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2 **The acquisition of coda consonants by**  
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4 **Catalan and Spanish children: Effects of**  
5 **prominence and frequency of exposure**  
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7  
8 **Abstract:** One of the challenges of child language research is to identify the rele-  
9 vant factors that play a role in the acquisition course of a particular linguistic  
10 feature. This article analyzes the role of stress, word position, and word length in  
11 the acquisition of coda consonants by Catalan and Spanish children. The fact that  
12 the two languages differ substantially in their coda distribution (e.g., stressed  
13 word-final codas are more frequent in Catalan than in Spanish) will allow us to  
14 test the potential effects of coda distribution in the target language on early coda  
15 production. Sixteen Catalan-dominant and Spanish-dominant two-year-olds  
16 from the Barcelona area participated in two elicitation tasks with both novel and  
17 familiar words of different phonological shapes. Coda productions were assessed  
18 in stressed vs. unstressed syllables, in word-medial vs. word-final syllables, and  
19 in monosyllables vs. polysyllables. Results showed that the distributional differ-  
20 ence between coda consonants in the two languages has crucial effects on the  
21 children's coda production. That is, Catalan-dominant children produce signifi-  
22 cantly more stressed word-final codas than Spanish-dominant children. This  
23 result lends support to the idea that when prominence is held equal, as in a con-  
24 trolled experiment, there are still crosslinguistic differences in coda production  
25 that are consistent with the frequency distribution of coda consonants in the  
26 respective languages, which means that children are very closely attuned to the  
27 frequency patterns of prosodic structure in the input language and are aware of  
28 their specific distributions across the lexicon.

29 **Keywords:** ■■  
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# 1 Introduction

Over the past twenty years, researchers have increasingly started to examine children's acquisition of syllable and prosodic word structures. They have found that syllabic development varies significantly across languages and that it is affected by a variety of factors such as stress, within-word position, and word length (Fikkert, 1994; Kehoe & Stoel-Gammon, 2001; Kirk & Demuth, 2006; Stites et al., 2004; Zamuner & Gerken, 1998; and others). In addition, it is well known that the frequency of exposure to coda consonants in a given language facilitates their acquisition: while English and German learners produce codas in the initial stages of word production (Lleó et al., 2003), this has been shown not to be the case for learners of languages with a lower frequency of codas in the input, such as Japanese (Ota, 2003) or Spanish (Lleó et al., 2003).

As Prieto and Bosch-Baliarda (2006: 238) state, stressed syllables are prominent prosodic units that typically “protect” phonological information: they “inhibit” processes of segmental deletion or reduction, while unstressed syllables frequently allow these processes to apply. Similarly, the psycholinguistic literature shows that stressed syllables facilitate language processing (Seguí et al., 1990). In line with these findings, the high perceptibility of stressed syllables facilitates early coda acquisition, and codas in stressed/accented syllables tend to be produced before codas in unstressed syllables. This tendency has been found for Catalan (Prieto & Bosch-Baliarda, 2006; Prieto et al., 2005), English (Kirk & Demuth, 2006; Zamuner & Gerken, 1998), European Portuguese (Freitas et al., 2001; Jordão & Frota, 2008), and Spanish (Lleó, 2003; Prieto et al., 2005; Saceda, 2005). In their study about the effects of stress on the acquisition of English coda consonants in word-final position, Zamuner and Gerken (1998) found that English-speaking two-year-olds imitating novel words were more likely to delete word-final codas in unstressed syllables than in stressed syllables. Kirk and Demuth (2006) examined the production of English coda consonants by two-year-olds in different phonological contexts using a controlled set of novel words elicited in a production task. Their results showed that the production of English single codas by young children was affected by stress environment, within-word position, and word length. Like Zamuner and Gerken (1998), they found that children were more likely to produce codas in stressed syllables, and concluded that “longer durations of acoustically prominent syllables provide learners with more time to articulate coda consonants, thereby enhancing production accuracy” (Kirk & Demuth, 2006: 97).

Several studies have shown the effects of within-word position on coda production. Some longitudinal studies have reported that word-final codas are produced before medial codas – this tendency has been found for Dutch (Fikkert,

1 1994), French (Rose, 2000), and English (Goad & Brannen, 2000; Echols & Newport, 1992; Kirk & Demuth, 2006). Hypothetically, syllables in word-final position are acoustically more salient than syllables in word-medial position due to their longer duration in certain prosodic contexts. Yet studies involving other languages have claimed that medial codas are acquired before final codas (Lleó, 2003, for Spanish) or have reported conflicting evidence (Freitas et al., 2001, and Jordão & Frota, 2008, for European Portuguese). These contradictory findings might be due to differences in unmarked stress location in these languages or differences in final lengthening.

10 Another important factor in explaining early coda production is word length (Ladefoged, 1993; Lehiste, 1972; Port, 1981). Children have been reported to produce codas occurring in monosyllabic words more accurately than those occurring in disyllabic words. Along these lines, Kirk and Demuth (2006) found that codas were better produced in CVC monosyllables (93%) than in CV.CVC iambs (79%). They claimed that the fact that monosyllabic words have acoustically longer syllables than polysyllabic words could explain the higher accuracy of English-speaking children in these contexts.

18 The majority of studies have investigated the role of all of these factors in coda acquisition using longitudinal data. This type of data does not allow for a strict control of the materials and thus does not control the effects of potential confounding factors, such as the effects of word position in conjunction with stress. To our knowledge, the only study which has used controlled materials with a variety of phonological shapes is that of Kirk and Demuth (2006) for American English. They designed the materials so that they would contain target codas in word-medial vs. word-final positions in iambic vs. trochaic words. They found significant effects of stress, word-position effects in unstressed syllables, and word length effects, and argued that acoustically prominent syllables, which were of a longer duration, allowed more time for learners to articulate their codas.

30 The first goal of the present study is to investigate the role of stress, word-position and word length in the process of coda acquisition in Catalan and Spanish, two languages that have not been studied systematically in this respect. Previous studies on the acquisition of coda consonants of these two languages have relied exclusively on longitudinal data (Prieto & Bosch-Baliarda, 2006, and Prieto et al., 2005, for Catalan; Lleó, 2003, Prieto et al., 2005, and Saceda, 2005, for Spanish). To circumvent the methodological problem of the interaction between factors, we designed two experimental tasks (a picture identification task, with familiar words, and an elicited imitation task, with novel words) using a set of controlled target words with a variety of phonological shapes. Both sets of target words (real words and novel words) were either monosyllabic or disyllabic

words consisting of two different prosodic shapes, i.e., trochees and iambs, and with codas in final or medial positions.

