'βjon] [aβi'jɔ:m] 'airplane' Miguel 2;10.09

b. French

lion [ljɔ̃] [li.'ã] 'lion' El 2;7.07

piano [pja'no] [pi'jano] 'piano' Au 2;6.08

Epenthesis errors potentially provide information on the child's representation of rising diphthongs because as output patterns they are unambiguously two timing units. As mentioned earlier, they have been attested to varying degrees in children's acquisition of branching onsets and have been used as evidence for the structural representation of branching onsets as complex syllable structure (Barlow & Dinnsen, 1998). Their presence in the case of CjV sequences implies that children analyze the target structure jV as having two timing units. At this stage, we do not have a clear explanation as to why CjV sequences were more susceptible to insertion errors than CwV/CWV sequences. It may be the case that the palatal glide lends itself to vocalization more easily than the labial glide; the labial glide being more susceptible to other types of error patterns (e.g., reduction to C₂).²⁰

4.5. Summary of Analyses

Let us summarize the findings to this point. We have compared the patterning of CLV and CGV sequences on several different measures aimed at evaluating French- and Spanish-

speaking children's representation of rising diphthongs as complex segments and branching onsets as complex syllable structure. The findings showed:

1. **Order of Acquisition:** Rising diphthongs, as a group, were not acquired before branching onsets, providing no support for the developmental sequence complex segment -> complex syllable structure (assuming that rising diphthongs are represented as complex segments).

2. **Categorical vs. Gradual Acquisition:** Systematic differences in acquisition rate were observed between rising diphthongs (CwV/CWV -> CjV) and between branching onsets (CIV -> CrV), although the differences were significant only in the latter case. Thus our findings did not support our prediction, based on Rose's (2000) findings, that rising diphthongs should be acquired gradually as opposed to branching onsets which should be acquired categorically. Branching onsets were not acquired categorically in this study: Cl clusters were acquired before Cr clusters.

3. **Positional Faithfulness Effects:** Rising diphthongs were subject to positional faithfulness effects in the French data, being more accurately produced in stressed syllables; branching onsets were not subject to these effects. The presence of positional faithfulness effects in rising diphthongs might suggest that the positional effects operative in the grammar of these children target melodic rather than timing units, thus offering potential support for the differing structural representations of CGV and CLV sequences. Alternatively, these sequences may be represented similarly and the absence of positional faithfulness effects in branching onsets may relate to the poor performance of Cr clusters overall (i.e., floor effects). Findings on positional faithfulness effects in the Spanish data were inconclusive.

4. **Error Patterns:** There were no error patterns that distinguished rising diphthongs from branching onsets. Furthermore, certain error patterns were consistent with a structural similarity between CLV and CGV sequences, and with the representation of target CGV

sequences as containing two timing units. They included liquid substitutions (e.g., viande [plãd]; brosse [plos]), reduction to C₂, coalescence and epenthesis errors.

In short, these findings do not provide strong support for a structural difference between target CLV and CGV sequences in the early grammars of French and Spanish children.

However, if children do not represent CGV sequences as rising diphthongs initially, how do they represent rising diphthongs and when do they acquire the adult-like representation of these strings of segments? We explore these questions in the discussion.

6. DISCUSSION

The aim of this study was to examine the structure of CLV and CGV sequences in early child French and Spanish in order to determine whether these sequences are represented similarly or differently. Using a variety of measures, we did not find clear support for a structural distinction between CGV and CLV sequences. The only finding suggestive of a distinction between the two groups was the third measure (positional faithfulness) but the findings were far from being persuasive. Instead, the findings from the first two measures (order of acquisition and style of acquisition) revealed that CGV and CLV sequences did not pattern as two distinct groups. If anything, there appeared to be a distinction between CGV and CIV sequences on the one hand and CrV sequences on the other hand. The findings of the last measure (error patterns) suggested that rising diphthongs often patterned as having two timing units and, furthermore, the glide appeared to be aligned with the onset rather than with the nucleus. In sum, the findings seem to suggest that CGV sequences pattern as branching onsets during some stage of acquisition, at least for some children. How should we interpret these findings given that the child must eventually arrive at the target representation of rising diphthongs being that of a complex segment?

6.1. Differences between CIV vs. CrV sequences

First, we consider the disparate findings between CIV and CrV sequences. Is there a structural account for these differences? CIV (and CGV) sequences could be represented as rising diphthongs; only CrV sequences would be represented as branching onsets. Such a proposal is not completely unreasonable since CLV sequences have been shown to pattern as rising diphthongs in some adult languages (Kaye, 1985). In the case of child French and Spanish, it would be CIV and not CLV sequences in general that would be represented as rising diphthongs. Nevertheless, this proposal is not a desirable one, given a great deal of evidence from a variety of languages showing that /l/s and /r/s form a natural class.

Admittedly, there is also evidence (particularly with respect to place and sonority) showing that /l/s and /r/s differ. Most importantly, however, the proposal is not consistent with our findings since there was little evidence that CIV sequences patterned as complex segments (e.g., error pattern such as liquid substitutions, reductions to C₂).

If the different acquisition patterns of Cl and Cr sequences cannot be accounted for structurally at the level of the syllable, the most likely explanation relates to segmental differences between /l/ and /r/. We observed that /r/ as a singleton or as part of a complex onset proved a particularly difficult segment for the French and Spanish children. This difficulty may relate to its phonetic realization as a uvular approximant or as an alveolar tap, these segments generally being acknowledged as phonetically marked and late acquired (Bernhardt & Stemberger, 1998: 331). This difficulty may also relate to its phonological ambiguity as a placeless segment (see proposals by Goad & Rose, 2004; Rose, 2000). Certain aspects of /r/'s patterning in onset clusters lead us to believe that the children in this study may also have differed in their place representations of /r/. For example, some French-speaking children substituted /pr, br, tr, dr/ clusters with /kr/ (e.g., bracelet -> kracelet) suggesting a velar representation of /r/, whereas other children did not display this pattern (see Rose, 2000). We hypothesize that segmental-prosodic interactions relating to the

representation of /r/ may underlie the disparate behavior between Cl and Cr clusters. The fact that the Spanish results showed reduction to C₁ and C₂ for CIV sequences and reduction to C₁ only for CrV sequences also suggests that segmental factors play a role in the late acquisition of CrV sequences.

6.2. The Representation of CGV Sequences in Acquisition

6.2.1. Rising Diphthong or Branching Onset?

The previous section argues that the structure of CLV sequences is that of branching onsets and that the asymmetry between CIV and CrV sequences arises from segmental effects. Next, we need to account for why CGV sequences patterned similarly to branching onsets (in particular, CIV sequences) during acquisition. The evidence suggests that children initially posit that CGV sequences are represented as branching syllable structure. The problem with this proposal is 1) why should children posit a representation that is different from the input representation, and 2) how do they eventually arrive at the adult-like representation?

The fact that children assume CGV sequences to be branching onsets is not a bizarre one given that this is a possible representation of CGV sequences in some languages such as Dutch and English (in English, CwV sequences only). Rose (1999, 2000) argues that it is a more marked option than a rising diphthong analysis on the basis of a typological survey of CGV sequences (see footnote 7). However, as mentioned above, the number of languages Rose (1999, 2000) surveyed was relatively small and a more extensive study may produce different findings. Furthermore, markedness is a complex notion, which encompasses many aspects, not just cross-linguistic frequency. Thus, on the basis of this information, markedness does not appear to help us in determining why children posit a branching onset representation.

