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Consonant acquisition: a first approach to the distribution of errors in four positions in the word

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Resumen

El objetivo de este estudio es describir el comportamiento de los errores que se producen en dos tipos de ataques (inicial e intervocálico) y dos tipos de codas (medial y final de palabra) para determinar si estas posiciones son propensas a una tipología específica de errores. Con este fin, se han estudiado los errores que se producen habitualmente en estos cuatro contextos durante la adquisición de los sonidos consonánticos de la lengua catalana, en 90 niños de edades comprendidas entre 3 y 5 años, procedentes de diversos centros educativos. Los resultados muestran que hay diferencias en el tipo de errores que experimenta cada posición.

Palabras clave: Adquisición del lenguaje; Catalán; Errores consonánticos; Fonología.

Abstract

The goal of this study is to describe the behavior of errors in two types of onsets (initial and intervocalic) and two types of codas (in the middle and end of the word) in order to determine if any of these positions are more prone to specific types of errors than the others.We have looked into the errors that are frequently produced in these four contexts during the acquisition of consonant sounds in the Catalan language. The data were taken from a study on the acquisition of consonants in Catalan, carried out on 90 children between the ages of 3 and 5 years from several kindergarten schools. The results do show that there are characteristic errors depending on the position within the word.

Key words: Catalan language; Consonant errors; Language acquisition; Phonology.

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Introduction

The acquisition of the sound system of a language is a topic that has produced several seminal works, like Jakobson (1968, 1971), Templin (1957), Smith (1973), Stampe (1979), Ingram (1976), Grunwell (1987) or Vihman (1993). The objective in some of these studies has been either the description of the order in which the sounds appear, i.e., the emerging segments of the system under construction (Jakobson, 1968, 1971), or the study of errors or non-target-like productions (Ingram,1976).

With regard to the Catalan language, we have both general descriptive works, like those by Bosch (1987), Secall and Crespí (1987), De Ribot (1992) and Llach (2007) and other more detailed ones, like Aguilar and Serra (2004); Prieto and Bosch-Baliarda (2006) and Borrás-Comes and Prieto (2011) for the acquisition of the codas.

Bosch (1987), who examines Central Catalan, makes a qualitative assessment of production corresponding to 250 children aged between 3 and 7 years. The errors observed there are classified following Ingram's (1976) proposal, and the phonological profiles are also presented for the various ages. Secall and Crespí (1987), on the other hand, present two tests of phonological analysis, one comprehensive screening test for children and adults, and a screening for children between 3 to 7 years of age. The results in this case follow the classification criteria used in Templin (1957) and Ingram (1976). De Ribot (1992) conducted a production test, and the classification utilized there was also that put forward by Ingram (1976) for the phonological processes. Finally, Llach (2007) describes and analyzes errors produced by children between 3 and 7 based on production and perception parameters. Studies by Prieto and Bosch-Baliarda (2006) and Borràs-Comes and Prieto (2011) are recent contributions that focus on the acquisition of codas in Catalan. Aguilar and Serra (2004) provide a series of standards aimed at analyzing phonetic and phonological aspects on children over the ages of 3 and 6 years as well as the scale of the Screening Protocol test on a population of 92 children.

The present study is in line with the works that analyze errors or non-target-like productions for the acquisition of the sound system. In particular, we examine errors affecting the segments individually, and exclude errors affecting the whole syllable or longer phonological units. The aim is to describe the behavior of segmental errors in four positions in the word, corresponding to two onsets and two codas, in order to obtain information on how the errors are distributed. The objective is an attempt to integrate the advantages from the theoretical approach that focuses on the study of

prosodic features (among which the syllabic position) to explain phonological processes, such as Îto (1986) or Golsdmith (1990); and from more recent theoretical perspectives, like that of Steriade (1995, 1997, 1999), who shows that phonological contrasts in adult systems are neutralized in environments with poor perceptual cues, and hence the importance of context. Even though Steriade's line of argument is perceptive, therefore not related to the goal of this article, what we do find in her work is the explanation of phonological processes by means of the adjacent context. For example, the processes do not occur "in coda", but "before an obstruent". The existence of these two perspectives on the phonological processes is the basis of the study that we have carried out since they have been applied to the errors made over the acquisition period. Thus, our study draws on these two lines of work by presenting a view which comes from examining the analysis of data on the phonological acquisition of consonants, i.e., errors in Catalan produced by children between the ages of 3 and 5.

We start off with the analysis of the syllabic and the contextual positions where the consonant errors occur, which are the two syllabic positions (onset, coda) and four contextual positions (word-initial, word-final, intervocalic position and post-nuclear heterosyllabic position). We consider initial and intervocalic positions as onsets[1], and final and post-nuclear heterosyllabic positions as codas. We analize the errors in order to observe whether or not there are differences between the initial onset (without a previous segment) and the intervocalic onset (with a previous segment), as well as the final coda (without a following segment) and the heterosyllabic coda (with a following segment).[2] The orientation of this work has similarities to the study by Rvachew and Andrews (2002), who divide the processes into three types: the ones depending on the syllabic position (such as cluster reduction and consonant deletion); the ones depending on particular positions in the word (such as prevocalic voicing and post-vocalic voicing); and the ones the exact dependence on what is unknown (substitutions, such as velar fronting, or stopping of fricatives).

