MORPHOPHONOLOGICAL COMPLEXITY IN THE ACQUISITION OF EUROPEAN PORTUGUESE: THE CASE OF NOMINAL PLURAL FORMS WITH FINAL NASAL DIPHTHONGS[1]

A. MARGARIDA RAMALHO
AND M. JOÃO FREITAS

Introduction

Several aspects of children's phonological development have been systematically investigated over the last four decades, both from a segmental and a prosodic perspective (see, for different overviews, Menn & Stoel-Gammon, 1995; Vihman, 1996; Bernhardt & Stemberger, 1998; Fikkert, 2005, 2007, among others). In what concerns the mastery of morphological structures in the path of language acquisition, the topic has been frequently inspected from a morphosyntactic point of view (see, among many others, Ingram, 1989 and Guasti, 2002 for different overviews). On the contrary, studies on the interplay of phonology and morphology are less frequent within the field of language acquisition research (see Lleó & Demuth, 1999; Demuth, 2001; Freitas, Miguel & Faria, 2001; Hayes, 2004; Fikkert & Freitas, 2006; Kerkhoff, 2007; Song et al., 2009; Zamuner et al., to appear). The present paper will contribute to the growing body of literature in this field: we will address the phonology/morphology interface in the process of language acquisition by observing the mastery of nominal plural forms with word-final nasal diphthongs in European Portuguese (EP). As we will see below, these are considered to be morphophonological complex structures since they involve branching configurations at the Rhyme level, the processing of nasality, the activation of different phonological processes, which generate allophonic and allomorphic variation, and irregular nominal inflection.

Despite their inherent complexity, nasal diphthongs in nominal plural forms are made of morphophonological structures that are reported to emerge quite early in the Portuguese children's language development path: (i) nasal segments, (ii) Coda fricatives, and (iii) the plural marker assignment in nominal forms. The early acquisition of these grammatical facts contrasts (a) with the frequency of the structure under evaluation in the target system (nasal diphthongs in the nominal paradigm are not frequently attested both in adults' utterances and in the child's lexicon) and (b) with references in the literature on the late acquisition of the focused structure (Sim-Sim, 1998; Castro, 2010).

The central aim of this paper is thus to evaluate the impact of the conflict between (i) the morphophonological complexity[2] of nasal diphthongs in nominal plural forms and (ii) the early acquisition of their phonological constituents in Portuguese children's linguistic development. Furthermore, we will contribute with original empirical data to the debate on the effect of frequency rates and grammar events in language acquisition.

1. On nasal diphthongs in European Portuguese

It is generally assumed that only oral vowels are stored in EP phonological representations; nasal vowels and nasal glides are not part of the segmental phonological inventory of the language and are assumed to result from a nasal autosegment spreading under the Nucleus domain (Mateus & Andrade, 2000).

Nasal diphthongs are rarely attested in the languages of the world (Ladefoged & Maddieson, 1996; Maddieson, 2005). In EP, these structures are present in different word classes (nouns, adjectives, verbs and adverbs). The same output form ([ɐ̃w̃]) emerges as the result of the presence of different morphophonological structures: in verbal forms (*falam* ['falɐ̃w̃] 'they speak'), the nasal diphthong incorporates the theme vowel and the person-number morpheme (a nasal floating autosegment): /fal+a+ra[+nasal]/.[3] In the nominal and the adjectival paradigms, a singular/plural contrast is attested, with the presence of the same diphthong [ɐ̃w̃]in all singular forms and the emergence of three different formats of the diphthong in the plural forms ([ɐ̃w̃ʃ], [õj̃ʃ] and [ɐ̃j̃ʃ]). The homogeneity in the singular form and the variability exhibited in the plural forms is normally assigned to different morphophonological aspects: (a) the phonological properties of the last vowel of the stem (see the contrast with lexically related words in (1))[4]; (b) the properties of the class marker (in both (1a) and (1b), a phonology/morphology interplay is triggered); (c)

the phonological processes related to the spreading of the nasal autosegment:

(1)   Nasal diphthongs in the nominal paradigm

	a. Singular	b. Plural	c. Lexically related words
paradigm 1 *mão* 'hand'	['mẽw̃]	['mẽw̃ʃ]	*manual* [mɐˈnwał] 'manual'
paradigm 2 *limão* 'lemon'	[liˈmẽw̃]	[liˈmõj̃ʃ]	*limonada* [limuˈnadɐ] 'lemonade'
paradigm 3 *pão* 'bread'	['pẽw̃]	['pẽj̃ʃ]	*panificadora* [pɐnifikɐˈdorɐ] 'bread factory'

The lexically related productions in the three columns above illustrate the presence of allomorphy in the target system, which involves the following constituents in nominal and adjectival plural forms in EP:
(i) the *last vowel of the stem*: the vowel /a/ in paradigms 1 (['mẽw̃ʃ]) and 3 (['pẽj̃ʃ]); the vowel /o/ in paradigm 2 ([liˈmõj̃ʃ]);
(ii) the *nasal autosegment*: it may surface as nasality projected within the Nucleus domain (singular and plural forms – see (1a) and (1b)) or as a Coronal [+anterior] nasal segment in the lexically derived words (see the consonant [n] in the examples in (1c));
(iii) the *class marker*: depending on the analyses displayed in the literature, the glide is either the result of gliding of the class marker, triggered by the hiatus sequence /stem vowel+class marker vowel/ (/o/ in paradigm 1 and /e/ or /E/ in paradigms 2 and 3) or the result of glide insertion (the class marker is thus an empty category), following the EP tendency to generate nasal glides at the right edge of word-final nasal vowels (Morales-Front & Holt, 1997; Mateus & Andrade, 2000; Veloso, 2005; Vilallva, 2008, among others).
    The inflectional category *number* in EP contrasts a word-final empty category for singular forms with a word-final /+s/ for plural forms. The plural-formation rule adjoins the plural morpheme /+s/ to the lexical format of the singular word (*pato* /pat+o+Ø / 'duck'*; patos* /pat+o+s/ 'ducks'). In the case of nasal diphthongs in nominal plural forms (['mẽw̃ʃ], [liˈmõj̃ʃ] and ['pẽj̃ʃ]), the Rhyme hosting the sequences [ẽw̃ʃ], [õj̃ʃ] and [ẽj̃ʃ] shows a word-final Coda fricative in the plural form, derived from the plural marker /+s/, underspecified for voice and place of articulation in the lexical representation (Mateus & Andrade, 2000: 70). This fricative is produced as [ʃ], resulting from the activation of a post-lexical Coda rule (Mateus & Andrade, 2000: 37), according to which the underspecified

Coda /s/ becomes Coronal [-anterior] and [-voiced], when no right adjacent segments trigger voice assimilation ([+voiced] consonants trigger [ʒ], as in *as mãos* [ɐʒ'mɐ̃w̃ʃ] 'the hands'; vowels trigger [z], as in *as aves* [ɐz'aviʃ] 'the birds').