Indeed, we may ask if there are any cues in the ambient input which may lead children into assuming this representation. Here, we remind the reader that rising diphthongs in Spanish pattern in a complex way with respect to stress, sometimes behaving as if they are heavy and sometimes as if they are light. Furthermore, in some dialects of Spanish (and French – see section 2.3.), an alternate pronunciation of rising diphthongs as vowel hiatus is possible. This has led some authors to assume an underlying bipositional structure for rising diphthongs (Carreira, 1992; Senturia, 1998). Thus, we hypothesize that children may be exposed to adult surface forms which consist of two variants for rising diphthongs: a monopositional and a bipositional form. Given variation in the ambient input, children may posit a representation for rising diphthongs with an additional timing unit resulting in a representation which parallels that of branching onsets.

We propose that development of branching onsets and rising diphthongs proceeds as follows. Initially, children produce only simple onsets and nuclei. The selection of the onset may be done on the basis of sonority or relative prominence, leading to a C_1 pattern (see 22a) or it may be influenced by other segmental constraints (e.g., *VoicedObstruent; MaxLabial) or factors such as contiguity, leading to a C_2 pattern (see 22b). Both patterns were evident in our data for CLV (particularly CIV sequences in Spanish) and CGV sequences, although, given the overall low frequency of C_2 selection, we consider it to be the minority pattern.

(22) Stage 1: Simple Onset Stage

a) C₁ selection (majority pattern)

i. Branching Onsets

O		N
X	X	X
C	L	V

ii. Rising Diphthongs

O		N
X	X	X
C	G	V

b) C₂ selection (minority pattern)

i. Branching Onsets

	O	N
X	X	X
C	L	V

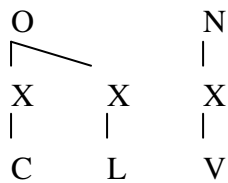
ii. Rising Diphthongs

	O	N
X	X	X
C	G	V

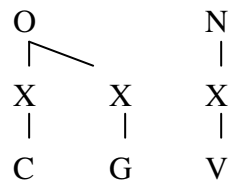
At the next stage of acquisition, children produce both CLV and CGV sequences as branching onsets (see (23)). We hypothesize that this stage comes about because ambiguity in the ambient input leads children to assume an extra timing unit for GV structures. Children's output representations do not mirror the surface form, however, but reflect the constraints operative in their grammars that favor a branching onset representation. That is, given the option of aligning the extra timing unit with the onset or nucleus, we propose that children align the timing unit (i.e., glide) with the onset because in terms of sonority sequencing, CG sequences are well-formed onsets. They will be less inclined to align the glide with the vowel because this would lead to a bipositional rising diphthong, the more marked option. Given that children's early phonologies are characterized by unmarked forms (Gnanadesikan, 1995/2004), alignment of the glide with the onset is arguably the most natural strategy. Children may also insert a nucleus, creating a bisyllabic form. This was evident for a small proportion of error patterns in the current study.

(23) Stage 2: Branching Onset Stage

i. Branching Onsets



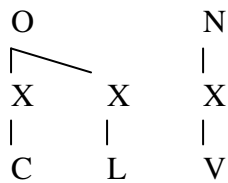
ii. Rising Diphthongs



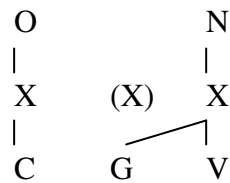
Finally, children need to acquire the adult-like representation of rising diphthongs as complex segments. We propose that this process occurs when they have developed a more thorough knowledge of the segmental and phonotactic constraints of the language, which includes awareness of constraints against homorganicity, or two sonorants being together in onset clusters. Children may also restructure their representations when faced with producing CLGV sequences, that is, sequences consisting of a branching onset followed by a rising diphthong (e.g., French trois /tʁwa/ ‘three’). Because French and Spanish only allow two element onset clusters, a CLGV sequence forces the glide to align itself with the nucleus. Again, since bipositional rising diphthongs are marked structures, deletion of a timing unit may automatically result. In the child data, very few CLGV target sequences were present but when they were, they were consistently reduced to two elements (trois [tʁwa] ‘three’-> [twa]), thus, suggesting that children were not yet capable of producing a branching onset followed by a rising diphthong. Finally, we do not exclude the possibility that the final representation for rising diphthongs may be that of a complex segment and a floating timing unit (i.e., a timing unit which is not prosodified in the output) which surfaces along with its nuclear projection for a small selection of words or indeed according to speech mode. The final stage in the representation of branching onsets and rising diphthongs is shown in (24). The floating timing unit in rising diphthongs is shown in (24ii) as (X).

(24) Stage 3: Branching Onset and Rising Diphthong Stage

i. Branching Onsets

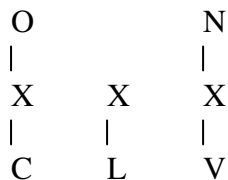


ii. Rising Diphthongs



Note that our findings are compatible with a recent proposal by Goad (2006), who posits that children pass through a stage in which their derived CG forms (target CLV forms produced as CGV forms, e.g., play [pleɪ] → [pweɪ]) are best accounted for by a floating timing unit. In particular, she observed considerable variation in the realization of derived glides in the productions of an English-speaking child, which were consistent with either a branching onset, rising diphthong or secondary articulated representation of CGV sequences. Given the variation in the data, she argues that the timing unit of the derived G (which is underlyingly represented as L) is not yet prosodified in the output at this stage (25).

(25) Outputs of the phonological grammar: CG stage



(Goad, 2006, p.17)

In the current account, we have argued for an intermediate branching onset stage since we did not observe strong differences between CLV and CGV sequences; however we do not exclude the possibility, given the variability of error patterns, that the glide may not yet be prosodified in the output of some of the children.

6.2.2. Other Possible Representations?

The preceding discussion has focused on the possibility that CGV sequences are represented as branching onsets or as rising diphthongs in developing grammars. What about

the other two representations proposed in (1), namely a secondary articulated segment (1c) or dual membership with the onset and nucleus (1d)? Although these two representations have not been claimed for Adult French or Spanish, this does not preclude the fact that the child may posit such structures in the acquisition of these languages. We do not think that this is likely, however. In the case of the former, we have already mentioned above that robust restrictions exist between C and G in secondary articulated segments in adult languages (e.g., labialized labials and labialized coronals are dispreferred in languages), whereas the children in this study produced such forms frequently. Consider Ar (age 2;6,11) who produced forms such as poire ([pwaɾ] ‘pear’) as [pwa:ɾ], beignoire ([bɛʝwaɾ] ‘bath’) as [bɛ̃'mwaɾ] and etoile ([e'twal] ‘star’) as [e'twalə], although her percent correct production of 39% (20/51) suggests that she was still at the earliest stages of acquiring these structures. In the case of the dual membership representation, we originally posited that such a representation might be preferred over a branching onset representation for French speaking children, given that they must eventually restructure their representations to acquire the target language (Kehoe & Hilaire-Debove, 2004). A representation in which the glide is already affiliated to the nucleus might facilitate the acquisition of rising diphthongs. Reanalysis has led us to alter our conclusion, however. The dual membership representation is a highly marked one and, given that there is no evidence for it in Adult French and Spanish, in contrast to Adult English, it is unlikely that a child would posit such a representation (see also Goad, 2006).

