The Emergence of First Language Phonology: Perception, Articulation and Representation*

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Introduction

Since the mid-1990s, we have observed a resurgence in the number of competing approaches to linguistics and language acquisition, a few of which also came with a noticeable degree of radicalization in the area of theoretical modelling. Focussing on phonology and phonological development, recent proposals now range from views that explicitly depend on phonological features as innately available primitives (Hale & Reiss 2008) or, at the other extreme of the spectrum, reject the notion of phonological feature altogether (Vihman & Croft 2007).

In this paper, I argue that neither of these (irreconcilable) views is tenable. I instead defend the view that while abstract phonological categories are crucially relevant to both developing and end-state phonological systems, these categories need not be assumed to be innately available.

The paper is organized as follows. In section 1, I address the two approaches mentioned above, both of which I consider to be too radical to provide an adequate level of explanatory power for phonological development, an issue I discuss in section 2. I move to the current proposal in section 3. My general aim is to explain relationships between phonological perception, representation, and production in the context of first language development while keeping with the relevant scientific literature on the topic. I discuss this proposal in light of data on the first language acquisition of French and of European Portuguese, in section 4. A brief discussion of additional implications and perspectives follows, in section 5.

1. Background: Radical approaches to child phonology

In this section, I summarize what are perhaps the two most radical views expressed in the recent literature about the nature of phonological systems and of their acquisition. The first view, developed within a series of publications by Mark Hale, Charles Reiss, and colleagues (e.g., Hale & Reiss 1998, 2003; Hale, Kissock & Reiss 2007), and subsequently assembled in a monograph (Hale & Reiss 2008; henceforth H&R), takes segmental features as necessary primitives to phonological development. H&R claims that features (a) exist as independent categories within phonological systems, and (b) are necessarily innate. Under their view, phonological learning consists of assigning innately-available representational primitives (here, features) to dimensions of the stimulus present in the ambient language. Putting a strong emphasis on the notion of phonological competence, Hale & Reiss reject the study of children's phonological productions as a source of evidence for the study of child phonology, on grounds that, according to their (dubious) claim, these productions are plagued with inconsistencies which do not properly reflect the properties of the underlying system. (See Rose & Inkelas 2011 for a critical discussion of this claim.)

The second view, diametrically opposed to that of H&R, is formulated by Vihman & Croft (2007; henceforth, V&C), who build on earlier works on phonological development by Macken (1979), Menn (1983), Waterson (1987), Vihman (1996) as well as on the exemplar approach to phonology proposed by Bybee (2001). Within V&C's model, which they refer to as 'radical' templatic phonology, words are represented in the lexicon as phonotactic templates in which speech sounds (or segments) are mere positions within phonotactic templates. V&C claim that phonological development is best captured through an appeal to emerging word templates, which formally represent the child's 'preferred word patterns' (as defined by Macken 1979), themselves constrained by the child's own limited articulatory abilities. Crucially, V&C reject constructs such as segments, features, or any other hierarchically organized units (e.g., syllable structure constituents) as independent categories within lexical representations. Word-size units, as opposed to segments or prosodic domains (e.g., within syllables, words, or larger domains), thus govern the speaker's repertoire of productive abilities.

In the next section, I address some of the limitations inherent to each of these proposals.

2. Criticisms

Conspicuous in both H&R and V&C is the virtual absence of references to three important and, I argue, crucially relevant bodies of research which should inform any theory of phonology and phonological development. The first is the literature on the acquisition of phonology published within the various flavours of the generative program (e.g., Smith 1973; Spencer 1986; Fikkert 1994; Fikkert &

Freitas 1997, 2006; Levelt 1994; Freitas 1997; Pater 1997; Barlow 1997; Rose 2000, 2003; Goad & Rose 2004; Levelt & van Oostendorp 2007; Fikkert & Levelt 2008; *inter alia*). Among other observations, this literature most often makes reference to sweeping changes across the child's productive lexicon, which systematically affect segmental and/or prosodic aspects of the child's phonological abilities. While H&R reject this body of research as theoretically irrelevant, V&C fail to address many of the empirical generalizations which emerge from it. Clearly, however, these *systematic* behaviours must be revealing of aspects of the developing system (cf. H&R). These patterns also pose challenges to templatic models of phonology, as many properties of the patterns documented in the works cited above transcend the types of predictions one can make based on word-level units alone (cf. V&C).

The second body of literature comes from research on infant speech perception. While both H&R and V&C pay some lip service to this literature, neither truly engages with it. In both cases, references are limited to general observations about speech perception which they take as support for their respective proposals. In section 3.1 below, I return to this literature, and address emerging behaviours in the area of linguistic analyses that infants perform over the speech signal.

The third body of literature comes from the computational modelling of speech processing and learning. While these models may not always be representative of how language and language acquisition truly take place within human cognition, they highlight important considerations about both capacities and limitations affecting the learning and processing of linguistic data. On the one hand, H&R squarely reject the possibility that learners can derive phonological categories from domain-general mechanisms (e.g., Pierrehumbert 2001, 2003).[1] While, on the other hand, V&C embrace general learning mechanisms as part of their model, they fail to consider computational models based on bayesian (maximum entropy) learning. These models clearly demonstrate that computational systems can derive (i.e., abstract away) categories through detections of regularities within the stimulus (e.g., Goldwater 2006; see also Hayes & Wilson 2008, Mielke 2008, and references therein).

Finally, from an empirical standpoint, neither of the views offered by H&R and V&C affords much predictive power. This problem is most acute in the case of H&R, who, as mentioned above, reject the theoretical relevance of production data. As for V&C, their explicit focus on children's own preferred word patterns as predictors of phonological performance poses a circularity problem, if only at the level of individual learners. Further, V&C's rejection of formal categories at both the segmental and prosodic levels restricts the range of hypotheses that can be tested within their model. Predictions are thus limited to general considerations about perceptually or statistically defined properties of the target language.

In the next section, I turn to the current proposal, which builds on a number of recent findings from the literature mentioned above.

3. Current proposal

The proposal sketched in this section is an attempt at engaging with three main bodies of research, namely that on phonological theory (within and outside the realm of child language), that on infant speech perception, as well as that on early phonological development. This exercise is motivated by two inter-related goals. First, to incorporate the contributions, both formal and empirical, emerging from each field. Second, to explore relationships between these areas of investigation.

I take as a starting point the view generally held, implicitly or not, that the development of phonological representations is intimately related to that of the lexicon (e.g., Stoel-Gammon 2011 for a recent summary). I claim that the child builds his/her phonology from abstract analyses of word forms stored within his/her developing lexicon. Under this logic, phonological development begins on the basis of broad, perceptually-defined lexical representations, the segmental and prosodic dimensions of which gradually emerge through successive rounds of learning.