Unlike verbs and adverbs, the nominal and the adjectival forms exhibiting nasal diphthongs show allophonic and allomorphic variation, deriving from different underlying morphophonological properties (Morales-Front & Holt, 1997; Mateus & Andrade, 2000; Veloso, 2005; Vilallva, 2008, among others). They may be considered complex structures for the following set of reasons:

(a) from a *segmental perspective*, different phonological processes are attested in the production of nasal diphthongs in nominal plural forms: (i) spreading of a nasal autosegment within the Nucleus domain; (ii) vowel gliding or glide insertion; (iii) segmental specification for place and voice features affecting the plural marker. If we assume that the co-occurrence of different phonological processes in a specific structure is a clue for segmental complexity[5], then we may consider nasal diphthongs in nominal plural forms to be complex structures.

(b) from a *prosodic perspective*, nasal diphthongs in nominal (and adjectival) plural forms involve branching configurations under the Rhyme and the Nucleus domains: (i) the nasal diphthong is represented under a branching Nucleus; (ii) the plural marker /+s/ is hosted in the Coda domain, which implies a branching configuration at the Rhyme level. If we assume that branching syllable constituents are marked structures (Fikkert, 1994), we may then postulate that the mentioned branching structures carry prosodic complexity into the structure under evaluation in this paper.

(c) from a *morphological perspective*, the singular/plural asymmetry attested in paradigms 1, 2 and 3 (only [ɐ̃w̃] in the singular form, [ɐ̃w̃ʃ], [õȷ̃ʃ] and [ɐ̃ȷ̃ʃ] in the plural forms) derives from the nature of the last vowel of the stem and of the class marker. A contrast is also attested in the different formats of the nasal autosegment (see the root and the derived forms in Table 1). We assume in this paper that the allomorphy inherent to these contrasts in the focused irregular plural forms may encode morphological complexity.

As for the frequency of the structure(s) targeted in this paper, it is traditionally assumed that [õȷ̃ʃ] is clearly the most frequent nasal diphthong both in the EP lexicon and the adults' production data, [ɐ̃ȷ̃ʃ] and [ɐ̃w̃ʃ] being much less frequent than the former (Cunha & Cintra, 1984). Quantitative information on types in EP provided by the MorDebe[6] database shows that only 3,7% of the lexical items in this database (6764

over 182046 inflected forms) contains one of the three nasal diphthongs in plural contexts; within this lexical subset, the frequency attested for each of the structures is as follows: 97, 4% for [õĩʃ]; 1,8% for [ɐ̃w̃ʃ]; 0,75% for [ẽĩʃ]. This allows us to order the focused structures as follows, [õĩʃ] being massively more frequent and contrasting with the two other sequences: [õĩʃ] >> [ɐ̃w̃ʃ] >> [ẽĩʃ]. Considering the asymmetry between the type frequency for [õĩʃ] (97%)[7] and [ɐ̃w̃ʃ] (1,8%), and in the absence of token information on these word paradigms in the target system, we will assume that token in the adult system will somehow mirror the asymmetry exhibited for types.

We showed in the present section that, both for phonological and for morphological reasons, nasal diphthongs in nominal plural forms are assumed to be complex structures in EP. This complexity contrasts with the acquisition rate of each of the structures involved in the *nasal diphthong + Coda fricative* sequence, as we will see in the next section: (i) the emergence of Coda fricatives; (ii) the emergence of nasal diphthongs; (iii) the emergence of plural assignment in the nominal paradigm.

2. On the acquisition of European Portuguese phonology: Facts and predictions

Studies on the acquisition of nasal diphthongs in EP, both from a phonological and a morphological perspective, are scarce (Freitas, Gonçalves & Gonçalves, 2009; Ramalho & Freitas, 2009; Ramalho, 2010; Castro, 2010). It is normally assumed that these structures are mastered at later stages of language acquisition (Sim-Sim, 1998). On the contrary, both Coda fricatives and nasal diphthongs are available at early stages in Portuguese children's phonological development. As for other languages, number features in the nominal paradigm emerge at early stages in the acquisition of EP: the plural morpheme is produced as soon as Coda fricatives are available in the child's system, as we will see below.

Fricatives are the first segments to emerge in Coda position in Portuguese children's production data; its acquisition is not categorical (Freitas, 1997). According to the effect of the phonological facts *word primary stress* and *position in the word* reported in the literature on language processing and on language acquisition (stress promotes acquisition; the word-final position is a non-prominent one), our prediction in previous work (Freitas & Miguel, 1998; Freitas, Miguel & Faria, 2001) was that the plural marker would be the last Coda fricative to emerge in Portuguese children's data, since it is normally produced in a non-prominent context: an unstressed syllable in word-final position ['patuʃ].

However, contrary to expectations, the results showed that word-final Coda fricatives, especially the ones that function as plural markers in the grammatical system, are the first ones to emerge in production:

(2) Acquisition of Coda fricatives: data from Inês (Freitas, Miguel & Faria, 2001)

Context	Example		
stressed/word-medial - *lexical*	*festa 'party'*	['tɛtɐ]	1;9
√ **stressed/word-final - *morphological***	*meus 'mine'*	['mewʃ]	1;9
stressed/word-final - *lexical*	*nariz 'nose'*	[ɐ'giɐ]	1;9
unstressed/word-medial - *lexical*	*buscar 'to get'*	[βu'ka]	1;10
√ **Unstressed/word-final - *morphological***	*bolos 'cakes'*	['boloʃ]	1;9
unstressed/word-final - *lexical*	*lápis 'pencil'*	['patu]	1;9

The hypothesis proposed on the basis of the empirical data was that the interplay of phonology and morphology was bootstrapping the early acquisition of unstressed word-final Coda fricatives in the Portuguese children observed (Freitas & Miguel, 1998; Freitas, Miguel & Faria, 2001). The order of acquisition of Coda fricatives attested in the study was as follows:

(3) Order of acquisition for Coda fricatives (Freitas, Miguel & Faria, 2001)

1. Word-final unstressed and stressed syllables (lexical and morpho-logical Codas);
2. Word-medial stressed syllables (lexical Codas);
3. Word-medial unstressed syllables (lexical Codas).