6.3. Individual Differences

The previous section has discussed the group data as a whole. However, it is clear that individual differences were present in the data, which possibly reflect differing structural representations among children. For example, three types of acquisition patterns were observed in the French data: one in which rising diphthongs and C1 sequences were acquired at similar time points (pattern 1), a second in which branching onsets were acquired before

rising diphthongs (pattern 2) and a third in which rising diphthongs were acquired before branching onsets (pattern 3). Interestingly, pattern 2 was attested in children who tended to be at the latter stages of acquisition, based on their overall percent scores. If CGV sequences were represented as branching onsets, the acquisition of CLV before CGV sequences would be difficult to account for since the sonority sequencing principle would predict that CG sequences should emerge first due to sonority distance. Thus, this group of children may already be at the stage of representing CGV sequences as rising diphthongs.

Individual differences were also present in our analyses of different types of CGV sequences (see section 4.1). When we divided target CGV sequences into two groups based on their phonotactic characteristics (CG sequences consisting of two sonorants or two consonants sharing the same place of articulation (Group 1) versus CG sequences consisting of two consonants differing in terms of place of articulation (Group 2)), our results revealed a tendency for some French speaking children to treat the two sets of words differently. They displayed higher percent correct scores for Group 1 versus Group 2 words. This may suggest that these children have acquired sufficient knowledge of the linguistic characteristics of their language so as to represent at least a certain group of target sequences as rising diphthongs.

Individual differences were evident at other occasions in the data as well. Error patterns such as liquid substitutions, reduction to C₂, coalescence, and insertion errors characterized the patterns of a substantial number of children but certainly not all children. Furthermore, certain error patterns were ambiguous, consistent with both a branching onset and rising diphthong representation. For example, an analysis of coalescence errors revealed that the labial feature of the glide sometimes coalesced with the onset and sometimes with the nucleus (María, Miguel and Nils) and in the case of one child (Jens), coalesced more often with the nucleus than with the onset. The cases in which both patterns occurred, suggest that, at a certain stage, children may fluctuate between both representations. The case in which

predominantly vowel coalescence occurred, suggests that this child may posit only a rising diphthong representation. Thus, our claim that children represent CGV sequences as branching onsets does not extend to all children nor necessarily to an extensive period of development. Indeed, given ambiguity in the input, individual differences are predicted.

6.4. Comparison of Current Results with Other Findings

One final point is how we reconcile the current results with those offering support for CGV sequences as rising diphthongs in early acquisition (Barlow, 2005; Rose, 2000). First, it should be noted that Barlow's (2005) and Rose's (2000) studies are based on analyses of one or two children, whereas the current study was based on a larger number of children. The findings of the current study are further reinforced by the fact that similar acquisition patterns were observed within and across languages, despite differences in experimental methodology. Second, as discussed above, we do not exclude the possibility that individual differences in structural representations may exist. Some children such as the ones in Barlow's (2005) and Rose's (2000) studies may initially represent CGV sequences as rising diphthongs; other children, such as the ones in the current study, may represent CGV sequences as branching onsets. Crucially, however, our results do not provide support for the rising diphthong pattern as being the majority pattern for CGV sequences in early acquisition.

6.4. Conclusion

In conclusion, our comparison of the acquisition patterns of CLV and CGV sequences in French and Spanish best support a representation in which CGV sequences are represented as branching onsets for at least some stage in acquisition. We posit that children assume this representation because they are exposed to ambiguous input in which rising diphthongs may contain two timing units. Our results also reveal an asymmetry in the development of Cl and Cr clusters, a finding that may relate to the specific phonetics and phonology of /r/ in these languages, and one that should be explored in future research.

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Appendix 1

French Stimuli

- Cl *blanc [blɑ̃] ‘white’, clé [kle] ‘key’, clown [klun] ‘clown’, fleur [flœʁ] ‘flower’,
flûte ‘flute’ [flyt], glace [glas] ‘icecream’, plage [plɑʒ] ‘beach’, tableau [ta'blo]
‘picture’
- Cɤ biberon [bi'bɛʁɔ̃] ‘baby’s bottle’, bracelet [bʁas'le] ‘bracelet’, bras [bʁa] ‘arm’,
brosse [bʁɔs] ‘brush’, brun [bʁœ̃] ‘brown’, citrouille [si'tʁuj] ‘pumpkin’, crayon
[kʁɛ'jɔ̃] ‘crayon’, crêpe [kʁɛp] ‘pancake’, fraise [fʁɛz] ‘strawberry’, *framboise
[fʁɑ̃'bwaz] ‘raspberry’, frigo [fʁi'go] ‘fridge’, frites [fʁit] ‘french fries’, fromage
[fʁɑ'mɑʒ] ‘cheese’, grand [gʁɑ̃] ‘big/tall’, grenouille [gʁənuj] ‘frog’, *micro
[mi'kʁɔ] ‘microphone’, tracteur [tʁak'tœʁ] ‘tractor’, train [tʁɛ̃] ‘train’, trompette
[tʁɔ̃'pɛt] ‘trumpet’
- Cj assiette [a'sjɛt] ‘plate’, avion [a'vjɔ̃] ‘plane’, chien [ʃjɛ̃] ‘dog’, escalier [eska'lje]
‘staircase’, lion [ljɔ̃] ‘lion’, lumière [ly'mjɛʁ] ‘light’, piano [pjɑ'no] ‘piano’, ped
[pje] ‘foot’, pierre [pjɛʁ] ‘stone’, serviette [sɛʁ'vjɛt] ‘towel’, viande [vjɑ̃d] ‘meat’
- Cw armoire [ɑʁ'mwaʁ] ‘cupboard’, baignoire [bɛ'ɲwaʁ] ‘bath’, bavoir [ba'vwɑʁ] ‘bib’,
*boire [bwɑʁ] ‘to drink’, boîte [bwat] ‘box’, camion [ka'mjɔ̃] ‘truck’, *coin [kwɛ̃]
‘corner’, doigt [dwa] ‘finger’, étoile [e'twal] ‘star’, *noir [nwɑʁ] ‘black’, *noisette
[nwa'zɛt] ‘hazel-nut’, poire [pwɑʁ] ‘pear’, (petit) pois [pwa] ‘pea’, poisson
[pwa'sɔ̃] ‘fish’, *quoi [kwa] ‘what’, voiture [vwɑ'tyʁ] ‘car’
- Cɥ biscuit [bis'kɥi] ‘biscuit’, cuillère [kɥi'jɛʁ] ‘spoon’, cuisine [kɥi'zin] ‘kitchen’,
*nuage [nyɑʒ] ‘cloud’, nuit [nyi] ‘night’, puits [pyi] ‘well’