Following Pierrehumbert (2003), I assume two inter-related levels of representation, a concrete/variable level, and an abstract/discrete level, a dichotomy which broadly follows traditionally-held distinctions between phonetics and phonology (cf. Steriade 1999):

> "A category is a mental construct which relates two levels of representation, a discrete level and a parametric level. Specifically, a category defines a density distribution over the parametric level, and a category system defines a set of such distributions." (Pierrehumbert 2003: 119)

This definition provides the essential elements for the development of perceptual categories. Another important task for the child consists of linking these categories to speech articulations. I argue that segmental features, which provide the formal link between speech sounds and their articulations, emerge through a series of generalizations attained by the learner, the first of which takes place during the babbling stage, during which the child gradually aligns his/her production patterns to the properties of the ambient language (e.g., Kern & Davis 2009). Full segmental representations thus emerge from the relations that exist between acoustic dimensions of the speech signal identified by the child and the properties of the articulations required to reproduce these dimensions in spoken forms. For example, continuancy among obstruent fricatives is characterized acoustically by the presence of high frequency aperiodic noise (e.g., Ladefoged & Maddieson 1996). If the child generalizes between this perceptual dimension and the manner of articulation required to reproduce it, s/he is likely to display phonological behaviours that highlight this generalization. I provide evidence in support for this claim in section 4 below.

The development of prosodic categories follows the exact same logic:

> "On this understanding, the system of phonological categories includes not only segments, but also other types of discrete entities in the phonological grammar, such as tones, syllables, and metrical feet." (Pierrehumbert 2003: 119)

While speech acoustics plays a central role in all aspects of phonological development, distributional evidence must also be considered. As Goad & Rose (2004) argue, before the child can arrive at fully elaborated prosodic representations, segmental content must be sufficiently specified, in order for the child to infer the segmental distributions relevant to a given prosodic context.[2]

Without denying the fact that statistical pressures may have an influence on the child's developing system, I claim that, while these pressures must be considered in our interpretation of the data, more fundamental aspects of phonological development lie in the learner's analysis of the system of categories that compose the target phonological system. In line with Bybee (2001), it seems obvious that particular areas of historical language change are governed by frequency effects emerging from language use. However, the detection of frequency effects in a particular area of language does not entail that everything about language processing should relate to statistical effects. While I also claim that not all of the child's articulatory behaviours should be directly attributed to phonology *per se* (e.g., Rose & Inkelas 2011 for an extended discussion), important developmental patterns are also noticed across the child's productive lexicon, the systematicity of which cannot be explained on phonetic grounds only (e.g., Inkelas & Rose 2007; Rose 2009; McAllister Byun et al. 2012).

This hypothesis receives strong support from studies of phonological development based on production data. On the one hand, few studies demonstrate a clear, demonstrably independent role for statistics in the development of productive abilities (e.g., Demuth 2007; Levelt & van Oostendorp 2007; Rose

2009; Almeida 2011; see also Rose & Inkelas 2011 and references therein for further discussion). On the other hand, when approached from a more abstract perspective, in which a given unit (e.g., segment) may be decomposed into its sub-parts (e.g., phonological features), strong generalizations emerge from the data, which provide insights into formal aspects of the child's developing system.

This proposal also implies a number of linguistic analyses on the child's part. This begs the question as to what are the origins of the child's analytical abilities. Of particular relevance in this context is current research on young infants' linguistic behaviours, to which I turn next.

3.1. Evidence from infant speech perception

In this section, I summarize findings from the literature on speech segmentation by young infants. Broadly construed, speech segmentation consists of identifying individual words within spoken utterances. As we will see, infants appear to transition from a statistical mode of parsing the stimuli to analyses based on linguistic categories, irrespective of statistical pressures. I interpret this transition as a progression from domain-general (statistical) to domain-specific (linguistic) modes of analysis.

We know since Jusczyk et al. (1993) that 9-month-old English-learning infants associate stressed syllables with word onsets. This association is consistent with general properties of English word forms. As Jusczyk et al. (1999) show, infants in fact over-apply this generalization in their attempts at identifying the beginning of words within spoken utterances: If given a phrase such that 'the guitar is,' they are likely to cue into the stressed syllable 'tar' as a word onset, and thus to identify 'taris' as a word. Stress-based segmentation is however not the only way in which infants can perform word segmentation. Using a set of synthesized stimuli, Saffran et al. (1996) show that 8-month-old infants are sensitive to transitional probabilities between syllables, even in the absence of cues such as stress or coarticulatory information. Infants can identify words based on stable sequences of syllables identified within the stimuli (see further below).

Young children can thus process syllable-level units in two different ways: Linguistic, cuing on syllable prominence, and statistical, cuing on transitional probabilities between syllables. Addressing this intriguing observation, Johnson & Jusczyk (2001) designed an experiment pitting statistical probabilities against stress cues. They designed a continuous string of disyllabic non-words, the left edges of which can be identified by syllable prominence (stress), but not by any particular transitional probability between syllables. However, an analysis of the same stimuli based on transitional probabilities between syllables would yield different conclusions about word boundaries, thereby creating a conflict between prosodic *versus* statistical word segmentations. Their results show that 8-month-old English-learning infants favour the segmentation strategy based on stress, the linguistic condition, over transitional probabilities, the statistical condition.

From a developmental perspective, these observations also beg the question as to when children begin to display each mode of word segmentation. This is the question taken up by Thiessen & Saffran (2003), who conducted a series of experiments in which they compare 7- and 9-month-old infants' use of statistical and prosodic cues in word segmentation. Their results are highly suggestive of a transition in processing strategies across ages: While 9-month-old infants segment their speech primarily based on stress cues, 7-month-olds perform the same task based on statistical cues.

These results lend support to the emergent view of linguistic categories defined above: Once infants have generalized a property over a given speech cue, they can abstract that property away, in the form of a category that they can then use as a basis for their further analysis of the signal. This does not imply that infants end up ignoring non-speech cues altogether, as they still can resort to such cues in the absence of linguistic cues. Thiessen & Saffran (2003:715) suggest that using the stress cue may make the task of segmentation easier than the compiling of more complicated statistical cues.

This view also finds validation in the area of computational modelling: While categories may arguably emerge through statistical inference, each acquired category added to the system provides an analogical 'shortcut' to the dimension it defines. These categories may in fact be a condition to make possible the learning and processing of natural languages. As argued for by, e.g., Kwisthout et al. (2011), analyses based solely on statistics of the input can rapidly overwhelm the processor. An implication of this is that behavioural models based on statistical processing can rapidly become intractable in the real world. More generally, while a speaker's perceptual categories may evolve over time, few scholars actually claim that linguistic systems can function in the absence of an abstract level of analysis (e.g., Ambridge & Lieven 2011 for a recent discussion).