The data presented in this work are all part of a more extensive and descriptive project (Llach, 2007), but here we only discuss the results relevant to the comparison of four contexts.

[1] Several studies have suggested that intervocalic consonants can behave like codas. Here we assume that they are onsets,following an onset maximization principle (Jakobson, 1968; Grunwell, 1985).

[2] Post-consonantal onset positions are not included since they are considered equivalent to word-initial onset positions (following Steriade (1997, 1999), who shows the importance of the adjacent segment on the right). The classification used here is also found in Grunwell (1987).

Method

Participants

The study sample consists of 90 typically developing children aged 3-5 years (30 respondents for each age group: 3;1-3;11, 4;2-4:11, 5;1-5:10; 53 girls and 37 boys) from four schools in towns from the province of Girona. The requirements were that their first language was Catalan and that this was the language used in communicating with both their parents. We excluded children with organic and functional problems related to the production and the perception of speech and language.

Stimuli

In order to examine the behavior of Catalan consonant phonemes during the acquisition stage of 3-5 years, a corpus of words and pseudowords was designed. Those were later included in two different tests: a word naming test and a pseudoword repetition test. The production of consonant phonemes was analyzed in absolute initial position of the word, in post-nuclear heterosyllabic position, in intervocalic position, and in word-final position. The phonemes and the contexts under examination had previously been established by Wheeler (1987) and Recasens (1993); these are shown in table 1. This initial corpus was later restricted according to the child's vocabulary, and those items that could have presented some difficulty for the individuals taking part in the test were replaced. After that, the words constituting the final list of this test became the reference for the design of a pseudoword repetition test. As an example, table 2 contains words and pseudowords analized with regard to the sound [s].

Table 1. Sounds analized.

	Bilabial	Labiodental	Alveolar	Prepalatal	Palatal	Velar	Labiovelar
Plosives	[p][b]		[t][d]			[k][g]	
Nasals	[m]		[n]		[ɲ]		
Fricatives		[f]	[s][z]	[ʃ][ʒ]			
Rothics			[ɾ][r]				
Laterals			[l]		[ʎ]		
approximants	[β]		[ð]		[j]	[ɣ]	[w]

Table 2. Sample of words and pseudowords corresponding to the sound [s].

Sounds	Word-initial	Intervocalic	Word-final	Heterosyllabic coda
[s] Words	[ˈsɔl] 'sun' [ˈserp]'snake' [ˈsukɾə] 'sugar' [subməˈɾi] 'submarine' [suˌˈdat] 'soldier'	[ˈtasə]'cup' [ˈbasə]'bond'	[ˈbɾas] 'arm' [ˈninəs] 'dolls' [ˈgləβus] 'balloon' [ˈkalsəs] 'panties'	[pisˈtələ] 'gun' [əsˈpazə] 'sword' [əsˈkombɾə] 'broom'
[s] Pseudowords	[ˈseʎəs] [ˈsurðə] [sərˈtuʎ] [ˈsirkə] [susˈpanə]	[ˈtusə] [ˈtisu]	[ˈseʎəs] [ˈkɾatus] [ˈmalsəs]	[ˈʒustu] [susˈpanə] [ˈtuskə]

Test administration

The first task was a word elicitation test, and used the sentence completion method based on pictures displayed on a laptop. According to Gierut (2008), an important advantage of elicitation tasks is that the target productions can be controlled since each sound can be evoked in all possible word positions in a fixed number of opportunities. The test administrator started the sentence. The word under analysis was the last one in the sentence, and was the one the informant had to pronounce. This prevented unwanted sound coarticulations from words preceding or following the target item. The second test consisted of the immediate repetition of pseudowords pronounced by the test administrator.

The recording was carried out in small school rooms. The rooms contained various materials, such as books and boxes, with a view to reducing extraneous noise. Recordings were directly made in digital format on a laptop HP Pentium IV with a Creative external sound card and a unidirectional microphone Extigy Shure 515SD. The software used to obtain the data was the Creative Sound Studio application. The sampling frequency was 22 kHz, with a 16-bit resolution.

Procedure

After recording, data from four (independent) transcriptions were analyzed by two transcribers. The first listening was an approach to the recording. On the second one, the errors were written down on a template. The third listening was done individually in order to revise the transcriptions. Between the third and the fourth listenings, the transcriptions that did not match up on the two transcribers were detected, and an agreement was reached by common consent (Shriberg, Kwiatkowski & Hoffman, 1984). Those were finally revised on the fourth listening.

Once the errors related to the segments under examination were logged, they were codified into different variables (which can be found in the appendix section). These variables are called result-variables, and allow us to observe the results at various levels of detail and according to different classification criteria. Those variables are the following:

(1) Variable r1. This is the most generic variable. It separates correctly pronounced cases from those containing phonetic and phonological errors. It includes all the segments analyzed (22,932 segments).

