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Stages in the Development of Prosodic Words*

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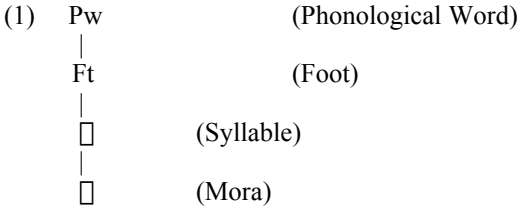
Child phonology data has long been noted for its variability: Some children appear to prefer certain segments over others, and a given child may use certain segments in some contexts but not others (e.g. Vihman, Macken, Miller, Simmons, & Miller 1985). This variation in the segmental realization of children's early words has made it difficult to identify common stages of development across children and/or across languages. However, despite certain types of inter- and intra-speaker variation, recent research on the prosodic development of words has identified several stages in the acquisition of prosodic structures (Fee 1992, Demuth 1995a, Demuth & Fee 1995).

The purpose of this paper is to provide an account of inter-speaker variation at different stages in the development of prosodic words. In section 1. I present the Prosodic Hierarchy and the stages in the development of prosodic words. In section 2. I examine the form that variation takes at different stages of prosodic development, showing that children are working simultaneously at different levels of phonological structure, and that much of the variation in form results from competing wellformedness requirements from each of these levels of structure. In section 3. I discus various ways in which this type of variation can be handled from an optimality-theoretic perspective (Prince & Smolensky in press), exploring the notion of 'soft constraint' and 'tied constraints' and the implications for a theory of language development (see also Demuth 1995b).

1. Stages in the Development of Prosodic Words

Drawing on insights from the Prosodic Hierarchy given in (1) (Selkirk 1984, Nespor & Vogel 1986),

(1)


Demuth (1995b) and Demuth & Fee (1995) identify four major stages in the acquisition of English and Dutch prosodic words.

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(2) Stages in the Development of Prosodic Words

Stage I. Core Syllables - CV
No vowel length distinctions

Stage II. Minimal Words/Binary Feet
a. Core Syllables - (C)VCV
b. Closed Syllables - (C)VC
c. Vowel length distinctions - (C)VV

Stage III. Stress-Feet
a. One Stress-Foot per word
b. Two Feet per word

Stage IV. Phonological Words
Extrametrical syllables permitted

Each of these represents both a lower and upper bound on the form that a child's words take at a particular stage of development. That is, the child's grammar seems to be prosodically 'constrained' to produce no more than one syllable at Stage I, a binary foot at Stage II (either a bisyllabic foot (CVCV) or monosyllabic bimoraic foot (CVC or CVV)), and Stress-Feet at Stage III. Yet sometimes sub-Minimal Words occur when the overwhelming pattern in the child's grammar indicates that she or he is at the Minimal Word Stage II. How do we account for this type of variability? And what does it mean to identify 'stages' in development given this type of variation?

In the following discussion I adopt an autosegmental account of phonological structure, where segments and prosodic structures exist on separate tiers or levels, and where these are mapped onto each other when a word is actually produced (or phonetically realized). Second, I suggest that children acquiring language are working simultaneously at both segmental and prosodic levels of structure. Third, I assume that children's grammars are composed of (potentially violable) grammatical constraints, and that these constraints are reranked over time, with constraints yielding unmarked structures initially ranked highest (Demuth 1995b). Fourth, I argue that children try to map (or parse) as much of the segmental and prosodic information from the input/target form into their surface output forms as their grammars will allow at a given stage of development. This is generally known within Optimality Theory as the Faithfulness Condition (Prince & Smolensky in press).

In the next section I provide examples of the types of variation found in the acquisition of prosodic words, and show that the much of the variation at Stage II can be accounted for in terms of competing requirements at segmental and prosodic levels of structure. The data examined here include Dutch data from Fikkert 1994 (child J) and English data from Smith 1973 (child AS) and Demuth & Fee 1995 (children MH and PJ).

2. Inter-speaker Variation in Prosodic Structures

At Stage I children generally produce words that are CV in form. However, words at this point also show some variation in shape. Fikkert (1994) notes that children do not control vowel length at this time. In other words, vowel length is not distinctive, and so variation occurs (see Rice this volume).

(3) Stage I - Lack of contrastive vowel length

	Child	Adult Target		
a.	[ka:], [kɑ]	/kla:r/	klaar	J (1;4-1;5)
b.	[da:], [dɑ]	/da:r/		daar

The forms in (4), however, show variation not only in vowel length, but also between the presence or lack of a coda consonant.