* = items not targeted as stimuli

Spanish Stimuli

- Cl aplauso [a'plauso] 'applause', bicicleta [biθi'kleta] 'bicycle', blanco ['blaŋko] 'white', claro ['klaro] 'clear', completo [kom'pleto] 'complete', explota [eks'plota] '(it) explodes', flan [flan] 'caramel custard', flauta ['flauta] 'flute', flecha ['fletʃa] 'arrow', flor [flor] 'flower', flota ['flota] 'fleet', globo ['gloβo] 'balloon', iglesia [i'ɣlesja] 'church', plancha ['plantʃa] 'iron', plátano ['platano] 'banana', plato ['plato] 'plate', playa ['plaja] 'beach', pluma ['pluma] 'feather'
- Cr abrir [a'βrir] 'to open', brazo ['braθo] 'arm', bruja ['bruxo] 'witch', brutal [bru'tal] 'brutal', cangrejo [kan'grexo] 'crab', cocodrilo [koko'ðrilo] 'crocodile', dentro ['dentro] 'inside', drácula ['drakula] 'dracula', dragon [dra'ɣon] 'dragon', freno ['freno] 'brake', fresa ['fresa] 'strawberry', frío ['fri.o] 'cold', fruta ['fruta] 'fruit', grande ['grande] 'big, tall', gris [gris] 'grey', grita ['grita] 'shout, yell', hambre ['ambre] 'hunger', hombre ['ombre] 'man', libro ['liβro] 'book', negro ['neɣro] 'black', otro ['otro] 'another, other', peligro [pe'liɣro] 'danger', primo ['primo] 'cousin', sombrero [som'brero] 'hat', tigre [tiɣre] 'tiger', tractor [trak'tor] 'tractor', tren [tren] 'train', tres [tres] 'three', trompa ['trompa] 'trunk', trompeta [trom'peta] 'trumpet', tronco ['tronko] 'log'
- Cj avión [a'βjon] 'airplane', bien [bjen] 'good', caliente [ka'ljente] 'hot', camión [ka'mjon] 'truck', canción [kan'θjon] 'song', cielo ['θjelo] 'sky', ciervo ['θjerβo] 'deer', comiendo [ko'mjendo] 'eating', diente ['djente] 'tooth', diez [djeθ] 'ten', durmiendo [dur'mjendo] 'sleeping', empieza [em'pjeθa] '(it) starts' or 'start! [Imperative]', estación [esta'θjon] 'station', fiesta ['fjesta] 'party', funciona

[fun'θjona] ‘(it) works’, hacienda [a'θjenda] ‘farm’, limpiar [lim'pjɑr] ‘clean, wipe’, miel ['mjel] ‘honey’, nieve [njeβe] ‘snow’, piano ['pjano] ‘piano’, pie [pje] ‘foot’, piedra ['pjeðra] ‘stone’, serpiente [ser'pjente] ‘snake’, sierra [sjera] ‘saw’, también [tam'bjen] ‘also, too’, tiene ['tjene] ‘has, holds’, valiente [ba'ljente] ‘brave’, viendo ['bjendo] ‘seeing’

Cw abuela [a'βwela] ‘grandmother’, agua ['aɣwa] ‘water’, bueno ['bweno] ‘good’, cuál [kwal] ‘which one?’, cuando ['kwando] ‘when’, cuánto ['kwanto] ‘how much?’ cuatro ['kwatro] ‘four’, cuello ['kweʎo] ‘neck’, cuento ['kwento] ‘story’, duele ['dwele] ‘(it) hurts’, duerme ['dwerme] ‘(he/she) sleeps’, fuego ['fweɣo] ‘fire’, fuera ['fweɾa] ‘away outside’, guapo ['gwapo] ‘good-looking’, igual [i'ɣwal] ‘equal, like’, lengua ['leŋgwa] ‘tongue’, llueve ['ʎweβe] ‘(it) rains’, muerde ['mwerde] ‘(he/she) bites’, paraguas [pa'raɣwas] ‘umbrella’, pingüino [piŋ'gwino] ‘penguin’, puede [pweðe] ‘can’, puerta [pwerta] ‘door’, rueda [rweða] ‘wheel’, ruido [rwiðo] ‘noise’, suelo [swelo] ‘floor’, vuelo [bwelo] ‘flight’, vueltas [bweltas] ‘turns’

Appendix 2

Table A. Percent correct scores of rising diphthongs (CjV vs. CWV) and branching onsets (CIV vs. CɤV) for individual French-speaking children.

Child	Rising Diphthongs		Branching Onsets	
	CjV	CWV	CIV	CɤV
El	87% (13/15)	97% (34/35)	100% (7/7)	81% (25/31)
Cl	77% (10/13)	100% (26/26)	80% (4/5)	55% (11/20)
Im	70% (7/10)	100% (28/28)	100% (8/8)	94% (17/18)
Lo	80% (20/25)	86% (24/28)	100% (11/11)	100% (32/32)
My	73% (8/11)	100% (24/24)	100% (7/7)	68% (13/19)
Ag	58% (11/19)	77% (23/30)	90% (18/20)	93% (27/29)
Ba	68% (13/19)	92% (33/36)	100% (18/18)	32% (10/31)
Pa	53% (9/17)	57% (13/23)	63% (5/8)	11% (3/28)
Ta	54% (6/11)	0 (0/4)	50% (3/6)	11% (1/9)
Je	25% (6/24)	59% (13/22)	0 (0/11)	10% (3/30)
Ar	33% (6/18)	42% (14/33)	75% (9/12)	17% (6/35)
Qu	36% (5/14)	36% (10/28)	35% (7/20)	0 (0/13)
Le	33% (2/6)	0 (0/8)	0 (0/1)	0 (0/7)
Mr	14% (2/14)	12% (2/17)	86% (6/7)	3% (1/30)

Table B. Percent correct scores of rising diphthongs (CjV vs. CwV) and branching onsets (CIV vs. CrV) for individual Spanish-speaking children.

periods	Rising Diphthongs		Branching Onsets	
	CjV	CwV	CIV	CrV
<u>Miguel</u>				
Onset-1;6	(0/1)	0 (0/11)	(0/2)	0 (0/3)
1;6 - 1;9	0 (0/3)	(0/2)	(0/1)	0 (0/23)
1;9 - 2;0	8% (1/12)	(1/2)	0 (0/4)	5% (1/19)
2;0 - 2;3	71% (5/7)	14% (2/14)	57% (8/14)	0 (0/9)
2;3 - 2;6	80% (20/25)	58% (14/24)	86% (12/14)	16% (5/32)
2;6 - 2;9	67% (22/33)	53% (26/49)	92% (11/12)	18% (5/28)
2;9 - 3;0	23% (3/13)	73% (8/11)	(2/2)	0 (0/7)
3;0 - 3;3	74% (46/62)	78% (7/9)	88% (7/8)	38% (6/16)
<u>María</u>				
Onset-1;6	0 (0/6)	0 (0/5)	--	13% (1/8)
1;6 - 1;9	0 (0/12)	40% (2/5)	0 (0/16)	0 (0/4)
1;9 - 2;0	33% (3/9)	(0/1)	0 (0/8)	0 (0/12)
2;0 - 2;3	25% (3/12)	29% (5/17)	33% (2/6)	8% (1/13)
2;3 - 2;6	55% (12/22)	42% (5/12)	0 (0/7)	0 (0/21)
2;6 - 2;9	47% (17/36)	65% (13/20)	50% (2/4)	7% (2/30)
<u>Simon</u>				
1;6 - 1;9	0 (0/3)	33% (3/9)	--	0 (0/12)
1;9 - 2;0	0 (0/5)	12% (4/34)	0 (0/14)	0 (0/47)

2;0 – 2;3	10% (3/29)	20% (3/15)	0 (0/11)	2% (1/46)
2;3 – 2;6	83% (24/29)	61% (31/51)	47% (9/19)	16% (11/69)
2;6 – 2;9	67% (8/12)	85% (11/13)	80% (4/5)	18% (2/11)

Jens

Onset–1;6	--	0 (0/9)	--	0 (0/3)
1;6 - 1;9	--	0 (0/8)	--	--
1;9 – 2;0	20% (1/5)	--	0 (0/4)	9% (1/11)
2;0 – 2;3	(0/2)	--	0 (0/6)	0 (0/16)
2;3 – 2;6	27% (4/15)	33% (3/9)	63% (5/8)	0 (0/37)
2;6 – 2;9	58% (7/12)	(0/2)	100% (6/6)	0 (0/11)
2;9 – 3;0	95% (18/19)	77% (17/22)	94% (15/16)	8% (2/26)