The inclusion of both a picture identification task and an elicited imitation task was a way to test whether children would show the same patterns of coda acquisition in both tasks. The elicited imitation task with novel nonsense words controls for the fact that children are not more familiar with certain words than with others. Moreover, recent studies in phonological acquisition have successfully used elicitation tasks with non-words (Zamuner & Gerken, 1998, Kehoe & Stoel-Gammon, 2001, and Kirk & Demuth, 2006, for the acquisition of codas in English; Zamuner, 2009, for the acquisition of phonotactic production performance). Though it has been suggested that imitative speech may not be reflecting the child's phonological system in the same way as spontaneous speech, there are results that indicate very similar patterns in both imitation tasks and spontaneous speech. In particular, the study by Kehoe and Stoel-Gammon (2001) showed no differences in the accuracy of imitated and spontaneous productions of coda consonants by English monolinguals aged 1;06 to 2;00. Similarly, Llach's (2007) study involving Catalan speakers aged 3 to 7 also showed that child productions do not vary with respect to this factor. In our study, we will compare the results of the picture elicitation task with the elicited imitation task in order to test whether they show the same patterns.

In general, acquisition studies have reported that phonological acquisition is very sensitive to frequently occurring patterns in the ambient language (see an overview in Werker & Curtin, 2005). In particular, exposure to a higher frequency of coda consonants and more complex rhymes in a given language does favor early coda acquisition. For example, while in English and German codas appear at the initial stage of word production (see Bernhardt & Stemberger, 1998, for English; Grijzenhout & Joppen, 1998, and Lleó et al., 2003, for German), languages with a low frequency of codas in the input such as Japanese or Spanish are reported to start producing codas at later developmental stages (Ota, 2003, for Japanese; Lleó, 2003, for Spanish). Yet these studies have not analyzed the role of specific distributional patterns in the ambient language on the acquisition of coda consonants, that is, whether children are sensitive to the frequency patterns of coda consonants in different positions (for example, higher rates of codas in stressed word-final position). The second goal of the present study is to assess the potential role of coda distribution in the target languages in early coda production. One of the main prosodic differences between Catalan and Spanish is coda distribution, a difference which can be traced back to the historical loss of word-final masculine marker *-o* in Catalan but not in Spanish (e.g., Latin *CABALLUM*, *-OS* 'horse' > Sp. *caballo*, *caballos*, Cat. *cavall*, *cavalls*). Because of this, Catalan has more codas (and complex codas) in stressed word-final

1 positions than Spanish (Span. *arco* vs. Cat. *arc* ‘arch’; see Prieto et al., 2005).  
2 Crucially, this prosodic difference in frequency distribution between Catalan and  
3 Spanish will allow us to investigate the potential effects of this factor on coda  
4 acquisition. Earlier results from the analysis of two longitudinal Catalan and  
5 Spanish data sets seemed to suggest that this distributional difference was  
6 important in the acquisition of codas in the two languages (Prieto et al., 2005).  
7 In the present study, if distributional frequency properties are important, we  
8 expect Catalan-dominant children to reflect the coda distribution of the ambient  
9 language in their coda productions and differ from the patterns displayed by  
10 Spanish-dominant children.

11 A specific issue being investigated in this article is whether a prominence-  
12 based hypothesis of the type put forward by Kirk and Demuth (2006) can success-  
13 fully account for the Catalan and Spanish acquisition data. Such a hypothesis  
14 based on acoustic prominence makes the prediction that children will systemati-  
15 cally produce more codas in acoustically prominent syllables (stressed syllables  
16 and word-final syllables), regardless of the frequency distribution of codas in  
17 their languages. Moreover, it has been described that English has more final  
18 lengthening than Catalan and Spanish (Hualde, 2005; Ortega-Llebaria & Prieto,  
19 2007; Prieto et al., 2011; see also Wightman et al., 1992). A recent study by Prieto  
20 et al. (in press) on Catalan, English and Spanish rhythm confirms the existence of  
21 important timing differences between the three languages which are instantiated  
22 through more accentual lengthening and final lengthening in English than in  
23 Spanish or Catalan. Importantly, the results of this paper suggest no remarkable  
24 differences between Catalan and Spanish in terms of the possible predictions of a  
25 prominence-based hypothesis regarding coda production. By contrast, a distribu-  
26 tional frequency-based hypothesis predicts differences in the acquisition of coda  
27 consonants by Catalan and Spanish learners which will be based on the differ-  
28 ences in coda occurrence frequency between the two languages. Even though  
29 there is nothing inherently incompatible with both frequency and prominence  
30 contributing to early acquisition in language production, our coda production  
31 data by Catalan-dominant and Spanish-dominant learners can test whether  
32 prominence has a consistent boosting effect in coda learning and also whether  
33 differences in frequency distribution play a role in coda acquisition in the two  
34 languages.

35 The article is organized as follows. Section 2 presents distributional data on  
36 coda occurrence in Catalan and Spanish, which will allow us to make specific  
37 predictions based on the frequency hypothesis. Section 3 describes the methodol-  
38 ogy used to elicit and code the data from the two experiments. Section 4 presents  
39 the results of the experiments. Finally, Section 5 discusses the results and con-  
40 tains the main conclusions of this article.

## 2 Coda consonants in Catalan and in Spanish

One of the important prosodic differences between Spanish and Catalan is coda distribution. As noted above, due to the historical loss of the word-final masculine marker *-o*, Catalan has more codas in stressed word-final positions (Span. *pelo* vs. Cat. *pèl* ‘hair’; Span. *marco* vs. Cat. *marc* ‘frame’; see Prieto et al., 2005). Moreover, while Catalan allows a maximum of three or even four consonants in word-final position (Wheeler, 1987; Bonet & Lloret, 1997; *absolts* [əp'sòlts] ‘absolved’, masc. pl., *porcs* [ˈporks] ‘pigs’, *bascs* [ˈbask] ‘Basques’, *calbs* [ˈkalps] ‘bald people’, *text* [ˈtɛkst] ‘text’, *corbs* [ˈkɔrps] ‘crows’, *diürns* [diˈurns] ‘diurnal’, masc. pl., *exempt* [əɣˈzɛmst] ‘exempt’, masc. pl., *remolcs* [rəˈmɔlks] ‘towtrucks’, *trionfs* [ˈtrjɔmf] ‘triumphs’, *mixts* [ˈmikst] ‘mixed’, masc. pl.), Spanish does not allow more than one consonant in word-final position except in cases of foreign words such as *film* [ˈfilm] ‘film’. The segments that most frequently occur in coda position are coronals: *esto* [ˈesto] (‘this’), *hablar* [aˈβlar] (‘to talk’), *alma* [ˈalma] (‘soul’), *charlatán* [tʃarlaˈtan] (‘chatterbox’), *adalió* [aðaˈlið] (‘leader’), and complex codas like [ns] or [rs] can appear in word-medial position in both languages, e.g., Catalan *auster* [əwsˈter] (‘austere’), *abstenció* [əpstənˈsjɔ] (‘abstention’), *expressar* [əkspɾəˈsa] (‘to express’), Spanish *perspicaz* [pɛrspiˈkaθ] ‘shrewd’, *construcción* [konstrukˈθjon] ‘construction’. Nevertheless, in colloquial Spanish there is a tendency to assimilate or reduce these complex codas to an /s/ (e.g., *abstención* [astɛnˈθjon] ‘abstention’, *transferencia* [trasfeˈrɛnθja] ‘transfer’ or *técnica* [ˈteθnika] / [ˈtenika] ‘technique’).<sup>1</sup>

