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Publication Date

2018-05-24

DOI

10.1075/tilar.23.10vih

CHAPTER 10

The development of prosodic structure: A usage-based approach

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Scholarly views are divided as to the source of children's knowledge of prosodic structure. Within the framework of a usage-based approach, this chapter compares prosodic structures in children learning four languages at the end of the single-word period in order to identify sources of both similarities and differences between children, within and across language groups. The similarities can generally be traced back to common constraints on the neurophysiology of infant vocal production, while the differences between language groups reflect ambient language accentual patterning and dominant word shapes. Individual differences within and across groups additionally relate to differing child mappings of input forms to familiar production patterns.

Introduction

Scholarly views are divided as to the source of children's knowledge of prosodic structure. Reflecting one prominent view, Selkirk (1996: 201) refers to 'innate knowledge of ... universal constraints'. However, since the arguments for infant foreknowledge of linguistic principles remain more logical than empirical, others find it implausible and unnecessary to invoke innate knowledge. Instead, a usage-based approach (Bybee, 2001, 2010; Pierrehumbert, 2003; Munson, Edwards, & Beckman, 2012) to the acquisition of prosodic structure appeals to learning based on both initial perceptual biases of possible evolutionary origin (Kuhl, 1987) and infants' experience, along with neurophysiological maturation, of vocal production practice (Vihman & Croft, 2007; Vihman, 2014).

Kehoe (2013, this volume) has described the theory of Prosodic Phonology and various attempts to test it as an account of development in different languages (see also Demuth, this volume; Vihman, 2014, Ch. 9). This chapter proposes an alternative account of prosodic development, supported by quantitative analysis of early child word structures in four languages. The claim is that instead of positing innate knowledge, it is possible to trace the origins of children's initial representations of prosodic structure to three types of learning that increasingly interact over the course of the first years of life: (i) experience of salient elements of the input speech stream, (ii) constraints imposed by the neurophysiology of vocal production, and (iii) memory processes that relate heard patterns to existing knowledge based on production. This approach is in accord with usage-based accounts of adult phonology (and sound change) that argue that 'inherent biases in production, perception, and learning operate continually to influence the range of variants that arise... The synchronic properties of a given phonological system arise in part through these processes' (Hall, Hume, Jaeger, & Wedel, in submission, p. 57). Furthermore, as will be evident in what follows, the analyses proposed here draw on much the same principles as are outlined by these authors with reference to adults: '(i) linguistic categories maintain some record of experienced variation rather than being fully abstract... and (ii) experiencing a particular category variant influences future production and perception behavior not only for that category, but also for similar categories' (p. 57f.).

As regards perception, ample experimental evidence has demonstrated infant sensitivity to the rhythms of the ambient language from birth, initially gained from 'listening' in the womb (e.g., Mehler et al., 1988; see Post & Payne, this volume). Over the course of the first year of life, infant attraction to what is prosodically salient in a given language further shapes the child's emergent representations of speech. For example, Fernald (1991) described the effects on language development of prosodic modulation in infant-directed speech; Jusczyk (1993, 1997) modelled advances over the first year in the grouping of prominent acoustic features such as syllables with higher or more dynamic pitch pattern or longer duration.

As regards production, it is widely acknowledged that the first adult-like syllables are simple sequences of 'mandibular oscillation' (jaw opening and closing: Davis and MacNeilage, 2000), or <CV>, <CVCV>, <VCV>. These vocalizations, which Oller (1980) termed 'canonical babbling', are reliably first observed from about the middle of the first year. Little if any cross-linguistic variation has been reported in the phonetics of these first adult-like syllables, which appear to be largely maturationally based, given typical auditory and vocal capacities (Oller & Eilers, 1988).

How might adult-like vocal production practice serve to orient the child to the prosodic structures of input speech? Although babbling sometimes involves long sequences of repeated or variegated syllables, it more often takes the form of one- and two-syllable strings – and the first words in most of the languages that have been analysed for early lexical and phonological learning are similarly constrained to one or two syllables. Accordingly, it has been proposed that infants respond differently to speech once they have begun to gain stable control of a small number of adult speech sounds (Vihman, 1993, 1996; for experimental support, see DePaolis, Vihman, & Keren-Portnoy, 2011; DePaolis, Vihman, & Nakai, 2013; Majorano, Vihman, & DePaolis, 2013; DePaolis, Keren-Portnoy, & Vihman, 2016). In the prelinguistic period, then, experience with vocal production can be taken to create a sample of known patterns to which novel word forms can be mapped. This in turn leads to more robust representations of such forms as they are fleetingly but repeatedly heard in ambient speech (see studies of ‘the production effect in memory’ in both adults and older children, e.g., MacLeod et al., 2010; Icht & Mama, 2015; Zamuner, Morin-Lessard, Strahm, & Page, 2016).

