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From phonetics to phonology: The emergence of first words in Italian*

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ABSTRACT

This study assesses the extent of phonetic continuity between babble and words in four Italian children followed longitudinally from 0;9 or 0;10 to 2;0 – two with relatively rapid and two with slower lexical growth. Prelinguistic phonetic characteristics, including both (a) consistent use of specific consonants and (b) age of onset and extent of consonant variegation in babble, are found to predict rate of lexical advance and to relate to the form of the early words. In addition, each child's lexical profile is analyzed to test the hypothesis of non-linearity in phonological development. All of the children show the expected pattern of phonological advance: Relatively accurate first word production is followed by lexical expansion, characterized by a decrease in accuracy and an increase of similarity between word forms. We interpret such a profile as reflecting the emergence of word templates, a first step in phonological organization.

The understanding of prespeech development and its relationship to early meaningful speech has greatly increased in recent years. Since the studies and reviews of the 1980s (Locke, 1983; Menn, 1983; Stoel-Gammon & Cooper, 1984; Vihman, Macken, Miller, Simmons & Miller, 1985; Menyuk,

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Menn & Silber, 1986) a good deal of research has focused on describing the phonetic characteristics of babbling and first words in an attempt to identify predictors of lexical development (cf. Menyuk, Liebergott & Schultz, 1986; Stoel-Gammon, 1992). Many studies have compared the phonetic characteristics of typically developing children in the transition into language to a group of toddlers known as Late Talkers (children who fail to produce at least fifty words or any two-word combinations by two years of age: Rescorla, 1989; Pharr, Ratner & Rescorla, 2000; D'Odorico, Bortolini, De Gasperi & Assanelli, 1999). Late Talkers have been found to be less voluble than their typically developing peers (Thal, Oroz & McCaw, 1995; Pharr *et al.*, 2000) and weaker on most phonetic measures in comparison to their age-matched controls but similar to or stronger than younger children matched for number of words reported on the CDI (Thal *et al.*, 1995). In addition, their lack of experience with producing consonants has been identified as a possible cause for their lexical delay (Stoel-Gammon, 1989; cf. also Thal *et al.*, 1995; Pharr *et al.*, 2000), suggesting a relationship between phonetic skills and rate of lexical advance.

This study set out to follow the phonological development of four Italian children up to age 2;0, two who advance relatively quickly in acquiring a lexicon and two who advance relatively slowly. Although many studies have analyzed the phonetic characteristics of typically developing children and Late Talkers acquiring English (e.g. Stoel-Gammon, 1989; Pharr *et al.*, 2000), fewer studies have addressed the phonetic and phonological characteristics of children acquiring other languages, including Italian (but see D'Odorico *et al.*, 1999; Orsolini, 2002). This study explores the range of typical development by characterizing its extremes: children within the norm who are either very quick to acquire words or relatively slow. It extends from the earliest expression of phonetic skills in children's babbled productions, through changes and advances in early word use, and into the beginnings of the construction of a phonological system. At the most general level we look for relationships between prelinguistic phonetic characteristics of children's babble or first words and their lexical advance at age 2;0, i.e. to see whether and in what way lexically advanced two-year-olds differ from slow-to-advance two-year-olds in their prelinguistic phonetic characteristics. At a more detailed level, we seek to understand how these relationships come about, and to sketch the trajectory of phonetic and phonological advance over time.

We therefore follow the children's progress from babble to words in some detail, to observe how early phonetic characteristics influence children's progress in word learning, from the very earliest stages of word production to more advanced stages. We trace each child's developmental path, highlighting individual differences as well as showing the similarities within each pair of children – the lexically advanced and the lexically slow to advance.

In this paper we will be following a model stressing non-linear development and individual differences in the transition into language which has been proposed in several studies by Vihman and her colleagues (e.g. Vihman, 1996; Vihman & Velleman, 1989, 2000; Vihman, Velleman & McCune, 1994; Velleman & Vihman, 2002; Vihman & Kunnari, 2006; Vihman & Croft, 2007). According to these studies formal accuracy, that is, the child's ability to approximate adult word targets, shows non-linear development or regression and considerable individual differences. Vihman & Velleman (2000) suggested that the first words, which are relatively accurate and which also closely resemble the repertoire of babbling patterns of the individual child, should be seen as the product of the child's implicit matching of his/her own production patterns to roughly similar input word forms (mediated by the articulatory filter[1]: Vihman, 1993; see now DePaolis, 2006), resulting in the selection of words to say on the basis of their phonetic accessiblity (cf. also Ferguson & Farwell, 1975). In line with this claim, McCune & Vihman (2001) and Keren-Portnoy, DePaolis & Vihman (2005) looked at the effect of children's emerging consonant production skill on word learning. They followed the children's development of Vocal Motor Schemes (VMS) – generalized articulatory plans indexed by children's ability to consistently produce a given consonant over a period of time. Both studies found that children who master one or more VMS earlier start to learn words earlier, and that these words are largely based on VMS consonants.

Vihman & Croft (2007) suggest that the earliest phonological structures are whole-word based. This claim rests on three types of evidence seen in children's productions:

> (1) a child may produce the same sounds differently in different words, and some words may be more variable than others … (2) the relation of early child words to their adult models is often found to be difficult to account for on a segment-by-segment basis … (3) the interrelation between the child's own words may be more evident than the relation to the adult models (p. 690)

[1] Vihman (1993) defines the articulatory filter as a phonetic pattern, specific to each child, 'which renders similar patterns in adult speech unusually salient or memorable; in particular, the filter picks out patterns for which the child has already established a "motor plan" or "gestural score"' (p. 74); according to Vihman (1996), such a filter 'selectively enhances motoric recall of phonetically accessible words' (p. 142).

The dominant child patterns of the early word production period are seen as responses to challenges posed by adult target words, primarily, the challenge of producing distinct consonants or distinct vowels, or both, in different syllables or different word positions.

New words which enter a child's productive lexicon do not constitute a mechanical extension of previously used phonetic structures (Vihman & Velleman, 2000). Instead, individual children must arrive at their own solutions to the mismatch between their phonetic skills and the challenges presented by the ambient language. Children's use of well-practised vocal patterns to produce words which, in their adult target form, are only broadly similar to the pattern can be conceptualized as child reliance on 'word templates'. The patterns which were first based on the child's experience of an implicit match between an existing ('in repertoire') vocal form and closely similar adult targets (i.e. on the operation of an 'articulatory filter': see footnote 1) tend later to be applied to word targets which provide no direct phonetic motivation for the pattern. As suggested by Vihman & Croft (2007), word templates 'constitute patterns that reconcile (or ''adapt'') the model provided by target words with the child's own phonetic repertoire of syllables or word shapes – typically extending or building on the forms initially ''selected'' for first word production, in which adult and child forms show a close match' (p. 683). As indicated by Vihman & Croft, who provide a brief history, the idea of 'whole word patterning', encapsulated in the term 'word template', is based on earlier work by Waterson (1971), Menn (1971), Ferguson & Farwell (1975) and Macken (1979), among others.

We term the earliest, relatively 'accurate' word forms SELECTED. Later words are categorized as either SELECTED or ADAPTED. SELECTED words often resemble the repertoire of babbling patterns of the individual child and manifest phonological patterns which may fit many of the child's words as well as constituting a close match to the adult targets. ADAPTED words manifest the same phonological patterns, extended to target words that are less similar to the child's template. In the ADAPTED words the child:

> no longer draws on experience of a match but, rather, projects his own well-practiced output routine onto adult words that require a more or less radical ADAPTATION, such as metathesis, if they are to be accommodated within the child's system. The child is thus drawing on an internal schema, abstracted away from his experience in producing some or all of his early words (Vihman, in press: 6).

The apparent regression in accuracy often seen in relation to the target form in these later words actually demonstrates the increased flexibility in word production afforded by the freedom to adapt adult word forms to existing production resources (Vihman, in press).

Phonetic and phonological phenomena explored in this study

In this study we use two different phonetic indices to characterize babble and early words: the achievement of stability of consonant production (Vocal Motor Schemes, or VMS: McCune & Vihman, 2001) and the phonotactic complexity of babble, specifically the extent of intersyllabic consonantal variegation (Stoel-Gammon, 1989; Pharr *et al.*, 2000). The VMS concept was developed by McCune & Vihman (2001) as a way of capturing a child's emerging competence at reliably producing consonants. A VMS is a consonant which the child produces to criterion frequency over a set number of recording sessions. It is taken to assess the child's ability to target a specific sound and reproduce it successfully, i.e. it is a measure of stability in intentional consonant production. Intersyllabic consonantal variegation in babbling (Smith, Brown-Sweeney & Stoel-Gammon, 1989; Stoel-Gammon, 1989), on the other hand, focuses on a different skill which also first emerges in babbling, namely, the ability to produce consonants differing in place of articulation within a single vocalization. It is thus a measure of the phonotactic complexity of babble. It has been found that children tend to start producing referential (or symbolic) words only once they have attained at least two VMS (McCune & Vihman, 2001). Similarly, the capacity for combining two different consonants in one vocalization in babble (henceforth 'variegated babble') can be expected to prepare the child for producing words which contain different consonants (henceforth 'variegated words'). This skill should take some consolidation, and as we did not know in advance how long this might take, we looked at the use of consonant variegation both in early words and in later words, to see if consonant variegation in babble can serve as a predictor for the emergence of consonant variegation in words over the entire period of this study.