Natural classes of phones, defined as groupings of elements within perceptual dimensions and related phonological features, and their combinations within syllable-, word-, or higher-level representational units are thus predicted to display patterns of categorical emergence in word representations, as entailed by the generative literature on phonological representation (e.g., Chomsky & Halle 1968; Selkirk 1982, McCarthy & Prince 1986/1995). Below I provide additional evidence in favour of this hypothesis. In short, while the current proposal poses a challenge the oft-held innateness assumption within generative phonology, it offers a validation from developmental data about some of the most important generalizations and related theoretical constructs obtained within this tradition.

3.2. General predictions

As spoken languages involve a number of different systems (minimally, for the perception, representation, and production of spoken forms), each system is likely to impose a bias on the overall outcome of learning. Focussing on developmental trajectories, I summarize general predictions of the current approach in (1):

(1) The emergence of phonological representation: General predictions
- a. Perception: Acoustic and distributional opacity hinder acquisition.
- b. Representation:
  - i. Simple units are acquired before complex ones (e.g., simple vs. complex onset clusters);
  - ii. Inter-relations between representational units.
- c. Production: Articulatory complexity hinders mastery.

In the next section, I discuss these predictions in light of two case studies of the acquisition of Romance languages. I focus on the development of complex onsets in the productions of French-learning child Anaé, and on the development of singleton onsets and codas in the productions of Portuguese-learning child Inês.

4. Case studies

The two case studies discussed in this section come from longitudinal, naturalistic corpora of phonological development. Anaé's data are from the Paris corpus (Leroy-Collombel & Morgenstern 2011; Morgenstern & Parisse 2012; Yamaguchi 2012) and Inês's data are from the Portuguese-Lisbon corpus (Correia 2009; Costa 2010; Correia, Costa & Freitas 2010). Both of these corpora are available through the CHILDES/PhonBank database (http://childes.psy.cmu.edu/phon/). In both cases, the children were recorded in their natural environments, during regular activities. While this sampling method is limited in that it may underestimate the true extent of the child's phonological abilities, it offers a maximally unbiased approach to the documentation of these abilities.

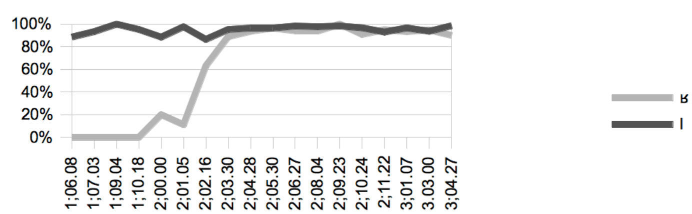
In order to characterize the children's development of phonology, we conducted a series of analyses of their productive abilities within specific phonological contexts (e.g., onset, coda), and plotted these data on a timeline. This method, and some results from Inês's development discussed below, is discussed in more detail by Burkinshaw (in prep.). As we will see, phonological development takes place in a generally categorical fashion, and the few areas of variability observed can be explained through a closer look at the data.

4.1. Anaé's complex onsets

In this subsection, I focus on Anaé's development of obstruent+liquid clusters as they appear pre-vocalically within the syllable. From a representational perspective, the development of these clusters is predicted to proceed from simple to complex, with the child initially producing only the obstruent part of the clusters (e.g., Spencer 1986; Fikkert 1994; Barlow 1997; Rose 2000; Goad & Rose 2004).

We first observe, in (2), the rate of accurate productions of [l] and [ʁ] in singleton onsets. [l] is already produced with high rates of accuracy at the beginning of the observation period. In contrast to this, [ʁ] only begins to emerge at age 2;0, with accurate productions reaching the 80% range at 2;03.30.

(2) Accuracy of [l] and [ʁ] productions in singleton onsets

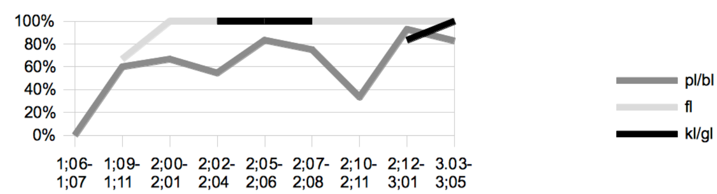


As we will see next, the same general pattern applies to the development of Anaé's onset clusters.

4.1.1. Anaé's development of obstruent+[l] clusters

Starting with the development of obstruent+[l] clusters, I present in (3) the accuracy rates for [pl]/[bl], [fl], and [kl]/[gl] clusters. Given the relative sparsity of the relevant data in the corpus, especially during the first few sessions, I collapse grouping of two adjacent recording sessions together, following a method developed by Santos (2007). As we can see, all clusters except [pl]/[bl] begin to emerge at 1;09.04 and are rapidly acquired, at 2;0.

(3) Anaé's development of obstruent+[l] onsets



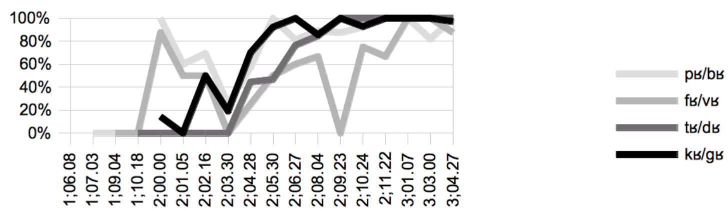
I attribute this rapid pattern of development to the fact that, at the time she began positing branching onsets in her representations, Anaé had already acquired all component sounds contained in the target clusters. Concerning [pl]/[bl], the clusters that display sizeable amounts of variability in (3), a more detailed look at the data reveal that this variability is in fact restricted to two lexical items, *plus* 'more/no more' and *oublié/er* 'forgotten/to forget', both of which show persisting patterns of [l] deletion. The behaviour of *plus* can be related to an input effect, as this word is often pronounced without an [l], especially when used in negative contexts (e.g., *on n'en a plus* [py] 'we have no more of it'). As for *oublié/er*, the pattern may actually relate to phonotactic opacity of the target string. As noted by Rose (1999), [ljV] sequences are typologically disfavoured.[3]

In spite of the few noted exceptions, Anaé thus mastered obstruent+[l] clusters at 2;0. However, it is only around then that she began to master the segmental representation for [ʁ], as we saw in (2). We will see in the next subsection that this fact is reflected in her more progressive development of obstruent+[ʁ] clusters.

4.1.2. Anaé's development of obstruent+[ʁ] clusters

As we can see in (4), Anaé's general pattern of development for obstruent+[ʁ] clusters consists, during the very first sessions documented, of the deletion of the second consonant from the target cluster. Labial+[ʁ] clusters then emerge, at age 2;0, followed by coronal+[ʁ] clusters, whose realization is variable until the mastery stage, at 2;04.28, when velar+[ʁ] clusters are also acquired.