Thus, in this approach, accentual prominence initially attracts and shapes infant attention to speech (Teixidó, François, Bosch, & Männel, this volume) and vocal production further supports retention of certain repeatedly heard patterns. In addition, the relatively infrequent but readily recognized words produced in isolation in the everyday routines of infant life have been found to play a disproportionate role in the choice of first words to produce (Brent & Siskind, 2001; Vihman, in press). All of these factors are critical elements in the construction of phonological memory, or the ability to retain novel phonological strings (Keren-Portnoy et al., 2010), a key element in word learning (Gathercole & Baddeley, 1989). It is thus likely that the gradual process of construction of memory for speech, based on vocal practice, is one reason for the delay between first adult-like vocal production, almost always observed in the middle of the first year, and first word use, typically identified only toward the end of the first year at the earliest.

The term ‘prosodic structure’ can be used in a number of different ways. It may refer to the accentual pattern of words (trochaic, or strong-weak, vs. iambic, or weak-strong stress on disyllables, for example; see Bhatara, Boll-Avetisyan, Höhle, & Nazzi, this volume), the overall rhythmic pattern of a language (e.g., Mehler et al., 1988; Mehler, Dupoux, Nazzi, & Dehaene-Lambertz, 1996; Ramus, Nespor, & Mehler, 1999) or, more specifically, the units of the prosodic hierarchy proposed by Selkirk (1978, 1980; see also Nespor & Vogel, 1986). ‘Prosodic structure’ is also used to refer to units below the phonological or prosodic word level, the lowest level in the prosodic hierarchy (Fikkert, 1994; Kehoe, 2013). This chapter will focus on word-shapes consisting of syllable sequences of different lengths and organization, such as the universally occurring <CV>, disyllabic <CVCV>, onsetless <VCV> or the final-consonant-bearing structures <CVC>, <CVCVC>. In this usage, ‘prosodic structure’ is similar to the skeleton of autosegmental phonology (Goldsmith, 1990). The prosodic structures that will be the focus of interest here are the first word forms observable in data from children learning one of four languages. These structures can be taken to reflect infant experience with the most frequent accentual patterns in the input, their own production of adult-like vocalizations and their growing ability to map input word forms onto their existing vocal patterns. The analyses reported here will make it possible to identify similarities and differences in the types of first structures produced. After the findings have been presented and illustrated, the likely sources of children’s early prosodic structures will

be more broadly considered, including aspects of input speech, constraints on vocal production and the interaction of the two.

A developmental perspective on early prosodic structures

The ‘accuracy’ of children’s first words, first noted by Ferguson and Farwell (1975), is largely due to children’s (unconscious) ‘selection’ of the word targets that are the most accessible, given their limited production skills. As illustrated with the first few words identified for 48 children learning 10 languages (Menn & Vihman, 2011, App. 1), target words are seldom more than one or two syllables in length and word length is usually matched by the child forms. The target words are limited to a single supraglottal consonant type per word about half the time and to stops, nasals, glottals and glides somewhat more often; this also supports relatively accurate production, as these are the consonants that are well practiced in babbling. Finally, although word-final consonants are generally omitted and heterogeneous clusters reduced, diphthongs are often matched. This is the starting point of word production: Children are sensitive to target forms for which they may have a rough vocal match in repertoire and their first identifiable words are similarly constrained cross-linguistically.

Children’s production skills advance only quite slowly; what changes with the onset of word production is child familiarity, through on-going experience with production and the acoustic output that accompanies it, with a growing number of phonological forms related to often-heard input forms. For the purposes of understanding the formation of preferred prosodic structures a key point is that the timing of this development is highly variable, differing from one child to the next, but that persistent production of words of a particular prosodic structure is typically seen only after a period of early word use. An initial data sample, leading to a few well-developed word-production routines, needs to develop first. This accounts for the typical lack of systematicity, or relatively rare re-use of particular word shapes, syllables or features, in the first few recorded words (Menn & Vihman, 2011).

Individual phonological templates have been defined as idiosyncratic patterns or prosodic structures used by a given child, sometimes based on ‘overselecting’ of a particular structure compared to other children learning the same language but more often based on adaptation, or modification of target word forms to fit the particular structure (Vihman, 2014). Vihman & Velleman (2000) introduced the terms ‘select’ and ‘adapt’ to characterize words that differ in this way in their relationship to the child’s template; the terms are applied here to prosodic structures that are not further segmentally specified.

Data analysis

To gain an idea of cross-linguistic similarity or differences, comparably complete data are taken for analysis from one recording session for each of 44 children learning one of four languages: American or British English, French, Italian and Finnish. The data derive from the end of the single-word period, when children can be observed to be producing a small set of preferred prosodic structures, some of which may come to serve as templates, or more fully specified attractors for new word forms. Actual word forms produced by children in each group are amply illustrated, to demonstrate how children pursue individual developmental

paths, each of them in their own way mapping more or less well-suited adult target forms to the prosodic structures that the child has mastered.