In order to investigate whether coda acquisition by learners of Catalan and Spanish is influenced by the frequency of occurrence of the coda consonants in certain prosodic positions, we need to compute the frequency counts in the two target languages. For this purpose we used the Catalan and Spanish editions of the LC-STAR corpus-based electronic dictionary (Conejero & Moreno, 2005a, 2005b). Each dictionary includes more than one hundred thousand entries, separated into common and proper nouns, together with their phonetic transcription and frequency of appearance in the corpora. For our study, we used the 55,831

<sup>1</sup> As reported in Saceda (2005: 70), Spanish does *not* allow for complex final codas and, in the case of words ending in a closed syllable, an epenthetic /e/ has to be added between the final coda and the plural marker *-s*. For instance, the plural for ‘bread’ is *panes* in Spanish but *pans* in Catalan. This makes Catalan a language with shorter words than Spanish and with more complex consonant clusters in coda position. However, longitudinal studies for both Catalan and Spanish have not found that morphosyntactic information facilitates the emergence of a prosodic structure “earlier than one would expect to occur based on purely prosodic factors” (Prieto & Bosch-Baliarda, 2006: 239; see also Saceda, 2005, and Lleó, 2003).

	% syllables		% syllables with coda	
	Catalan	Spanish	Catalan	Spanish
Medial Unstressed	57.45	49.76	34.39	30.51
Medial Stressed	14.50	22.44	33.75	25.75
Final Unstressed	14.39	21.81	26.87	47.51
Final Stressed	13.66	6.00	67.12	47.27

**Table 1:** Percentage of syllables in the language as a function of word position and syllable stress (first two columns) and percentages of these syllables with coda consonants (last two columns), in Catalan and Spanish

	% syllables		% syllables with coda	
	Catalan	Spanish	Catalan	Spanish
Monosyllables	5.32	5.00	84.16	53.02
Oxytonic polysyllables	94.68	95.00	66.16	46.96

**Table 2:** Percentage of syllables in the language as a function of word length (first two columns) and percentages of these syllables with coda consonants (last two columns), in Catalan and Spanish

Catalan common nouns and the 56,863 Spanish common nouns. Once we had converted the phonetic transcriptions from SAMPA to Unicode UTF-8, we used Phon (Rose et al., 2006) to perform queries by using the PhonEx function. After each query, we obtained a list of all the target words that matched our phonetic transcription search criteria.

Table 1 shows the percentages of target coda consonants as a function of stress and within-word position. In Catalan, 67.12% of the stressed word-final syllables have a coda, whereas an average of only 31.67% of other syllables have one. By contrast, in Spanish, an average of 47.39% of word-final syllables contain a coda, with no clear differences in terms of stress properties, whereas medial-word syllables present a coda in only 28.13% of instances, on average.<sup>2</sup>

Table 2 shows the absolute number and percentages of target coda consonants as a function of word length (monosyllabic vs. oxytonic polysyllabic words). As can be seen below, in Catalan, word-final codas appear in 92.85% of the mono-

<sup>2</sup> Prieto and Bosch-Baliarda (2006) also note the high frequency of stressed word-final codas in a child speech corpus. Over the period that ranges from 2;00 to 2;06, Catalan learners produce target words with a larger proportion of codas in word-final stressed positions (90.50%) in comparison with other phonological contexts (53.42% for word-medial unstressed position, 63.37% for word-medial stressed position, and 65.45% for word-final unstressed position).



syllables and in 65.74% of the oxytonic polysyllables. By contrast, in Spanish, word-final codas appear in 82.32% of the monosyllables and in 45.75% of the oxytonic polysyllables.

In sum, a prominence-based hypothesis and a frequency-based hypothesis would make closely related predictions. On the one hand, the prominence-based hypothesis would predict that there should be no substantial differences between Catalan and Spanish learners (i.e., in either language, children would consistently produce codas more accurately when they belong to stressed syllables, word-final syllables, and monosyllabic words). The frequency-based hypothesis would also predict that Catalan-dominant learners would produce more coda consonants in word-final stressed syllables than in the three other conditions, yet it makes different predictions for Catalan and Spanish. More specifically, Spanish-dominant learners might show a preference for producing codas in word-final syllables, regardless of whether they were stressed syllables or not. This means that under either hypothesis acoustic prominence would have a boosting effect on early coda production, but for the frequency-based hypothesis this effect would be mediated by frequency and distributional factors. In our experiments, controlling for the different prosodic issues will be key in order to accommodate these different but related predictions.

On the other hand, the frequency-based hypothesis predicts that both Catalan-dominant and Spanish-dominant children will produce more codas in monosyllables than in polysyllables. This would happen to a lesser extent for Spanish, and it would also be expected that Catalan-dominant learners will produce more codas than Spanish-dominant learners in these two conditions, since Catalan has a greater frequency of codas in word-final stressed syllables.

### 3 Method

#### 3.1 Participants

Eight Catalan-dominant children (from 1;11,29 to 2;04,22; average = 2;02,08; stdev = 61.8 days) and eight Spanish-dominant children (from 2;03,02 to 2;05,17; average = 2;04,09; stdev = 28.7 days) participated in the two experimental tasks.<sup>3</sup>

<sup>3</sup> A Wilcoxon signed-rank test revealed an age-related difference between the two groups of learners ( $p = .05$ ,  $Z = -1.960$ ). However, this difference is in fact beneficial for our study because Spanish children present a later acquisition of codas (Saceda, 2005; Prieto & Bosch-Baliarda, 2006), thus enabling us to analyze the two populations when they were at more similar developmental stages.