(2) Variable r2 groups the 2,482 errors detected according to the properties involved in the error: voicing, manner of articulation and place of articulation of the segments (for example, processes affecting position, processes affecting voicing or processes affecting manner) in a way similar to that in Dyson and Amayreh (2000). The analysis focuses on the errors where a change of one, two or three of these properties is observed. Errors affecting the entire segment (905 errors) or the entire syllable are not included.

Example of error involving the **place of articulation**:

ʃ→s [ˈ**s**aj] instead of [ˈ**ʃ**aj] 'lamb'

(3) Variable r3 groups the cases by the type of error affecting the segment (substitution, assimilation, deletion, metathesis and epenthesis). It is based on 3,387 errors detected out of the 22,932 segments analyzed.

Example of error involving **deletion** in pseudowords:

k→∅ [uˈɾim] instead of [**k**uˈɾim]

(4) Variable r4 groups the information provided by r2 and r3 (for example, processes involving substitution (r2) in the place of articulation (r3)). It is based on 3,387 errors detected out of the 22,932 segments studied.

Example of error involving **substitution** and **manner of articulation**:

r→l ['**l**ɔzə] instead of ['**r**ɔzə] 'rose'

Analysis

The error rates (errors/analyzed cases) have been calculated for each informant and for each of the four variables in the four contextual positions (word-initial, word-final, intervocalic, and post-nuclear heterosyllabic position V<u>C</u>.C).Those four categories coincide with the four contexts used in Grunwell (1987) and adopted by Davis (1998) for pathological patterns.

When the error rates in the four variables were obtained, the Kolmogorov-Smirnov normality test was applied with a result of $p < .001$ for the four variables. Once we saw that the rates did not follow a normal distribution, we proceeded to use the Kruskal-Wallis test so we could determine whether or not significant differences were given among the four positions in the values of the variables under observation. After that, we applied the Games-Howell test for post-hoc multiple comparisons to see which groups differed from the rest. In all the tests we have assumed a level of significance at $p=.05$.

Results

The results are presented in the form of tables. For each variable, the first table contains the total number of errors that occurred in each word-context, the mean error rates of the total number of cases examined, and the p-value obtained from applying the Kruskal-Wallis test. The second table shows the p-values obtained in the Games-Howell test for post-hoc multiple comparisons.

Table 3. r1. Number of errors and error rates/cases analyzed and p-value according to the four contexts

Context	Total Errors	Mean rate
Initial-word position (onset)	1273	.13073
Intervocalic position (onset)	368	.18383
Final-word position (coda)	538	.11369
Post-nuclear heterosyllabic position (coda)	1208	.18696
(p-value Kruskal-Wallis = 0.009; chi-square 11.450, 3df)		

Table 4. r1. p-value from the Games-Howell test for post-hoc multiple comparisons

	p-value
Initial-word position (onset) vs. final-word position (coda)	.260
Initial-word position (onset) vs. post-nuclear heterosyllabic position (coda)	.004
Initial-word position (onset) vs. intervocalic position (onset)	.026
Final-word position (coda) vs. post-nuclear heterosyllabic position (coda)	<.001
Final-word position (coda) vs. intervocalic position (onset)	.001
Post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset)	.999

As we can see from table 3 above, the r1 variable, which separates the errors from the correct pronunciations, shows a different behavior depending on the context. When the four contextual positions are taken into account, two positions show the highest rates. These are the post-nuclear heterosyllabic position (coda) and the intervocalic position (onset). The lowest rates belong to the word-initial position (onset) and word-final position (coda), which is the one with the lowest error rates. In table 4, we can observe that there are no significant differences between initial-word position (onset) and final-word position (coda), which are the two positions with the lowest rates; and there are no significant differences between post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset) either, which are the positions with the highest rates.

Table 5. r2. Errors, error rates/cases and p-value for the four contexts.

Properties affected by the error	p-value Kruskal-Wallis	Context							
		Onset				Coda			
		Initial		Intervocalic		Post-nuc. Hetero		Final	
		Total errors	Mean rate	Total errors	Mean rate	Total errors	Mean rate	Total errors	Mean rate
Voicing	p-value <.001 chi-square 138.405, 3df	107	.01098	120	.05994	0	0	0	0
Place	p-value = .003 chi-square 134.830, 3df	177	.01817	15	.00749	184	.02847	94	.01986
Manner	p-value <.001 chi-square 207.527, 3df	363	.03728	34	.01698	309	.04782	277	.05853
Voicing+place	p-value <.001 chi-square 22.923, 3df	13	.00133	7	.00349	0	0	0	0
Voicing+manner	p-value <.001 chi-square 53.295, 3df	20	.00205	1	.00049	0	0	0	0
Place+manner	p-value <.001 chi-square 160.403, 3df	178	.01828	145	.07242	164	.02538	58	.01225
Voicing+place+manner	p-value <.001 chi-square 66.496, 3df	15	.00154	1	.00049	0	0	0	0

Table 6. r2: p-value from the Games-Howell test for post-hoc multiple comparisons.