All of the data analysed were recorded while the children were in interaction with one or more family members in the presence of a familiar investigator, for 20-30 minutes of unstructured play. Table 1 lists the number of children in each group, their age range (year; month) and the mean number of different target words produced in the session analysed. Imitations as well as spontaneous word forms and variant prosodic shapes that fit distinct structures were included in the analysis to assure sufficient material, at as early an age as possible, to identify favoured prosodic structures and allow for cross-linguistic comparative analysis.

For all but the Italian data the first recording in which about 25 different word types were produced spontaneously was analysed. The Italian data are drawn from a study of 30 children recorded twice, at 1 year and 3 months, and at 1 year and 9 months (Vihman and Majorano, in press); only the 15 children who produced, at either age, between 30 and 60 words in the recorded sessions are included here, in order to provide a comparable level of prosodic variants and structural diversity to that seen in the other groups.

Table 1. Language groups, ages and mean number of words attempted ('target words') Data sources: Boysson-Bardies & Vihman, 1991; Kunnari, 2000; Veneziano & Sinclair, 2000; Vihman, 1993, 1996, 2010, 2014; Vihman, Keren-Portnoy, Khattab, & Wauquier, 2011; Vihman & Kunnari, 2006; Vihman & Majorano, in press; Vihman & Velleman, 1989; Vihman, Velleman, & McCune, 1994; Wauquier & Yamaguchi, 2013.

Language group	Number of children	Age-range	Mean target words
English	US 6, UK 4	US 1;4-1;5, UK 1;5-1;11	US 35, UK 41
Finnish	6	1;3-1;11	30
French	13	1;2-1;10	35
Italian	15	(1;3, 1;9)	41

For each child, more than a single variant word shape (token) of any word type was included in the prosodic structure analysis only if those variants fall into distinct structures (see Vihman, 2016). To focus in on the main prosodic structures used in each group, only those that accounted for 20% or more of a child's variants are listed. None of the structures are specified as to segmental content for any slot, distinguishing the 'generic' prosodic structures from the more specified 'templates' described elsewhere. (For example, a melodic template may be specified to include constraints on place of articulation – e.g., C1 is labial, C2 is coronal or velar, Macken, 1979, or a particular segment may be specified, like medial yod, in Priestly, 1977, or medial [l], in Vihman, 1993.)

English

Table 2 provides an overview of the structures most used by the 10 children acquiring English.

Table 2. Prosodic structures in English.

Structure	Number of children with over 20% use of structure	Mean proportion of all variants (and range)
CV	6	.31 (.23-.44)
CV1V2	2	.24 (.21-.26)
CV and CVV combined ¹	3	.31 (.26-.35)
CVC, CV?	5	.34 (.23-.44)
C ₁ VC ₁ V	3	.30 (.28-.31)
C ₁ VC ₂ V(C)	3	.25 (.22-.26)
C ₁ VC ₂ VC	1	.41

The hallmark of the English profile is monosyllabic production, often with a coda. Note that just one child makes criterial use (i.e., at least 20% of the structures produced by that child) of the more challenging structure, disyllabic variants with coda (<CVCVC>).

English: Selected and adapted variants

By the end of the single word point, when the first word combinations can be observed, most children are beginning to fit more difficult target words into their favored structures. Tables 3 and 4 provide examples to illustrate the effect of a child's preferred production patterns on their phonological advances, drawing on the children with the highest proportion of a given structure. Selected words are defined as accurate within the limits of the child's resources: coda omission is disregarded, for example, if the child is not yet producing codas. Adapted words reflect changes to fit the structure, such as truncation (Emily, *apple*, *button*) or metathesis (Timmy, *sun*, Sean, *Ian*). Note that some children preferentially select words of a particular structure but do not show adaptation (e.g., Geoff, for <CVC>).

Table 3. <CV(V)> Note that vowel length, which is not contrastive in English, is disregarded in allocating forms to this structure. (im. 'imitation', *N 'number of tokens of same form', if more than one)

more than one)

Select		Adapt	
Emily (.53: 24/45)			
<i>beαds</i>	pi (*2)	<i>αll gone</i> (im.)	kã:
<i>box</i>	p ^h α:	<i>αpple</i>	bɪ: (*2, im.)
<i>more</i>	mɔə	<i>button</i>	bα:
Timmy (.40: 14/43)			
<i>bαll</i>	bæ::	<i>bαlloon</i>	bɛ::
<i>cαr</i>	kα, gα	<i>sun</i>	næ
Sean (.40: 14/43)			
<i>blocks</i>	bα (2)	<i>bug</i>	βαɪ
<i>blue</i>	bwe:, bʊ ^h ,	<i>dog</i>	dαʊ, taʊ

¹ 'Combined' figures refer to children whose use reaches 20% only when two structures are combined that, for other children, reach that level independently; cf. also Table 14, Finnish.