In investigating the children's construction of a phonological system, in line with the model suggested by Vihman and her colleagues (Vihman & Velleman, 2000; Vihman & Croft, 2007), we test the claim of non-linearity in the developmental trajectory of each child's word forms as he or she moves away from the early SELECTED word forms to later ADAPTED forms. In each of the corpora we look for evidence for such a trend, starting by testing whether the very early words SELECTED by a child on phonetic grounds resemble the repertoire of babbling patterns of that child, and then seeing to what extent later forms (a) deviate from the target forms and (b) adhere to the child's idiosyncratic emergent phonology.

A brief description of the phonemic inventory and phonotactic structure of Italian

The Italian phonemic inventory includes twenty-seven consonants and seven vowels (De Mauro, 2003; see Table 1) and is thus not very different

TABLE 1. *Phoneme inventory in Italian*

	Consonants							Vowels		
Voiceless stops and affricates	p		t	ts	tʃ	c	k	i		u
Voiced stops and affricates	b		d	dz	dʒ	ɟ	ɡ	e		o
Voiceless fricatives		f	s		ʃ			ɛ		ɔ
Voiced fricatives		v	z						a	
Nasals	m	ɱ	n			ɲ	ŋ			
Laterals			l			ʎ				
Trill			r							
Glides	w					j				

from English in terms of the phonetic challenges it presents to the child. However, the phonological structure of Italian differs from English in ways that are likely to affect child learners. Most words addressed to children have two or three syllables (e.g. CVCV, CVCVCV, VCVCV); monosyllabic words are rare, as are codas. As Bortolini & Leonard (2000) report, words are usually trochaic (e.g. *pane* [ˈpane] 'bread', *mucca* [ˈmukːa] 'cow'), but Italian also has many words with penultimate (e.g. *ancora* [aŋˈkora] 'again', *cavallo* [kaˈvalːo] 'horse') or antepenultimate stress (e.g. *macchina* [ˈmakːina] 'car', *pecora* [ˈpɛkora] 'sheep'). Word-initial and word-final consonant clusters are uncommon (Barca, Burani & Arduino, 2002).

Previous studies of phonetic and phonological acquisition in Italian

There are very few studies of early phonological development in Italian. Zmarich & Bonifacio (2005) analyzed the phonetic inventories of thirteen children at 1;6, 1;9, 2;0 and 2;3. The first words were found to be characterized by CV structure and to consist mostly of stops and nasals. A study by Bortolini (1995) also found that the most frequent consonants in Italian children's first words are stops and nasals.

Majorano & D'Odorico (in press) analyzed data from eleven typically developing children (four of whom provide the corpora analyzed in this paper). They found that the children's first words had a CVCV structure (e.g. *mamma* [mam:a], *papá* [papa], *tata* [tata]).[2] In the period from 1;6 to 1;8 the children began to produce words with consonantal variegation (e.g. *cade* [kade], *tappo* [tap:o]) and also longer words (three or more syllables, e.g. *banana* [banana], *piccolo* [pikolo], *pericoloso* [perikolozo]); the number

[2] Rather than encumber the text with glosses for Italian target words we list all those mentioned in the paper in the Appendix, in alphabetical order.

of words containing a consonantal cluster also increased (e.g. *bimba* [bimba], *prendi* [pendi], *grande* [grande]).

Quantitative and qualitative hypotheses

Although, given the small sample size, no statistical tests could be run, some of the hypotheses are based on quantifiable measures, such as ages or frequencies. The qualitative hypotheses involve no measurable variables but seek to characterize the data descriptively. The hypotheses were tested on the production data of four children, two with relatively rapid and two with relatively slow lexical advance. Our hypotheses were as follows (purely QUALITATIVE HYPOTHESES are marked as such):

1. Early phonetic characteristics: Testing the empirical construct
   All indices of prelinguistic phonetic skill (VMS mastery, gauged both by age at the first two VMS and by total number attained, and Consonant variegation skill, gauged both by age at first consonant variegation in babble and by total number of variegated babble vocalizations) will be inter-correlated, suggesting that they tap the same underlying variable of prelinguistic phonetic competence.
2. Predicting lexical advance at age two: correspondence of prelinguistic phonetic skill and early word forms to reported lexical advance at 2;0.
   - 2.1. Good early phonetic skill, gauged by the four prelinguistic phonetic skill measures (two measures each of VMS mastery and of skill in consonant variegation), will be positively related to lexicon size at 2;0.
   - 2.2. *Qualitative*: We expect to see differences between the lexically advanced and the less lexically advanced children in the forms of the earliest words.
3. Characterizing the course of lexical growth: continuity between early phonetic skills and word production. These hypotheses were first tested relative to the children's early words and then, if relevant, to their later words.
   - 3.1. Early emergent mastery of consonant production, as gauged by age at two VMS, will be related to onset of word use, as gauged by age at a cumulative lexicon of ten words as well as age at the '10-word-point' (i.e. the first half-hour session at which at least ten words are produced).
   - 3.2. Words will be largely based on VMS consonants.
   - 3.3. Mastery of consonant variegation in babble (gauged by age at first variegated babble production and by total number of variegated babbling vocalizations) will be related to consonant variegation in words (measured by age at the first variegated word and by the

age at which variegated words become a sizeable proportion of a child's word forms).

   3.4. The identity of the consonants participating in variegation in early words will be related to the identity of the consonants participating in variegation in babble.

4. Non-linearity in phonological development – *Qualitative*
   4.1. Early child word forms will, on the whole, be closer to the target forms than later words, which will show targeting of a wider range of adult forms and ADAPTATION of targets to the child's other word-form patterns.
   4.2. The lexically advanced children will differ from the lexically slow-to-advance children in the kinds of word templates they use.

METHOD

Participants

The participants in this study are drawn from a larger sample of eleven Italian children included in a longitudinal study of phonological development (Majorano & D'Odorico, in press). Each child was followed from 0;10 to 2;0. The four children included in this study contrasted sharply in their vocabulary development, as assessed by the *Primo Vocabolario del Bambino* – PVB (Caselli & Casadio, 1995; an Italian version of the MacArthur-Bates Communicative Development Inventory [CDI]): two children (Anna [female] and Luca [male]) showed the most advanced productive vocabulary development of the entire group at 2;0 (355 words and 360 words reported in the PVB, respectively, both corresponding to the 75th percentile), and the other two children (Nicola [male] and Nina [female]) showed the slowest lexical development (220 words and 71 words, respectively, corresponding to the 25th and 10th percentiles).[3]

The children were recruited through infant-care classes; all were first-born. All of the parents had at least completed high school; one had a postgraduate degree. The children had normal hearing and no evident motor or cognitive deficits.

Data collection

The children were video-recorded once a month in the home for half an hour of free play, using a standard set of toys, from age 0;9 or 0;10 through age 1;2. A digital handycam DCR-PC 105 was used for the video-recording. A Sony ICD-P17 microphone was hidden in a cloth vest worn by the children. The observations were supplemented by monthly maternal reports

[3] Percentiles are based on norms for PVB data from 386 Italian children between ages 1;6 and 2;6 (Caselli & Casadio, 1995).

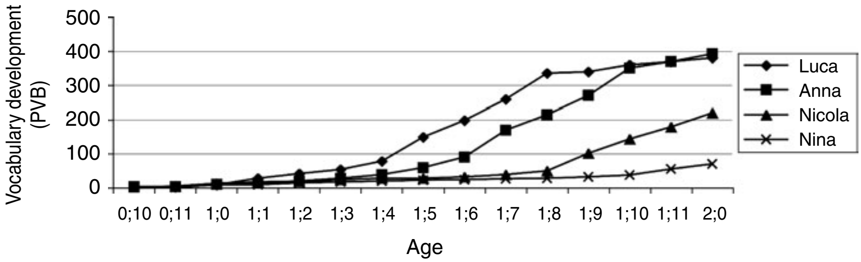

Fig. 1. Vocabulary development of the four children.

regarding the child's lexicon (both productive and receptive), using the PVB.

From 1;4 to 2;0 the children attended bimonthly recording sessions at the Infancy Laboratory of the University of Parma. The children were video-recorded with their mothers for thirty minutes. Four different sets of toys were used: a farm, a 'nurturing' set (a telephone, a doll with bed, mattress and pillow), a 'food' set (plastic fruit and vegetables with dishes and cutlery) and some illustrated books. Mothers were asked to play with their children as they usually do, but to draw their attention to each set of toys. Thus the children were observed monthly from the age of 0;9 or 0;10 to 1;2, and then at 1;4, 1;6, 1;8, 1;10 and 2;0. Vocabulary development as reported monthly in the PVB is shown in Figure 1.

As shown in Figure 1, the lexical development of the two more advanced children is quite similar; they reach the same level by 2;0. The lexical development of the two children who made slower progress is similar until around 1;7, but from this point on their trajectories diverge, with Nicola showing a vocabulary spurt while Nina maintains her slow growth.

Transcription

Two experienced transcribers broadly transcribed the videotape recordings using the International Phonetic Alphabet (IPA), with contextual information (child activity, gestures and direction of gaze) relating to vocalizations and all of the mother's and observer's actions or talk addressed to the child. Vocalizations composed of singing, counting, grunts, cries, screams, laughs or vocalizations overlaid by noise or parent's voice were not transcribed.