1 Nine additional participants were tested but not included in the analysis because  
2 they did not complete the experiment or did not meet the language requirements.  
3 All children came from the metropolitan area of Barcelona and were recruited  
4 from three different childcare centers – Gespa (Bellaterra, Cerdanyola del Vallès),  
5 L’Estel Blau (Bellvitge, L’Hospitalet de Llobregat) and La Casa dels Arbres (Santa  
6 Eulàlia, L’Hospitalet de Llobregat) – see Appendix for a list of participants and  
7 the community each came from.

8 Since both Catalan and Spanish are spoken in this geographical region, it  
9 was necessary to previously determine the dominant language of the child. A lan-  
10 guage questionnaire was administered to each child’s parents in which they had  
11 to report about languages used at home and the relative duration of the child’s  
12 regular exposure to Catalan and Spanish. Specifically, questions were asked  
13 about: (1) language(s) spoken to the child while bathing, eating, getting dressed,  
14 and playing, (2) languages heard in the childcare center and (3) potential contact  
15 with other languages during the week, with the average number of hours of  
16 exposure noted. Participants were classified as Catalan-dominants or Spanish-  
17 dominants if they only answered “Catalan” or “Spanish” respectively to the first  
18 question and reported less than two hours per week of continuous exposure  
19 to the other language outside their childcare center and home. This means that  
20 participants who had one Catalan-speaking parent and one Spanish-speaking  
21 parent were not analyzed in the present study. All participants shared Catalan  
22 as the main language heard in the childcare center and had some exposure to  
23 Spanish language through, for example, the public broadcast media, which does  
24 not mean that Catalan-dominant bilinguals are less aware of the situation of  
25 language contact in the metropolitan area of Barcelona (see Cortés et al., 2009,  
26 for a summary of the language contact situation between Catalan and Spanish in  
27 this area).<sup>4</sup>

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### 30 **3.2 Procedure**

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33 To test the effects of phonological context on coda production, the first author  
34 conducted two experimental tasks, with the occasional assistance of the nursery  
35 caretakers. The children were tested on production accuracy by using a picture

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38 **4** Regarding the issue of potential effects of bilingualism, we have made sure that we analyzed  
39 only Spanish-dominant children by excluding the more balanced bilinguals. Yet we cannot  
40 completely rule out a small effect of second language presence and contact.

identification task involving familiar words and an elicited imitation task involving nonsense words. In the first task, the experimenter asked the two-year-old participants to name a set of real objects shown in pictures by saying, “*What is this? Can you tell me what this is?*” In the second task, the experimenter showed the participants a set of cartoon-like faces to which nonsense names had been assigned and then, pointing to each face one at a time, said, “*This is an X. Can you say X?*” (where X stands for one of the nonsense names).

As mentioned above, one of the goals of this study was to compare the results of a picture identification task involving familiar words with an elicited imitation task featuring novel words. As noted, the use of an imitation task with novel, nonsense words was intended to ensure that a greater prior familiarity with certain words did not skew our results.

All children performed the picture identification task first and the elicited imitation task second (with durations of roughly 7 and 3 minutes respectively). All child participants completed all items. The experimenter interacted with the participants only in the language of the task, and so participants were tested in a monolingual mode (cf. Grosjean, 1998, 2001). The stimuli were presented using a PowerPoint presentation. Real words and nonwords were ordered pseudo-randomly in order to avoid sequences where two adjacent words had the same phonological shape or the same segment in coda position.

### 3.3 Materials

In order to test the effect of phonological context on coda production, a set of target words were constructed that were strictly controlled for target segment, stress position, within-word position, and word length. Each task contained 20 items. For both tasks, the target words included only four types of singleton codas, namely the lateral [l], the nasal [n], the rhotic [r], and the fricative [s], a set of consonants that are common in coda position in both languages (stop consonants were not included because they are very rare in Spanish in coda position).

The syllable nuclei of our nonword materials were also controlled in order to avoid language differences. First, we rejected /e/ and /o/ for two reasons: (1) Central Catalan reduces them to [ə] and [u] in unstressed positions, so this could cause confusions with /a/ and /u/, and (2) we wanted to avoid possible [ɛ] and [ɔ] pronunciations by Catalan participants. Second, although Central Catalan theoretically reduces /a/ to [ə] in unstressed positions, we did not differ in the pronunciations of /a/ regarding stress or language in order to have balanced materials between the two groups of participants. Support for this lack of distinction in the Barcelona area comes from Cortés et al. (2009), who studied a group of 3–5-year-

1 Segment type	CVC.'CV	'CVC.CV	'CV.CVC	CV.'CVC	'CVC
2 lateral	<i>balcó</i>	<i>galta</i>	<i>núvol</i>	<i>mussol</i>	<i>sol</i>
3	[bəl.'kɔ]	['gal.tə]	['nu.βul]	[mu.'sɔl]	['sɔl]
4	'balcony'	'cheek'	'cloud'	'owl'	'sun'
5 nasal	<i>menjar</i>	<i>panxa</i>	<i>plàtan</i>	<i>davant</i>	<i>nen</i>
6	[mən.'dʒa]	['pan.tʃə]	['plə.tən]	[də.'βan]	['nɛn]
7	'food'	'belly'	'banana'	'in front'	'child'
8 rhotic	<i>dormir</i>	<i>porta</i>	<i>vàter</i>	<i>iogur</i>	<i>cor</i>
9	[dur.'mi]	['pɔr.tə]	['ba.tɛr]	[ju.'yur]	['kɔr]
10	'to sleep'	'door'	'toilet'	'yoghurt'	'heart'
11 fricative	<i>bastó</i>	<i>mosca</i>	<i>llapis</i>	<i>arròs</i>	<i>gos</i>
12	[bəs.'tɔ]	['mos.kə]	['lɔ.pis]	[ə.'rɔs]	['gɔs]
13	'stick'	'fly'	'pencil'	'rice'	'dog'

15 **Table 3:** Catalan real words used for the picture identification task

16  
17 olds from the Barcelona area and showed that less than a half of them noticed the  
18 difference between [a] and [ə].