<i>mama</i>	mɑ, mɑ: (3), mɔ:	<i>Ian</i> (im.)	nĩ
<i>quack</i>	ʔɑ::	<i>mouse</i>	mɑʊ, mɑ:i

Table 4. <CVC>

Select		Adapt	
Geoff (.44: 17/45)			
cars	k ^h ɑ:ʃ		
dog	gɒ:g		
pig	p ^{hi} :k ^h		
sheep	p ^{hi} :p ^h		
toys	t ^h ɔʊ:s:		

French

Table 5 provides an overview of the most-used structures in French. Overall, the children produce a higher proportion of disyllabic than monosyllabic structures, the reverse of the English distribution. Furthermore, one of the two most-often used French structures is the onsetless disyllable (VCV), which is not found in English.

Table 5. Prosodic structures in French.

Structure	Number of children with over 20% use of structure	Mean proportion of all variants (and range)
CV	10	.32 (.22-.54)
CVC	1	.26
VCV	8	.37 (.21-.64)
C ₁ VC ₁ V (including Reduplication) Mean: .31	9	.31 (.22-.42)
C ₁ VC ₂ V	2	.31 (.23-.38)

French: Selected and adapted variants

Tables 6 to 9 illustrate French structures. Table 6 again shows adaptations that include not only truncation but also metathesis (Camille, *musique*, Julien, *pique*). Whereas the English <CV(V)> adaptations are generally based on the initial (stressed) syllable of the target word, in French both the initial (Camille, *couvercle*, Julien *canard*) and final syllables (Camille, *attends*, *chercher*; Julien *araignée*, *encore*, *lapin*) provide a basis for the child forms.

Table 6. <CV>

Select	Adapt
Camille (.54: 25/46)	

<i>chat</i> ‘cat’	ʃa	<i>attends</i> ‘wait!’	tã
<i>main</i> ‘hand’	mẽ	<i>chercher</i> ‘look for’	ʃe
<i>plus</i> ‘[no] more’	py	<i>couvercle</i> ‘lid’	ku
		<i>musique</i> ‘music’	ki
Julien (.50: 20/40)			
<i>cou</i> ‘neck’	ku	<i>araignée</i> ‘spider’	ne (*3)
<i>plein</i> ‘full’	pẽ	<i>encore</i> ‘again, more’	kõ
<i>thé</i> ‘tea’	te (*3), ke (*3)	<i>lapin</i> ‘rabbit’	pẽ
<i>trois</i> ‘three’	ka (*4)	<i>pique</i> ‘stings’	ki (*8), ke, ti
Basile (.36: 21/59)			
<i>bottes</i> ‘boots’	bo (*2)	<i>bisou</i> ‘kiss’	bu
<i>ça</i> ‘that’	ʒa (*10)	<i>livre</i> ‘book’	lə (*3)
Adeline (.34: 13/38)			
<i>lave</i> ‘wash’	la (*4)	<i>au revoir</i> ‘goodbye’	bwa
<i>moi</i> ‘me’	ma	<i>lave</i> ‘wash’	kɔ

As can be seen in Table 7, Beryl, who makes especially heavy use of the <VCV> structure, also shows instances of metathesis (*crapeau*, perhaps also *nuage*).

Table 7. <VCV>

Select	Adapt		
Beryl (.64: 46/72)			
<i>encore</i> ‘again, more’	ãkɔ	<i>l’éléphant</i> ‘the elephant’	afɔ
<i>étoile</i> ‘star’	ata	<i>crapeau</i> ‘toad’	ako (*2)
<i>hibou</i> ‘owl’	abu	<i>micro</i> ‘microphone’	a xo (*13)
<i>un coeur</i> ‘a heart’	akɔ	<i>nɥaʒ</i> ‘cloud’	aʒa
Charles (.44: 14/32)			
<i>allo</i> ‘hello’	al:ɔ	<i>c’est bon</i> ‘it’s good’	habõ
<i>attends!</i> ‘wait’	atæ	<i>garçon</i> ‘boy’	haʒœ (*3)
<i>au revoir</i> ‘byebye’	avwa	<i>va pas</i> ‘doesn’t go’	apa (*3)
Adeline (.42: 16/38)			
<i>au revoir</i> ‘goodbye’	ova, opa	<i>bisou</i> ‘kiss’	atu
<i>trois</i> ‘three’	ka	<i>chapeau</i> ‘hat’	apo (*4)
<i>brosse</i> ‘brush’	ə ɡʁɔ	<i>voiture</i> ‘car’	atu (*2)
Vincent (.41: 19/46)			
<i>allô</i> ‘hello (telephone)’	alɔ (*2)	<i>bravo</i>	avo (*4), awo
<i>essaye</i> ‘try!’	eʁe	<i>caché</i> ‘hidden’	aʁe
<i>ici</i> ‘here’	isi	<i>marche pas</i> ‘doesn’t work’	afpa (*6)
Gaël (.37: 18/49)			
<i>écrit</i> ‘written’	eʁi	<i>c’est ça</i> ‘that’s it’	esa (*11)
<i>ici</i> ‘here’	isi	<i>chercher</i> ‘to look for’	aʃe
<i>ouvrir</i> ‘to open’	oʁi. uvʁi (*2)	<i>grelot</i> ‘rattle, bell’	eʁo