As for the diphthong [ɐ̃w̃], the research
showed that the structure emerges quite early in the production of nouns by Portuguese children (Freitas, Gonçalves & Gonçalves, 2010). In Table 4, we register the first data collection session where values above 50% were attested in the study; after the age mentioned in (4), a consistent behavior with rates above this value was observed:

(4) Early production of nasal diphthongs (Freitas, Gonçalves & Gonçalves, 2010)

Children	Rates	Age
Marta	73%	1;04
Inês	88%	1;08
Luís	80%	1;09
Raquel	100%	1;10
João	100%	1;11

The same output form [ẽw̃] is present in different word paradigms in EP (verbs, adverbs, nouns and adjectives). The research question formulated in the focused study was as follows: Is one single output form - [ẽw̃] - acquired similarly in all word paradigms? The results showed a word class effect; the diphthong is not similarly acquired in the different paradigms: (i) it first emerges and becomes stable in nouns; (ii) the rate of accuracy is higher for nouns and verbs than for adverbs; (iii) a mirror behavior is attested for nouns and adverbs: nouns show values mainly above 50%; adverbs show values mainly below 50%.

In what concerns the word class which is the focus of the present paper (nouns), the data described above allow us to predict the early acquisition of nasal diphthongs.

However, if we inspect the Portuguese children's spontaneous data for nasal diphthongs in nominal plural forms, very few cases are attested. In a database with 18656 utterances produced by 7 Portuguese children aged 0;10 to 3;7 (Freitas, 1997), only 6 instances of target [ẽw̃ʃ] (3 of them produced target-like), 28 instances of target [õj̃ʃ] (17 of them target-like) and 2 instances of [ẽj̃ʃ] (1 of them target-like) were attested (Freitas, Gonçalves & Gonçalves, 2010). The spontaneous data showed that this structure is not productive in the child's system in the first 3/4 years of life. Based on this sample, one may consider to be facing marked structures in the system (see the segmental, prosodic and morphological complexity mentioned in the previous section in this paper), which contrasts with the early emergence of the phonological structures involved: nasal diphthongs and Coda fricatives.

From the 36 tokens reported above (6 tokens for target [ẽw̃ʃ]; 28 tokens for target [õj̃ʃ]; 2 tokens for target [ẽj̃ʃ]), most are instances of [õj̃ʃ]. The frequency attested in production by the Portuguese children observed (77% of target [õj̃ʃ]; 17% of target [ẽw̃ʃ]; 6% of target [ẽj̃ʃ]) matches the ordering of these structures in the target system (see section 1): 97,4% for [õj̃ʃ]; 1,8% for [ẽw̃ʃ]; 0,75% for [ẽj̃ʃ]. Notice, however, that the frequency

for [ẽw̃ʃ] is clearly higher in the children's system: 17% of target [ẽw̃ʃ], against the 1,8% forms with [ẽw̃ʃ] reported for the target system (*MorDebe* database).

As mentioned in the introduction, the general goal of this research is to study the impact of the conflict between the morphophonological complexity associated to the nasal diphthong in nominal plural forms (see the allophonic/allomorphic variants characterized in section 1) and the early acquisition of its phonological constituents in Portuguese children's phonological development. Plus, we will contribute empirical evidence for the debate on grammar and frequency effects in language acquisition (see Bybee & Hopper, 2001; Vigário, Freitas & Frota, 2006; Gulzow & Gagarina, 2007, among many others). Let us consider the following facts: (i) plural forms in the nominal paradigm involve the adjunction of the morpheme /+s/ to the singular form (*pato/patos* 'duck/ducks'); (ii) the most frequent nasal diphthong in nominal plural forms in the adult system is [õj̃ʃ], as mentioned in section 1; (iii) nasal diphthongs and Coda fricatives are early available in the Portuguese children's phonological system; (iv) although complexity may promote the acquisition of specific structures (Fikkert & Freitas, 1998, 2006; Correia, 2004), it is assumed that allomorphy is acquired at later stages in language development (Peperkamp & Dupoux, 2002; Hayes, 2004). Based on the facts listed above, we will address the following research questions:

(1) *Research question 1*: are nominal plural forms with nasal diphthongs accurately produced at early stages in the acquisition of EP?

(2) *Research question 2*: when children use repair strategies to deal with this target structure, are they constrained by a grammar effect (adjunction of the plural morpheme /+s/ to the format of the singular form - [ẽw̃]/ [ẽw̃ʃ]) or by a frequency effect (preference for the most frequent nasal diphthong in nominal plural forms in the target system - [õj̃ʃ])?

(3) *Research question 3*: what is the impact of lexical knowledge in the production of the focused structures?

Considering the early mastery of nasal diphthongs and Coda fricatives in EP (*research question 1*), we predict the nominal plural forms with nasal diphthongs to be early acquired in EP. As for *research question 2,* our predictions are: in case children are mostly constrained by a *frequency effect*, the preferred repair format will be [õj̃ʃ]; in case children are mostly constrained by a *grammar* effect, the preferred repair format will be [ẽw̃ʃ].

Finally, for the discussion of the *research question 3,* we compared the children's behaviour when faced with words and pseudowords; assuming that children will phonologically process words and pseudowords similarly, the prediction is that the effect(s) registered for pseudowords will mirror the one(s) attested for words.

3. Data collection

The present paper reports a cross-sectional experimental study, where a sample of 130 monolingual Portuguese children organized in four age groups were observed:

(5) The sample

Group	Age	Number
Group I	3;0-3;11	32
Group II	4;0-4;11	32
Group III	5;0-6;02	34
Group IV	6;0-7;01	32

The inclusion factors for the selection of the subjects were: (i) all children were EP monolinguals; (ii) children in Groups I, II and III were all kindergarten attendants in the city of Lisbon; Group IV were 1st grade students in Lisbon. The exclusion factor was the presence of speech or language disorders or any other clinical diagnosis constraining each child's linguistic development.

    All children were tested under a picture-naming task, with visual stimuli for 9 words (cf. (6)), 9 pseudowords (cf. (7)), 9 distractor words and 9 distractor pseudowords (36 items in total). The 9 target words selected are presented in (6). The fact that words with the focused structure are not frequent in the child's lexicon constrained the lexical selection for the experiment and, therefore, a phonological control of the stimuli was not possible, although they all show syllable-final stress and exhibit the most frequent word size in Portuguese children's early productions – up to three syllables *per* word (Vigário, Freitas & Frota, 2006).