(4) Stage I - Lack of contrastive vowel length

	Child	Adult Target		
a.	[du], [du:]	/ʤus/	'juice'	PJ (1;8)
b.	[gu], [gu:]			
c.	[gus], [dʊs]			

PJ appears to be moving into the next stage of development (Minimal Words), where coda consonants begin to be used. Thus, some types of variation may occur due to a lack of contrastiveness, whereas other types of variation may be a result of a transition between different stages of development. In this case a No-Coda constraint may be 'tied' (or equally ranked) with a constraint requiring Minimal Words, resulting in variation in surface form.

Some children enter the Minimal Word stage (Stage II) without being able to produce coda consonants. For these children CVCV forms are found (Stage IIa). However, Fee (1992, this volume) and Fikkert (1994) find that most English-speaking and Dutch-speaking children seem to move quickly to being able to produce coda consonants - Stage IIb (5).

(5) Stage IIb ~ I - (C)VC~ CV

	Child	Adult Target		
a.	[a:p], [ɑp]	/a:p/	aap	J (1;6-1;7)
b.	[teif], [de:s]	/ˈde:ze/	deze	
c.	[bɑf],	/bɑl/	bal	
d.	[bɑ]	/bɑl/	bal	

However, despite the general use of coda consonants at Stage IIb, J produces a sub-Minimal Word in (5d). Note that the target coda is /l/. J uses two strategies to deal with the problematic segment: In (5c) he substitutes /f/ for /l/, but in (5d) he produces the word with no coda at all. Because the vowel is not bimoraic, his production results in a sub-Minimal Word. Such examples indicate that parsing segmental information into the output form may come at a 'cost' if that segment is not actually part of the input as well. In other words, [bɑf] is costly because it has a segmental violation, and [bɑ] is costly because it has a prosodic violation, as well as a segmental violation of a different type (omission rather than substitution).

Interestingly, Fikkert (1994) shows that J then goes through a stage where sonorant-final target words are realized with either a long vowel (6a-d) or a vowel plus sonorant consonant (6e-g), but not both. In other words, J is beginning to control vowel length, but his forms are still maximally a binary foot/Minimal Word.

(6) Stage IIb ~ IIc - (C)VC$_{son}$ ~ (C)VV

	Child	Adult Target		
a.	[tèi]	/trèin/ trein	J 1;10.9	
b.	[da:]	/da:r/	daar	
c.	[ty:]	/stu:l/	stoel	
d.	[bo:], [bɑu]	/bɑl/	bal	
e.	[œ□]	/œyl/	uil	
f.	[bɑl]	/bɑl/	bal	J 1;10.23
g.	[pɑv]	/bɑl/	bal	J 1;11.20

Again, /l/ proves problematic, surfacing initially as a long vowel in (6c), and as a substituted consonant in (6e,g). It also, however, surfaces in the appropriate form in (6f). Obviously, sonorant codas are still difficult at this point, but the /l/ target is beginning to be met. Furthermore, in all cases where /l/ is not produced, the form that results is a Minimal Word, rather than sub-Minimal as in (5d). Thus, prosodic form is maintained at this stage, even though the segments used to realize it may not be part of the target itself. At this point it would appear that violating prosodic structure comes at a higher cost than inserting segmental material that is not part of the input. In other words, constraints on prosodic structure now take precedence over segmental considerations; we might conclude that they are now more highly ranked.

Similar variations are found in the early words of child MH, where the first coda consonants are generally glottal stops (though a /g/ is actually produced in (7d)).

(7) Stage IIb ~ I ~ IIc - (C)VC~ CV ~ (C)VV

	Child	Adult Target		
a.	[dʌʔ]	/dɑg/	'dog'	MH (1;7)
b.	[dʌ]	/dɑg/	'dog'	
c.	[ɪʔ], [ɛʔ]	/ɛg/	'egg'	
d.	[ɛg]	/ɛg/	'egg'	

In (7b), however, the coda is omitted, resulting in a sub-Minimal Word. It would appear that codas are still not fully controlled at this point, and that, although a substitute /ʔ/ is generally used, the trade off is to use no coda, even at the cost of producing a sub-Minimal Word.

Given evidence from both J and MH, we might expect that sub-Minimal Word forms disappear once vowel length is controlled at Stage IIc. This appears to be 'almost' true. The following forms from child PJ demonstrate that she is at the Minimal Word stage of development, with alternations between CVC and CVV forms.