19 Target coda consonants were placed in different prosodic environments,  
20 namely in stressed vs. unstressed syllables, in word-medial vs. word-final syllables,  
21 and in monosyllabic vs. disyllabic words. Five different word shapes were  
22 used, each containing one target coda (underlined): (a) monosyllabic 'CVC  
23 patterns, (b) iambic patterns with a final coda consonant (CV.'CVC), (c) trochaic  
24 patterns with a medial coda ('CVC.CV), (d) iambic patterns with a medial coda  
25 (CVC.'CV), and (e) trochaic patterns with a final coda ('CV.CVC). Each of the 5  
26 word shapes occurred with the 4 target coda consonants [l, n, r, s], yielding a total  
27 of 20 test items per language. The real words were selected from a set of common  
28 words in early child language (see Águila et al., 2005, 2008). Tables 3 and 4 contain  
29 the 40 target words selected for the picture identification task for Catalan  
30 (Table 3) and Spanish (Table 4). The researcher elicited the target words *galta* Cat.  
31 'cheek', *panxa* Cat. 'belly', and *nariz* Span. 'nose' without the use of pictures but  
32 by touching the appropriate part of his own body.<sup>5</sup>

33 The same word shapes used for the real words were used for the nonwords. A  
34 list of the nonword stimuli is presented in Table 5. As mentioned above, each of

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37 <sup>5</sup> We selected *flor*, which is actually CCVC, because it provided a good example of a well-  
38 known word and thus ideal for a picture elicitation task. Although *llaves* has a coda carrying  
39 morphological meaning, we selected it because it is a lexical item usually produced in plural  
40 in child speech while constituting a representative example of the role of such codas in this  
specific prosodic context.

Segment type	CVC.'CV	'CVC.CV	'CV.CVC	CV.'CVC	'CVC
lateral	<i>salto</i>	<i>pulpo</i>	<i>móvil</i>	<i>papel</i>	<i>sol</i>
	[sal.'to]	['pul.po]	['mo.βil]	[pa.'pel]	['sol]
	's/he jumped'	'octopus'	'mobile'	'paper'	'sun'
nasal	<i>pintó</i>	<i>manta</i>	<i>comen</i>	<i>limón</i>	<i>pan</i>
	[pin.'to]	['man.ta]	['ko.men]	[li.'mon]	['pan]
	's/he painted'	'blanket'	'they eat'	'lemon'	'bread'
rhotic	<i>cortó</i>	<i>carne</i>	<i>váter</i>	<i>yogur</i>	<i>flor</i>
	[kor.'to]	['kar.ne]	['ba.ter]	[jo.'γur]	['flor]
	's/he cut'	'meat'	'toilet'	'yoghurt'	'flower'
fricative	<i>gastó</i>	<i>mosca</i>	<i>llaves</i>	<i>nariz</i>	<i>dos</i>
	[gas.'to]	['mos.ka]	['ʎa.βes]	[na'riθ]	['dos]
	's/he spent'	'fly'	'keys'	'nose'	'two'

**Table 4:** Spanish real words used for the picture identification task

	CVC.'CV	'CVC.CV	'CV.CVC	CV.'CVC	'CVC
lateral	[pil'na]	['pilna]	['napil]	[na'pil]	['pil]
nasal	[kun'ta]	['kunta]	['takun]	[ta'kun]	['kun]
rhotic	[lar'βu]	['larβu]	['bular]	[bu'lar]	['lar]
fricative	[niz'ma]	['nizma]	['manis]	[ma'nis]	['nis]

**Table 5:** Nonword materials used for the elicited imitation task

these nonwords was paired with a cartoon face and presented using a PowerPoint presentation.<sup>6</sup>

### 3.4 Data transcription and analysis

All of the children's productions were phonetically transcribed. The mean percentage number of produced words was 94.27% (see Appendix for percentages

<sup>6</sup> Though [kun'ta] is the most common pronunciation of the Catalan infinitive *comptar* 'to count', we did not expect this to have any influence on coda realization, since this and all nonwords were tested as being proper names of a series of drawn characters and thus the context suggested no relation to common Catalan or Spanish words.

1 of coda production for each child). An inter-transcriber reliability test was con-  
2 ducted with a subset of our data, which consisted of a total of 67 productions from  
3 the combined recordings selected by one of the authors, who ensured that all  
4 participants and tasks were uniformly represented. A comparison of the tran-  
5 scriptions across the three transcribers revealed 82.01% overall agreement in  
6 coda fulfillment decisions (Fleiss' fixed-marginal kappa coefficient = .641). In  
7 general, this level of agreement is considered to indicate a moderate degree of  
8 confidence in the reliability of the transcriptions (see Landis & Koch, 1977). Dis-  
9 agreements can be explained by differences in noticing geminates, since coda  
10 position can be one of the weakest perceived positions (i.e., compared to the  
11 onset position).

12 One of the important questions that preceded data analysis was what would  
13 be counted as a target coda. Children either produced coda consonants correctly  
14 or replaced them by other consonants (e.g., ['bater] Span./Cat. 'toilet' pronounced  
15 ['batet], [bal'kon] Span. 'balcony' pronounced [baj'kon]). Jordão and Frota (2008)  
16 call such substitutions repair strategies, and they include substitutions, vocaliza-  
17 tions, assimilations, and vowel lengthening. Assimilation is a very specific case  
18 of substitution motivated by a coarticulation process (e.g., ['pɔrtə] Cat. 'door' pro-  
19 nounced ['pɔttə], or [pəl'rɔtʃ] Cat. 'red-haired' pronounced [pəl'lɔ]). In our data,  
20 we found 27.95% correct productions, 33.62% (consonant or glide) substitution  
21 strategies, 13.39% cases of vowel lengthening, and 25.03% omissions. All cases of  
22 correct production and substitution were counted as produced codas.<sup>7</sup> By con-  
23 trast, we did not count as codas cases of vowel lengthening (e.g., [kor'to] 'Sp.  
24 short' pronounced [ko:'to]) or any case of epenthesis (e.g., [pil'nas] 'nonsense  
25 word' pronounced [pilu'las]) or consonant deletions which caused the target con-  
26 sonant to be in the onset position of the following syllable (e.g., ['pilna] 'non-  
27 sense word' pronounced ['pila]).