(6) Nominal lexical forms with nasal diphthongs

	Words	**[ẽw̃ʃ]**	**[õj̃ʃ]**	**[ẽj̃ʃ]**
Paradigm 1	*mão* 'hand'		▓	▓
	irmão 'brother'		▓	▓
	grão 'grain'		▓	▓
Paradigm 2	*avião* 'plane'	▓		▓
	balão 'balloon'	▓		▓
	limão 'lemon'	▓		▓
Paradigm 1	*cão* 'dog'	▓	▓	
	capitão 'captain	▓	▓	
	pão 'bread'	▓	▓	

In the absence of information on lexical frequency for older children, we inspected the database used in Freitas (1997) – 18656 spontaneous utterances from 7 Portuguese children aged 0;10 to 3;7 – in order to look for lexically plausible items to be used in the experiment. We found: (i) *mão/mãos* 'hand(s)' for paradigm 1, (ii) *avião/aviões* 'plane(s)', *balão/balões* 'balloon(s)' and *limão* 'lemon' for paradigm 2, and (iii) *cão* 'dog', *pão* 'bread' and *capitão* 'captain' for paradigm 3.[8]

The 9 pseudowords (see (7)) were phonologically controlled for word size (dissyllabic forms), syllable structure (all word initial CV syllables), stress pattern (word stress in the nasal diphthong) and type of Onset consonants (obstruents or nasals). The control of these variables was based on facts from phonological acquisition: dissyllabic forms, CV syllables and obstruents and nasals (plosives; nasals>>fricatives) are all early available in Portuguese children's phonological development (Freitas, 1997; Vigário, Freitas & Frota, 2006; Costa, 2010). The selected stress pattern is the one present in the lexical forms in (6). The pseudowords were presented as types of animals (thus, noun forms)[9].

For the reasons listed above, the distractor stimuli were all phonologically controlled for word size (dissyllabic forms), syllable structure (only CV syllables), stress pattern (penultimate stress, the default pattern in the target system) and type of Onset consonants (obstruents or nasals): (i) 9 words from the regular paradigm were used, like *pato/patos* 'duck/ducks'; (ii) 9 pseudowords were created, with shapes similar to *boma/bomas*. The three training items for words and pseudowords all exhibited the shapes just mentioned; no items with word-final nasal diphthong were used in the training period, in order not to constrain the children's answers when faced with the targeted items in the study.

(7) Pseudowords

| pifão	[pi'fɐ̃w̃]
catão	[kɐ'tɐ̃w̃]
tipão	[ti'pɐ̃w̃]
bitão	[bi'tɐ̃w̃]
futão	[fu'tɐ̃w̃]
nibão	[ni'bɐ̃w̃]
vatão	[vɐ'tɐ̃w̃]
sufão	[su'fɐ̃w̃]
midão	[mi'dɐ̃w̃]

All stimuli were randomly presented, first within the set of words and then within the set of pseudowords. For the visual naming task, a computer screen was used. Isolated and duplicated images were presented to elicitate singular and plural forms, respectively.

4. Results

In the present section, we will present quantitative data on the production of the three target diphthongs ([õĩʃ], [ɐ̃w̃ʃ] and [ɐ̃ĩʃ]) by the four age groups observed. First, we will focus on the results for the target lexical items used in the experiment; then, we will present data for the pseudowords mentioned in section 3.

Figure 1 provides a general picture of the productivity of each structure ([õĩʃ], [ɐ̃w̃ʃ] and [ɐ̃ĩʃ]) in the four age groups tested (GI: 3;00 to 4;00; GII: 4;00 to 5;00; GIII: 5;00 to 6;00; GIV: 6;00 to 7;00), without specifically considering the relation *target structure/children's production*. The category 'other types of answers' includes very few mispronunciations and some singular forms for plural targets.

Figure 1: Distribution of types of diphthongs per age group.
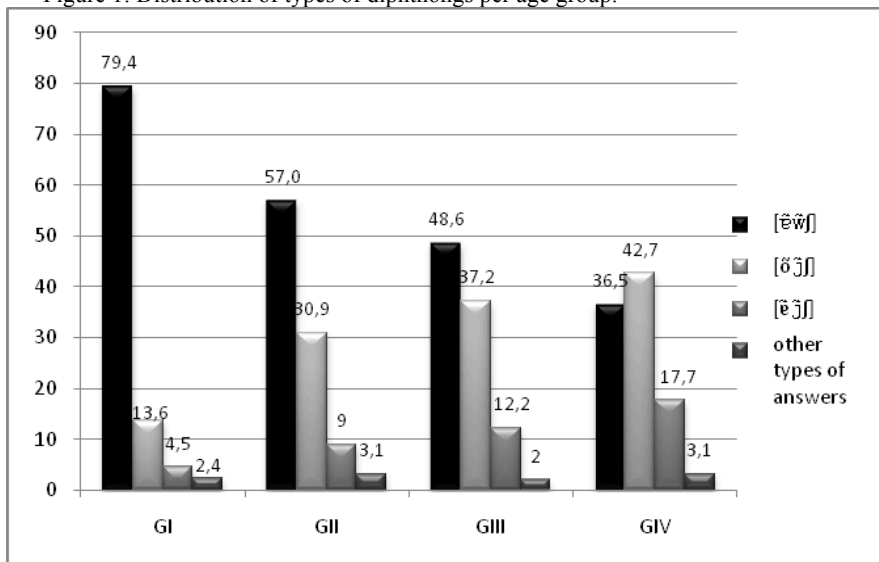
In Figure 1 above, we can observe a clear preference for the format [ẽw̃ʃ] by the children in Group I (79%). The use of this structure is gradually reduced in the older age groups (Group II: 57%; Group III: 49%; Group IV: 37%). As for the structure [õj̃ʃ], a low rate in Group I (14%) gradually increases in the older age groups (Group II: 31%; Group III: 37%; Group IV: 43%). Finally, notice that, unlike [ẽw̃ʃ] and [õj̃ʃ], the format [ẽj̃ʃ] is highly non-productive in all age groups: it is almost absent in Group I (5%); a slow increase is attested across the age groups but the oldest children in the sample are still far from using this structure productively (Group II: 9%; Group III: 12%; Group IV: 18%). As one may observe by the rates in the fourth column of each age group, the rates for other types of answers (basically, non-production of the plural form) are extremely low.

From this point on, we will specifically focus on each of the three target structures (paradigms 1, 2 and 3 in section 1). Figure 2 presents quantitative data on the performance of each age group when lexical items with [ẽw̃ʃ] were targeted – paradigm 1. Information on the successful production rate per item is provided.