French children who use harmony generally have a large number of reduplicated forms as well (Table 8).

Table 8. Consonant harmony (and reduplication)

Select		Adapt	
Carole (.42: 16/38)			
<i>Babar</i>	baba (x3)	<i>chapeau</i> ‘hat’	papo: (x3)
<i>bébé</i> ‘baby’	be:be	<i>fromage</i> ‘cheese’	məmə
<i>Mimi</i>	mimi (2)	<i>lapin</i> ‘rabbit’	pa:pa
Laurent (.41: 13/32)			
<i>bébé</i> ‘baby’	bəbə	<i>chapeau</i> ‘hat’	bobo (x5)
<i>coucou</i> ‘peek-a-boo’	kuku	<i>chaussettes/chaussures</i> ‘socks/shoes’	ʃoʃy
<i>dodo</i> ‘sleep (BT)’	dodɔ	<i>gateau</i> ‘cake’	tato (x3)

One French child makes use of a <C1VC2V> structure in over a third of his variants, with medial [l] in all 12 forms (see Vihman, 1993, who shows Laurent’s attraction to medial [l] already in his first word forms).

Table 9. <C1VC2V>

Select		Adapt	
Laurent (.38: 12/32)			
<i>ballon</i> ‘big ball’	palõ	(<i>la</i>) <i>brosse</i> ‘brush’	bəla
<i>de l’eau</i> ‘some water’	dəlo	(<i>le</i>) <i>canard</i> ‘duck’	kɔ̃la
<i>voilà</i> ‘here you are’	wal:a	(<i>le</i>) <i>chapeau</i> ‘hat’	bolo (x2)

It is evident here that word forms with more than a single supraglottal consonant are especially challenging for the children and that different children deal differently with the difficulty. Certain aspects of French structure appear to affect these pre-grammatical word productions. First, phrase-final lengthening may draw attention away from the word-initial consonant (Vihman, Nakai, DePaolis, & Hallé, 2004), resulting in some children making (unconscious or implicit) recourse to <VCV>, which removes the problem. Second, the fact that French nouns are typically labelled with an article (*le chien*, *la brosse*, *un coeur*, *de l’eau*) may help account for the strong preference for disyllables over monosyllables in the French children’s production (Wauquier & Yamaguchi, 2013). More specifically, the definite articles and pronouns in /IV.../ (*le* ‘the, m.’, *la* ‘the, f.’, *les* ‘the, pl.’, *lui* ‘to him’, *leur* ‘their’) may have shaped Laurent’s attraction to medial [l], with the routine use of a fixed sequence <CVIV> providing another solution to the memory and planning issues posed by within-word consonant change.

Italian

Table 10 provides an overview of the most-used structures in Italian. The minimal <CV(V)> structure occurs only rarely. Italian content words are seldom monosyllabic; two of the three monosyllables produced by several children each are deictics (*qua*, *qui*).

Table 10. Prosodic structures in Italian. (Co indicates optional consonant: i.e., forms with and without medial clusters are included)

Structure	Number of children with over 20% use of structure	Mean proportion of all variants (and range)
VCCoV	7	.27 (.21-.36)
C ₁ VC ₁ V (including Reduplication)	8	.27 (.22-.36)
CVCCV	14	.29 (.22-.38)
C1VC2V(CV)	6	.26 (.21-.29)
Longer words	C.L.	.25 (13/51)

Another Italian characteristic is the wider distribution of variants in differing structures: No structures account, on average, for as much as one-third of the variants produced. This may be due to the fact that so many children often produce the geminate (<CVCCV>) structure that the analysis set it apart from the corresponding medial-singleton structure, <C1VC2V>. This latter structure, often with a within-word change of place of articulation, occurs rarely in English and French child forms, mainly as part of a more specified template. No such templatic specialization is seen in these cases in Italian.

Italian: Selected and adapted variants

As in French, many Italian children make use of the onsetless disyllabic pattern, omitting word-initial consonants that are well within their repertoire in other positions (Table 11).