Nils

Onset–1;6	--	0 (0/21)	--	--
1;6 - 1;9	33% (1/3)	0 (0/5)	(0/1)	3% (1/29)
1;9 – 2;0	17% (2/21)	0 (0/18)	36% (8/22)	0 (0/35)
2;0 – 2;3	24% (8/34)	18% (8/44)	90% (28/31)	0 (0/45)
2;3 – 2;6	40% (4/10)	50% (7/14)	86% (6/7)	3% (1/31)
2;6 – 2;9	40% (2/5)	71% (5/7)	100% (5/5)	18% (5/28)

Footnotes

1. Kaye (1985) argues that LV sequences may pattern as rising diphthongs in some African languages. Similar to Rose (2000), we assume this representation to be a marked one.
2. Throughout the manuscript, “CGV” and “CLV” sequences will be used to refer to rising diphthongs and branching onsets respectively, although technically only the “GV” sequence is the rising diphthong and the “CL” sequence is the branching onset.
3. We focus primarily on syllable-initial (tautosyllabic) consonant clusters. French and Spanish allow other combinations in different word positions (e.g., /tʎ/ word-medially as in French atlète and Spanish atleta ‘athlete’; /vr/ word finally as in French livre ‘book’).
4. The statement that stress is word-final is an oversimplification of the stress system of French, which typically exhibits lengthening or stress on the final syllable of a phonological phrase.
5. These examples were transcribed from sung productions in a French opera.
6. For the sake of simplicity, Rising Diphthong 2 is represented as a bipositional monosyllabic form, although we acknowledge that some authors propose a bisyllabic bipositional variant for CGV strings (Carreira, 1988, Senturia, 1998). As suggested later (see (24b)), an alternate representation of rising diphthongs could be that of a monopositional form plus floating timing unit. The latter representation has the advantage of capturing the variability in the system, since rising diphthongs sometimes function as heavy and sometimes as light.
7. Rose’s (1999, 2000) survey included nine languages. He found that two languages syllabified CGV sequences as branching onsets, six languages syllabified CGV sequences as rising diphthongs, and one language (English) allowed for both options. Rose (1999, 2000) acknowledges that this survey should not be taken as definitive, since cross-linguistic

frequency does not always translate into unmarked status. Furthermore, the number of languages surveyed was very small.

8. “Epenthesis” is the term generally used by child phonologists to refer to insertion of a vowel into a target consonant cluster, e.g., brush -> [bərʌʃ]. Paradis and Béland (2002) utilize the term “insertion” and distinguish between hiatus creation (insertion of a nucleus - buisson [bɥisɔ̃] ‘bush’ becomes [py.isɔ̃]) and consonant insertion (insertion of a consonant between two vowels - pion [pjɔ̃] ‘pawn’ becomes [piju]), what we are referring to as nuclear and onset epenthesis respectively. In the case of target branching onsets, nuclear epenthesis was observed whereas in the case of target rising diphthongs both nuclear and onset epenthesis were observed. Paradis and Béland (2002) observed that nuclear epenthesis was more frequent than onset epenthesis in their data. Our results revealed the opposite: children more often inserted a consonant onset than created a vowel hiatus (e.g., lion [ljɔ̃] ‘lion’ > [dijo]). However, we do not take this distinction into consideration due to the infrequency of epenthesis errors overall.

9. Dominance factors do not seem to be influencing the current results, since it will be seen that the three bilingual children display similar acquisition patterns with branching onsets and rising diphthongs, despite their differing dominance profiles.

10. In this analysis, place of articulation was classified into three main groups: labial, coronal, and dorsal. Thus, a word such as assiette /a'sjɛt/ “plate” would be classified as a Group 1 word because the consonant and glide both belong to the coronal place of articulation.

11. Rose considers [w] to have a single articulator (labial) underneath the place node, in contrast to certain accounts which assign it two (labial and velar).

12. Rose observed the developmental order of rising diphthongs as Cj > Cw > Cɥ in both of his subjects; however, he noted that Clara did not produce Cw sequences until 1;9.01 after Cj

had begun to appear. Hence it is possible that Cw sequences may have been mastered prior to Cj sequences.

13. The superior performance of rising diphthongs in unstressed versus stressed syllables in the Spanish data may result from lexical familiarity effects. Certain familiar words, such as agua ‘water’, which contain a rising diphthong in an unstressed syllable, were frequently produced correctly.

14. An anonymous reviewer points out that cases in which the entire CL or CG sequence was deleted may contain relevant information since deletion of the entire CG sequence potentially suggests that the glide is associated with the onset. Interestingly, two children in the French data (Qu and Je) displayed several examples of full deletion across both CGV and CLV sequences. For example, Qui produced pierre ([pjɛʁ] ‘stone’) as [ɛʁ], voiture ([vwa'tyʁ] ‘car’) as [a'tyʁ], glace ([glas] ‘ice cream’) as [as], and brosse ([bʁɔs] ‘brush’) as [os]. We do not devote a separate section to the analysis of these patterns since, apart from the productions of these two children, they were not frequent in the data.

15. It has been frequently reported that children substitute glides for liquids in early acquisition (/r/ -> [w], /l/ -> [j]) at least in languages such as Dutch and English (e.g., Fikkert, 1994). This would not explain the current errors, however, which involved substitutions of glides by the liquid /l/. Furthermore, none of the children exhibited substitution patterns of this nature for singleton glides.

16. See also Barlow (2003) who employs *VoicedObstruent to account for heterosyllabic cluster reduction patterns in Spanish-speaking children)

17. In Spanish, voiced stops in non phrase-initial position are weakened to voiced fricatives (or approximants), thus, creating a situation in which the sonority gradient between the two members of the cluster is further reduced. This process may also play a role in the frequent preservation of the liquid or glide over the obstruent. In those cases in which the obstruent is

weakened to an approximant, a constraint such as *VoicedObstruent would not be implicated, rather, one that made a choice between the two approximants (e.g., MaxLabial).

18. The astute reader may wonder why similar effects were not observed in the French data. The fact that MaxLabial did not appear to play a role in the French children's productions may relate to the nature of the target words. A large proportion of the French CWV target words contained a labial consonant as C₁ (e.g., poisson, poire, pois, boire, boite, voiture, puits, moi). Therefore, a MaxLabial constraint may still have been highly ranked but other constraints (relating to head selection or sonority) would have played the decisive role in which segment was preserved. Interestingly, the sequences most susceptible to the C₂ preservation pattern in the French data included voiced obstruents + glides (e.g., avion, serviette, bavoir), suggesting that constraints similar to those posited in the Spanish data (e.g., *voiced obstruent or *voiced fricative) may be at play.

19. Forms such as [ʃelo] for cielo [θjelo] 'circle' (Miguel 2;4.03) and [sepinde] for serpiente [serpjente] 'snake' (Miguel 2;6.17) are possible examples of consonant and vowel coalescence in the Spanish data, but overall coalescence in CjV forms was infrequent. It is possible that labial place is more robust than palatal place in coalescence. In a similar vein, the lack of coalescence in CIV sequences (see following discussion) may be related to the fact that coronal place often behaves as unmarked for place and therefore it does not survive in coalescence.

20. There is some suggestion in the literature that hiatus pronunciation is more frequent in CjV forms in French, in particular, for onsets of high sonority (Klein, 1993, see also discussion in Goad, 2006, footnote 8). Hence, it is possible that some of these productions are not "errors" but represent dialectal variation.