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## 30 4 Results

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33 In this section we report the results of coda consonant production with respect  
34 to the combined effects of stress environment (stressed vs. unstressed) and

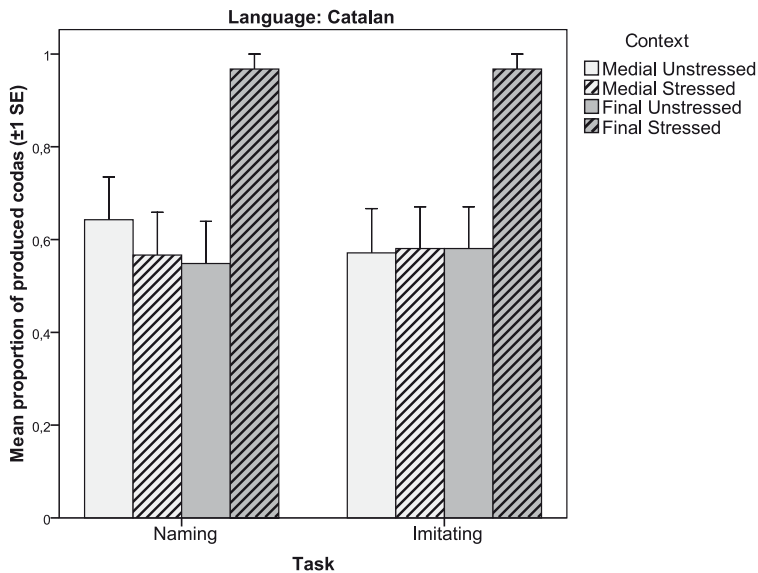
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38 <sup>7</sup> As stated by Saceda (2005) and Prieto and Bosch-Baliarda (2006), /l,r/ are reported to be  
39 acquired relatively late compared with /n,s/ for both Catalan and Spanish. However, because  
40 all cases of correct production and substitution are counted as produced codas in our analysis,  
we do not expect articulatory-related phenomena to affect our results.



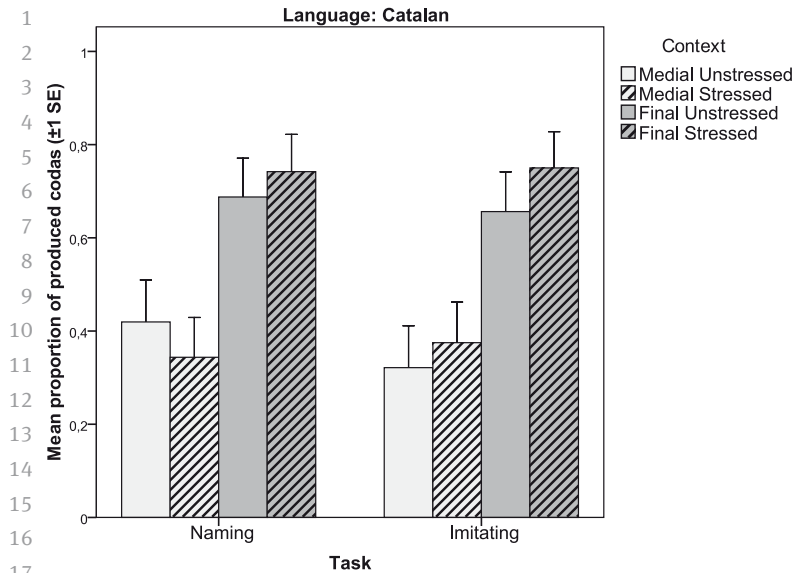
**Fig. 1:** Mean proportion of produced codas in disyllabic words as a function of within-word position and stress, for Catalan-dominant learners in both tasks. Error bars show  $\pm 1$  Standard Error.

within-word position (word medial vs. word final), and with respect to word length (monosyllabic vs. disyllabic).

#### 4.1 Effects of stress and within-word position

Figure 1 shows the mean proportion of codas produced by Catalan-dominant children as a function of within-word position and stress, for both tasks. The graph shows that the Catalan-dominant children behaved very similarly in both tasks, namely, they produced a higher rate of target codas in stressed word-final contexts than in the other three contexts (final unstressed, medial stressed, and medial unstressed).

Figure 2 shows the mean proportion of codas produced by Spanish-dominant children as a function of within-word position and stress, for both naming and imitation tasks. The graph shows that the Spanish-dominant children produced a larger proportion of codas when they were in word-final position (in both stressed and unstressed syllables) than when they were in other positions. Importantly, the same pattern of results is found in both tasks.



**Fig. 2:** Mean proportion of produced codas in disyllabic words as a function of within-word position and stress, for Spanish-dominant learners in both tasks. Error bars show  $\pm 1$  Standard Error.

A Generalized Linear Mixed Model (GLMM) analysis (binomial distribution) was performed with CODA PRODUCTION as the dependent variable.<sup>8</sup> The fixed factors were TASK (naming, imitation), WITHIN-WORD POSITION (medial, final), STRESS (unstressed, stressed), and LANGUAGE (Catalan, Spanish). PARTICIPANT and SEGMENT were set again as random factors. Main effects of STRESS ( $F_{1,475} = 11.792, p = .001$ ) and WITHIN WORD-POSITION ( $F_{1,475} = 38.685, p < .001$ ) were found. Neither TASK ( $F_{1,475} = 0.038, p = .846$ ) nor LANGUAGE ( $F_{1,13} = 3.132, p = .100$ ) had a significant main effect. Only three interactions were found to be significant: LANGUAGE  $\times$  STRESS ( $F_{1,475} = 7.394, p = .007$ ), STRESS  $\times$  WITHIN-WORD POSITION ( $F_{1,475} = 14.155, p < .001$ ), and the triple interaction LANGUAGE  $\times$  STRESS  $\times$  WITHIN-WORD POSITION ( $F_{1,475} = 9.010, p = .003$ ).

<sup>8</sup> All responses were analyzed through a Generalized Linear Mixed Model (GLMM) using IBM SPSS Statistics 19.0 (IBM Corporation, 2010). As Baayen et al. (2008) and Quené and van den Bergh (2008) point out, mixed-effects modeling offers considerable advantages over repeated measures ANOVA. Specifically for our data, they are suitable to properly analyze noncontinuous dependent variables, such as binomial responses. On the other hand, we can control for both fixed and random factors at the same time.