(4) Anaé's development of obstruent+[ʁ] onsets



Performance issues also introduce a certain amount of variability in the data. This can be observed with target [pʁ]/[bʁ] clusters, which display apparently random patterns of (non-)production. As alluded to above, we can draw a parallel between this and Anaé's segmental development, as the variability is most notable between 2;0 and 2;04.28, the period within which [ʁ] in singleton onsets also shows accuracy rates fluctuating between 20% and 94%, as we saw in (2).

A closer look at the data for [fʁ]/[vʁ] as well as [tʁ]/[dʁ] clusters also reveals noticeable patterns of variability. Starting with [fʁ]/[vʁ], the accuracy rates are affected by a persistent pattern of [ʁ] deletion from the moment these clusters are first attempted by the child. This pattern is however not phonological; it relates to a lexical exception. Of the 27 cases of [ʁ] deletion observed in these data, 18 (67%) come from a single lexical item, *ouvrir* 'to open', which was only rarely produced with both target onset consonants (7/26 attempts; 27%). Further, 5 of the 7 target-like productions of this word come from an early session, at 2;0. This suggests that while Anaé's phonological system had generally progressed, she settled for a non-target representation of this word for almost the duration of the period observed.[4]

Moving on to [tʁ]/[dʁ] clusters, we observe a two-stage developmental pattern. First, the target cluster is realized as a singleton velar consonant (1;07.03-2;01.05). These productions later become inter-mixed with velar+[ʁ] and target-like, coronal+[ʁ] realizations, which become the leading pattern at 2;06.27. The variability between coronal and velar outcomes cannot be linked to any lexical item. As we can see in (5), the velar outcomes in fact occur in contexts where the cluster is followed by a (non-nasal) back rounded vowel.[5]

(5) Realization of [tʁ] and [dʁ] clusters (examples from Inês at 2;03.30)

a. [t/dʁ]+[u, o]: [k/gV] > [k/gʁV] > [t/dʁV]

Examples: *trop* 'too much' [tʁo] → [kʁɔ]

trouver 'to find' [tʁuve] → [kuve]

b. [t/dʁ]+$V_{[\text{-back, -round}]}$: [t/dV] > [t/dʁV]

Examples: *trésor* 'treasure' [tʁezɔʁ] → [tezɔʁ]

dragon 'dragon' [dʁagɔ̃] → [dagɔ̃]

Again here, it is only after 2;04.28, when Anaé masters [ʁ] in singleton onsets (as we saw in (2)), that target-like productions finally become the norm.

The link between the development of velar+[ʁ] clusters in (2) and the pattern exemplified in (5) is also not trivial: The resolution of velar-influenced productions in (5) takes place within the period when velar+[ʁ] clusters also emerge in the child's productions. Under the view entertained in this paper, the importance of this relation centres around perceptual factors, as phonologically opaque contexts may hinder the child's analysis of the basic segments contained in a given string. The child's analysis can thus be biased by relatively fine phonetic distinctions, here the interaction between coronals, velars and [ʁ], all of which are lingual consonants with relatively similar acoustic cues concerning their respective places of articulation (e.g., Borden et al. 2006). Further evidence for this analysis comes from similar velarization patterns affecting coronal+[ʁ] clusters in French child language, by Théo, a learner of Québec French (Rose 2000), and Marilyn, a learner of Lyon French (Santos 2007). Clearly, uvular [ʁ] casts a perceptual shadow over the preceding coronal within onsets, the effect of which may also be influenced by the following vowel, as seen in Anaé's data above. Also common to all three children is the fact that velarization does not affect their target labial consonants.

In sum, we observe important relationships between the emergence of target clusters and that of the segmental categories that compose these clusters. While the systematic nature of the learning curves displayed by the child may at times be partially hindered by lexical or phonological exceptions, their interpretation offers important insights into the nature of the child's developing system, here for example about Anaé's development of branching onsets, itself influenced by her acquisition of places of articulation among lingual consonants. Similar findings are uncovered in the next section, where we turn to Inês's development of European Portuguese.

4.2. Inês's [l/ɫ], [ɾ], and [ʃ/ʒ] in onsets and codas

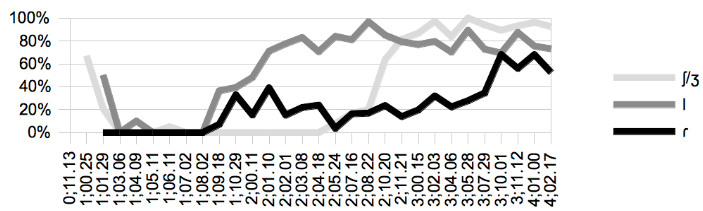
In this section, I discuss the development of [l/ɫ], [ɾ], and [ʃ/ʒ] in Inês's word productions. Many of the data compilations discussed in this section are adapted from Burkinshaw's (in prep.) study of relationships between segmental and prosodic levels of phonological development. Similar to what we saw above, variability also manifests itself in contexts where the child's analysis is hindered by properties of the Portuguese phonological system.

Before we move to the data, I first describe a few aspects of the phonology of European Portuguese which are relevant for the discussion. As reported by Mateus & d'Andrade (2000), [l/ɫ], [ɾ], and [ʃ/ʒ] are the only consonants allowed in coda position in Portuguese. Of these, the lateral is realized as the apical (or 'clear') allophone [l] in onset, and as the velarized (or 'dark') allophone [ɫ] in coda. Also determined allophonically is the realization of the alveopalatal fricative, following two rules of sandhi. The first rule governs the voicing of fricative codas, which assimilate in voicing to the following onsets. This rule is ignored below, where the focus revolves around the second sandhi rule, according to which word-final consonants undergo resyllabification into the onset of any vowel-initial word following it. Voicing also applies in this intervocalic context, where the fricative is allophonically realized as its anterior counterpart [z] (e.g., *pois acho* /pojʃ aʃu/ → [ˈpojˈzaʃu]; Inês at 3;04.06). Given this system of allophony, the child is faced with significant patterns of variation each time she encounters a [ʃ/ʒ]-final lexical item across different allophonic contexts. While approaches based primarily on input effects would predict relative randomness in early renditions of these words, Inês actually displays a high level of command of this system, even in her earliest productions. Again here, the systematicity of the patterns is taken as support for the emergence of a categorical system of representations in the child's lexicon.

4.2.1. Inês's development of [l], [ɾ], and [ʃ/ʒ] in onsets

Starting with singleton onsets in (6), the only clear picture comes from [l], which emerges first at 1;09.18 and is mastered by the child a few months later, at 2;01.10. In contrast to this, Inês does not attain mastery of [ɾ] during the observed period. This consonant is realized in various ways (e.g., as [l], [j], [d/t]) or undergoes deletion altogether. Finally, [ʃ/ʒ] show an interesting pattern of development. These fricatives are first produced as [t/d], between 1;10.29 and 2;08.22, when target-like productions begin to emerge, to become the norm two months later at 2;10.20.