Reliability

Following Thal *et al.* (1995) and McCune & Vihman (2001), the reliability of phonetic transcription was evaluated by point-to-point agreement for the two transcribers, based on approximately ten minutes of recording from each participant. Reliability for the number of vocalizations included in the samples was 0.98. Across child vocalizations there was agreement on the specific identity of the consonant in 89% of all cases.

Data analysis

The children's productions were divided into three classes on the basis of phonological and semantic properties: babbling, words and unintelligible utterances. Following Stoel-Gammon (1989) and Vihman & McCune (1994), vocalizations which had no consistent sound–meaning relationship were classified as babbling while those which evidenced a consistent sound–meaning relationship and a phonological form identifiable as based on an adult model were classified as real words. Completely unintelligible vocalizations, defined as vocalizations that could not be confidently transcribed after four listenings, were eliminated from the analysis (twenty-three such vocalizations were eliminated). Imitated vocalizations, self-repetitions and fillers were disregarded in the analyses, as were word combinations (altogether Anna produced twelve and Luca twenty word combinations; the other children produced none).

The following measures were used in the analysis:

(*1*) *Vocal Motor schemes* (*VMS*). Following McCune & Vihman (2001), a given supraglottal consonant was identified as VMS if it occurred at least ten times, in babble and words combined, in each of three or more consecutive sessions, separated by no more than one session. The child was credited with VMS mastery as of the first such session. Stop voicing is not distinguished in our analyses, both because infants have been found to control voice onset time contrastively only some time later than the period covered by this study (Macken, 1980) and because stop voicing is difficult to transcribe reliably. Thus, for example, [k] and [g] are considered a single consonant type [k/g]). Both glides and glottals occur in infant vocalizations in the period before the emergence of canonical babbling; we exclude both from consideration as VMS (again following McCune & Vihman, 2001).

(*2*) *Variegated babbling*. Following Stoel-Gammon (1989), variegated babbling vocalizations are defined as prelinguistic productions that contain two or more different consonant types, disregarding voicing differences. Some examples of variegated babble vocalizations from Luca's corpus are: [boto], [bodo], [botobo] (1;1) and [dokodoko], [petapeta], [towotopodo] (1;2). Consonant variegation sequences were categorized according to places of articulation only (disregarding manner), i.e.: labial + alveolar (e.g. bata or taba); velar + alveolar (e.g. teke or kete); labial + velar (e.g. bake or gaba).[4] We do not distinguish different internal orders between the

[4] Manner of articulation changes within a vocalization occur earlier and are more common in babbling than place changes (Davis, MacNeilage & Matyear, 2002).

TABLE 2. *Prelinguistic phonetic descriptors*

	Age VMS[a]						Age 2 VMS[b]	N VMS[c]	Age VB[d]	N VB[e]	Lex 2;0[f]
	p/b	t/d	k/g	m	n	l					
Anna	0;10	0;10	0;10	0;10	1;8	1;8	0;10	6	0;10	21	355
Luca	0;9	1;0	1;2	1;2	1;8	1;6	1;0	6	1;0	18	360
Nicola	1;1	1;8	1;4	1;4	—	—	1;4	4	1;2	6	220
Nina	1;8	—	1;8	1;4	—	—	1;8	3	—	0	71

[a] Age VMS: age at which each consonant became a VMS.
[b] Age 2 VMS: age at second VMS.
[c] N VMS: number of VMS consonants.
[d] Age VB: age at first variegated babbling vocalization.
[e] N VB: number of variegated babbling vocalizations.
[f] Lex 2;0: Lexicon size at 2;0, based on PVB.

syllables (e.g. [ba] preceding [ta] or vice versa), because the majority of the variegated vocalizations are multisyllabic (trisyllabic or more), with recurring syllables. It seems that the motor ability exhibited by the children is not limited to a specific sequence (as exemplified, for example, in a multisyllabic vocalization such as [bagebagebageba]: Anna, 0;10): the place of articulation alternates between labial and velar. We therefore prefer to treat this as a LABIAL+VELAR pattern, remaining agnostic as to the internal order among these places of articulation.

(*3*) *SELECTED and ADAPTED words*. As recommended in Ingram (2002), only a single production shape is considered for each word. If more than one word shape occurs, the most frequent shape is considered. If there is no one dominant shape, the last one produced is considered. Following Vihman & Velleman (2000) and Vihman & Croft (2007) a template-based approach is used in the phonological analyses.

RESULTS

Babbling and early words

(*1*) *Early phonetic characteristics: Testing the empirical construct*. Table 2 reports data on VMS acquisition and variegated babbling (VB). We investigated the correspondences between each pair of measures of prelinguistic phonetic skill (age at two VMS, number of VMS, age at first VB vocalization and number of VB vocalizations). As can be seen, the different measures all rank the children in the same way: Anna > Luca > Nicola > Nina, such that number of VB and of VMS is highest for Anna and lowest for Nina, and the ages at two VMS and at VB are lowest for Anna and highest for Nina. These results support the claim that all four variables measure aspects of the same underlying variable, 'prelinguistic phonetic skill'.

(*2*) *Correspondence of prelinguistic phonetic skill to lexical advance*

(2.1) The four measures of prelinguistic phonetic skill all rank the advanced children, Anna and Luca, highest (three out of four rank Anna higher), with Nicola third and Nina last, mirroring the children's vocabulary attainments at 2;0 (see Table 2).

(2.2) *Qualitative*: some phonotactic differences between the more and the less lexically advanced children can already be seen in the earliest words (see Table 3). All of the children's early words are disyllabic (the only exception is Nina's [mem] for *mamma*). Some structures are used by both the more advanced and the slower children: the majority of words produced by all of the children have a C_1VC_1V structure, e.g. Nicola [kaka] for *cavallo*. A minority have VCV structure, e.g. Luca [a'go] *occhio*. However, one structure, C_1VNC_1V (where N stands for a nasal consonant), is produced only by the two advanced children at this stage, e.g. Anna [bombœ] *bambola*. A different structure is used only by the slower children: VV with medial consonant omission, e.g. Nicola [ae] *Vale*, Nina [aɛ] *caffè*. This structure is unusual for typically developing children (Majorano & D'Odorico, in press) and is never produced by the two more advanced children.

(*3*) *Continuity between babble and words*

(3.1) Children who master VMS early (see Table 2) tend to produce words early (see Table 3). We looked at the correspondences between the phonetic measure (age at two VMS) and the word onset measures (age at cumulative recorded lexicon of ten words and age at the 10-word point, i.e. the first session at which a child produced around ten different word types). The 10-word-point is reached by different children at different ages: Luca reaches it at 1;4, Anna at 1;6, Nicola at 1;8 and Nina at 2;0.[5] The correspondence between the phonetic measure and the two word onset measures is very high: all three measures rank Anna and Luca highest, followed by Nicola and then Nina.

(3.2) Reliance on VMS in early words: The first ten words produced by each child were considered for this analysis. Table 3 reports the first ten words produced in the sessions by the children, the age at which each word was first produced, and whether the word form as produced by the child is reliant on VMS.

A word was considered VMS-based if at least one of the supraglottal consonants in the child form of that word was VMS for the child at the time

[5] At the '10-word point' Luca and Anna actually have eleven words each; Nicola has only seven words, since at 1;10 he has twnety-five words. Nina's '10-word point' is her final session, when she produces the most words in a session (seven words).

TABLE 3. *First ten words and VMS consonant use in words*

Anna (0;10–1;2)				Luca (0;10–1;2)				Nicola (0;10–1;6)				Nina (1;1–1;8)			
Age/1st use	Child form and gloss	VMS used	Non-VMS used	Age/1st use	Child form and gloss	VMS used	Non-VMS used	Age/1st use	Child form and gloss	VMS used	Non-VMS used	Age/1st use	Child form and gloss	VMS used	Non-VMS used
0;10	bombø *bambola*	**p/b m**	—	0;10	mom:œ *mamma*	—	**m**	0;10	mama *mamma*	**m**	—	1;1	baː'baː *baubau*	—	**p/b**
0;10	mamːa *mamma*	**m**	—	1;0	beja *bella*	**p/b**	—	1;1	bœbːɛ *bimba*	**p/b**	—	1;1	mio *mio*	—	**m**
1;0	bebɛ *bebè*	**p/b**	—	1;1	a'go *occhio*	—	**k/g**	1;1	nenːa *nonna*	—	**n**	1;2	mem *mamma*	—	**m**
1;1	dende *dindon*	**t/d**	**n**	1;1	akwa *acqua*	—	**k/g**	1;2	nanːa *nanna*	—	**n**	1;4	ia *zia*	—	—
1;1	kakɛ *caffè*	**k/g**	—	1;1	be'bɛ *bebè*	**p/b**	—	1;4	ae *Vale*	—	—	1;6	aɛ *caffè*	—	—
1;1	kakːo *cavallo*	**k/g**	—	1;1	bimba *bimba*	**p/b**	**m**	1;4	papːa *papà*	**p/b**	—	1;6	bibːo *bimbo*	—	**p/b**
1;1	nanːa *nanna*	—	**n**	1;1	ka'ka *cocò*	—	**k/g**	1;4	tata *tata*	**t/d**	—	1;8	apːa *scarpa*	**p/b**	—
1;1	nanːa *nonna*	—	**n**	1;1	mi'mi *mimì*	—	**m**	1;6	ame *fame*	**m**	—	1;8	api *apri*	**p/b**	—
1;1	paːpa *papà*	**p/b**	—	1;1	papːa *pappa*	**p/b**	—	1;6	kaka *cavallo*	**k/g**	—	1;8	kaka *acqua*	**k/g**	—
1;2	kalːo *gallo*	**k/g**	**l**	1;1	titːa *tata*	**t/d**	—	1;6	kakːo *casco*	**k/g**	—	1;8	kukːo *ciuccio*	**k/g**	—
Proportion words based on VMS		**8/10**				**5/10**				**7/9**				**4/8**	

the word was first used[6] (note that consonants which are not VMS are not necessarily outside the child's repertoire, but they are not used as consistently as frequently as the VMS consonants). The results are mixed: In two of the corpora (Anna's and Nicola's) there is a clear correspondence between the children's VMS and the sounds used in their first words. As can be seen in Table 3, Anna and Nicola base the majority of their words with consonants on VMS: 7/9 for Nicola, 8/10 for Anna. However, only half of the first words used by Luca and Nina are based on VMS. These results do not strongly support our hypothesis that early words would be VMS-based.