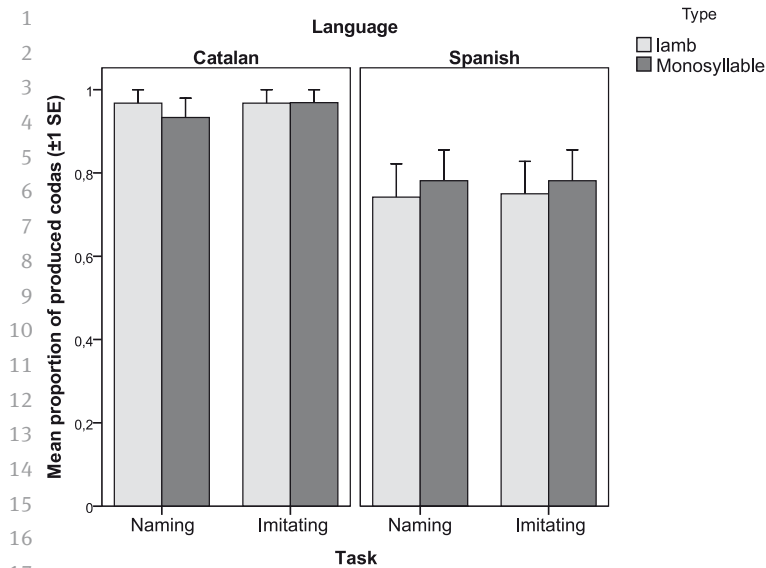
Bonferroni post-hoc paired contrasts were extracted in order to determine the directions of the effects in the triple interaction, i.e., the effect of each separate factor when the other two are under control. First, post-hoc tests revealed that Catalan-dominant learners produced more codas than Spanish-dominant learners only in stress word-final position ( $t_{77} = 2.630, p = .010$ ). Second, Catalan-dominant learners produced more codas in stressed syllables than in unstressed syllables only when they occurred in word-final position ( $t_{475} = 4.378, p < .001$ ), with no effects of stress concerning Spanish-dominant learners. Third, word-final codas were produced more than word-medial codas for Spanish-dominant learners both in stressed syllables ( $t_{475} = 4.517, p < .001$ ) and unstressed syllables ( $t_{475} = 3.660, p < .001$ ); however, Catalan-dominant listeners showed an effect of within-word position when they occurred in stressed syllables ( $t_{475} = 4.345, p < .001$ ), but not in unstressed syllables ( $t_{475} = 0.416, p = .657$ ).

The prominence hypothesis predicted that both Catalan-dominant and Spanish-dominant learners would produce more codas systematically when they were in stressed syllables. This general prediction was borne out by our data by finding a main effect of STRESS, but the results also show that the role played by STRESS is different across the two languages investigated and that it is mediated by the effect of WITHIN WORD-POSITION (which has general effects for the productions of Spanish-dominant learners).<sup>9</sup> These results clearly suggest that frequency patterns in the ambient language determine coda production accuracy.

## 4.2 Effects of word length

To test the effects of word length, the number of coda productions in monosyllables was compared with the number of coda productions in disyllabic iambic words with a final coda consonant. In this way, coda productions could be analyzed in the same conditions of prominence (stressed syllables) and within-word position (word-final condition). The graph in Figure 3 shows the mean proportion of codas produced by Catalan-dominant and Spanish-dominant children as a function of word length (iamb, monosyllable), for both tasks. The graph clearly illustrates how the patterns of results for Catalan-dominant and Spanish-dominant children are again overwhelmingly similar across both tasks and num-

<sup>9</sup> Though the literature has shown that some Spanish children produce word-medial codas more often and more accurately than final codas (cf. Lleó, 2003, and Lleó et al., 2003), a subject-by-subject analysis revealed no preference for word-medial codas for any participant from the Spanish-dominant group.



**Fig. 3:** Mean proportion of produced codas in stressed word-final positions as a function of word length (disyllabic iambs vs. monosyllables). Error bars show  $\pm 1$  Standard Error.

ber of syllables. As for the language difference, while Catalan-dominant learners produce more codas overall in these specific contexts and show a ceiling effect, Spanish-dominant learners do not display a strong difference between the two conditions (iamb vs. monosyllable) in either of the tasks.

Another GLMM analysis (binomial distribution) was performed with CODA PRODUCTION as the dependent variable. The fixed factors were TASK (naming, imitation), WORD LENGTH (monosyllables, disyllables), and LANGUAGE (Catalan, Spanish). The variable PARTICIPANT was set as random factor again. A main effects of LANGUAGE was found ( $F_{1,25} = 10.905$ ,  $p = .003$ ), such that Catalan-dominant learners produced more codas than Spanish-dominant learners overall ( $t_{25} = 3.302$ ,  $p < .001$ ). Neither TASK ( $F_{1,243} = 0.181$ ,  $p = .671$ ) nor WORD-LENGTH ( $F_{1,243} = 0.028$ ,  $p = .867$ ) nor any of the analyzed interactions were found to be significant.<sup>10</sup>

In accordance with the prominence-based hypothesis, we would have expected both Catalan-dominant and Spanish-dominant children to produce more

<sup>10</sup> Additional Bonferroni post-hoc tests applied to the interaction WORD-LENGTH  $\times$  LANGUAGE revealed that the effect of language is greater in polysyllables ( $t_{83} = 2.775$ ,  $p = .007$ ) than in monosyllables ( $t_{60} = 2.269$ ,  $p = .027$ ).

codas in monosyllables than in disyllables (e.g., Catalan *sol* ‘sun’ vs. *mussol* 1  
‘owl’), and no difference would be expected between the two groups of learners. 2  
Yet this is not confirmed by our results; the effect of word length is found to be 3  
non-significant in both Catalan and Spanish (all  $p > .05$ ). On the other hand, the 4  
frequency-based hypothesis predicts that Catalan-dominant learners would 5  
produce significantly more codas in word-final stressed syllables – as Catalan has 6  
84.16% of monosyllables with coda and 66.16% of disyllabic iambs with word- 7  
final stressed coda (see Table 1). Yet this prediction cannot be tested because we 8  
have a ceiling effect for Catalan. On the other hand, since the percentage differ- 9  
ence is much lower in for Spanish-dominant children (53.02% of codas in mono- 10  
syllables vs. 46.96% in disyllabic iambs) we would expect similar rates of coda 11  
production in these positions in Spanish. The results reported in these sections 12  
reveal only a difference between the overall higher number of codas by Catalan- 13  
dominant compared to Spanish-dominant children. 14

## 5 Discussion and conclusions 17

In this article, we examined the production of coda consonants by 2-year-old 20  
Catalan-dominant and Spanish-dominant bilingual children using a controlled 21  
set of target words with different phonological shapes. Two production experi- 22  
ments were carried out, namely a picture identification task with familiar words 23  
and an elicited imitation task with novel nonsense words. The goal of the study 24  
was twofold: first, to test the effects of stress, within-word position, and word 25  
length on coda production in the two languages; and second, to assess whether 26  
patterns of children’s coda production reflect the frequency distribution with 27  
which coda consonants appear in different phonological contexts in the respec- 28  
tive input language, or instead respond to patterns of acoustic prominence. The 29  
results obtained in the two tasks have revealed some interesting patterns that 30  
are relevant for an evaluation of these partially competing hypotheses on early 31  
prosodic acquisition. 32