(8) Stage IIb ~ I ~ IIc - (C)VC~ CV ~ (C)VV

	Child	Adult Target		
a.	[rɑʔ]	/wɑk/	'walk'	PJ (1;11)
b.	[to:s]	/tost/	'toast'	
c.	[du:s], [ʤu:s], [ʤu:]	/ʤus/	'juice'	
d.	[bi:s], [be:]	/bidz/	'beads'	
e.	[sup], [su:], [sʊ]	/sup/	'soup'	

Both (8c,d) show that PJ uses a long vowel when a coda consonant is not used. The same occurs in (8e), except that a short lax vowel also occurs in one of the forms. Here again there is an occasional use of a sub-Minimal Word, even at the point where the large majority of the words are wellformed binary feet. We suggest that PJ has not yet fully arrived at Stage IIc where vowel length is completely controlled. In contrast, child AS is well into the CVC stage of Minimal Words when he occasionally omits /z/ coda consonants. In all cases of coda omission the vowel is tense and bimoraic, resulting in a well-formed Minimal Word.

(9) Stage IIb,c – CVC ~ CV_{tense}

	Child	Adult Target		
a.	[di]	/Ciz/	'cheese'	AS (2;2)
b.	[nu]	/noz/	'nose'	
c.	[pi]	/pliz/	'please'	

Thus, despite the challenges that certain segments pose for some children, it is still possible to talk about 'stages' of prosodic development. In fact, appealing to a semi-autonomous level of prosodic structure provides a frame of reference for understanding much of the segmental variation noted in the acquisition literature. Furthermore, much of the variation found in the shape of prosodic words can be accounted for in terms of segmental problems such as lack of contrastive vowel length and the 'cost' of parsing segments into the output if they are not part of the input/target form. Finally, these 'costs' will change as certain grammatical constraints in children's grammars, including Faithfulness constraints which entail mapping the input into the output form, become more highly ranked over time.

Children eventually move beyond the Minimal Word stage and begin to produce words that are larger than simply a binary foot. The next stage of development appears to be limited to Stress-Feet - Stage III, as evidenced by the inclusion of epenthetic syllables to the trisyllabic targets in (10a,b).

(10) Stage IIIb - Stress-Feet

	Child	Adult Target		
a.	['ɛbininin]	/'ɛləfənt/	'elephant'	AS (2;3)
b.	['mu:gəga:baik]	/'motərbaik/	'motorbike'	

The form in (11a) is composed of only one Stress-Foot, not two. The nature of the target, however, is somewhat different, with stress on the second syllable rather than on the first.

(11) Stages III ~ IV - Stress-Feet ~ Phonological Words

	Child	Adult Target
a.	['ma:do]	/tə'mato/'tomato' AS (2;3)
b.	[də'ma:do]	/tə'mato/'tomato'

In (10) it appears that it was easier for AS to produce Stress-Feet rather than allow unfooted (extrametrical) syllables, even at the 'cost' of including a syllable in the output that was not part of the input. However, an extrametrical syllable is produced in (11b), illustrating that AS is moving on to Stage IV (Phonological Words). As Fikkert (1994) also notes, it appears that extrametrical syllables first appear at the edges of words, rather than word internally. This would account for the fact that the target forms /'ɛləfənt/ 'elephant' and /'motərbaik/ 'motorbike' are not yet produced at this point. The trade-off would then be to produce only a Stress-Foot, or to add an a syllable to these forms to produce two Stress-Feet. It appears that the need to parse more of the surface input at this point is greater than the cost of including an epenthetic syllable.

In sum, the examples presented above show two different types of inter-speaker variation with respect to the structure of prosodic words. The first is due to a lack of contrast such as that between short/long or tense/lax vowels at Stage I. The second is due to competing segmental /syllabic and prosodic requirements like those found at Stage II and between Stages III and IV. Both can pose problems for the prosodic realization of early words. In such cases children's variant forms may 'optimally' satisfy either segmental/syllabic or prosodic requirements, but not both. In the following section I briefly outline what a model of such a system might look like, where different grammatical constraints in the child's developing phonology are in direct competition with one another.

3. Constraints and Levels of Phonological Representation

In the foregoing discussion I have talked about interactions between segmental, phonotactic, and prosodic structure in the construction of children's early words. In the following discussion I deal with these levels of structure and the notion of 'constraints' in an informal manner, focusing on interactions between them and implications for the structure of children's developing grammars. (See Prince & Smolensky (in press) and Demuth 1995b for a more formal treatment of these issues in adult and child grammars respectively).

Given an input/target form, such as /dɑg/ 'dog' (from MH in (7a,b)), along with phonotactic constraints that permit coda consonants, segmental constraints that disallow /g/ codas, and prosodic constraints that require a Minimal Word (e.g. Stage IIb), the respective output forms can be derived as follows:

(12)

	INPUT	Phonotactic CVC	Phonotactic *g	Segmental MinWd	Prosodic	OUTPUT[1]
a.	/dɑg/	/dɑg/	/dʌ/	*		[dʌ]
b.	/dɑg/	/dɑg/	/dʌ*ʔ/ [dʌʔ]		[dʌʔ]	

Due to the prohibition in the child's grammar against /g/ codas (a segmental constraint), two possible output forms can be generated. The form in (12a) deletes the offending segment altogether, resulting in an ill-formed prosodic word. In contrast, the form in (12b) replaces it with a different stop from a nearby place of articulation, introducing a new segment into the output form, but preserving prosodic word structure in the process.