(3.3) Reliance on consonant variegation in words: at the early word stage, when the children's cumulative lexicon included ten words, only one of the children produced a word with supraglottal consonants differing in place (Anna [kal:o] *gallo*), although three of the children exhibit such sequences in their babble during this period. Consonant variegation could thus be said not to occur in the early words. As the relationship between variegation in babble and in early words therefore could not be investigated, we analyzed it in the children's more advanced lexicons.

The prelinguistic phonetic skill measures relating to variegated babbling (see Table 2) and the two measures of onset of consonant variegation IN WORDS (age at production of first word with consonant variegation and age at which at least 30% of the child's word forms contain consonant variegation; see Table 4) are fully correlated: all four measures rank the children in the same order (Anna < Luca < Nicola < Nina. Nina produced neither babble nor words with consonant variegation during the period of the study).[7] This supports our hypothesis of continuity between babble and later words in regards to consonant variegation.

(3.4) The relationship between the consonants participating in variegation in early words and those participating in variegation in babble could not be tested, due to the small amount of variegated babble produced. However, informal comparison of the consonant variegation sequences in babble and in the advanced words failed to show any relationship between the two. Interestingly, however, close examination of the variegation patterns in the children's words revealed that all three children who produced words with consonant variegation during the data collection period tended to deploy the

[6] A word can be considered to be VMS-based only if the VMS has begun to be produced consistently by the time the word is used. Therefore words containing VMS which are not produced consistently until later are not considered to be based on VMS; see, for example, Anna [nanːa] *nonna*, produced before she attained the VMS [n] at age 1;8.

[7] Note that production of words with consonant variegation is not simply a function of the number of child words produced in the session: Anna has five words with consonant variegation out of only eleven words produced in her 1;6 session (45%), while Luca has only one such word out of twenty in his 1;6 session (5%).

TABLE 4. *Use of consonant sequences in later words*

Child	Age	N words[a]	N VW[b] (proportion of all words)	N words with single POA[c]			N VW: 2 POA[d] (proportion out of VW with 2 POA) [Less favoured order]		
				V[e]	L[f]	A[g]	VA [AV]	LV [VL]	LA [AL]
Anna	1;2 (*1st VW*)[h]	***5***	***1 (0·20)***	1	2	1	**1** (1·00)	**0** (0·00)	**0** (0·00)
	1;4	6	1 (0·17)	2	3	0	**1** (1·00)	**0** (0·00)	**0** (0·00)
	1;6 (*30% VW*)[i]	***11***	***5 (0·45)***	2	1	3	**3** (0·60) [**1** (0·20)]	**0** (0·00) [**1** (0·20)]	**0** (0·00)
	1;8	27	17 (0·63)	0	5	5	**7** (0·41)	**2** (0·12)	**8** (0·47)
	1;10	27	22 (0·82)	0	1	4	**8** (0·47)	**1** (0·06)	**8** (0·47)
	2;0	34	26 (0·77)	1	0	7	**5** (0·28)	**1** (0·06)	**12** (0·67)
Luca	1;2	5	0 (0·00)	1	1	3	**0** (0·00)	**0** (0·00)	**0** (0·00)
	1;4 (*1st VW*)	***11***	***2 (0·18)***	4	2	3	**0** (0·00)	**0** (0·00)	**2** (1·00)
	1;6	20	1 (0·05)	4	3	12	**1** (1·00)	**0** (0·00)	**0** (0·00)
	1;8 (30% *VW*)	***24***	***18 (0·75)***	1	1	4	**4** (0·25)	**2** (0·13)	**10** (0·63)
	1;10	27	18 (0·67)	1	2	6	**5** (0·29) [**1** (0·06)]	**2** (0·12)	**8** (0·47) [**1** (0·06)]
	2;0	33	24 (0·73)	0	2	6	**5** (0·32) [**2** (0·09)]	**3** (0·14)	**10** (0·45) [**2** (0·09)]
Nicola	1;2	2	0 (0·00)	0	1	1	**0** (0·00)	**0** (0·00)	**0** (0·00)
	1;4	6	0 (0·00)	0	2	3	**0** (0·00)	**0** (0·00)	**0** (0·00)
	1;6 (*1st VW*)	***6***	***2 (0·33)***	2	2	0	**2** (1·00)	**0** (0·00)	**0** (0·00)
	1;8	7	1 (0·14)	0	3	3	**1** (1·00)	**0** (0·00)	**0** (0·00)
	1;10 (*30% VW*)	***25***	***8 (0·32)***	1	2	13	**3** (0·38)	**0** (0·00)	**5** (0·63)
	2;0	31	7 (0·23)	1	4	19	**0** (0·00) [**1** (0·14)]	**1** (0·14)	**5** (0·71)
PVB							**59** (0·22) [**12** (0·05)]	**11** (0·04) [**7** (0·03)]	**153** (0·58) [**23** (0·09)]

[a] The total number of words includes words with no supraglottal consonants as well as words with all three places of articulation, not otherwise detailed in the table.
[b] VW: variegated words. The numbers in this column include variegated words with all three places of articulation.
[c] POA: place/s of articulation.
[d] only the last place-of-articulation change was noted, if more than one, e.g. labial-velar-labial is reported as velar-labial.
[e] V: velar.
[f] L: labial.
[g] A: alveolar.
[h] 1st VW: first session with a variegated word (in italics).
[i] 30% VW: first session (with more than ten words) in which variegated words form at least 30% of all words (in italics).

same two sequences: a velar or labial followed by an alveolar (see Table 4; note that the reverse, 'less-favoured' orders, e.g. alveolar followed by velar or labial, are rare at all ages for all of the children). As can be seen in Table 4, as they approach 2;0 all three children come to strongly favour labial–alveolar sequences (67% of Anna's words with consonant variegation, 45% of Luca's and 71% of Nicola's). In addition, words which lack consonant variegation tend to include sequences of alveolars rather than of velars or labials in all three corpora at nearly every age from 1;2 to 2;0, a preference which strengthens and stabilizes at ages 1;10 and 2;0. (This pattern is not apparent in Nina's corpus.) In summary, the children all tend to produce words beginning with a labial, velar or alveolar consonant followed by an alveolar later in the word, and ending with alveolars in the final syllable.

The similarity in patterning across the different children prompted us to ask whether its origins may be not child-internal but rather related to the ambient language. We therefore compared the identity of the consonants participating in variegation in the children's words to the identity of the consonants participating in variegation in the ambient language input. The distribution of variegation patterns in the children's word forms was compared to the distribution of variegation in Italian CDS in order to determine whether the bias in the children's word forms might derive from the input they were likely to have experienced. We tabulated the variegation patterns in all of the nouns and adjectives appearing in the PVB (the Italian version of the CDI). Note that, like other CDI instruments, the PVB is intended to assess comprehension as well as production and therefore can be taken to constitute a reasonable approximation of parental input to a young child. As can be seen by comparing the results of the tally of consonant variegation in the PVB (Table 4, last row) with that of the children's sequences (Table 4, all but the last row), the child words effectively mirror the Italian input: labial–alveolar sequences are the most frequent in the input (58%), followed by velar–alveolar (22%) and lastly by labial–velar sequences (4%) (and, as in the child data, for each variegation combination there is a strong preference for one order, e.g. velar–alveolar, over the reverse order, e.g. alveolar–velar). This is the pattern on which the children settle by age 2;0, as described above. In particular, labial–alveolar words increase steadily until they reach a proportion similar to that of the input data.

(*4*) *Nonlinearity in phonological development* (*Qualitative*)

(4.1) Word templates in the children's corpora: Individual developmental trajectories. Following the concept of 'whole word patterning' (Vihman & Croft, 2007), SELECTED words are distinguished here from ADAPTED words. SELECTED words derive their form directly from the target, allowing for such typical developmental processes as fronting or gliding and cluster reduction, for example, which affect the word locally, e.g. only with respect to a single segment or cluster. On the other hand, the child forms of ADAPTED words, while generally similar to the child's other word forms, are farther from the adult target and often reflect the operation of phonological processes which involve change across the word as a whole (e.g. assimilation, truncation and metathesis). We begin by analyzing the forms of the two children with more rapid lexical development and then turn to the other two children. Recall that Italian words are typically made up of sequences of two or more CV syllables, with a good deal of the basic input vocabulary consisting of three- or four-syllable structures (see Appendix). Thus at the early stages Italian children attempt many more long words than children acquiring English, for example (Vihman, in press).