(6) Inês’s [l], [ɾ], and [ʃ/ʒ] in singleton onsets



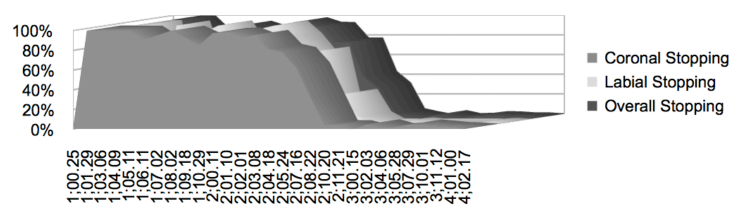
The acquisition of [l] is a textbook example of categorical development: The child masters the lateral articulation of [l] during a small developmental window (between 1;09.18 and 2;01.10), and from there maintains a strong accuracy rate. The late development of the rhotic [ɾ] is consistent with observations of other learners of Portuguese (e.g., Freitas 1997; Costa 2010) as well as of learners of other languages with this phone in their inventories (e.g., Spanish; Bedore 1999). Note that this observation is contrary to expectations if input frequency were to be the determining factor in consonant development: [ɾ] is indeed a very frequent consonant in Portuguese (e.g., Almeida 2011: 60), and is the second-most attempted consonant in Inês’s corpus, immediately after [ʃ].[6]

The three-stage developmental sequence for [ʃ/ʒ], which begins with [ʃ/ʒ] deletion, followed by a stopping stage ([ʃ/ʒ] → [t/d]) between 1;10.29 and 2;10.20, when the consonants are finally mastered, requires further attention. I interpret these three stages as follows. During the initial stage of consonant deletion, the child did not have a representation for [ʃ/ʒ] coronal fricatives, which were omitted altogether in her spoken forms. The child then mastered the place feature of these fricatives, however without an articulatory match for continuancy, hence the stopping pattern. Continuancy was acquired later, at 2;10.20.

As discussed by Inkelas & Rose (2007), prosodic positions within the syllable or word can leave their signatures at the articulatory level. Syllable onsets, for example, are generally more prone to forceful articulations than syllable codas. Continuant stopping, which involves a more extended gesture of the mobile articulator toward the point of articulation, is thus more likely to occur in onsets than in codas (see, also Marshall & Chiat 2003). One of the challenges for the child is thus to control the extent of the gesture toward the point of articulation in order not to fully obstruct the airflow.

While this analysis makes reference to articulatory pressures, I maintain that the generalization attained by the child is at a deeper, more abstract level. This contention is independently supported by data on the acquisition of both [s/z] and [f/v]. As we can see in (7), these consonants, together with [ʃ/ʒ], follow essentially the same developmental sequence (deletion-stopping-target), with stopping resolved for both labials and coronals during the same, narrow time window. As the two places of articulation involve largely different sets of articulators (and related motor plans), the robustness of the pattern in 15) must involve a deeper level of abstraction, which I take here as the featural level of representation.

(7) Stopping rates across sessions



It is also interesting in this context to note that target approximants, which do not involve fricative noise, must be analyzed by the child as a separate manner category. As noted above, the child did not fully master the flapping articulation required for the production of [ɾ] during the period documented in the corpus. [l] substitutions, which account for the vast majority of the substitutions for [ɾ] in onsets, however enabled the child to maintain the continuancy of the target approximant. In line with Santos (2007), I analyze this substitution as optimal since the lateral articulation of [l] enables both a full articulatory point of contact (between the apex and the alveolar ridge) and the production of a continuant, non-fricative consonant.

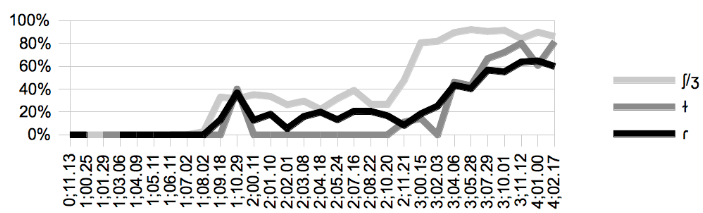
In the next subsection, I turn to the acquisition of the same classes of phones in coda. As we will see, while the codas emerge at the same time as their onset counterparts, they do not follow the same developmental path. Among other differences, target fricatives virtually never undergo stopping when produced in syllable codas, as correctly predicted by the current analysis.

4.2.2. Inês's development of [ɫ], [ɾ], and [ʃ/ʒ] in codas

As mentioned above, all three coda types found in the ambient language begin to emerge during the same period as in onset (1;07.02 to 1;08.02). However, the mastery of these consonants in coda is hindered by a partially different set of perceptual and articulatory pressures. Below I discuss a number of such pressures, including the velarity of the [ɫ] allophone as well as the articulations involved in the production of flap [ɾ] and of the fricatives [ʃ/ʒ].

Starting with [ɫ], we observe in (8) the first target-like productions of this consonant at 2;11.21, the accuracy rate of which increases between 3;04.06 and the end of the documented corpus, although it never reaches the 80% threshold. During the period of variable productions, the most noticeable pattern of substitution involves the production of [l] for [ɫ], from 1;07.02 to 3;07.29, when the predominant substitution pattern becomes [ɫ] → [ɾ] and remains so during the last five sessions documented in the corpus.

(8) Inês's [ɫ], [ɾ], and [ʃ/ʒ] in codas



Importantly, in virtually all cases of target [ɫ] produced as [l], the lateral is syllabified in an onset in the form produced by the child, due to either final vowel epenthesis, as in (9a, b), or following the general rule of external sandhi, as in (9c).

(9) Examples of coda [ɫ] resyllabification as [l] in onsets

a. *azul*	[ɐˈzuɫ]	[ɐˈduli]	2;05.24
b. *pincel*	[pĩˈsɛɫ]	[piˈʃɛli]	2;08.22
c. *igual à outra*	[iˈgwaɫ a ˈotɾɐ]	[iˈgwa la ˈotɐ]	3;04.06

The development of coda [ɾ] follows a similar trajectory. We observe sporadic target-like productions of this consonant from 1;09.18 (at a rate of 25% of all productions or less), a pattern which becomes more prominent at 3;04.06 (reaching between 40% and 60% of all productions). However, similar to [ɫ], [ɾ] is never acquired during the observed period. From the beginning, the most common pattern of substitution is [ɾ] → [ɫ], the predominance of which is supplanted by the more frequent target-like productions of [ɾ] at 3;04.06 noted above. Interestingly, while target [ɾ] is substituted by 'clear' [l] in onsets, it is substituted by 'dark' [ɫ] in codas (e.g., *tocar* [tuˈkaɾ] → [tuˈkali] at 2;03.08; *lugar* [luˈgaɾ] → [luˈgaɫ] at 2;10.20), also in line with the general phonotactic distributions of Portuguese.