Although the constraints here are ordered in linear fashion, they can be thought of in terms of mutual satisfaction as opposed to the ordered application of rules. Note, however, that the prosodic constraint requiring Minimal Words seems to function as a type of 'repair' strategy, where it has a chance to compensate for the effects of phonotactic and segmental constraints. In other words, prosodic structure is violated in (12a), but segment structure is violated in (12b). Given that these forms appear in free-variation, it might be reasonable to assume that constraints governing these forms are equally ranked within the child's grammar at this point. However, given that the other forms the child produces at this time seem to surface in forms consistent with (12b), it appears that prosodic constraints are actually more dominant (i.e. more highly ranked). In other words, an examination of the child's entire phonological system at this point will show the constraint requiring the output of well-formed Minimal Words is more highly ranked, but that it may occasionally be violated - i.e. it is a 'soft' constraint.

This same type of variation can also account for the form of words at later stages of acquisition. Consider the variation in (11) with 'tomato', where AS alternates between a Stress-Foot ['ma:do] and a form with an extrametrical syllable [də'ma:do]. In this case phonotactic and segmental factors play a negligible role in determining prosodic structure. Rather, there seems to be a trade-off between producing only Stress-Feet, and parsing more of the syllabic content of the word to into the output form, in accord with the Faithfulness Condition.

(13)

	INPUT	Prosodic Stress-Feet	Parse	OUTPUT
a.	/tə'mato/	*	[də'ma:do]	[də'ma:do]
b.	/tə'mato/ ['ma:do]	*	['ma:do]	

[1] See Levelt (1994, this volume) for discussion of early consonant-vowel interactions at the level of the prosodic word.

Further examination of the child's prosodic system at this point would be needed to determine if prosodic and parse constraints are equally ranked at this time, or if one of the constraints is more highly ranked than the other, but occasionally violated. I assume that both situations may occur in language development, and that each may account for different types of variation that occur. Only a thorough treatment of a child's phonological system at a given stage of development will provide the evidence needed to decide between the two.

Variation can, of course, arise for other reasons as well. Grimshaw (1995) discusses a different type of surface 'optionality', where variation results from a difference in input form. Translating her syntactic examples into child phonology, these would be case where the actual target form the child was trying to produce would be different. Such cases might entail the use of stressed versus unstressed pronouns, or the use of a word in isolation as opposed to one embedded in larger phonological phrases. Variation arising in such situations would be due to different types of input (e.g. different contexts) rather than to 'tied' or 'violated' constraints. In other words, given a different phonological context, the 'optimal' form will be different. Ultimately, then, a discussion of children's developing phonologies, as well as stages in the development of prosodic words, will have to consider the larger contexts in which these words are produced.

The approach to stages of prosodic development outlined here relies critically on looking at the shape of children's words as part of an entire phonological system. At any given stage of development, there may be some forms that do not prosodically comply due to competing constraints from other levels of phonological structure (e.g. segmental, phonotactic, etc.). A constraint-based approach to these issues provides a framework within which to examine some of these competing forces in children's early grammars. In so doing, I assume that the input is accurately perceived, providing the correct lexical representation for the child's output form. Such a model of phonological competence is similar to Macken's (1980) 'one-lexicon' model in that input and output representations are the same, but shares with Kiparsky and Menn's (1977) two-lexicon model the notion that input is generally well-formed. The result is quite a different 'constraint-based' model, employing one lexical representation, but an output form that is filtered through various grammatical constraints. Rerankings of these constraints over time will produce different surface forms, all operating on the same lexical representation (see Demuth 1995b, Demuth & Fee 1995).

4. Conclusion

In this paper I presented evidence that, despite certain amounts of syllabic and segmental variation, it is nonetheless possible to identify discrete stages of prosodic development. Using a 'constraint-based' approach to early child grammars and the notion of different levels of phonological structure, I showed informally how segmental and Faithfulness/parsing constraints may compete with prosodic constraints to produce variations in the shape of children's early words. Critically, I have assumed that inputs for these various word forms are the same, and that the types of variation examined here result from constraints which are

either equally ranked within the child's grammar ('tied' constraints), or by the occasional violation of 'soft' constraints. The first produce actual free-variation, the second only 'exceptions' to a more systematic phonological pattern. In both these respects, children's grammars differ somewhat from adult grammars, where constraints are less often 'tied' and less often violable, resulting in less variation overall.

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