On the one hand, the prominence hypothesis predicts for both language 33  
groups that (a) codas in stressed positions will be more frequently produced than 34  
codas in unstressed positions, and (b) codas in monosyllabic words will be more 35  
frequently produced than codas in disyllabic words. This is not what our results 36  
show. First, a main effect of stress was found for children’s productions, but this 37  
effect was mediated by both within-word position and language dominance, i.e., 38  
our data do not show, for example, any preference for stressed codas in word- 39  
medial contexts or in the productions of the Spanish-dominant group (Figure 2). 40

1 Moreover, the effect of stress is exclusively found for Catalan-dominant children  
2 producing codas in word-final position, which is in line with the predictions of  
3 the frequency-based hypothesis (Figure 1) and demonstrates that prominence by  
4 itself does *not* have a generalized boosting effect on coda production. Second,  
5 neither group of children showed an effect of word-length in coda productions  
6 when comparing monosyllabic with disyllabic words (Figure 3). In short, the per-  
7 formance reported for the various contexts does not provide evidence in favor of  
8 a frequency-independent prominence hypothesis, i.e., coda consonants are not  
9 necessarily more frequently produced when they occur in acoustically prominent  
10 positions.

11 All in all, this is different from a null hypothesis, which would predict no  
12 language differences given similar stimuli. Thus, we claim that the patterns of  
13 early coda production seen in Catalan-dominant and Spanish-dominant children  
14 are motivated by the frequency distribution patterns found in the input lan-  
15 guage. A robust result in this regard is the special status of stressed word-final  
16 positions in Catalan – which coincides with a pattern that is particularly frequent  
17 in this language – and the frequency of word-final codas produced by Spanish-  
18 dominant learners (see Figures 1 and 2).<sup>11</sup> On the other hand, in terms of the  
19 effects of word length, the results also show a language-specific tendency. As  
20 predicted by the frequency-based hypothesis, Catalan-dominant learners pro-  
21 duce more codas in this position (albeit showing a ceiling effect) than Spanish-  
22 dominant learners. As for the difference between word length conditions, in  
23 Catalan it cannot be tested due the ceiling effect. As for Spanish, similar percent-  
24 ages of occurrence of codas in the two conditions can explain the null effect of  
25 this factor in this language.

26 Our results regarding word length differ from those of Kirk and Demuth  
27 (2006) for English, which showed a clear contrast between coda production  
28 in monosyllabic and disyllabic words. In this regard, we suggest that English  
29 learners' preference for codas in monosyllables vs. polysyllables can be explained  
30 in terms of frequency, i.e., in English, codas in monosyllables are overwhelmingly  
31 more frequent than in disyllables (cf. Roark & Demuth, 2000).

32 Our results thus suggest that linguistic dominance plays a very important role  
33 in the development of syllable structure by showing that bilinguals are precisely

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35

36 <sup>11</sup> In addition, it is also possible that learners are better at producing codas when they occur  
37 in the prosodic contexts they are most familiar with. This is both related to lexical encoding and  
38 retrieval issues (though we obtain similar results in the two tasks reported in this study) and  
39 to the perception of higher frequency phonological patterns in the target language (recall that  
40 whereas 14% of Catalan syllables are stressed word-final, the proportion for Spanish is only 6%  
in Spanish; see Song et al., 2009, and Sundara et al., 2011).

attuned to the prosodic structure of their dominant language. However, an amount there exists a body of research that demonstrates that bilingualism can have an explicit beneficial influence on language acquisition. In line with this, Lleó et al. (2003) found that German-Spanish bilingual children produced the same number of codas as monolingual German children when speaking German, but their coda productions clearly outnumbered those of Spanish monolinguals when speaking Spanish. Future research could clarify if Spanish-dominant bilinguals as in our study show facilitation effects when compared with Spanish monolinguals.

The early coda production results presented in this article thus support a theory of phonological development that is mediated by the distributional patterns of frequency in the input language. Our results provide additional evidence that the statistical distributional patterns in the ambient language play an important role in the development of speech perception and production abilities (Werker & Curtin, 2005; Zamuner, 2009, Zamuner et al., 2004; and others). Zamuner et al. (2004) found that children were sensitive to the transitional probabilities between the vowel and the following coda consonant in word-production tasks. These results suggest that children are able to keep track of frequency effects at several levels of prosodic structure. In our data, acoustic prominence (stress) is found to have a boosting effect on early coda production, but it is crucially mediated by frequency and distributional factors.

In addition, as stated above, the fact that Catalan lacks an explicit word-final masculine marker increases the number of codas (and complex codas) in this language compared with Spanish. This makes Catalan a language with shorter words and with more codas in acoustically prominent syllables. The same pattern is also found in English and could explain the earlier acquisition of coda consonants by Catalan learners compared to Spanish learners (Prieto & Bosch-Baliarda, 2006). One could argue that this structural pattern underlies the timing of the acquisition of coda consonants between learners of different languages.

Finally, our results contribute to the discussion of whether coda productions may vary depending on the elicitation procedure used, specifically on the impact of using tasks that involve the naming of familiar words or the imitation of non-words. Our results are extremely consistent in this regard. No differences were found between coda productions when the results of the two tasks were compared, and crucially the same patterns of coda production were found for the two resulting data sets. Our results are thus in agreement with Kehoe and Stoel-Gammon (2001), Llach (2007), and Kirk and Demuth (2006), among others, who did not find substantial differences between these two methods in normally developing children.

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## Appendix

List of participants, home communities, ages, percentages of codas produced by each child and their home language.

Name	Location	Age	Codas Prod. (%)	Language dominance
Berta	Bellaterra	2;04.20	73	Catalan
Irene	Bellaterra	2;01.28	74	Catalan
Jan	Bellvitge	2;01.02	42	Catalan
Joan	Bellaterra	2;04.22	72	Catalan
Laura	Bellaterra	2;04.13	98	Catalan
Marina	Bellaterra	1;11.29	76	Catalan
Martina (1)	Bellaterra	2;00.04	46	Catalan
Martina (2)	Bellaterra	2;01.08	68	Catalan
Alexia	Bellvitge	2;05.17	67	Spanish
Dayana	Bellvitge	2;02.30	51	Spanish
Derek	Bellvitge	2;05.09	30	Spanish
Elia	Santa Eulàlia	2;03.19	58	Spanish
Elsa	Bellvitge	2;04.14	67	Spanish
Jorge	Bellvitge	2;03.28	56	Spanish
Miguel	Bellvitge	2;05.05	83	Spanish
Tomy	Santa Eulàlia	2;03.13	43	Spanish

## Bionotes