Comparisons r2	Voicing	Place	Manner	Voicing+ place	Voicing+ manner	Place+ manner	Voicing+ place+ manner
Initial-word position (onset) vs. final-word position (coda)	<.001	.950	<.001	.006	<.001	<.001	<.001
Initial-word position (onset) vs. post-nuclear heterosyllabic position (coda)	<.001	<.001	<.001	.006	<.001	<.001	<.001
Initial-word position (onset) vs. intervocalic position (onset)	<.001	.004	<.001	.828	.07	<.001	.313
Final-word position (coda) vs. post-nuclear heterosyllabic position (coda)	N/A	<.001	<.001	N/A	N/A	.002	N/A
Final-word position (coda) vs. intervocalic position (onset)	<.001	.003	<.001	.526	.751	<.001	<.001
Post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset)	<.001	.017	<.001	.526	.751	<.001	.750

As it can be observed from table 5 above, the r2 variable, which tells us about the properties of the segments affected by the errors, also shows a different behavior according to the context. As far as voicing is concerned, in Catalan there are processes of neutralization of the contrast of voicing in the final position and in the post-nuclear

heterosyllabic position. Because of this, we have not considered these automatic processes as acquisition processes in two codas. These are automatic procedures that prevent error processes from happening in the opposite direction (for instance, voicing at the end of the word). If the tests are considered, significant differences are given in all properties in the four positions. When the rates of four contextual positions are taken into account (table 5), we can see that the errors affecting voicing (excluding the two codas) are concentrated in the intervocalic position; the errors of place, in the post-nuclear heterosyllabic position; the errors of manner of articulation in three contexts, except for the intervocalic one; the errors involving both place and manner of articulation are concentrated in the intervocalic position.

With regard to the multiple comparisons, the p-values in table 6 show that significant differences are given in most of the combinations, except for the following cases:

i) For the comparison between initial-word position (onset) vs. final-word position (coda), there are no significant differences in the place of articulation (p=.950).

ii) For the comparison between initial-word position (onset) vs. post-nuclear heterosyllabic position (coda), there are significant differences in all the properties.

iii) For the comparison between initial-word position (onset) vs. intervocalic position (onset), there are no significant differences in voicing+place (p=.828), voicing+manner (p=.07), and voicing + place + manner (p=.313).

iiii) For the comparison between final-word position (coda) vs. post-nuclear heterosyllabic position (coda), there are significant differences in all the properties.

iiiii) For the comparison between final-word position (coda) vs. intervocalic position (onset), there are no significant differences between voicing+place (p=.526), and voicing+manner (p=.751).

iiiiii) For the comparison between post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset), there are no significant differences between voicing+place (p=.526), voicing+manner (p=.751), and voicing+place+manner (p=0.750).

Table 7. r3. Errors, error rates/cases, and p-value for the four contexts.

Type of error	p-value Kruskal-Wallis	Context							
		Onset				Coda			
		Initial		Intervocalic		Post-nuc. hetero		Final	
		Total errors	Mean rate	Total errors	Mean rate	Total errors	Mean Rate	Total errors	Mean rate
Substitution	p-value <.001 chi-square 26.935, 3df	797	.08185	280	.13986	366	.05664	427	.09023
Assimilation	p-value <.001 chi-square 214.282, 3df	76	.00780	43	.02147	491	.07599	2	.00042
Deletion	p-value <.001 chi-square 94.846, 3df	103	.01057	5	.00249	307	.04751	23	.00486
Epenthesis	p-value <.001 chi-square 167.871, 3df	240	.02464	10	.00499	3	.00046	81	.01711
Metathesis	p-value <.001 chi-square 18.558, 3df	16	.00164	17	.00849	28	.00433	4	.00084

Table 8. r3: p-value from the Games-Howell test for post-hoc multiple comparisons

Comparisons r3	Substitution	Assimilation	Deletion	Epenthesis	Metathesis
Initial-word position (onset) vs. final-word position (coda)	.642	<.001	.048	.003	.549
Initial-word position (onset) vs. post-nuclear heterosyllabic position (coda)	.001	<.001	.001	<.001	.008
Initial-word position (onset) vs. intervocalic position (onset)	.002	<.001	.002	<.001	.045
Final-word position (coda) vs. post-nuclear heterosyllabic position (coda)	<.001	<.001	<.001	<.001	<.001
Final-word position (coda) vs. intervocalic position (onset)	.012	<.001	.380	<.001	.020
Post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset)	<.001	<.001	<.001	.043	.382

We can see from table 7 above that the r3 variable, which tells us about the type of error in the process that has occurred, also shows a different behavior. If the tests are considered, significant differences occur in all the properties in the four positions. When the rates of the four contexts of study are taken into account (table 7), it can be observed that the substitutions in the onset position have to be especially attributed to the intervocalic position, followed by the final and initial positions, which have very similar rates. The position with fewer substitutions is the post-nuclearheterosyllabic one. As far as the assimilations are concerned, they are found in the post-nuclear heterosyllabic position (coda) and, to a lesser extent, in the intervocalic position (onset). Regarding the deletions, they can be particularly observed in the post-nuclearheterosyllabic position

(coda) and, to a lesser degree, in initial position (onset). Finally, the epentheses are especially found in initial position (onset) and in final position (coda).