Finally, the fricatives [ʃ/ʒ] first emerge at 1;08.0, but are produced at a rate consistently inferior to 50% until 2;11.21. From the next session (3;00.15) onward, target-like productions become the norm, with accuracy rates consistently above 80% until the end of the period covered by the corpus.

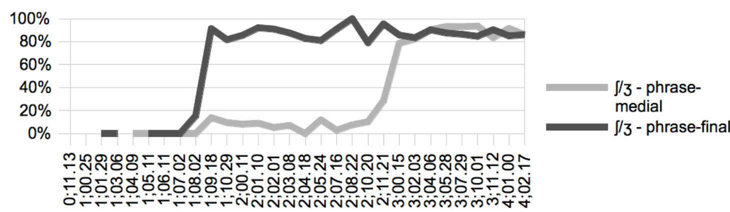
Contrary to what we observed for [l] in onsets, the dark allophone [ɫ] is thus not mastered during the period covered by the corpus. I attribute the late acquisition of this consonant to general properties of voiced velar constrictions and related to articulatory constraints (e.g., Ohala 1983; McAllister Byun 2009, 2012). Also, while [l] is the optimal substitute for the production of approximants in onsets, it is not an appropriate substitute in coda, where its apicality does not offer perceptual or articulatory matches for either target [ɾ] or [ɫ].

While gradual/variable development is predicted for coda [ɫ] and [ɾ] above, the same should not apply in the case of [ʃ/ʒ]. Recall, however, that the development of obstruent continuants displays categorical patterning in onset, even in the context of articulatory pressures (resulting in stopping). In light of this, the below-50% rate of productions of [ʃ/ʒ] sustained for over a year (1;08.02 to 2;11.21) is rather unexpected. A closer look at the data however reveals conspiring effects, which, when considered, provide an explanation for this variability.

The first effect is lexical, and relates to Inês's own name, her production of which as [(ne)ˈnɛ] for an extended period of time did not keep up with the remainder of the Inês's own productive abilities. Indeed, from the beginning of the corpus until 2;04.18, she deleted 98% (175/179) of target [ʃ] in *Inês*.

Also at work are phonological factors which directly relate to the phonotactics of Portuguese. As described above, coda [ʃ/ʒ] are produced as [s/z] when resyllabified in onsets in Portuguese. Inês closely adheres to this rule, which adds to the variability of her target [ʃ/ʒ] codas. Crucially, this variability is only superficial in that once the conditioning factors are identified, a clear and systematic picture emerges from the data (see (10) below). External sandhi plays another role in the variability observed in the data. As shown by Freitas (1997), child learners of European Portuguese first develop coda fricatives in word-final position, before these same consonants appear word-medially before onsets.[7] Inês follows this developmental pattern systematically, however with an additional twist: The phrase, as opposed to the word, is the relevant domain of analysis in the present case. A separation of the data between phrase-medial and phrase-final attempts at coronal fricatives indeed reveals that the child mastered [ʃ/ʒ] phrase-finally at 1;09.18, much earlier than in non-final positions, at 3;00.15. This distinction is best represented in (10), which excludes attempts at *Inês* as well as all cases of resyllabification of target [ʃ/ʒ] in onsets, the patterning of which is already discussed above.

(10) Production of [ʃ/ʒ] in codas



This positionally-determined asymmetry in the acquisition of [ʃ/ʒ] in coda supports Freitas's (1997) contention that Portuguese learners initially analyze medial and final coda fricatives in different ways. Again here, the evidence supports the need for highly-articulated representations, to account for the child's analyses of the target language. The asymmetries observed also reveal a great deal of understanding of the phonotactics of the target system by Inês, who obviously became aware of the relation between syllabification and the distribution of [ʃ/ʒ] and [s/z] relatively early on.

5. Discussion

I discussed in relative detail patterns of phonological development in first-language learners of two Romance languages. The data reveal systematic changes in the phonological patterning of the children's productions across the developmental periods observed: A given structure (segment or syllabic constituent) first emerges in a small number of word forms, and then rapidly spreads across the productive lexicon. We also witnessed a number of inter-relations between segmental and syllable-level units. Segmental development, even if incomplete, is a pre-condition to the elaboration of syllable constituents, as discussed in section 3 and evidenced in several areas of the case studies in section 4 above. Certain positions within the syllable may also constrain segmental production and thus induce substitution patterns (e.g., stopping, in section 4.2.1). We also observed a number of lexical exceptions which, while they can be explained, add a certain amount of noise to the overall data. These are analyzed as phonological misrepresentations within the lexicon, be they induced by children's misanalyses of the ambient signal or by peculiarities of language varieties spoken in the child's environment. Together, these observations support the current view of the child's building of phonological representations. These representations consist of the set of segmental and prosodic categories identified through analyses of the ambient signal into discrete categories as well as of the articulatory properties required to reproduce these categories in spoken forms. Importantly, these phonological categories transcend both purely superficial (acoustic, statistical) properties of the signal or the range of articulations required for the reproduction of these categories.

From a formal perspective, the relations between segmental and syllable-level development observed in both case studies above pose a clear empirical challenge for views of phonology that reject independent phonological categories such as the segment or hierarchically-organized levels of prosodic representation (V&C). From a developmental perspective, the emergent nature of the patterns observed would remain unexplained (undescribed, even) within radical nativist approaches to phonology (H&R). The emergentist view adopted here is consistent with formal and developmental considerations, the latter extending into early linguistic behaviours unveiled by experimental research on infant speech perception.

However, while the proposal sketched in this paper provides a general frame of analysis for the development of phonological productions, it is also limited in that it does not specify in their detail many of the mechanisms invoked. Focussing on phonology proper, a more detailed analysis should explicitly specify the segmental features and prosodic representations present in the children's representations at each developmental stage described above (e.g., Goad & Rose 2004; Levelt & van Oostendorp 2007; Fikkert & Levelt 2008). These representations should also make reference to the relevant set of acoustic dimensions detected by the child, as posited for example within the PRIMIR model of perceptual development (Werker & Curtin 2005; see also Zamuner 2011, in press). Finally, this work also has implications for models of lexical development (e.g., Stoel-Gammon 2011 for a recent summary). I leave the exploration of these further horizons for future research.

References

Almeida, L. (2011). Acquisition de la structure syllabique en contexte de bilinguisme simultané portugais-français. Doctoral dissertation, Universidade de Lisboa.

Ambridge, B. & Lieven, E.V.M. (2011). *Child Language Acquisition: Contrasting Theoretical Approaches*. Cambridge: Cambridge University Press.

Barlow, J. (1997). A Constraint-Based Account of Syllable Onsets: Evidence from Developing Systems. Doctoral dissertation, Indiana University.