Figure 2: Production of target [ẽw̃ʃ] per age group (paradigm 1).
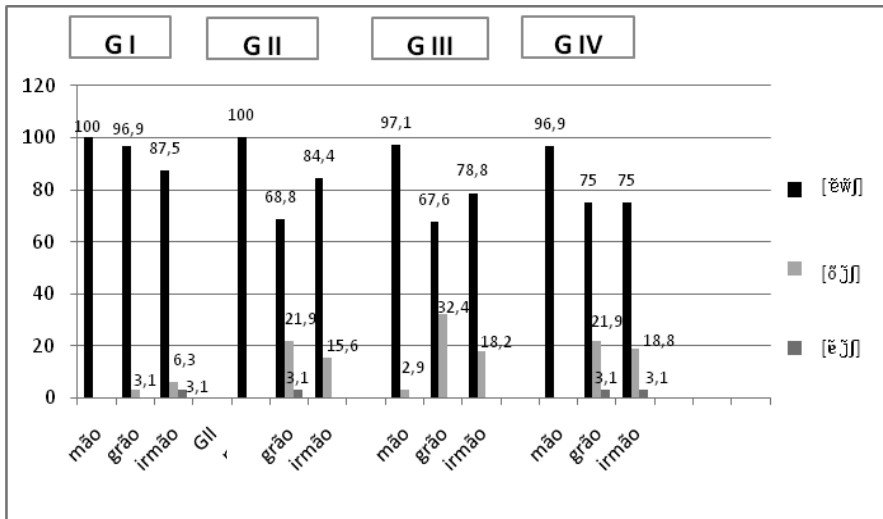

Figure 2 shows that [ẽw̃ʃ] is the predominant format in paradigm 1, matching the target forms, all with word-final [ẽw̃ʃ]. The rates for Group I apparently show that the structure is productive (from 87,5% to 100% of success). However, the high level of accuracy attested in Group I contrasts with a decrease in the children's performances in the subsequent groups: Group II shows rates ranging from 68,8% to 100%; a similar variation is attested in Group III (67,6% to 97,1%) and in Group IV (75% to 96,9%). The high level of accuracy registered for target [ẽw̃ʃ] in Group I may be the result of the preference for this structure in all paradigms at this age, as we will see below.

A lexical effect is attested: the word *mãos* 'hands' clearly facilitates the children's task. Notice that this target is more frequent in the target system than the lexical items *grãos* 'grains' and *irmãos* 'brothers' (see the ordering *mãos>>irmãos>>grãos*[10]). Plus, a phonological aspect may be constraining the children's behavior when facing the target *grãos* (the one exhibiting the lowest rate of success in Groups II and III): the Onset within its syllable structure is a branching one; this syllable constituent is acquired late in Portuguese children's phonological development (Freitas, 2003), which may affect the processing of the (morpho)phonological structure of this particular word and, thus, compromise the children's accuracy for this specific item. What is interesting, however, is to notice the non interference of this syllabic aspect in the children's performance in

Group I: the youngest children observed show no effect of the syllabic complexity in *grãos* 'grains' (target [ẽw̃ʃ]), which illustrates the clear preference for this type of structure from 3;00 to 4;00, when the processing of nasal diphthongs in nominal plural forms is concerned.

When repair patterns occur in paradigm 1, the preferred one is [õj̃ʃ], although the rates are always below 32%: the use of [õj̃ʃ] is non-productive in Group I (mean value: 3%); Group II (mean value: 13%), Group III (mean value: 18%) and Group IV (mean value: 4%) show some productivity of [õj̃ʃ] especially in the less frequent targets (*irmãos* 'brothers' and *grãos* 'grains'). The rates in Figure 2 also show that the use of the structure [ẽj̃ʃ] as a possible repair pattern is clearly non-productive in the children's system.

Figure 3 displays information on each of the four age group's performances when dealing with lexical items that imply the use of [õj̃ʃ] in the plural form – paradigm 2.

Figure 3: production of target [õj̃ʃ] per age group (paradigm 2)
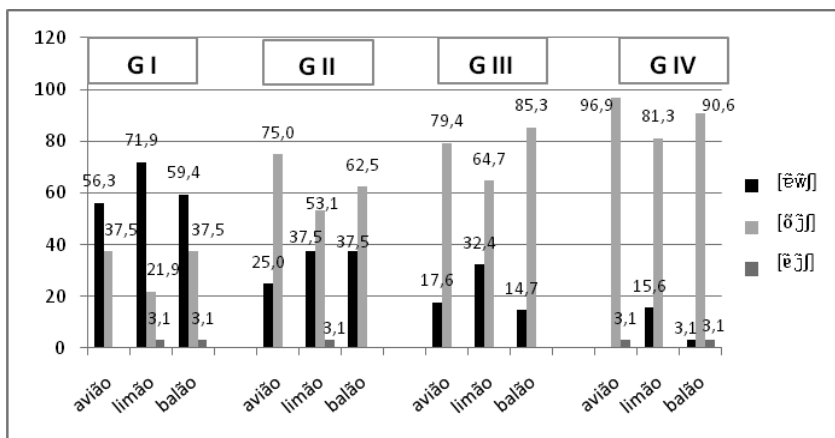
The results presented in Figure 3 show that the rate of accurate productions for paradigm 2 (targeted forms with [õj̃ʃ]) gradually increases with age: (i) Group I shows very low levels of success (21,9% to 37, 5%); (ii) accuracy gradually increases from Group II (53,1% to 75%) to Group III (64,7 to 85,3%) and Group IV (success rates above 81%).

In the case of the items exhibiting [õj̃ʃ] in the plural form (paradigm 2), no clear promoting lexical effect was attested: although the frequency in the target system shows the ordering *aviões>>balões>>limões*[11], any of

the items seems to facilitate the task across the four age groups, unlike what happened with *mãos* 'hands' in Figure 2. On the contrary, the word *limões* 'lemons', the least frequent item in the target system, seems to be the most problematic one.

As for the repair patterns Portuguese children select to deal with forms in paradigm 2, the shape [ẽw̃ʃ] is clearly the preferred one in Group I (56,3% to 71,9%). This preference gradually decreases in the other age groups (Group II: 25% to 37%; Group III: 14,7% to 32,4%; Group IV: 3,1% to 15,6%). As attested in Figure 2 for target [ẽw̃ʃ], the format [ẽj̃ʃ] rarely emerges as a possible repair structure for target [õj̃ʃ], in the sample observed.

Figure 4 provides quantitative data on the sample's performance when faced with words whose plural forms imply the use of the format [ẽj̃ʃ] – paradigm 3.