On the multiple comparisons, the p-values in table 8 indicate that significant differences occur in most of the combinations, except for the following cases:

i) For the comparison between initial-word position (onset) vs. final-word position (coda), there are no significant differences in processes of substitution (p=.642) and metathesis (p=.549).

ii) For the comparison between initial-word position (onset) vs. post-nuclear heterosyllabic position (coda), there are significant differences in all the processes.

iii) For the comparison between initial-word position (onset) vs. intervocalic position (onset), there are significant differences in all the processes.

iiii) For the comparison between final-word position (coda) vs. post-nuclear heterosyllabic position (coda), there are significant differences in all the processes.

iiiii) For the comparison between final-word position (coda) vs. intervocalic position (onset), there are no significant differences in processes of deletion (p=.380).

iiiiii) For the comparison between post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset), there are no significant differences in the processes of metathesis (p=.382).

Table 9. r4: Errors, error rates/cases, and p-value for the four contexts.

r4 Type of error	p-value Kruskal-Wallis	Context							
		Onset				Coda			
		Initial		Intervocalic		Post-nuc. hetero		Final	
		total errors	mean rate	total errors	mean rate	total errors	mean rate	total errors	mean rate
Manner substitution	P <.001	361	.03707	31	.01548	173	.02677	277	.05853
Place substitution	p <.001	150	.01540	14	.00699	102	.01578	93	.01965
Voicing substitution	p <.001	106	.01088	120	.05994	0	0	0	0
Place+manner substitution	p <.001	147	.01509	106	.05294	66	.01021	15	.00316
Voicing+place+manner substitution	p <.001	11	.00112	1	.00049	13	.00201	42	.00887
Manner assimilation	p <.001	2	.00020	3	.00149	118	.01826	0	0
Place assimilation	p <.001	27	.00277	1	.00049	75	.01160	1	.00021
Place+manner assimilation	p <.001	31	.00318	39	.01948	54	.00835	0	0
Deletion	p <.001	103	.01057	5	.00249	307	.04751	23	.00486
Consonant epenthesis before target segment	p <.001	134	.01376	7	.00349	1	.00015	7	.00147
Consonant epenthesis after target segment	p <.001	23	.00236	0	0	1	.00015	64	.01352
Consonant epenthesis before target segment and place+manner substitution in target segment	(in one position)	40	0.00410	0	0	0	0	0	0

It includes the type of errors that recorded percentages above 1% of the total

Table 10. r.4. p-value from the Games-Howell test for post-hoc multiple comparisons.

	manner substitution	place substitution	voicing substitution *	place+manner substitution	voicing+place+manner substitution	manner assimilation	place assimilation	place+manner assimilation	deletion	consonant epenthesis before target segment	consonant epenthesis after target segment	consonant epenthesis bef. target
Initial-word position (onset) vs. final-word position (coda)	<.001	.435		<.001	<.001	-	<.001	-	.048	<.001	<.001	
Initial-word position (onset) vs. post-nuclear heterosyllabic position (coda)	<.001	.999		.225	.434	-	<.001	.011	.001	<.001	.001	
Initial-word position (onset) vs. intervocalic position (onset)	<.001	.023		<.001	.703	.29	<.001	<.001	.002	<.001	-	
Final-word position (coda) vs. post-nuclear heterosyllabic position (coda)	<.001	.736		<.001	<.001	-	<.001	-	<.001	.166	<.001	
Final-word position (coda) vs. intervocalic position (onset)	<.001	.001		<.001	<.001	-	.951		.380	.578	-	
Post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset)	<.001	.102		<.001	.156	<.01	<.001	<.001	<.001	.110	-	

(*) indicates that the tests could not be carried out because the error process only occurred in one or two positions. (–) indicates that the post-hoc tests could not be carried out because the error process only occurred in three positions.

We can observe from table 9 above that the r4 variable, which tells us about the property affected by the error and about the type of error in the process that has occurred, also shows a different behavior in each context. If the tests are considered, significant differences are given in all the properties in the four positions. When the rates of the four contexts of study are examined (table 9), it is seen that the substitutions in manner are found both in final position (coda) and in initial position (onset), although

the rate is slightly lower. With regard to the substitutions in place of articulation, they are given in all positions (two codas and one onset), except for the intervocalic position. On the other hand, the substitutions in voicing and the substitutions in manner and place at the same time are concentrated in the intervocalic position. The post-nuclear heterosyllabic position is the position where more assimilations of place, assimilations of manner and deletions are observed. Assimilations of manner and place at the same time are especially given in intervocalic position. Regarding the epentheses, the two types examined (epenthesis after the target segment, and epenthesis before the target segment) here are produced one in initial position (epenthesis before) and one in final position (epenthesis after).