Table 11. <VCV> (m. ‘masculine’)

Select	Adapt		
G.A. (.36: 12/33)			
<i>aqua</i> ‘water’	ak:a	<i>grazie</i> ‘thank you’	at:ʃe (6)
<i>ecco</i> ‘here it is’	ɛk:o (2)	<i>latte</i> ‘milk’	at:e
<i>occhio</i> ‘eye’	ok:o	<i>quello</i> ‘that, m.’	ɛl:o (2)
M.G. (.30: 14/46)			
<i>apri</i> ‘open (it)!’	api (5)	<i>basta</i> ‘enough, stop’	at:a (3)
<i>ecco</i> ‘here it is’	ɛk:o (12)	<i>grazie</i> ‘thank you’	at:e (5)
<i>uva</i> ‘grape’	uva (5)	<i>questo</i> ‘this, m.’	et:o (2)

Use of consonant harmony (Table 12) is seen in about half of the Italian children, with some forms showing full reduplication, usually in accurate replication of the target. G.C.’s harmony structure includes about equal numbers of simple harmony and reduplication, with far more selected than adapted variants and none suggesting adaptation to create a reduplicative pattern.

Table 12. Consonant harmony (C₁VC₁V)

Select	Adapt
G.C. (.33: 11/33)	

<i>mamma</i> ‘mama’	mam:a (3)	<i>latte</i> ‘milk’	tat:e (2)
<i>nanna</i> ‘to sleep (BT)’	nan:a		

Table 13 illustrates the large number of Italian children’s variants with non-harmonic two and three-syllable words with medial geminate. These words all involve change of place and/or manner of articulation. Note that adaptation here involves truncation – and many children, like A.P., simply ‘select’ these words, producing them accurately.

Table 13. Non-harmonic multisyllabic words with medial geminates

Select		Adapt	
A.B. (.38: 15/40)			
<i>bolle</i> ‘bubble’	bol:e	<i>aspetta</i> ‘wait!’	pet:a (2)
<i>grazie</i> ‘thank you’	gat:ʃe (5)	<i>bistecca</i> ‘steak’	tek:a (2)
<i>scarpe</i> ‘shoe’	kap:e	<i>piselli</i> ‘peas’	pɛl:i
A.F. (.36: 16/45)			
<i>bello</i> ‘beautiful, nice, m.’	bɛl:o	<i>padella</i> ‘pan’	pɛl:a
<i>grosso</i> ‘fat, m.’	ɡɔs:o	<i>bottiglia</i> ‘bottle’	bot:ja
<i>metti</i> ‘put’	met:i	<i>coperchio</i> ‘lid, cover’	pek:o
A.D.1 (.35: 15/43)			
<i>bimba</i> ‘baby, f.’	bimba (3)	<i>capretta</i> ‘little goat’	pet:a
<i>forte</i> ‘strong’	fot:e (3)	<i>Emilio</i>	miljo
<i>freddo</i> ‘cold’	fed:o		
A.P. (.33: 11/34)			
<i>basta</i>	bat:a		
<i>brucia</i>	bu'tʃa (3)		

Finnish

Table 14 provides an overview of the most-used structures of the six Finnish children.

Table 14 Prosodic structures in Finnish.

Structure	Number of children with over 20% use of structure	Mean proportion of all variants (and range)
CVV	1	.32
VCV	4	.38 (.29-.50)
Reduplication	1	.36
Consonant harmony Mean .29	4	.29 (.21-.38)
Reduplication and consonant harmony combined Mean .32	2	.23 (.22-.24)
C ₁ VC ₂ V Mean .21	1	.25 (7/28)

Finnish, like Italian, has contrast between medial singletons and geminates, which are influential in shaping children's early word patterns in languages that have them (see, for example, Khattab & Al-Tamimi, 2013, on Arabic; Vihman & Croft, 2007, on Hindi). However, the Finnish children's most-used prosodic structures are quite unlike those of the Italians.

First, monosyllabic content words are more common in the Finnish core vocabulary than in Italian (making up 13% of the target word types attempted by any of the six children). An important structural difference is the presence of long vowels in Finnish and the 'minimal word' constraint, such that <CV> does not occur in content words (see also Demuth, this volume).

Finnish has many long words, mostly due to the agglutinative morphology (several suffixes, each with separate meaning, can be strung together at the end of a noun, for example; see Savinainen-Makkonen, 2000a), but the basic uninflected content words are seldom longer than two syllables. Few long words were attempted (Eliisa *paperi* 'paper' [pape], Ilari *uppista* 'upsy-daisy' [up:i], Matti, *apelsiini* 'orange' [apetæ] are among the exceptions) and even fewer produced. And although word-medial geminates are common in Finnish as well as in Italian, Ilari, the one child who used non-harmonic <CVC(C)V>, targeted and accurately produced more words with singletons than with geminates in this structure.