The more advanced children[8]

Anna: The use of consonant harmony. Table 5 reports words produced by Anna at different ages, organized by their templates or word-structure patterns and divided into the two categories of SELECT and ADAPT. Note, however, that this division is fuzzy and somewhat arbitrary; the categories grade into one another, as a child's word forms may be partially 'selected' and partially 'adapted'. The main point to note is that the early words show few signs of radical change or 'adaptation' of the target form.

Anna's first SELECTED words are mostly disyllables (CVCV), with the consonants most commonly found in babbling: nasals and stops. For many words Anna uses consonant harmony, especially in the first sessions (1;2 and 1;4). Harmony spreads from labial and velar stops to other consonants (e.g. *caffè* [kakː'ɛ]), in some cases progressively, from onset to medial consonant (*pecora* [pɛpa]), in others regressively (*scarpe* [pap:e]). This pattern fades in the last sessions, i.e. from 1;8 on, in parallel with a gradual increase in the number of syllables Anna can produce accurately within a word.

At 1;8, ten words with the pattern C_1VC_2(C)V) are SELECTED (e.g. *bimba*, *cadi, coda*, *gallo*, *metto*) and six longer words containing different consonant types are ADAPTED into this pattern by omission of the unstressed first syllable (e.g. *animali*>[mali], *coperta*>[pɛt:a]). Another solution Anna

[8] Some conventions used in Tables 5–8:

- Target forms in italics;
- Patterns noted in SELECT columns apply to both target and child forms (here, as elsewhere, voicing distinctions are disregarded) while patterns noted in ADAPT columns apply to child output forms only;
- C: consonant (singleton, or, rarely, cluster); V: vowel;
- CH: consonant harmony ($C_1 \ldots C_1$).

TABLE 5. *Anna: Selected and adapted words*

SELECT		ADAPT	
1;2 (N=5)			
CH		CH, disyllable	
mamma	mam:a	*cavallo*	kak:a
nanna	nan:a		
papà	papa		
C_1VC_2			
gallo	kal:o		
1;4 (N=6)			
C_1VC_2V		CH, disyllable	
gallo	kal:o	*bambola*	bamba
		caffè	ka'kɛ
		cavallo	kak:o
		pecora	pɛpa
		scarpe	pap:e
1;6 (N=11)			
CH		CH, disyllable	
tutta	tut:a	*caffe*	ke'kɛ
C_1VC_2V		*scarpe*	pap:e
cadi	kadi	*scotta*	kok:a
gallo	kal:o	*sedia*	dida
gamba	gambo	… VIV	
tacco	tak:o	*cavallo*	takal:o
		VCV	
		pronta	ot:a
1;8 (N=27)			
C_1VC_2V		CVCV, disyllable	
bimba	bimba	*ancora*	kora
cadi	kadi	*animali*	mali
cane	kane	*coperta*	pɛt:a
coda	koda	*maialone*	mone
dritte	dit:e	*seduta*	duta
gallo	gal:o	CH	
giallo	dʒal:o	*baffi*	bap:i
grande	gande	*dorme*	bom:e
mucca	muk:a	*scarpe*	pap:e
metto	met:o	*vespa*	bep:a
1;8 (N=27)			
… VIV		CVIV, disyllable	
bambola	bambala	*cappello*	pɛl:o
		maiale	male
		CVIVIV[a]	
		cavallo	kalol:o
		piccolo	pilil:o
		CVV	
		sedia	sea
		anomalous	
		altri	nat:i
		macchina	mak:aja
1;10 (N=27)			
CVCV, disyllable		CVCV, disyllable	
grande	gande	*caduta*	duta
grosso	gos:o	*cappello*	pɛl:o
moto	moto	*coltello*	tɛl:o
mucca	muk:a	*maiale*	male
pollo	pol:o	*trattore*	tore
quanti	kwanti	*seduta*	duta
scala	kala	… VIV (and CH)[b]	
vespa	bep:a	*cavallo*	kalol:o
C_0VCVCV, trisyllable		*cuffia*	kuk:ala
bambola	bambala	*piccolo*	pilil:o
cammina	kam:ina	*tavolo*	pabolo
cassetto	keset:o		
cavolo	kavolo		
coperta	kopet:a		
eccola	ɛk:ola		
macchina	mak:ana		
maialino	malino		
CVCVCVCV, quadrisyllable			
piccolino	pek:olino		

TABLE 5. (*Cont.*)

SELECT		ADAPT		SELECT		ADAPT	
2;0 (N=34)				2;0 (N=34)			
CVCV, disyllable				C_0VCVCV, trisyllable			
mucca	muk:a			*escono*	ɛk:ono		
niente	njente			*macchina*	mak:ina		
porta	pot:a			*portone*	pot:one		
scotta	kot:a			*premere*	pemere		
sedia	sedja			*prigione*	pidʒone		
trento	treno			*rotelle*	rotel:e		
verde	ved:e			*seduta*	seduta		
C_0VCVCV, trisyllable		CVCVCV, trisyllable		*tavolo*	tavolo		
bottoni	bot:oni	*animali*	vimani	CVCVCVCV, quadrisyllable		CVCVCVCV, quadrisyllable	
caduta	kaduta	*leopardo*	lepad:o	*macchinina*	mak:inina	*pericoloso*	pɛkolozo
cammina	kam:ina			*piccolino*	pik:olino	*televisione*	tiveone
carota	karota			*seggiolino*	sedʒ:olino	*microfono*	korofono
casina	kazina			*si rovescia*	siroveʃa	*pomodori*	poromidi
cavallo	kaval:o			*trattorone*	tat:orone		
cavolo	kavolo						
cucchiaio	kuk:iajo						

[a] When not dropping a syllable to create a disyllabic word ending with VlV Anna maintains the three syllables but harmonizes one of the preceding consonants to the [l] in the final syllable, so that the resulting consonant sequence involves only two places of articulation.
[b] As at 1;8, Anna produces this pattern with consonant sequences consisting of two places of articulation at most, with the third consonant harmonized either to another consonant in the word or to the [l] in the final syllable.

adopts for dealing with the difficulty of producing long words is again harmony, but now combined with 'melody', or a pattern involving a specific consonant sequence. Building on her ability to produce a long word ending in [... VlV] (*cavallo* [takal:o]: 1;6), Anna harmonizes consonants in some longer words to create a sequence of only two different consonants, stop and /l/: *piccolo* [pilil:o], *cavallo* [kalol:o].

At 1;10, some words with consonants that are not yet well controlled (e.g. the fricatives [f] and [v]) are ADAPTED using the template <... VlV>, which developed in earlier sessions (e.g. *cuffia* [kuk:ala], *tavolo* [pabolo], both with consonant harmony as well). However, in this session many other multisyllabic words with different occlusives are produced accurately (SELECTED) (see *bambola, cammina, cassetto, cavolo, piccolino*).

At 2;0, a relaxing of the templatic constraints can be seen. Anna increases the number of long words produced accurately, even producing several quadrisyllabic words (e.g. *macchinina, trattorone, microfono*). In this session

TABLE 6. *Luca: selected and adapted words*

Age		Pattern	Target word	Child form
1;2 (N=6)	SELECT	CH	*mamma*	mamːa
	ADAPT	VCV	*latte*	ɑtːe
			rotto	otːo
		CVjV	*sedia*	tɛja
			cavallo	kajo
1;4 (N=11)	SELECT	CVCV	*bimba*	bimba
			bolle	bulːe
			ciuccio	tutːo
			moto	moto
	ADAPT	CVCV	*acqua*	kakwa
		CVV	*cavallo*	kaʊ
		… VjV	*bella*	baja
			casa	kaja
			cucchiaio	kajo
			sedia	teja
			trattore	totajo
1;6 (N=20)	SELECT	VCV	*acqua*	akwa
			apri	api
		CVCV	*bimba*	bimba
			casa	kaza
		CH	*casco*	kakːo
	ADAPT	VCV, disyllable	*capelli*	ɛlːi
			cappello	elːo
			forchetta	etːi
			fuoco	oko
			giochi	oki
			grazie	atːe
			luce	utʃe
			piatto	atːo
			prendi	endi
			ruota	ota
		CVjV	*gira*	dʒia
			terra	teja
		CH	*caffe*	peːpɛ
			cavallo	lalːo
			coltello	tɛtɛlːo
1;8 (N=24)	SELECT	CV(N)CV	*bimbo*	bimbo
			brodo	bodo
			casa	kaza
			corna	konːa
			dentro	dento
			forno	ponːo
			giallo	dʒalːo
			mangio	mandʒo
			moto	moto
			mucca	mukːa
			piange	pjandʒe
			porta	potːa
			prendi	pendi
			scale	kale
		Longer words	*bambolina*	bomboina
			maiale	majale
			pecora	pekua
	ADAPT	CVCV	*coltello*	tɛlːo
			forchetta	ketːa
		VCVCV	*sapone*	epone
		CH	*cuffia*	kukːia
		Longer words (Vowel Harmony)	*macchina*	makːana
			mescolo	mokːolo
			tortellini	totːolini
1;10 (N=27)	SELECT	CVCV	*bacio*	batʃo
			beve	beve
			casa	kaza
			cinque	tʃinkwe
			coda	koda
			dentro	dento
			fumo	fumo
			latte	latːe
			mangio	mandʒo
			mucca	mukːa
			prendi	pendi
			quattro	kwatːo
			questo	kwetːo
			tappo	tapːo
			torta	totːa
		Longer words	*accendo*	atʃːendo
			cavallo	kevalːo
			coperchio	kopɛkːjo
	ADAPT	CVCV	*coltello*	tɛlːo
			aspetto	petːa
		… VjV	*cucchiaio*	kiajo