Regarding the multiple comparisons, the p-values in table 10 show that significant differences occur in most of the combinations, except for the following cases:

i) For the comparison between initial-word position (onset) vs. final-word position (coda), there are no significant differences in the processes of place substitution (p=.435).

ii) For the comparison between initial-word position (onset) vs. post-nuclear heterosyllabic position (coda), there are no significant differences between the processes of place substitution (p=.999), place+manner substitution (p=.225), and voicing+place+manner substitution (p=.434).

iii) For the comparison between initial-word position (onset) vs.intervocalic position (onset), there are no significant differences in processes of voicing + place + manner sustitution (p=.703) and in manner assimilation (p=.298).

iiii) For the comparison between final-word position (coda) vs. post-nuclear heterosyllabic position (coda), there are no significant differences in processes of place substitution (p=.736) and consonant epenthesis before target segment (p=.166).

iiiii) For the comparison between final-word position (coda) vs. intervocalic position (onset), there are no significant differences in processes of place assimilation (p=.951), deletion (p=.380) and consonant epenthesis before target segment (p=.578).

iiiiii) For the comparison between post-nuclear heterosyllabic position (coda) vs. intervocalic position (onset), there are no significant differences in the processes of place substitution (p=.102), voicing+place+manner substitution (p=.156), and consonant epenthesis before target segment (p=.110).

Discussion

Our data suggest that the four contexts show different typology of errors. In the case of r1, it is found that the medial coda has a high error rate, but that, in the final coda, the error rate is much lower, even lower than in the word-initial position (a position not prone to errors in adult systems). In the case of onsets, there is also a factor to consider: the error rate is low in absolute initial position, but, in contrast, the intervocalic position presents a high index, like the medial coda, in a way similar to that in Davis (1998). Therefore, we can see here that the initial and word-final contexts undergo fewer errors than the medial coda and intervocalic contexts. So the consideration of four contexts does offer a great explanatory tool when trying to explain the presence of errors, and it also modulates the strong tendency to errors and phonological processes in the coda position. This result demonstrates the appropriateness of taking into account the two perspectives stated in the introduction at the same time, i.e., the more prosodic approach based on the syllabic position (Îto, 1986; Golsmith, 1990) and the views in which the phonetic context plays a more significant role, like Steriade (1995, 1977, 1999), as well as Ohala (1990), Browman and Golsdtein (1992) or Kirchner (2004), among others.

In the case of r2, the most evident distinction is the behavior of the intervocalic position, which displays a different kind of error from the other three positions (word-initial onset and two types of coda). The distinct behavior of the intervocalic position in relation to onsets and codas is described in Kehoe and Lleó (2002) and Bernhard and Stemberger (2002). In our study, this position concentrates most of the problems concerning voicing and place-manner at the same time. The other three positions undergo errors that affect the property of manner (especially the final position, followed by the post-nuclear heterosyllabic and the initial positions) and the property of place (particularly the post-nuclear position, followed by the final and initial positions with practically the same rate).

The r3 variable also shows that the context in the word seems to be a key factor in explaining these error processes, because epenthesis occurs in two contexts belonging to two different syllabic positions (word-initial, which is onset, and word-final, which is coda), and assimilation is observed in two positions (intervocalic, which is onset, and medial coda). This indicates that there is not a direct relationship between processes and syllable position, but between processes and the margins of the word. The data rather show that epenthesis is produced in free segment contexts (the left margin of the initial

context and the right margin of word final; for example, [ˈdɾɔzə] instead of [ˈrɔzə] 'rose'), whereas assimilation occurs in word internal contexts (for example, [ˈebbə] instead of [ˈerβə] 'grass'). There is a certain logic in seeing that the influence of the segments of a word on other segments is stronger coming into the word than into the margins.

Epenthesis mainly takes place in word-initial position (onset) and word-final position (coda). This coincidence in the two extremes of the word supports the idea of epenthesis as a strategy of strengthening, as already noted in Côté (2000). The optimum conditions of margins allow the licensing of segments, according to Côté (2000).

Substitutions occur in all four contexts, although the higher rate corresponds to the intervocalic context. This result would not be expected since this context is considered optimal from a perceptual and articulatory viewpoint (Gick, Campbell, Oh and Tamburri-Watt, 2006). However, our data show a strong tendency to make use of substitutions in this position. Bernhart and Stemberger (1998) provide a possible explanation for that. They claim that although intervocalic consonants are onsets, they are weaker than word-initial onsets, hence, more prone to undergo various kinds of processes. This idea allows us to take substitution as a creative process related to the learner's language reduced inventory of segments. Following this argument, and as pointed out above, we believe that substitution changes unavailable segments into highly available segments. Then substitution will allow the display of system properties under construction and the principles involved. In this sense, we take substitution to be more creative than assimilation and deletion. Thus, bearing all these factors in mind, we would like to suggest that intervocalic position is a context which favors preferred segments of the sound system that is being built.