Bedore, L. (1999). The Acquisition of Spanish. In O.L. Taylor & L.B. Leonard (Eds.) *Language Acquisition in North America*, pp. 157-208. San Diego, CA: Singular.

Borden, G.J., Harris, K.S. & Raphael, L.J. (2006). *Speech Science Primer: Physiology, Acoustics, and Perception of Speech*. Philadelphia: Lippincott Williams & Wilkins.

Burkinshaw, K. (in prep). Segmental and Prosodic Development: A Corpus-based, Cross--linguistic Investigation. Master's thesis, Memorial University of Newfoundland.

Bybee, J.L. (2001). *Phonology and Language Use*. Cambridge: Cambridge University Press.

Chomsky, N. & Morris H. (1968). *The Sound Pattern of English*. New York: Harper & Row.

Correia, S. (2009). The Acquisition of Primary Word Stress in European Portuguese. Doctoral dissertation, Universidade de Lisboa.

Correia, S., Costa T. & Freitas M. J. (2010). EP_Mono. Database of the Acquisition of European Portuguese as L1 (Monolingual Data). Lisbon: Laboratório de Psicolinguística, CLUL/PhonBank Project.

Costa, T. (2010). *The Acquisition of the Consonantal System in European Portuguese: Focus on Place and Manner Features*. Doctoral dissertation, Universidade de Lisboa.

Demuth, K. (2007). The Role of Frequency in Language Acquisition. In I. Gülzow & N. Gagarina (Eds.) *Frequency Effects in Language Acquisition*, pp. 528-538. Berlin: Mouton de Gruyter.

Fikkert, P. (1994). *On the Acquisition of Prosodic Structure*. The Hague: Holland Academic Graphics.

Fikkert, P. & Freitas, M.J. (1997). Acquisition of Syllable Structure Constraints: Evidence from Dutch and Portuguese. In A. Sorace, C. Heycock & R. Shillcock (Eds.) *Language Acquisition: Knowledge Representation and Processing. Proceedings of GALA 1997*, pp. 217-222. Edinburgh: Edinburgh University Press.

Fikkert, P. & Freitas, M.J. (2006). Allophony and Allomorphy Cue Phonological Development: Evidence from the European Portuguese Vowel System. *Journal of Catalan Linguistics* 5: 83-108.

Fikkert, P. & Levelt, C. (2008). How does Place Fall into Place? The Lexicon and Emergent Constraints in Children's Developing Grammars. In P. Avery, B.E. Dresher & K. Rice (Eds.) *Contrast in Phonology: Theory, Perception, Acquisition*, pp. 231-268. Berlin: Mouton de Gruyter.

Freitas, M.J. (1997). Aquisição da Estrutura Silábica do Português Europeu. Doctoral dissertation, Universidade de Lisboa.

Goad, H. & Rose, Y. (2004). Input Elaboration, Head Faithfulness and Evidence for Representation in the Acquisition of Left-edge Clusters in West Germanic. In R. Kager, J. Pater & W. Zonneveld (Eds.) *Constraints in Phonological Acquisition*, pp. 109-157. Cambridge: Cambridge University Press.

Goldwater, S. (2006). Nonparametric Bayesian Models of Lexical Acquisition. Doctoral dissertation, Brown University.

Hale, M., Kissock, M. & Reiss, C. (2007). Microvariation, Variation, and the Features of Universal Grammar. *Lingua* 1: 645-665.

Hale, M. & Reiss C. (1998). Formal and Empirical Arguments Concerning Phonological Acquisition. *Linguistic Inquiry* 29: 656-683.

Hale, M. & Reiss C. (2003). The Subset Principle in Phonology: Why the *Tabula* can't be *Rasa*. *Journal of Linguistics* 39: 219-244.

Hale, M. & Reiss C. (2008). *The Phonological Enterprise*. Oxford: Oxford University Press.

Hayes, B. & Wilson, C. (2008). A Maximum Entropy Model of Phonotactics and Phonotactic learning. *Linguistic Inquiry* 39: 379-440.

Inkelas, S. & Rose, Y. (2007). Positional Neutralization: A Case Study from Child Language. *Language* 83: 707-736.

Johnson, E.K. & Jusczyk, P.W. (2001). Word Segmentation by 8-Month-Olds: When Speech Cues Count More Than Statistics. *Journal of Memory and Language* 44: 548-567.

Jusczyk, P.W., Cutler, A. & Redanz, N.J. (1993). Infants' Preference for the Predominant Stress Patterns of English Words. *Child Development* 64: 675-687.

Jusczyk, P.W., Houston, D.M. & Newsome M. (1999). The Beginnings of Word Segmentation in English-Learning Infants. *Cognitive Psychology* 39: 159-207.

Kern, S. & Davis, B. (2009). Emergent Complexity in Early Vocal Acquisition: Cross--linguistic Comparisons of Canonical Babbling. In I. Chitoran, F. Pellegrino & E. Marsico (Eds.) *Approaches to Phonological Complexity*, pp. 353-375. Berlin: Mouton de Gruyter.

Kwisthout, J., Wareham, T. & van Rooij, I. (2011). Bayesian Intractability Is not an Ailment that Approximation can Cure. *Cognitive Science* 35: 779-784.

Ladefoged, P. & Maddieson, I. (1996). *The Sounds of the World's Languages*. Cambridge, MA: Blackwell.

Leroy-Collombel, M. & Morgenstern, A. (2012). Rising Grammatical Awareness in a French-Speaking Child from 18 Months to 36 Months: Uses and Misuses of Possession Markers. *French Language Studies* 22: 57-75.

Levelt, C. (1994). *On the Acquisition of Place* (HIL Dissertations in Linguistics 8). The Hague: Holland Academic Graphics.

Levelt, C. & van Oostendorp, M. (2007). Feature Co-occurrence Constraints in L1 Acquisition. In B. Los & M. van Koppen (Eds.) *Linguistics in the Netherlands 2007*, pp. 162-172. Amsterdam: John Benjamins.