TABLE 6. (*Cont.*)

SELECT		ADAPT		SELECT		ADAPT	
1;10 (N=27)				2;0 (N=33)			
Longer words				(C)VCV			
eccola	ɛkːola			*mucca*	mukːa		
maiale	majale			*olio*	ojo		
maionese	mejoneze			*piange*	pjandʒe		
mescolo	metːolo			*prendi*	pendi		
trattore	tatːoe			*quattro*	kwatːo		
vitello	vitɛlːo			*schiaccia*	kiatʃːa		
				stalla	talːa		
2;0 (N=33)				*tappo*	tapːo		
				tenda	tenda		
(C)VCV		CH		*tromba*	tomba		
				Longer words			
bimbo	bimbo	*maiale*	molale	*animali*	animali		
bolle	bolːe			*attacco*	atːakːo		
buchi	buki	VCV		*bambolina*	bambolina		
cade	kade	*ruspa*	upːa	*bottone*	botːone		
cinque	tʃinkwe			*bruciata*	butʃata		
coda	koda			*caduta*	kaduta		
dentro	dento			*cavallo*	kavalːo		
freno	feno			*dondolo*	dondolo		
latte	latːe			*mescolo*	mekːolo		
luce	lutʃe			*pecora*	pekea		
moto	moto						

she uses metathesis for some quadrisyllabic words (*animali* [vimani], *pomodori* [poromidi]), possibly due to the memory load imposed by such long words.

Luca: a large phonetic inventory. Table 6 reports the words that Luca produced in the recorded sessions, again organized by their templates or word-structure patterns.

At 1;2, Luca mostly uses two different patterns: he targets words containing difficult sounds such as [l] and [r], although he replaces medial [l] with a glide and omits both [l] and [r] at word onset, resulting in the patterns [CVjV] (*cavallo* [kajo]) and [VCV] (*latte* [atːe], *rotto* [otːo]). Luca attempts target words that are more phonetically advanced than Anna's in that they contain consonants rarely produced at that age, such as the trilled [r] and fricatives. As a result of aiming for words he cannot yet produce accurately, Luca has many ADAPTED words already at the 1;2 session. In the next two sessions Luca uses the same patterns to adapt many more words – the pattern <CVjV> (*casa* [kaja], *cucchiaio* [kajo]) in both sessions and <VCV> (*piatto* [at:o]) at 1;6 only.

Although by 1;8 Luca has the same number of VMS as Anna, he uses a larger number of non-VMS phones than the other children, especially between 1;6 and 1;10. In fact, already at 1;6, 20% of Luca's words include non-VMS consonants (four words/twenty; four consonants: [z], [tʃ], [n], [dʒ]), reminiscent of his non-reliance on VMS in his first ten words (see above). Anna also has 18% such uses at this age (two words/eleven), but all are due to the use of [l], which is soon to be established as a VMS. Thereafter, Luca continues to be 'bolder' in his willingness to use a wider range of non-VMS consonants and to use them more frequently in his words. At 1;10, 37% of Luca's words include non-VMS consonants (10/27; five consonants: [tʃ], [v], [z], [f], [dʒ]) vs. Anna's 15% (4/27; three consonants: [s], [v], [r]). In particular, Luca produces affricates at an earlier age (1;6). Anna produces such consonants only later, at 1;8 and 1;10, and Nicola and Nina never produce words with fricatives or affricates within the period of data collection. Luca produces consonant harmony forms as well, but much less frequently than Anna (e.g., *caffè* [pepɛ], *cavallo* [lal:o]). At 1;8 and 1;10, Luca begins to produce sequences of different consonants (C_1VC_2V) much more extensively, particularly stop consonants, in disyllabic and also in trisyllabic words, which he had previously tended to truncate (e.g. *porta* [pot:a], *mucca* [muk:a], *macchina* [mak:ana], *tortellini* [tot:olini]). Luca's ability to produce such sequences results in most of his words being SELECTED at this age, with only a minority of ADAPTED words. The adult targets that Luca attempts contain consonant clusters and diphthongs (e.g. *cinque, dentro, prendi, torta*), although /r/ is omitted in the child's productions (e.g. *trattore* [tat:oe]), which results in many clusters being produced as singletons. In fact, the only clusters which are accurately produced involve a nasal followed by a stop (which both Luca and Anna produce from early on). From 1;10 on Luca targets many more words with clusters than Anna or Nicola, especially clusters consisting of a nasal followed by a stop. By 1;8, the use of consonant harmony has largely faded out (the only remaining examples are *cuffia* [kuk:ia], *maiale* [molale]).

At 2;0, adult targets are produced accurately on the whole. There is only one example of the VCV pattern (*ruspa* [up:a]). Interestingly, although Luca's phonetic inventory is larger than Anna's, his words are shorter (his only quadrisyllabic words are *tortellini* (1;8), *maionese* (1;10) and *bambolina* (2;0)).

Children with slower vocabulary development

Nicola: the VCV pattern. In the earlier months Nicola produces far fewer words than Anna or Luca (see Table 7). Until the 1;6 session

TABLE 7. *Nicola: selected and adapted words*

SELECT		ADAPT	
1;2 (N=2)			
CH			
mamma	mamːa		
nanna	nanːa		
1;4 (N=6)			
CH		VV	
mamma	mamːa	*vale*	ae
nanna	nanːa		
nonna	nonːa		
papà	papa		
tata	tata		
1;6 (N=6)			
CH		CH	
casco	kakːo	*caduta*	kakuta
mamma	mamːa	*cavallo*	kaka
		grande	ŋande
		VCA	
		fame	ame
1;8 (N=7)			
CH		CH, disyllable	
bimba	bimba	*attenta*	tenta
		questa	tetːa
VCV		VCV	
apri	api	*latte*	atːe
C_2VC_2V		CVV	
cadi	kadi	*bravi*	bai
1;10 (N=25)			
VCA		VC(C)V	
alta	atːa	*cade*	ade
aria	aja	*cavallo*	alːo
erba	ɛbːa	*chiudo*	udu
		indietro	etro
		pronto	onto
		trattore	are
		vieni	ɛni
		zitto	itːo
C_1VC_2V		C_1VC_2V	
basta	bata	*coltello*	telːo
bello	belːo	*forchetta*	ketːa
bene	bene		
cane	kane		
dentro	dento		
grande	gadːe		
moto	moto		
prendi	pɛndi		
		CH	
		pancia	pampa
		VjV	
		pecora	kɛja
		taglia	tɛja
		VCVCV	
		banana	enana
2;0 (N=31)			
VCV		VCV, disyllable	
apri	api	*baffi*	apːi
CVV		*cadere*	are
ciao	tao	*cadi*	adi
		carne	anːe
		cavallo	alːo
		chiudo	udo
		forchetta	etːa
		forno	onːo
		Giovanni	anːi
		grande	ande
		maiale	ale
		palla	alːa
		pane	ane
		pianta	apːa
		piatto	atːo
		piselli	elːi
		ruote	ate
		siedo	edo
		zucchero	ukːo
C_1VC_2V		C_1VC_2V, disyllable	
basta	batːa	*animali*	mali
buona	bona	*coltello*	tɛlːo
butto	butːo	*trattore*	tore
caffè	kapːɛ	CH	
cane	kane	*vespa*	pɛpːa
prendi	pedi		

Nicola's words are simple disyllables containing a bilabial or alveolar stop or a nasal, as reported in Table 3. All words with consonants have consonant harmony in the adult form and are clearly SELECTED.

At 1;6 and 1;8, Nicola mainly attempts disyllabic words, except for *cavallo* and *caduta*, and he uses two patterns: consonant harmony (e.g. *cavallo* [kaka], *caduta* [kakuta], ADAPTED) and VCV (e.g. *apri* [api], SELECTED, and *fame* [ame] and *latte* [at:e], ADAPTED). Nicola produces only three words with consonant variegation at 1;6 and 1;8: *caduta* [kakuta], *grande* [ŋande], *cadi* [kadi].

At 1;10, Nicola begins to select more words with the pattern C_1VC_2V and to produce them accurately, always with an alveolar as the second consonant (e.g. *moto* [moto], *cane* [kane], *bene* [bene]). Consonant harmony occurs only in a single word with a labial stop (*pancia* [pampa]). With the exception of *banana* [enana], all trisyllabic words are reduced (e.g. *forchetta* [ket:a]) and the pattern VCV is used for adapting longer words and words with difficult onsets (e.g. *trattore* [are], *chiudo* [udu], *vieni* [ɛni]). Interestingly, this pattern is also used for *cade* [ade], despite the earlier, accurate form for *cadi* (cf. also *cadi* [adi] at 2;0). Although regression, or non-linear progress in whole-word accuracy, is the general finding for all eleven typically developing Italian children (Majorano & D'Odorico, in press) as for children learning other languages (Vihman & Kunnari, 2006), in general examples of regression affecting individual words are relatively rare (see also Luca's *maiale* [molale] at 2;0, which he previously produced accurately as [majale]).