Contrary to theories that consider the intervocalic position as the optimum one from a production and perception standpoint, Kirchner (2004) takes it as one of the positions most likely to undergo lenition. In this case, the fact that two vowels are the adjacent segments increases the displacement that the articulators must make to achieve the production of the target consonant. This situation is extreme when both the preceding and the following vowel are low back vowels. Thus, the tendency to minimise articulatory effort is also evident in this context. Our data here are compatible with the idea that intervocalic position is a position that allows the establishment of a reduced system, subject to the forces exerted by the articulatory and perceptual systems.

The rates of r4 distribute the errors into the four contexts. The results obtained in r4 are consistent with the ideas already outlined in relation to the r3 variable: initial and final contexts present processes of strengthening, whereas the context of medial coda undergoes processes of weakening. Intervocalic position involves some processes that are clearly differentiated from those found in absolute initial position. Thus, in this variable, as in r2 and r3, we see that there are more similarities between word-initial and word-final positions, on the one hand, and medial coda and intervocalic positions, on the other, an aspect that is not explained by syllable position. This idea supports Steriade's proposal (1999), which separates the behavior of the margins from the behavior outside the margins.

On the other hand, the multiple comparisons among the rates of the syllabic positions show that in most cases significant differences occur in the two positions being compared. In the contexts where no significant differences are given, most of the differences occur between two positions, one of them belonging to the syllable onset and the other to the syllable coda. This fact shows the importance of taking into account the context where the process occurs, apart from the syllable position. And this is so since the data indicate some parallelisms between positions that are usually considered different, such as initial word position or final word position; or some differences occur between two types of coda or between two types of onset.

Conclusions

In this paper we have seen that, in the errors examined, there are clear strategies associated with syllable positions, but these strategies are different depending on the context. For example, the coda position seems to favor deletion and assimilatory processes. In Llach (2007), though, we saw that the eventual process will be of one type or another depending on the segment: a plosive may undergo a process of assimilation, whereas a rhotic will most probably suffer a deletion. At the same time, the nature of the following segment will condition the process undergone. All these facts lead us to say that, in the phonological analysis of our samples, the position of the segments within the word has to be included, in line with Rvachew and Andrews (2002).

A comparison between the results of this study and those of some works on the acquisition of the sounds in Catalan, like Bosch (1987), Secall and Crespí (1987), De Ribot (1992) or Aguilar and Serra (2004), cannot be established since a different

classification of processes is used in each case. In these latter, the classification by Ingram (1976) is applied. Thus, the results presented here, for example, classify various types of assimilations into generic categories (like the assimilation in the variable r3), whereas in other studies those appear in different categories like frontalization or plosivization.

In summary, considering the results of rates, we claim that, in order to explain the processes that take place during the acquisition process, it is necessary to bear in mind the syllable position and other contextual positions in the word. We have shown the importance of the properties of the adjacent segments, and the more clarified paradigm that emerges when the syllable position is broken down into several word-context positions.

An interesting explanation would be to suppose an influence from various factors at various stages. Thus, the inherent properties of the segments, followed by adjacent context, would be a priority when designing the systems to choose what combinations could form onsets and codas. Later, the structures formed (e.g. syllable) could have their own influence. In fact, these are ideas already mentioned in Llach (1998) and can also be found in Blevins (2003) and Wheeler (2005).

Besides the influence of syllable position and context, other factors must be analyzed in future works, such as the comparison of the errors in the two tests administered (elicitation and repetition), or the type of acoustic cues and segments affected in the processes of error.

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Appendix

Categories of the four variables analyzed and examples

Variable r1

sound pronounced correctly

presence of phonological or phonetic error

Variable r2

error affecting voicing
z→s [ˈrɔsə]instead of [ˈrɔzə]

error affecting place of articulation
ʃ→s [ˈsaj]instead of [ˈʃaj]

error affecting manner of articulation
b→m [fumˈbɔl]instead of [fubˈbɔl]

error affecting voicing and place of articulation
ʒ→s [sərˈsɛj]instead of [ʒərˈsɛj]

error affecting voicing and manner of articulation
p→m [miˈɛt]instead of [piˈɛt]

error affecting place and manner of articulation
d→l [ˈlits]instead of [ˈdits]
r→d [ˈdɔzə]instead of [ˈrɔzə]

error affecting voicing, place and manner of articulation
r→k [ˈpak]instead of [ˈpar]
t→n [ˈminsə]instead of [ˈmitsə]

Variable r3

substitution
ʃ→s [ˈsaj]instead of [ˈʃaj]

assimilation
k→t [trətˈto]instead of [trəkˈto]

deletion
k→∅ [uˈɾim]instead of [kuˈɾim]

epenthesis
t→tɾ [ˈtɾuskə]instead of [ˈtuskə]
ʃ→tʃ [ˈpantʃə]instead of [ˈpaɲ̲ʃə]

metathesis
b↔m [sumbəˈɾi]instead of [subməˈɾi]
←ɾ→ [diˈɣɾo]instead of [dɾiˈɣo]