Table 1. Summary of predictions on the four measures.

	Rising Diphthongs (complex segment)	Branching Onsets (complex onset)
1. Order of Acquisition	Earlier	Later
2. Style of Acquisition	Gradual	Categorical
3. Positional Faithfulness Effects	No	Yes
4. Error Patterns	Insertions & Deletions	Mainly Deletions

Table 2. Comparison of CGV sequences in individual French-speaking children.

Children	Group 1 ^a (e.g., <u>noir</u> , <u>poisson</u>)	Group 2 ^b (e.g., <u>cuillère</u>)
El	96% (25/26)	92% (22/24)
Cl	90% (19/21)	100% (18/18)
Im	93% (14/15)	91% (21/23)
My	96% (24/25)	90% (9/10)
Ba	84% (27/32)	78% (18/23)
Lo	81% (30/37)	94% (15/16)
Ag	70% (19/27)	68% (15/22)
Pa	48% (10/20)	63% (12/19)
Je	61% (11/18)	29% (8/28)
Ta	50% (6/12)	0 (0/3)
Ar	39% (12/31)	40% (8/20)
Qu	50% (14/28)	7% (1/14)
Le	20% (2/10)	0 (0/4)
Mr	40% (4/10)	0 (0/21)

a. Group 1 consisted of sonorant-initial sequences and obstruent-initial sequences in which the obstruent and glide share place of articulation.

b. Group 2 consisted of obstruent-initial sequences in which the obstruent and glide differ in terms of place of articulation.

Table 3. Comparison of CGV sequences in individual Spanish-speaking children.

Children	Group 1 ^a (e.g., <u>nieve</u> , <u>bueno</u>)	Group 2 ^b (e.g., <u>cuatro</u>)
Miguel	53% (45/85)	56% (45/81)
María	37% (20/54)	51% (38/74)
Simon	36% (35/96)	52% (48/92)
Jens	56% (25/45)	63% (26/41)
Nils	25% (16/63)	23% (19/81)

a. Group 1 consisted of sonorant-initial sequences and obstruent-initial sequences in which the obstruent and glide share place of articulation.

b. Group 2 consisted of obstruent-initial sequences in which the obstruent and glide differ in terms of place of articulation.

Table 4. Means and standard deviations of percent correct scores of rising diphthongs (CjV, CɥV & CwV) and branching onsets (CIV & CɛV) for all French-speaking children.

	Mean	SD
CjV	54	23
CɥV	57	43
CwV	63	36
CIV	70	36
CɛV	41	39

Table 5. The influence of stress on the means and standard deviations of percent correct scores of rising diphthongs (CWV) and branching onsets (CɤV) for all French-speaking children.

	Stress		Unstressed	
	Mean	SD	Mean	SD
Rising Diphthongs (CWV)	71	38	44	41
Branching Onsets (CɤV)	46	41	42	37

Table 6. Influence of stress on percent correct scores of rising diphthongs (CWV) and branching onsets (CɤV) for individual French-speaking children.

Children	Rising Diphthongs (CWV)		Branching Onsets (CɤV)	
	Stress	Unstressed	Stress	Unstressed
Cl	100% (21/21)	100% (5/5)	46% (6/13)	86% (6/7)
My	100% (9/9)	93% (14/15)	80% (8/10)	44% (4/9)
Im	100% (23/23)	100% (5/5)	100% (10/10)	100% (7/7)
El	100% (23/23)	92% (11/12)	88% (14/16)	71% (10/14)
Ba	93% (27/29)	86% (6/7)	38% (6/16)	40% (6/15)
Lo	91% (20/22)	67% (4/6)	100% (19/19)	100% (13/13)
Pa	71% (12/17)	17% (1/6)	40% (6/15)	15% (2/13)
Je	67% (12/18)	25% (1/4)	11% (2/19)	9% (1/11)
Ag	100% (22/22)	13% (1/8)	100% (15/15)	86% (12/14)
Ar	100% (12/12)	10% (2/21)	12% (2/17)	22% (4/18)
Qu	53% (10/19)	0 (0/9)	17% (1/6)	0 (0/7)
Mr	14% (2/14)	0 (0/3)	7% (1/14)	6% (1/16)
Ta	0 (0/2)	0 (0/2)	0 (0/2)	14% (1/7)
Le	0 (0/2)	0 (0/6)	0 (0/3)	0 (0/4)

Table 7. The influence of stress on the means and standard deviations of percent correct scores of rising diphthongs (CwV) and branching onsets (CrV) for Spanish-speaking children.^a

	Stress		Unstressed	
	Mean	SD	Mean	SD
Rising Diphthongs (CwV)	42	27	56	40
Branching Onsets (CrV)	7	6	5	2

a. Due to data restrictions, only Simon, Jens, and Nils are included in the group data.

Table 8. Coalescence in CwV sequences in the Spanish data.

Children	No. of Targets ^a	Examples of Coalescence	
		Consonant <u>cuento</u> -> [pento]	Vowel <u>cuento</u> -> [konto]
Miguel	76	15	1
María	45	5	2
Simon	77	14	0
Jens	43	5	10
Nils	71	11	1
	312	50	14

a. No. of Targets refers to the number of CwV target words in the sample in which the first consonant was alveolar or dorsal.

Figure Captions

Figure 1. Percent correct scores of rising diphthongs (CjV vs. CWV) for individual French-speaking children.

Figure 2. Percent correct scores of branching onsets (CIV vs. CɤV) for individual French-speaking children.

Figure 3. Percent correct scores of rising diphthongs (CjV and CwV) and branching onsets (CIV and CrV) for the Spanish monolingual children, Miguel and María.

Figure 4. Percent correct scores of rising diphthongs (CjV and CwV) and branching onsets (CIV and CrV) for the Spanish bilingual children, Simon, Jens and Nils.

Figure 5. Distribution of the three main error patterns in the French data.

Figure 6. Distribution of the three main error patterns in the Spanish data.