At 2;0 Nicola's vocabulary has increased considerably but few of the words are produced accurately. In this session the pattern VCV is projected onto even more adult forms to adapt a large number of disyllabic and trisyllabic words (e.g. *Giovanni* [an:i], *maiale* [ale], *piselli* [el:i]). All trisyllabic (e.g. *trattore* [tore], *coltello* [tel:o]) and quadrisyllabic words (*animali* [mali]) are reduced to two syllables, some using the VCV pattern, others using a disyllabic C_1VC_2V pattern. As in the 1;10 session, at 2;0 consonant harmony is produced with the labial stop for a single target word, *vespa* [pɛp:a].

Nina: a reduced number of patterns. As shown in Table 8, Nina's lexical development is far slower than that of the other children. Nina generally communicates with simple proto-word vocalizations (e.g. [ae], [ow]) or gestures instead of adult-based words. Throughout the period of the study she produces words with simple structures only, including at most a single supraglottal consonant type per word. The only consonants used in words through the 1;10 session are [p], [b], [m] and [k]. At 2;0, she begins to use [t] as well. The pattern VCV is used to ADAPT four target words (*latte* [at:e], *lecca* [ɛkːa], *scarpe* [ap:e], *vino* [awi]).

TABLE 8. *Nina: selected and adapted words*

SELECT		ADAPT	
1;2 (N=2)			
CH			
mamma	mem		
CVV			
mio	mio		
1;4 (N=2)			
CVV		VV	
mio	mio	*zia*	ia
1;6 (N=4)			
CH		VV	
bimbo	bibːo	*caffè*	aɛ
baubau	baːˈbaː	*zia*	ia
1;8 (N=5)			
CH		CH	
bimbo	bibːo	*acqua*	kaka
		ciuccio	kukːo
VCV		VCV	
apri	api	*scarpa*	apːa

SELECT		ADAPT	
1;10 (N=5)			
VCV		VCV	
apro	e..apo	*scarpa*	apːa
CH			
mommo	momːo		
mimmi	mimːi		
bibi	bibi		
2;0 (N=7)			
CVV		VCV	
bar	bae	*latte*	atːe
CH		*lecca*	ɛkːa
bimbo/bambola	bibo	*scarpe*	apːe
		vino	awi
		CVjV	
		ancora	koja

(*4.2*) *Comparing the word templates of the children with faster vs. slower lexical advance*. We will first look at the children's 10-word-point sessions (Luca, 1;4; Anna, 1;6; Nicola, 1;8; Nina, 2;0; see Tables 5–8). Note that this is a more advanced stage than the early word stage defined in this study as the point at which the children had a CUMULATIVE lexicon of ten words. Although there are many individual differences between the children, analysis of the syllabic structure of the words produced at this developmental point shows that the two lexically advanced children, Anna and Luca, primarily produce structures made up of CV sequences; in their productions word-onset consonants are generally retained or harmonized (e.g. *bella* [baja]; *casa* [kaja]; *scarpe* [pap:e]), although Luca later develops a VCV pattern (used productively, i.e. for ADAPTATION, only at 1;6). At the 10-word point Nicola has 29% VCV patterns (see Table 7) and produces one word in which a medial consonant is omitted to give a V_1V_2 sequence (*bravi* [bai]), as does Luca (*cavallo* [kaʊ]). In Nina's case, 57% of the words have the VCV structure at this point, and she also produces a word containing two vowels in succession, V_1V_2 (*bar* [bae]). It seems, then, that the two children with the slowest lexical development not only exhibit fewer VMS and less variegated babbling but also, at an early stage, produce somewhat different word structures, specifically patterns in which the ratio of vowels to consonants is higher.

By 2;0 (Tables 5 and 6) the two advanced children have each started to produce words of considerable complexity: Anna uses consonant variegation and attempts more long words while Luca exhibits more phonetic diversity in his words. Both children produce trisyllabic words. In contrast, by the last session, at 2;0 (Table 7), Nicola is producing about as many words as the two more advanced children, but he still produces no trisyllabic words and, due to his continued reliance on the VCV pattern, he also produces few words with consonant variegation. Nina produces neither trisyllabic words nor consonant variegation in the course of the data collection period (see Table 8). Moreover, her phonetic inventory is more limited than that of the other children and it develops more slowly until age 1;8, when she begins to develop more VMS. Her babbling patterns provide little support for representing adult target word forms as matches to her own production patterns. Nina's phonology resembles what is reported for Late Talkers acquiring English (Rescorla, 1989; Stoel-Gammon, 1989).

DISCUSSION

In this study we followed four Italian children, two with rapid lexical advance and two with slower advance, in an attempt to identify the associations between phonetic, phonological and lexical development. We have shown that the children's prelinguistic phonetic skills correlate with their lexical advance at age 2;0. This suggests that the two slow-to-advance children's delay at starting to produce words was due to their failure to develop the requisite phonetic skills in the prelinguistic period, specifically, their failure to develop consistent use of a VMS. In particular, Nina's early vocalizations typically contain only vowels or syllabic consonants (e.g. [o: o:], [ow], [m̩]) and can be characterized as 'level 1 babbling' (Stoel-Gammon, 1989). Nina starts to develop VMS consonants only at age 1;4, and has only a single VMS up to age 1;8. Unsurprisingly, Nina's first words contain fewer consonants than do the other children's (see Table 3): only the bilabial stop [p/b], the nasal [m] and the velar [k]. She thus seems to lack the tools for efficient word production until quite late. This is in accord with the claim that the phonetic skills developed in babbling support later lexical development: More complex babbling at an earlier age may predict more efficient word learning at a later age (compare Thal *et al.*, 1995).

We found strong evidence for global continuity between the phonetic characteristics of babble and of words, which also accords with findings regarding the differences in phonetic characteristics between Late Talkers and their age-matched peers (Thal *et al.*, 1995; Pharr *et al.*, 2000). Specifically, children who started mastering consonant production earlier and who mastered a larger number of consonants also started to produce words earlier, and children who produced consonant variegation in babble earlier and with higher frequency also started to use consonant variegation in words earlier and exhibited a higher relative frequency of consonant variegation in later words. These findings strongly suggest that the phonetic tools which children develop through babble serve later to support word use. However, the evidence regarding a more specific continuity, between the identity of segments or segment-sequences in babble and in words is less clear-cut. Early words tend to be based on VMS consonants in two of the four corpora. Previous studies (McCune & Vihman, 2001; Keren-Portnoy *et al.*, 2005) have found that children tend to base their words on VMS; more specifically, McCune & Vihman (2001) reported that VMS was a good predictor for referential word use, and found 92% reliance on VMS for 'stable words', i.e. words that were produced in two successive monthly sessions, at 1;3 and 1;4 (which only involved children who were using referential words). In the current study, the referential status of words was not assessed. This difference in methodology made it impossible to fully evaluate our results in relation to past findings in this respect. Furthermore, the scarcity of variegated babble precluded our testing whether the same consonant variegation sequences are used in babble and in early words. Both of these issues merit testing in the future on more densely collected corpora.

We found a bias in all of the corpora towards a particular consonant variegation pattern, which the children developed as they approached 2;0, and which was also found in the adult target forms. Input patterning is thus the most likely source of this patterning in the children's words. The pattern itself is in line with previous findings (MacNeilage, Davis, Kinney & Matyear, 1999). MacNeilage *et al.* see a cross-linguistic bias toward labial–coronal over coronal–labial sequences as an indication 'that languages perpetuate a strong infant preference' (p. 459; see also Davis *et al.*, 2002). However, in our data, consonant variegation in the children's forms converge, with development, on the most frequent input pattern rather than reflecting each child's own initial preferences. In addition, although our sample of variegated babble was small, those vocalizations tended to be multisyllabic, with recurring syllables or sequences, and thus provide no evidence of a clear preference for a specific variegation sequence in babble. Interestingly, only one of the children started using consonant variegation in words before having [t/d] as a VMS: Nicola has two such words at 1;6, a session prior to the one in which he attained [t/d] as a VMS. Nina, who never mastered [t/d] to VMS level, produces no such words. It seems, then, that at least three different variables conspire to affect the age at which the use of consonant variegation in words emerges in the corpora we investigated. Two of these variables involve production practice: first, the degree of practice with consonant variegation in babble; second, the mastery of alveolars (here, [t/d], typically the earliest alveolar to be acquired as a VMS); the third is an input variable, the forms of target words. Since most Italian target forms with consonant variegation include alveolars in the final syllable, such words cannot well be produced until the child has mastered alveolar consonants.

We have also identified the patterns used by the children in their words and the developmental trajectory of those patterns. Interestingly, we have found individual differences between the two advanced children, who are otherwise at a comparable developmental stage in terms of their lexicons. The lexical profiles of Anna and Luca are in accord with their early phonetic development. Anna is more able to use consonant variegation, while Luca, who has many VMS but less consonant variegation in either babble or words, has more phonetic diversity in his words but produces shorter words with less elaborate sequences: whereas by 1;10 and 2;0 Anna has five and eight words, respectively, with consonant variegation containing all three places of articulation, Luca has only two such words even at 2;0.

Beyond the individual differences between the children, different patterns emerged between the two pairs of children. In particular, the slower-to-advance children tended to use patterns with a higher ratio of vowels to consonants (e.g. V_1V_2 and V_1CV_2 structures) much more extensively. This difference could be explained by a difficulty for the slower children in using their emergent capacity to remember, or to efficiently represent and reproduce, sequences which involve multiple consonants. The lack of familiarity with consonants through production should lead, according to the Articulatory Filter hypothesis, to consonants not being as salient in the input speech stream, and therefore to sequences of consonants being more difficult to 'catch', or notice and remember, especially more complex sequences, such as those containing different consonants.