Figure 4: Production of target [ẽj̃ʃ] per age group (paradigm 3)
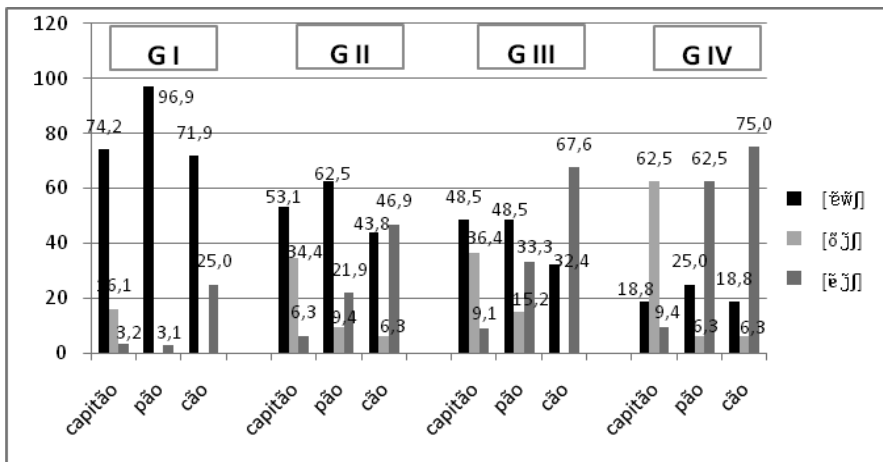
The data displayed in Figure 4 shows a low level of accuracy in the production of plural forms with target [ẽj̃ʃ]by the Portuguese children observed. If we consider the mean rate of success per age group in paradigm 3, although a gradual increase is attested, all age groups exhibit target-like production rates below 50%, showing that the structure is not yet mastered in any of the age groups tested (Group I: 10%, Group II: 25%; Group III: 37%; Group IV: 49%).

If we consider the rates per lexical item, values range from 3,2% to 25% in Group I, from 6,3% to 46,9% in Group II, from 9,1% to 67,6% in Group III, and, finally, from 9,4 to 75% in Group IV. In this paradigm, an obvious lexical effect is observed: the item *cão* 'dog' is the one promoting the children's performance; the item *capitão* 'captain' is the most problematic one.[12] The order resulting from data in Figure 4 is then *cães>>pães>>capitães*. These results, however, do not mirror the frequency of the items attested for the adult system: *cães>>capitães>>pães*.[13] This might be due to the specificity of the children's lexicon. In the spontaneous data observed in Freitas (1997), only *cães* is targeted; *pães* and *capitães* never occurred from 0;10 to 3;7, although their singular counterparts are present in the lexicon of the children observed.

Despite the lexical effects just reported, a low level of accuracy exhibited by the sample when facing target [ẽj̃ʃ] is attested, which contrasts with the earlier mastery of [ẽw̃ʃ] (see Figure 2) and [õj̃ʃ] (see Figure 3).

Let us now focus on the repair patterns used by the four age groups for the targeted [ẽj̃ʃ]. The data in Figure 4 shows that [ẽw̃ʃ] is massively the prevalent format in Group I (mean rate: 81%); it is still the preferred repair pattern in Group II (mean rate: 53%). The preference for [ẽw̃ʃ] gradually decreases in Group III (mean rate: 43%) and Group IV (mean rate: 21%). Notice, however, that the most problematic targets (*capitães* 'captains' and *pães* 'bread units') preferably trigger the format [ẽw̃ʃ] in Groups I, II and III. As for [õj̃ʃ], this repair pattern is basically non-selected by children in Group I (mean rate: 5%). As for Groups II and III (mean rate equals 17% in both cases), [õj̃ʃ] is hardly productive, except for the problematic target *capitão* 'captain'; the use of this pattern increases in Group IV, but only for this last problematic target.

We described, so far, the behavior displayed by Portuguese children when targeting the formats [ẽw̃ʃ] (paradigm 1), [õj̃ʃ] (paradigm 2) and [ẽj̃ʃ] (paradigm 3), present in the adult plural forms of the nouns included in the experiment. We now turn to the results obtained for the pseudowords presented in the experiment and listed in section 3. Figure 5 provides quantitative information on the production formats exhibited by each age group to generate the plural forms of the pseudowords presented in the experiment ([ẽw̃ʃ], [õj̃ʃ] or [ẽj̃ʃ]).

Figure 5: Production of nasal diphthongs in pseudowords.
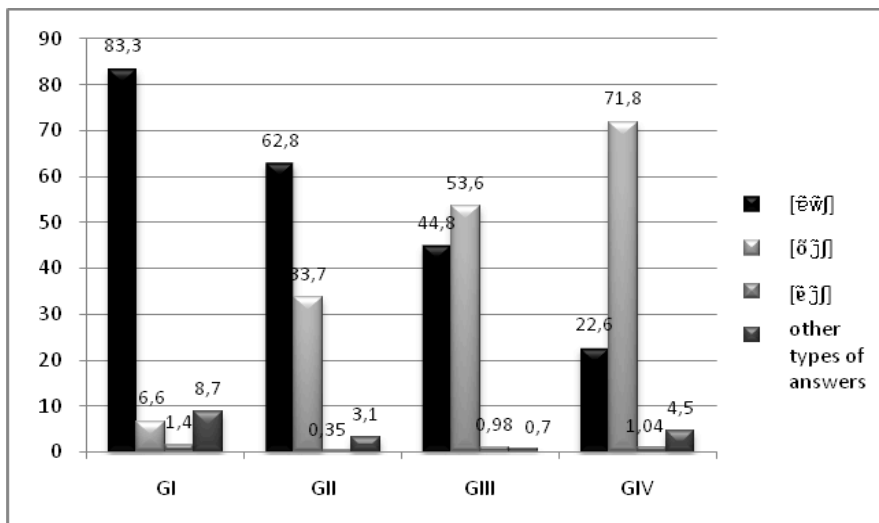
The data compiled in Figure 5 shows a gradual decrease in the use of the format [ẽw̃ʃ] and a gradual increase for [õj̃ʃ], when children are attempting the plural forms of the pseudowords presented in the experiment. A clear preference for [ẽw̃ʃ] is attested in the younger children: 83,3% in Group I; 62,8% in Group II. In Group III, no clear preference for this format is displayed: it seems that [ẽw̃ʃ] (44,8%) and [õj̃ʃ] (53,6%) are competing shapes when children aged 5;00 to 6;00 are processing this type of structures. The rate for [ẽw̃ʃ] clearly decreases in Group IV (22,6%).

As for the format [õj̃ʃ], it is basically non-selected by children in Group I (6,6%). Its use increases in the subsequent groups (Group II: 33,7%; Group III: 53,6%). Group IV shows a clear preference for [õj̃ʃ] (71,8%).