Finnish: Selected and adapted variants

Tables 15-17 illustrate the prosodic structures used for over 33% of any child's variant forms in Finnish. Here it can be seen that Finnish structure, like Italian, presents relatively few challenges to the child. For <VCV> initial consonant omission, unknown as a systematic process in English (Savinainen-Makkonen, 2000b), is the main adaptation.

Table 15. <VCV> sP: partitive singular

Select		Adapt	
Atte (.50: 16/32)			
<i>äiti</i> ‘mother’	æit:i (*7)	<i>kala</i> ‘fish’	ala
<i>isi</i> ‘father’	içi (*6), aiçi	<i>loppu</i> ‘end, all done’	op:u (*4)
<i>ukko</i> ‘old man’	uk:o (*3), auk:o	<i>pallo</i>	al:o (*2)
Matti (.39: 19/49)			
<i>ankka</i> ‘duck’	ak:a	<i>jalka</i> ‘foot’	ak:a
<i>anna</i> ‘give’	æn:æ	<i>katso</i> ‘look’	ato (*7)
<i>omppu</i> ‘apple’	ɔp:u (*3)	<i>vettä</i> ‘water, sP’	et:æ

Reduplication is more common in Finnish than in the other languages, but it nevertheless accounts for over 20% of the variants of only one child, Mira (Table 16); the closely related harmony forms are shown in Table 17.

Table 16. Reduplication (s3 'third person singular')

Select		Adapt	
Mira (.36: 12/33)			
mummu ‘grandma’	mum:u	jalka ‘foot’	lala
pappa ‘grandpa’	pap:a	kukka ‘flower’	kak ^h a
paapaa ‘sleeping’ (BT)	pa:pa:	nalle ‘teddybear’	ʌaʌ:a

Table 17. Consonant harmony

Select		Adapt	
Eliisa (.38: 13/34)			
<i>kukka</i> ‘flower’	kuk:a	<i>nuke</i> ‘doll’	kuk:e
<i>pupu</i> ‘bunny’	pupo	<i>pallo</i> ‘ball’	pap:u
<i>tyttö</i> ‘girl’	tyt:ö	<i>vettä</i> ‘water, sP’	tit:æ
Mira (.33: 11/33)			
<i>nenä</i> ‘nose’	nenæ	<i>lintu</i> ‘bird’	tito
<i>tonttu</i> ‘elf, brownie’	təto (*2)	<i>setä</i> ‘uncle	tetæ
<i>tyttö</i> ‘girl’	tyt:o (*2)	<i>tyyny</i> ‘pillow’	ny:ny

Overview of findings

An overall picture of the distribution of prosodic structures in the four languages is given in Table 18, with numbers of children making criterial use of each structure in each language group. (Recall that ‘criterial use’ means reaching at least 20% of a child’s structures.) With the exception of Italian, where some children are already beginning to accurately produce words of more than two syllables at this lexical level, one- and two-syllable forms account for all of the children’s often-used prosodic structures.

Table 18. Number of children producing over 20% of all variants in each structure. Shaded cells highlight use by over half the children in the group.

	English	French	Italian	Finnish
Total number of children	10	13	15	6
CV and/or CVV	9	10	0	1
CVC	5	1	0	0
VCV	0	8	7	4
Reduplication and/or Consonant Harmony	3	9	8	6
CVCCV	0	0	14	0
C1VC2V	4	2	7	1
CVCVC	1	0	0	0
longer words	0	0	1	0

Much of the ‘adaptation’ seen in the data analysed here relates to the challenge of producing (representing, planning and articulating) two different supraglottal consonants in a single word form. Table 18 shows that both English and Italian groups include more than one child who produces disyllables without harmony to criterion level. In addition, one French child, Laurent, produces 38% such forms, with a more specified structure – <CVIV> – accounting for all 12 such words. Such ‘overuse’ of a structure has been characterized as a phonological template (Vihman, 1993).

On closer examination, phonological templates can also account for at least two of the cases of high use of the <C1VC2V> structure in English. Molly overselects <CVC> target words (Vihman & Velleman, 1989), but adds a final schwa following her coda nasals – which effectively creates open disyllables (e.g., *bang* [pʌn:ɑ], *down* [tʰʌn:ə] and even, with metathesis, *Nicky* [In:i]). Alice shows a marked preference for palatal patterns, consistently producing disyllables with a medial palatal stop or nasal or yod (e.g., *flower* [pʰɑ:ji, pʰɑdʒi], *lady* [lɛji], *shiny* [tʰɑ:ji, daji]: Vihman et al., 1994). The one UK English child with over 20% <C1VC2V> disyllables has a glottal or glide as one of the two consonants in all but one word in this structure.