In the use of consonants in word templates and the resultant phonotactic patterns observed for each child, we see that different children follow different developmental paths: e.g. in the 'selection' of actual consonants for use, in the extent of reliance on consonants vs. vowels, on a varied or more limited repertoire of consonants, on consonant variegation, etc. We suggest that production is guiding perception here (as proposed by the Articulatory Filter model). Specifically, once a consonant has begun to be produced with some consistency (i.e. has become a VMS), input patterns including that consonant gain salience for the child. Such a clear effect of production on perception is less evident in our corpora as regards the development of consonant variegation in words, however. This may partly be because of our small sample of variegated babble utterances, which means that we cannot form a clear picture of the specific skills with which children approach the task of learning variegated words. Here the more striking impact is that of input frequency on production. However, the growing vocal production capacities that emerged in babble seem to have also led to differential intake for different children. This is suggested by the fact that the children who started using variegated babble earlier, or who produced more such babble, also began to produce variegated words earlier.

This study illustrates the continuity in development between babble and early words and tracks the way that this continuity interacts with input language characteristics as well as with each child's idiosyncratic word-shape constraints (i.e. templates) to shape a child's early words. The processes and forces we have described (repertoire of well-practiced consonants affecting the shape of first words, input language affecting consonant variegation, word-form repertoire constraining the forms of new words through the effects of templates, etc.) can be seen to operate in each and every corpus and to contribute to the similarities between the different children. However, 'accidents' (or idiosyncracies) of each child's specific history – his/her earliest mastered consonants, the age of mastery, the identity of the first words produced by that child – all lead to individual differences in the specifics of each child's phonetic repertoire and emergent phonological system, as manifested in his/her templates. We have shown the workings of these different forces in the corpora of typically developing children from the two extremes of the spectrum, that is, from both precocious and rather slowly developing children. Future research is needed to see if the same forces operate in a similar fashion in the language development of Late Talkers as well.

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APPENDIX. *Glossary for Italian words appearing in the text*

accendo /atʃ:endo/	*I light*
acqua /akwa/	*water*
alta /alta/	*high*
altri /altri/	*others*
ancora /aŋkora/	*again*
animali /animali/	*animals*
apri /apri/	*you open*
apro /apro/	*I open*
aria /arja/	*air*
aspetta /aspɛt:a/	*you wait*
attacco /at:ak:o/	*I attach*
attenta /at:enta	*alert*
bacio /batʃo/	*kiss*
baffi /baf:i/	*moustache*
bambola /bambola/	*doll*
bambolina /bambolina/	*little doll*
banana /banana/	*banana*
bar /bar/	*bar*
basta /basta/	*enough, stop it*
baubau /bawbaw/	*barking of the dog* (*onom.*)[a]
bebè /be'bɛ/	*little child* (*baby talk*)
bello/ bella /bɛl:o/	*pretty/nice* (*m/f*)
bene /bene/	*good*
beve /beve/	*he/she drinks*
bibi /bibi/	*hurt*
bimbo/a /bimbo/	*child/baby* (*m/f*)
bolle /bol:e/	*bubble*
bottone/i /bot:one/	*button/s* (*s/pl*)
bravi /bravi/	*clever* (*pl*)
brodo /brɔdo/	*broth*
bruciata /brutʃata/	*burnt*
buchi /buki/	*hole*
buona /bwɔna/	*good*
butto /but:o/	*I throw*
cade /kade/	*he/she falls down*
cadere /kadere/	*to fall down*
cadi /kadi/	*you fall down*
caduta /kaduta/	*she fell down*
caffè /ka'fɛ/	*coffee*
cagnolino /kaɲolino/	*little dog*
cammina /kam:ina/	*she/he walks*
cane /kane/	*dog*
capelli /kapel:i/	*hair*
cappello /kap:ɛl:o/	*hat*
carne /karne/	*flesh*
carota /carɔta/	*carrot*
casa /kaza/	*house*
casco /kasko/	*crash-helmet*
casina /kazina/	*little house*
cassette /kas:et:o/	*drawer*
cavallo /kaval:o/	*horse*
cavolo /kavolo/	*cabbage*
chiudo /cjudo/	*I close*
ciao /tʃao/	*hello*
cinque /tʃiŋkwe/	*five*
ciuccio /tʃutʃ:o/	*dummy*
coco /ko'kɔ/	*hen* (*baby talk*)
coda /koda/	*tail*
coltello /koltɛl:o/	*knife*
coperchio /kopɛrcjo/	*lid*
coperta /koperta/	*blanket*
corna /kɔrna/	*horns*
cucchiaio /kuc:iajo/	*spoon*
cuffia /kuf:ja/	*cap*
cuscino /kuʃino/	*pillow*
dentro /dentro/	*in*
dindon /dindon/	*sound of bells* (*onom.*)
dondolo /dondolo/	*I swing*
dorme /dɔrme/	*she/he sleeps*
dritte /drit:e/	*straights*
eccola /ɛk:ola/	*here she is*
erba /ɛrba/	*grass*
escono /ɛskono/	*they come out*
fame /fame/	*hunger*
forchetta /forket:a/	*fork*
forno /forno/	*oven*
freno /freno/	*brake*
fumo /fumo/	*smoke*
fuoco /fwɔko/	*fire*
gallo /gal:o/	*cock*
gamba /gamba/	*leg*
giallo /dʒal:o/	*yellow*
giochi /dʒɔki/	*toys*
gira /dʒira/	*he/she turns*
grande /grande/	*big*
grazie /gratsje/	*thank you*
grosso /grɔsso/	*very big*
indietro /indjetro/	*back*
l'acqua /lakwa/	*the water*
latte /lat:e/	*milk*
lecca /lek:a/	*you lick*
leopardo /leopardo/	*leopard*
luce /lutʃe/	*light*
macchina /mak:ina/	*car*
macchinina /mak:inina/	*little car*
maiale /majale/	*pig*
maialino /majalino/	*little pig*
maialone /majalone/	*big pig*
maionese /majoneze/	*mayonnaise*
mamma /mam:a/	*mum*
mangio /mandʒo/	*I eat*

APPENDIX (*Cont.*)

mescolo /meskolo/	*I mix*	ruota/e /rwɔte/	*wheel/s* (*s/pl*)
metto /met:o/	*I put*	ruspa /ruspa/	*bulldozer*
microfono /micrɔfono/	*microphone*	sapone /sapone/	*soap*
		scala/e /skala/	*stair/stairs*
mimì /miˈmi/	*pain* (*baby talk*)	scarpa/e /skarpe/	*shoe/s* (*s/pl*)
mimmi /mim:i/	*sweet*	schiaccia /skjatʃ:a/	*you push*
mio /mio/	*mine*	scotta /skɔt:a/	*it burns*
mommo /mɔm:o/	*food*	sedia /sɛdja/	*chair*
moto /mɔto/	*motorcycle*	seduta /seduta/	*she/he sits*
mucca /muk:a/	*cow*	seggiolino /sedʒol:ino/	*little chair*
nanna /nan:a	*to sleep* (*baby talk*)	si rovescia /sirovɛʃa/	*it upsets*
nonna /non:a/	*granny*	siedo /sjedo/	*I sit*
niente /njente/	*nothing*	stalla /stal:a/	*stable*
occhio /ɔcjo/	*eye*	tacco /tak:o/	*hell*
olio /ɔlio/	*oil*	taglia /taʎa/	*you cut*
palla /pal:a/	*ball*	tappo /tap:o/	*plug*
pancia /pantʃa/	*stomach*	tata /tata/	*child* (*baby talk*)
pane /pane/	*bread*	tavolo /tavolo/	*table*
papá /paˈpa/	*papa*	televisione /televizione/	*television*
pappa /pap:a/	*food* (*baby talk*)		
pecora /pɛkora/	*sheep*	tenda /tenda/	*curtain*
pericoloso /perikolozo/	*dangerous*	terra /tɛr:a/	*floor*
		torta /torta/	*cake*
piange /pjandʒe/	*she/he cries*	tortellini /tortel:ini/	*type of Italian pasta*
pianta /pjanta/	*plant*	trattore /trat:ore/	*track*
piatto /pjat:o/	*plate*	trattorone /trat:orone/	*big track*
piccolino /pik:olino/	*very little*	treno /treno/	*train*
piccolo /pik:olo	*little*	tromba /tromba/	*trumpet*
piselli /pizɛl:i/	*peas*	tutta /tut:a/	*whole*
pollo /pol:o/	*chicken*	vale /vale/	*Valentina* (*an Italian name*)
pomodori /pomodɔri/	*tomatos*		
porta /pɔrta/	*door*	verde /verde/	*green*
portone /portone/	*front door*	vespa /vɛspa/	*wasp or Vespa* (*an Italian motorcycle*)
premere /premere/	*to push*		
prendi /prendi	*you take*		
prigione /pridʒone/	*prison*	vieni /vjeni/	*you come*
pronto/a /pronto/	*ready* (*m/f*)	vino /vino/	*wine*
quanti /kwanti/	*how many?*	vitello /vitɛl:o/	*lamb*
quattro /kwat:ro/	*four*	zia /tsia/	*aunt*
questo/a /kwesto/	*this* (*m/f*)	zitto /tsit:o/	*silent*
rotelle /rotɛl:e/	*rollers*	zucchero /tsuk:ero/	*sugar*
rotto /rot:o/	*it is broken*		

[a] Onom.: onomatopoeia.