Variable r4 (includes all categories of the variable)

substitution of voicing
z→s [ˈrə**s**ə]instead of [ˈrə**z**ə]

assimilation of voicing
d→t [ˈ**t**its]instead of [ˈ**d**its]

substitution of place of articulation
d→g [**g**əl̪ˈto]instead of [**d**əl̪ˈto]

assimilation of place of articulation
k→t [ˈfra**t**tə]instead of [ˈfɾa**k**tə]

substitution of manner of articulation
r→l [ˈ**l**ɔzə]instead of [ˈ**r**ɔzə]

assimilation of manner of articulation
r→l [tə**l**ˈla]instead of [tə**r**ˈla]

substitution of voicing and place of articulation
z→θ [ˈrɔ**θ**ə]instead of [ˈrɔ**z**ə]

assimilation of voicing and place of articulation
ʒ→s [**s**ərˈsɛj]instead of [**ʒ**ərˈsɛj]

substitution of voicing and manner of articulation
p→m [**m**iˈɛt]instead of [**p**iˈɛt]

assimilation of voicing and manner of articulation
m→p [ˈ**p**itsə]instead of [ˈ**m**itsə]

substitution of place and manner of articulation
ð→ɾ [gəˈʎɛ**ɾ**ə]instead of [gəˈʎɛ**ð**ə]
ʒ→j [ˈ**j**ɛru]instead of [ˈ**ʒ**ɛru]

assimilation of place and manner of articulation
ð→ɾ [kəˈ**ɾ**iɾə]instead of [kəˈ**ð**iɾə]

substitution of voicing, place and manner of articulation
r→t [ˈma**t**]instead of [ˈma**r**]

assimilation of voicing, place and manner of articulation
b→f [**f**uˈfan̪də]instead of [**b**uˈfan̪də]

elision
k→∅ [tɾəˈto]instead of [tɾəkˈto]

vowel epenthesis (see cases 33-36)

consonant epenthesis (see cases 21-34)

metathesis by movement of a segment (with or without elisions)
←ɾ→ without elision [diˈɣ**ɾ**o] instead of [d**ɾ**iˈɣo]
←s→ with elision [fə**s**ˈtamə] instead of [[fən̪ˈta**z**mə]]

metathesis by exchange of a segment
b↔m [su**mb**əˈɾi]instead of [su**bm**əˈɾi]

substitution by an unidentified segment

substitution of voicing of the target segment and subsequent consonant epenthesis
b→pɾ [**pɾ**əlˈko]instead of [**b**əlˈko]

substitution of place of articulation of the target segment and subsequent consonant epenthesis
p→tɾ [ˈ**tɾ**ilkə]instead of [ˈ**p**ilkə]

substitution of manner of articulation of the target segment and subsequent consonant epenthesis
r→lt [ˈkɔ**lt**]instead of [ˈkɔ**r**]

substitution of place and manner of articulation of the target segment and subsequent consonant epenthesis
r→ðt [ˈpa**ðt**]instead of [ˈpa**r**]

no change in the target segment and subsequent consonant epenthesis

r→rt [ˈkɔ**rt**]instead of [ˈkɔ**r**]

previous consonant epenthesis and no change in the target segment
ɾ→ðɾ [əˈ**ðɾ**aɲə]instead of [əˈ**ɾ**aɲə]

previous consonant epenthesis and substitution of voicing of the target segment
ʒ→tʃ [**tʃ**ərˈsɛj] en lugar de [**ʒ**ərˈsɛj]

previous consonant epenthesis and substitution of place of articulation of the target segment
ʃ→ts [ˈ**ts**aj]instead of [ˈ**ʃ**aj]

previous consonant epenthesis and assimilation of the place of articulation of the target segment
ʒ→dz [**dz**ərˈsɛj]instead of [**ʒ**ərˈsɛj]

previous consonant epenthesis and substitution of manner of articulation of the target segment
r→dɾ [ˈ**dɾ**ɔzə]instead of [ˈ**r**ɔzə]

previous consonant epenthesis and substitution of place and manner of articulation of the target segment
ʎ→dʒ [ˈ**dʒ**am]instead of [ˈ**ʎ**am]

previous consonant epenthesis and substitution of voicing, place and manner of articulation of the target segment
ʎ→tʃ [ˈ**tʃ**am]instead of [ˈ**ʎ**am]

consonant and vowel epenthesis in the previous position and substitution of manner of articulation of the target segment
r→dəɾ [**də**ˈ**ɾ**izə]instead of [ˈ**r**izə]

substitution of place of articulation of the target segment and subsequent vowel epenthesis
ɲ→ne [ˈma**ne**]instead of [ˈma**ɲ**]

vowel epenthesis by fission of segments
ɲ→jn [ˈma**jn**]instead of [ˈma**ɲ**]

vowel epenthesis by fission of elements in reverse
ɲ→ni [ˈma**ni**]instead of [ˈma**ɲ**]

substitution of place and manner of articulation of the target segment and metathesis by movement of a following segment
ʒ→dɾ [**dɾ**əˈsɛj]instead of [**ʒ**ərˈsɛj]