In contrast with the English and French groups, disyllables (or longer words) with differing supraglottal consonants are quite common in Italian, even after <CVCCV>, the most used Italian structure, has been separated off. In general, the Italian children show great facility in producing differing consonants within a single word form, whether in disyllables or longer words and whether the word includes one or more geminates or not. This is evident from their lack of heavy concentration on a single structure. Although this might be supposed to relate to the fact that, on average, these Italian children are a little older than the other groups, the structures used here are quite similar to those reported for four Italian children in an earlier study of 11 children followed longitudinally to age two (Keren-Portnoy, Majorano, & Vihman, 2009).

Prosodic structures: production and representation

Both similarities and differences are apparent in the prosodic structures that the children in different language groups use the most. The similarities can be broadly summarized as (i) a constraint on length, with words of more than two syllables occurring as a dominant structure only in Italian, in a single child; (ii) a tendency to produce open syllables, with only the English-speaking children showing a substantial number of word forms with codas, almost exclusively in monosyllables; and (iii) a tendency to produce words with only a single place or manner of articulation found in many word forms in all four languages. This results in the well-known preference for consonant harmony and reduplication as well as in use of the <VCV> structure, seen in all languages but English.

The open syllables are a direct reflection of the canonical syllables that constitute the earliest adult-like babbling forms; similarly, both the constraint on word length and the relatively low level of within-word consonant variation have been identified, through earlier studies of individual children seen longitudinally, as reflecting continuity between babble and word use, both in concurrent analyses of the course of development in words and babble (Vihman et al., 1985) and in comparisons of words with earlier babble (e.g., Stoel-Gammon & Cooper, 1984; Keren-Portnoy, Majorano, & Vihman, 2009).

It is less straightforward to account for the differences across the language groups. They must in some sense relate to the differences in the adult languages, especially accentual and rhythmic differences. The absence of the <VCV> pattern in English could be ascribed to the preponderance of trochaic content words (Cutler & Carter, 1987), for example, but Finnish is exclusively trochaic and Italian is dominantly so. For both Finnish and Italian, the common presence of medial geminates appears to draw infant attention away from the onset consonant (Savinainen-Makkonen, 2000b; Vihman & Croft, 2007; see Vihman & Majorano, 2017, for experimental evidence from Italian). For French, on the other hand, phrase-final

lengthening is a likely contributor to the heavy use of the <VCV> structure, as noted earlier; the structure is also seen in languages more conventionally defined as iambic than French, such as Hebrew (Keren-Portnoy & Segal, 2016).

Three aspects of English structure appear to be particularly important in shaping children's word forms, which differ so strikingly here from those of children acquiring the other three languages. First, monosyllables dominate the input in English (Vihman et al., 1994). Second, most English words have codas. The fact that disyllabic structures with codas are rare even in English is most likely due to the complexity or inherent difficulty of this structure. And, finally, diphthongs are widely (and accurately) produced in early words in English (Kehoe & Stoel-Gammon, 2001) and German (Kehoe & Lleó, 2003). Diphthongs do not appear to constitute a difficulty for production; in the languages in which they occur, children often make use of them from their very first words. On the other hand, the only consonant clusters that consistently occur early in the languages in which they obtain are geminates, which appear to be not only salient but easily produced, given children's slow articulation (Vihman & Velleman, 2000).

Conclusion

Prosodic Phonology (Nespor & Vogel, 1986) has been seen as providing a unified framework for characterizing prosodic development cross-linguistically (Kehoe, this volume). Alternatively, or perhaps complementarily, metrics have been proposed as a way of creating a gradient of rhythmic types that might account for differences in prosodic development (Ramus, Nespor, & Mehler, 1999; Grabe & Low, 2002; Vihman, Nakai, & DePaolis, 2006; Payne et al., 2012; see Post & Payne, this volume). However, our emphasis here on individual differences within broadly similar typological effects by language group leads us to suggest that any one way of characterizing stages in prosodic development overall or the several languages in themselves is unlikely to suffice to account for the different ways in which the ambient language shapes the prosodic structures of individual children. That is because the individual differences between children reflect the many possible, sometimes idiosyncratic ways in which children respond to their experience of listening to and beginning to produce speech.

In short, the claim here is that innate knowledge of universal principles of prosodic structure need not be invoked to account for the structures found to predominate in the word forms analyzed here. Production constraints, a concomitant of the slow pace of advances in the neurophysiological control of vocal gestures, play an important role, as does exposure to frequently occurring structures in input speech. But perhaps the most crucial factor, demonstrated by the substantial role of adaptation in the children's use of prosodic structures, is the individual child's experience with vocal practice and the effect of that practice on memory for word forms. The adaptation of less congenial adult forms to the structures in which a particular child had begun to 'specialize' can be understood to reflect the child's filtering of what they hear through the patterns they have practiced the most. This filter manifests the effect of phonological memory, constructed through practice and serving as an essential framework for mapping new words to production routines. This suggests that the filtering of what children hear through what they are easily able to produce – with notable differences from one child to the next – is a critical aspect of prosodic development.

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