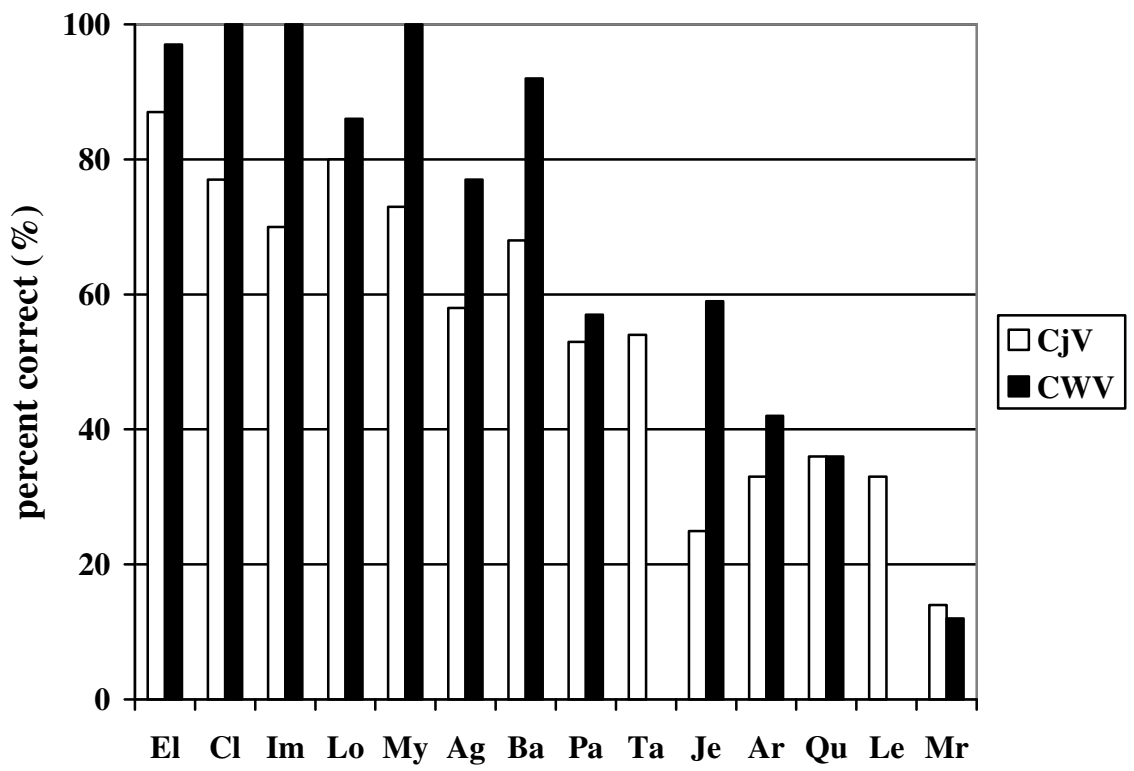


Figure 1.

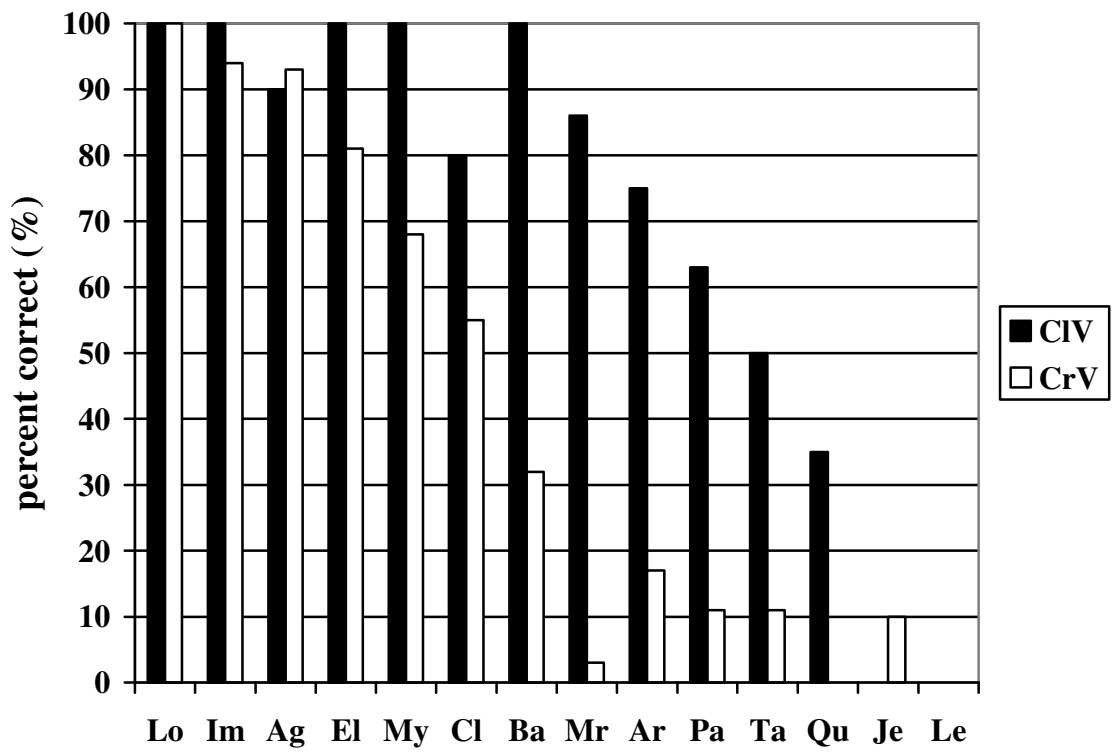
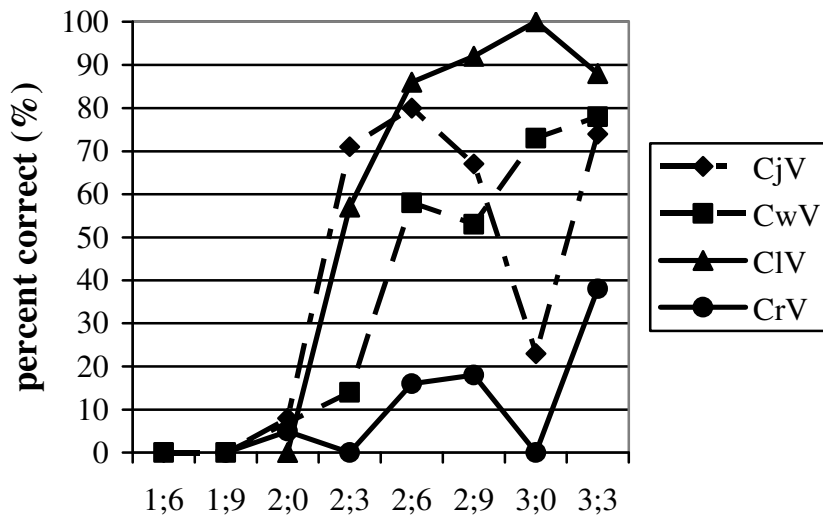


Figure 2.

Miguel



Maria

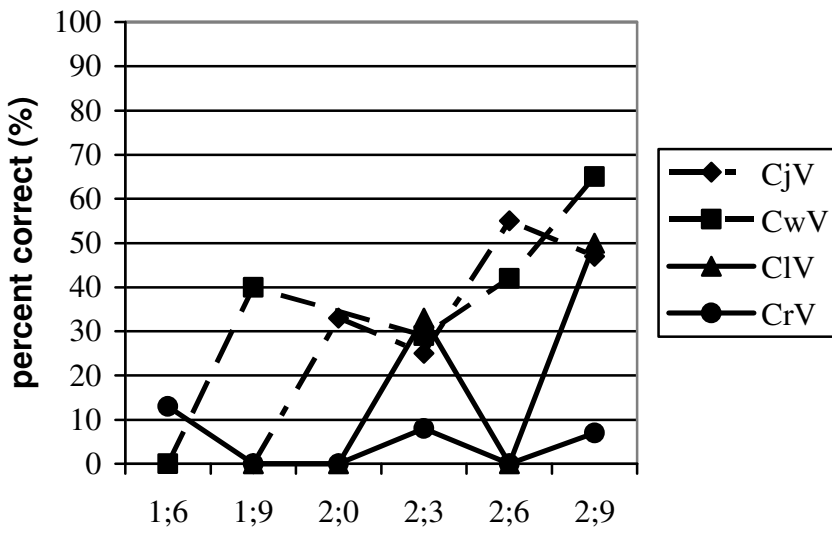
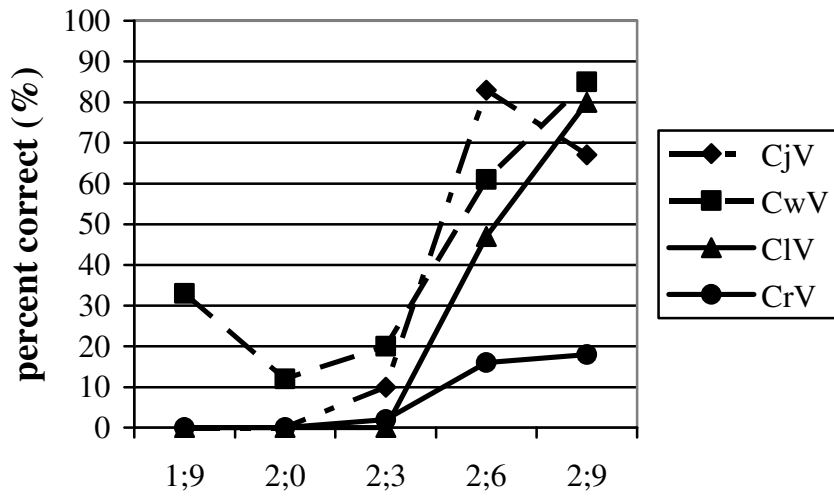


Figure 3.