Macken, M.A. (1979). Developmental Reorganization of Phonology: A Hierarchy of Basic Units of Acquisition. *Lingua* 49: 11-49.
Marshall, C. & Chiat, S. (2003). A Foot Domain Account of Prosodically-conditioned Substitutions. *Clinical Linguistics and Phonetics* 17: 645-657.
Mateus, M.H. & d'Andrade, E. (2000). *The Phonology of Portuguese*. Oxford: Oxford University Press.
McAllister Byun, T. (2009). The Articulatory Basis of Positional Asymmetries in Phonological Acquisition. Doctoral dissertation, Massachusetts Institute of Technology.
McAllister Byun, T. (2012). Positional Velar Fronting: An Updated Articulatory Account. *Journal of Child Language* 39: 1043-1076.
McAllister Byun, T., Inkelas, S. & Rose, Y. (2012). Transient Phonology, CON and Child Phonological Processes. Paper presented at the 20th Manchester Phonology Meeting, Manchester, May 24-26.
McCarthy, J.J. & Prince, A.S. (1986/1995). Prosodic Morphology. In J.A. Goldsmith (Ed.) *The Handbook of Phonological Theory*, pp. 318-366. Oxford: Blackwell.
Menn, L. (1983). Development of Articulatory, Phonetic, and Phonological Capabilities. In B. Butterworth (Ed.), *Language Production*, volume 2, pp. 1-49. London: Academic Press.
Mielke, J. (2008). *The Emergence of Distinctive Features*. Oxford: Oxford University Press.
Morgenstern, A. & Parisse, C. (2012). Constructing "Basic" Verbal Constructions: A Longitudinal Study of the Blossoming of Constructions with Six Frequent Verbs. In M. Bouveret & D. Legallois (Eds.) *Constructions in French*, pp. 127-153. Amsterdam: John Benjamins.
Ohala, J.J. (1983). The Origin of Sound Patterns in Vocal Tract Constraints. In P.F. MacNeilage (Ed.) *The Production of Speech*, pp. 189-216. New York: Springer.
Pater, J. (1997). Minimal Violation and Phonological Development. *Language Acquisition* 6: 201-253.
Pierrehumbert, J. (2001). Exemplar Dynamics: Word Frequency, Lenition and Contrast. In J.L. Bybee & P. Hoppe (Eds.) *Frequency and Emergence in Grammar*, pp. 137-157. Amsterdam: John Benjamins.
Pierrehumbert, J. (2003). Phonetic Diversity, Statistical Learning, and Acquisition of Phonology. *Language and Speech* 46: 115-154.
Rose, Y. (1999). A Structural Account of Root Node Deletion in Loanword Phonology. *The Canadian Journal of Linguistics / La revue canadienne de linguistique* 44: 359-404.
Rose, Y. (2000). Headedness and Prosodic Licensing in the L1 Acquisition of Phonology. Doctoral dissertation, McGill University.
Rose, Y. (2003). Place Specification and Segmental Distribution in the Acquisition of Word--final Consonant Syllabification. *The Canadian Journal of Linguistics / La revue canadienne de linguistique* 48: 409-435.
Rose, Y. (2009). Internal and External Influences on Child Language Productions. In F. Pellegrino, E. Marsico, I. Chitoran & C. Coupé (Eds.) *Approaches to Phonological Complexity*, pp. 329-351. Berlin: Mouton de Gruyter.

Rose, Y. & Inkelas, S. (2011). The Interpretation of Phonological Patterns in First Language Acquisition. In C.J. Ewen, E. Hume, M. van Oostendorp & K. Rice (Eds.) *The Blackwell Companion to Phonology*, pp. 2414-2438. Malden, MA: Wiley-Blackwell.

Saffran, J.R., Newport, E.L. & Aslin, R.N. (1996). Word Segmentation: The Role of Distributional Cues. *Journal of Memory and Language* 35: 606-621.

Santos, C. (2007). Développement phonologique en français langue maternelle: une étude de cas. Doctoral dissertation, University Lumière Lyon 2.

Selkirk, E.O. (1982). The Syllable. In H. van der Hulst & N. Smith (Eds.) *The Structure of Phonological Representation*, voume. 2, pp. 337-385. Dordrecht: Foris Publications.

Smith, N.V. (1973). *The Acquisition of Phonology: A Case Study*. Cambridge: Cambridge University Press.

Spencer, A. (1986). Towards a Theory of Phonological Development. *Lingua* 68: 3-38.

Steriade, D. (1999). Phonetics in Phonology: The Case of Laryngeal Neutralization. *UCLA Working Papers in Linguistics* 3: 25-246.

Stoel-Gammon, C. (2011). Relationships between Lexical and Phonological Development in Young Children. *Journal of Child Language* 38: 1-34.

Thiessen, E.D. & Saffran, J.R. (2003). When Cues Collide: Use of Stress and Statistical Cues to Word Boundaries by 7- to 9-Month-Old Infants. *Developmental Psychology* 39: 706-716.

Vihman, M. (1996). *Phonological Development: The Origins of Language in the Child*. Oxford: Blackwell.

Vihman, M. & Croft, W. (2007). Phonological Development: Toward a "Radical" Templatic Phonology. *Linguistics* 45: 683-725.

Waterson, N. (1987). *Prosodic Phonology: The Theory and its Application to Language Acquisition and Speech Processing*. Newcastle: Grevatt & Grevatt.

Werker, J.F. & Curtin, S. (2005). PRIMIR: A Developmental Framework of Infant Speech Processing. *Language Learning and Development* 1: 197-234.

Yamaguchi, N. (2012). Détermination des parcours d'acquisition des sons du langage chez des enfants francophones à développement typique. Doctoral dissertation, Université Sorbonne Nouvelle Paris 3.

Zamuner, T.S. (2011). Stepping Backwards in Development: Integrating Development Speech Perception with Lexical and Phonological Development – A Commentary on Stoel-Gammon's "Relationships Between Lexical and Phonological Development in Young Children". *Journal of Child Language* 38: 56-60.

Zamuner, T.S. (in press). Phonotactic Probabilities in Young Children's Speech Perception. *Language Acquisition.*

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[1] H&R not only reject this possibility, they also explicitly avoid discussing it on the grounds that such accounts are so divergent from theirs that they cannot "easily draw comparisons" (Hale, Kissock & Reiss 2006: 657).

[2] The current work however departs from Goad & Rose (2004) concerning the innateness of phonological primitives. Under the current hypothesis, the primitives of phonological systems can be inferred by the learner and, thus, need not be posited as innately available. Only the learning mechanisms as well as constraints on phonological perception, representation and production are considered to be universal.

[3] I leave for further investigation of Anaé's [j] behaviour both in singleton positions and in clusters for further research. The central point of the current discussion is that *oublié/oublier* behaves as a lexical exception.

[4] This observation actually suggests another line of analysis, namely that *ouvrir* is a morphologically complex word which, when uninflected, may be pronounced as [uv], instead of [uvʁ]. In case the child were sensitive to morphological structure during the relevant period, Anaé's productions of *ouvrir* as [uviʁ] would in fact reflect the correct morphological analysis based on the evidence available to her.

[5] Interestingly, nasal vowels do not yield the velarization process, irrespective of their places of articulation. This, too, suggests a subtle yet systematic analysis of the perceptual space on the child's part.

[6] As argued recently by Yamaguchi (2012), frequency may be a predictor if used at the level of the phonological feature; I leave this intriguing possibility for further consideration.

[7] The evidence in fact points at a word-final syllabification of these consonants as onsets of empty-headed syllables, for example the frequent epenthesis of a vowel after these consonants (see Freitas 1997 for an early analysis of the development of liquids in this position in European Portuguese).