Considering the results in Figure 5, we may state that the shape [ẽj̃ʃ] is definitely not productive when children aged 3;00 to 7;00 are attempting the plural forms of singular pseudowords with word-final [ẽw̃].

5. Discussion and final remarks

In this section, we will discuss the research questions formulated in section 2 and the predictions displayed on the basis of the information available in

the literature. To accomplish this purpose, let us first summarize the results described in section 4:

(1) Unlike paradigms 2 and 3 (target [õj̃ʃ] and target [ẽj̃ʃ], respectively), paradigm 1 (target [ẽw̃ʃ]) seems to be mastered in all children aged 3;00 to 4;00 (Group I). At this age group, a general preference for [ẽw̃ʃ] is attested, both in the context of processing words or pseudowords;

(2) From 4;00 to 5;00 (Group II), a regression occurs in paradigm 1 (target [ẽw̃ʃ] suffer a decrease in success rates). As for paradigm 2, a clear increase is observed (values with [õj̃ʃ] are all above 50%), although the structure is not yet mastered. Paradigm 3 (target [ẽj̃ʃ]) is far from the mastery level at this age group. Although productions matching the adult structures increase in children aged 4;00 to 5;00, they are still preferably using [ẽw̃ʃ] as a repair pattern for problematic lexical targets; as for pseudowords, the [ẽw̃ʃ] format remains dominant;

(3) From 5;00 to 6;00 (Group III), paradigm 1 keeps showing the regression effect reported for Group II. Production data generally matches target [õj̃ʃ] (paradigm 2 is globally reaching the mastery level). As for paradigm 3, children at this age clearly do not show the mastery of target [ẽj̃ʃ]. At this age group, [ẽw̃ʃ] is often the preferred repair format for the processing of problematic structures (target [ẽj̃ʃ] and pseudowords), although a competition with the shape [õj̃ʃ] is attested;

(4) Finally, from 6;00 to 7;00 (Group IV), children show the mastery of target [ẽw̃ʃ] and target [õj̃ʃ]: paradigms 1 and 2 are generally not problematic. As for paradigm 3, children often make use of repair patterns. Both [ẽw̃ʃ] and [õj̃ʃ] are productive to deal with problematic target [ẽj̃ʃ] and with pseudowords; this, again, clues a competition between both formats ([ẽw̃ʃ]/ [õj̃ʃ]) in the children's system. In the case of pseudowords, [õj̃ʃ] is clearly preferred over [ẽw̃ʃ].

The first research question we raised was related to the rate of accuracy of nasal diphthongs in nominal plural forms in EP. Considering the early mastery of nasal diphthongs and Coda fricatives in the path of phonological development observed in Portuguese children (Freitas, 1997; Freitas, Miguel & Faria, 2001; Correia, 2004), our prediction was that the structures focused in this study would be early acquired. However, the prediction was not confirmed by the data collected: although the production of each of the structures in the sequence *nasal diphthong +*

Coda fricative is early available in Portuguese children's phonological development (see the state of the art in section 2), the mastery of the sequence in this morphophonological context (plural assignment in the nominal paradigm) seems to be problematic up until 7;0, matching the statement in Sim-Sim (1998) and the results in Castro (2010).

The morphophonological complexity encoded in the sequence under study, described in section 1, seems to delay its mastery. As we have seen in section 1, the hypothesis is that this complexity is assigned by the confluence of the following facts:

(i)   the presence of branching configurations under the Rhyme domain (branching Rhymes and branching Nuclei);
(ii) the activation of different phonological processes, such as vowel gliding or glide insertion, spreading of the nasal autosegment under the Nucleus domain, and segmental (under)specification for place and voice features affecting the plural marker;
(iii) the presence of allophonic and allomorphic variation (see the lexically related forms in section 1, examples in (1));
(iv) the activation of the plural assignment rule (*adjunction of the plural morpheme /+s/ to the lexical format of the singular form of the word*);
(v)   the singular/plural asymmetry in paradigms 1, 2 and 3 (see examples in (1), section 1), deriving from the nature of the last vowel of the stem and of the class marker.

Based on our results, it seems that morphophonological complexity may, in fact, delay the acquisition process (Kager, 1999; Peperkamp & Dupoux, 2002; Kerkhoff, 2004; Hayes, 2004; see, however, Freitas & Miguel 1998; Freitas, Miguel & Faria, 2001 and Fikkert & Freitas, 2006 for opposite results in the presence of allophonic and allomorphic information). The question that remains for further investigation may be formulated as follows: when does morphology trigger and when does it delay language acquisition? Results on the acquisition of morphophonological aspects in EP are still scarce. Further research on this topic in different languages is needed in order to identify general developmental patterns, universal behaviours and idiosyncratic properties affecting the mastery of morphophonological aspects in different languages of the world.

The second question raised in section 2 was related to the effect of grammar and/or frequency events in the accuracy level of production of nominal plural forms with nasal diphthongs in EP. More specifically, when children use repair patterns to deal with the focused sequence, are

they constrained by a *grammar effect* (in this case, the adjunction of the plural morpheme /+s/ to the singular form - [ẽw̃] for singular forms; [ẽw̃ʃ] for plural forms) or by a *frequency effect* (in this case, the high frequency of [õj̃ʃ], contrasting with the low frequency of [ẽw̃ʃ] and [ẽj̃ʃ], both in adults and in the children's lexicon)? The predictions raised were as follows: (a) in case children show a *grammar effect*, [ẽw̃ʃ] will be the preferred format; since all singular forms show a word-final [ẽw̃] structure, the activation of the plural formation rule (*adjunction of /+s/ to the singular form*) will generate the sequence [ẽw̃ʃ]; (b) in case the children's behaviour is constrained by a *frequency effect*, the most frequent format in the adult system ([õj̃ʃ]) will emerge as the preferred format in the children's performance.

The results described in section 4 show that children are early constrained by a grammar effect; only later is a frequency effect attested. We will now summarize the empirical arguments underlying this statement. In the case of the lexical targets used in the experiment, the levels of accuracy for each of the three paradigms considered were as follows:

(1) In *paradigm 1*, [ẽw̃ʃ] is the dominant production at 3;0; however, the accuracy level in Group I decreases in the older groups; the high level of accuracy attested in Group I (a ceiling effect absent in the older children), may be interpreted as the result of the grammar effect in the first age group (predominance of [ẽw̃ʃ]). The fact that [ẽw̃ʃ] tends not to be replaced by other formats across the four age groups may also be interpreted as the result of a grammar effect.