Simon



Jens

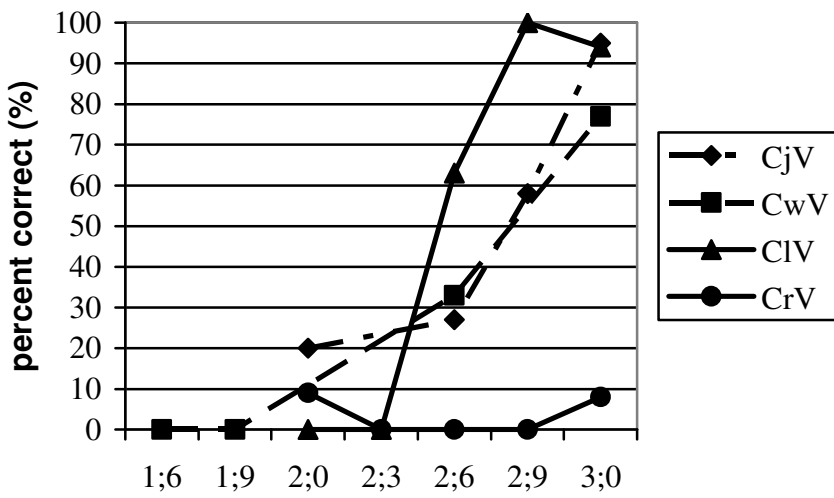


Figure 4.

Nils

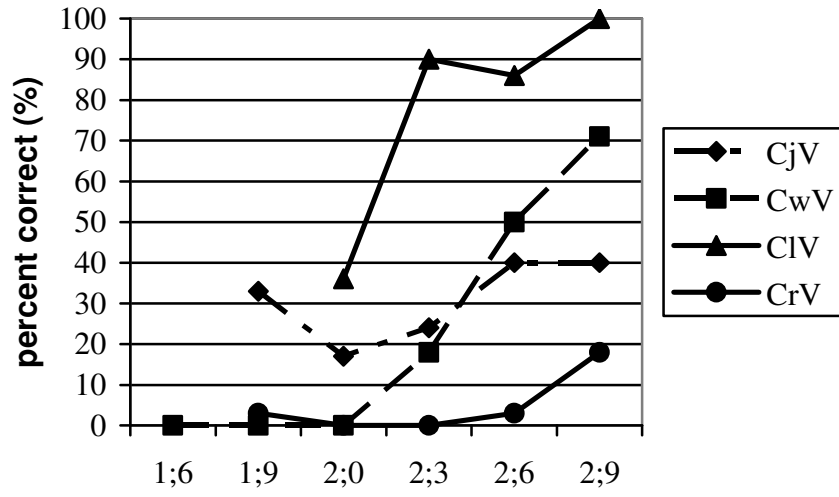


Figure 4. cont.

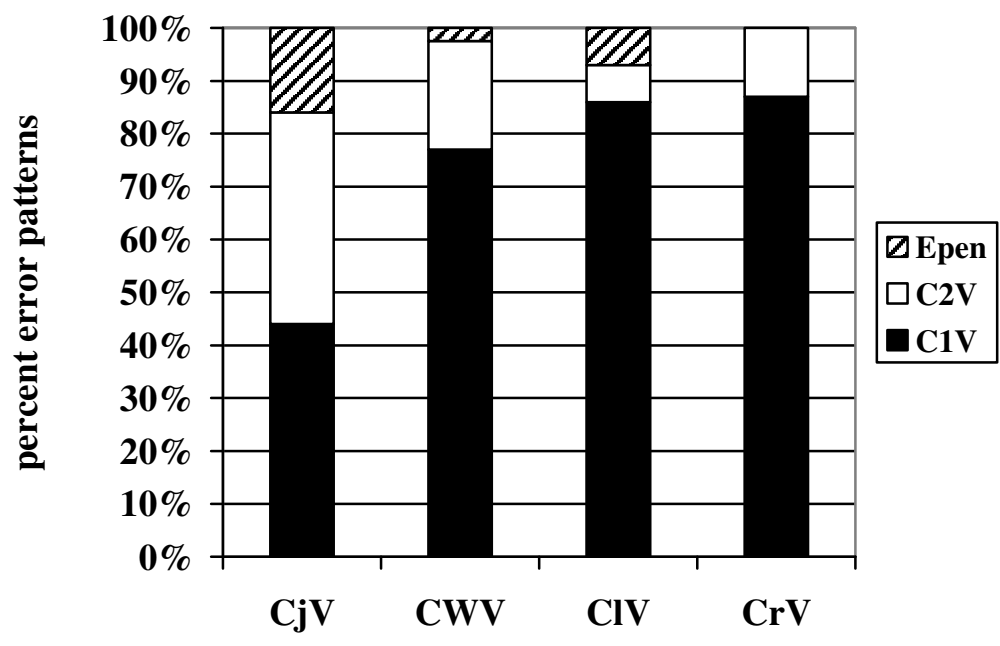


Figure 5.

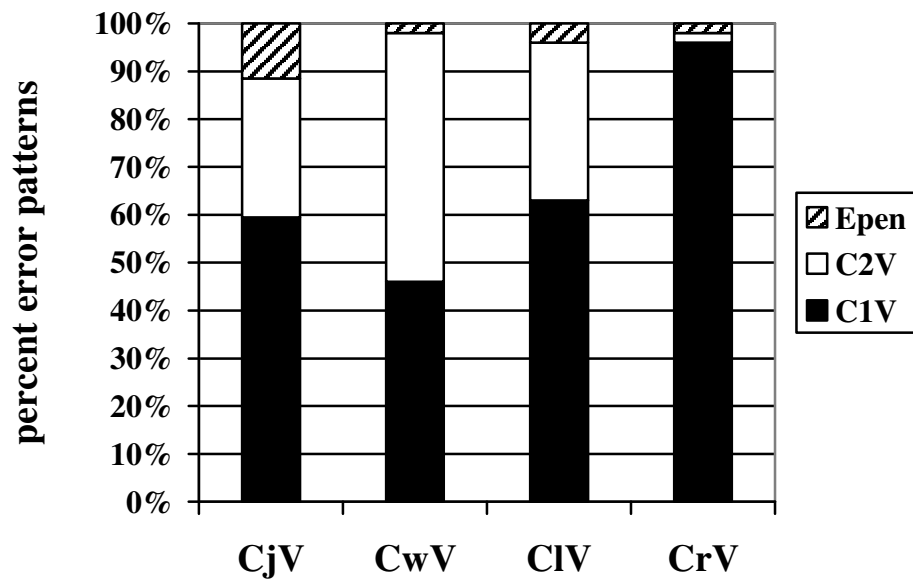


Figure 6.