(2) As for *paradigm 2*, there is a low degree of accuracy in the production of target [õj̃ʃ] at 3;0, with a preference for [ẽw̃ʃ] (a grammar effect is attested); a gradual increase from 4;0 to 7;0 is observed in the mastery of the targeted [õj̃ʃ].

(3) Paradigm 3 is problematic in all age groups observed. Except for *capitães* 'captains' in Group IV, children preferably select [ẽw̃ʃ] to deal with the targeted [ẽj̃ʃ], which, again, argues for a grammar effect.

Concerning the use of repair patterns for the lexical stimuli presented in the experiment, the data favor the grammar effect prediction: [ẽw̃ʃ] is the dominant repair pattern at 3;0 for target [õj̃ʃ] and the preferred repair for target [ẽj̃ʃ], in all age groups; (ii) [õj̃ʃ] is not productive at 3;0, and, except for *capitães* in Group IV, it is always a less productive repair pattern than [ẽw̃ʃ]; (iii) [ẽj̃ʃ] is not productive as a repair pattern, in all age groups and word paradigms tested. The low rate of [õj̃ʃ] in paradigm 1,

when [ɐ̃w̃ʃ] is targeted, also argues for a grammar effect over a frequency effect in the data collected.

Let us recall the low frequency of [ɐ̃w̃ʃ] in the adult system: 1,5% within the lexical subset of plural forms with nasal diphthongs in EP. The massive effect of [ɐ̃w̃ʃ] in the production data of the children observed when faced with the focused structures is unexpected from a frequency point of view and it may only be assigned to the relevance of the grammatical event "*adjunction of the plural morpheme /+s/ to the singular form*" in the processing of nasal diphthongs in nominal plural forms in EP.

As for the pseudowords tested in the experiment:

(1) [ɐ̃w̃ʃ] is clearly dominant in the first two age groups, from 3;00 to 5;00. At 5;00-6;00, it is used almost as frequently as [õjʃ]; its productivity clearly decreases in the last age group (6;00-7;00).

(2) The format [õjʃ] is basically absent in the first age group, at 3;00-4;00; production rates up to 50% occur from 4;0 to 6;0. No clear preference for [õjʃ] or [ɐ̃w̃ʃ] is attested at 5;0-6;0. This format becomes highly productive in the last age group observed, at 6;00-7;00.

(3) In all age groups observed, the format [ɐ̃jʃ] is never productive.

A grammar effect in the processing of pseudowords is thus present in children aged 3;00 to 5;00. A tension between a grammar and a frequency effect is attested from 5;00 to 6;00. In the last age group (6;00 to 7;00), a clear frequency effect emerges when children are processing pseudowords.

The results for words and pseudowords allow us to comment on the third research question raised in section 2, on the impact of lexical knowledge in the acquisition of the focused structures. In the youngest age groups observed (3;00-4;00 and 4;00-5;00), the grammar effect is the prevalent one, both for words and pseudowords. From 5;00 to 6;00, a grammar effect is still attested for the lexical stimuli (see the results for paradigm 3 in Figure 4), although a tension between grammar and the frequency events emerges for the processing of pseudowords. Finally, from 6;00 to 7;00, the last age group considered, the tension between grammar and frequency effects for words remains (see, again, the results for paradigm 3 in Figure 4), while the processing of pseudowords is clearly constrained by a frequency effect.

To sum up, lexical knowledge seems to be relevant for the processing of words and pseudowords but only in the older age groups (5;00-6;00; 6;00-7;00), when a shift from an early grammar effect to a later frequency effect is observed. In this case, the frequency effect is first activated in the pseudoword group of stimuli (the tension between the two effects remains until 7;00 for words; the prevalence of [õjʃ] is clear in pseudowords from

6;00 to 7;00). In the early age groups, the grammar effect (preference for [ɐ̃w̃ʃ]) affects both words and pseudowords, therefore, the prediction in section 2 (*the effects registered for pseudowords will mirror the ones attested for words*) was partially confirmed, only for the younger children (from 3;00 to 5;00).

Our research provided empirical evidence showing that the structure under study is not yet mastered by the time children reach 7;00. Therefore, further investigation is needed to set the age boundaries for its mastery. A clear grammatical effect in the younger children's performance was attested, which contrasts with the gradual activation of the frequency effect in older children tested in the current study. Although the phonological structures under analysis are early available in Portuguese children's phonological development, the morphophonological complexity encoded in the *nasal diphthong + Coda fricative* sequence in nominal plural forms seems to delay its mastery.

Notes

[2] As mentioned by one of the reviewers, the use of the term *complexity* is still problematic (see the workshop on *Complexity, Typology and Acquisition*, Lyon, May 2009, organized by Maddieson & Rose). As far as we know, we are still far from defining complexity in phonological acquisition. In this paper, we assume that allophonic and allomorphic variation, branching syllable constituency, irregular morphological inflection and presence of different phonological processes, all present in the structure under evaluation in the paper, may contribute to the fact that this might be considered a complex linguistic structure for Portuguese children.

[3] For further information on the verbal system, see Mateus & Andrade (2000).

[4] For further information on other types of diphthongs in singular nominal forms in EP, see Mateus & Andrade (2000) and Villalva (2008), among others.

[5] See footnote 2 on the notion of complexity.

[6] For further information on this database, see *www.iltec.pt/mordebe*.

[7] Notice that errors in adults preferably match the [õj̃ʃ] format.

[8] Due to the productivity of [õj̃ʃ] in the target system, it was easy to select items for paradigm 2 but not for paradigms 1 and 3. Our intuition is that, from the items not attested in the database used in Freitas (1997)*, irmão* 'brother' is common in the children's lexicon, but not *grão* 'grain'.

[9] Although pseudowords have been presented as types of animals, during the implementation of the experiment some children used them as proper names. This is problematic since proper names do not involve inflection.

[10] This ordering is based on the information provided by the database *Léxico Multifuncional Computorizado do Português Contemporâneo,* available at the website (http://www.clul.ul.pt/sectores/linguistica_de_corpus/projecto_lmcpc.php).

[11] See the reference in the previous endnote.

[12] Notice that the selection of *capitão* 'captain' is not ideal but words with [ẽj̃ʃ] are rare in the children's lexicon. The word in the singular form was used, in the experiment, in the context of the image of the character *capitão Gancho* 'captain Hook', from the children's tale *Peter Pan*.

[13] See the reference in endnote 6. Notice that it was not expected that *capitães* 'captain' would be more frequent than *pães* 'pães'. This may be due to the type of sources used to build the database *Léxico Multifuncional Computorizado do Português Contemporâneo.*

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