

# Markedness vs. Frequency Effects in Coda Acquisition\*

Jessica Stites, Katherine Demuth, and Cecilia Kirk  
Brown University

## 1. Introduction

The problem of individual variation has long plagued the field of language acquisition (e.g., Bloom, 1970; Nelson, 1981). This has been especially true in the area of phonology (e.g., Stoel-Gammon, 1985; Vihman, 1993; Vihman & Greenlee, 1987). Individual preferences for certain consonants begin at the babbling stage of development and persist into the formation of children's first words (Vihman, Macken, Miller, Simmons & Miller, 1985). Other individual differences emerge later, with variation reported in patterns of syllable structure (e.g., Barlow, 1997; Ingram, 1978; Rose, 2000), word structure (e.g., Fikkert, 1994) and filler syllables (e.g., Peters & Menn, 1993).

This high level of individual variation in children's early phonologies led Fergusson and Farewell (1975) to propose that each child had an individual 'learning style'. This suggests that learning language is a random process, with few constraints on the learning paths a child might take. Rule-based approaches to the acquisition of phonology (e.g. Smith, 1973), where many unmotivated phonological rules were invoked to capture a child's developing phonological system, only served to reinforce this notion of randomness. However, as Pater & Barlow (2002) demonstrate, the types of grammars attested are actually a restricted set of possible grammars. That is, the types of possible individual variation appear to be constrained.

Several decades ago Jakobson (1941/68) proposed that children would acquire the unmarked sounds of language first, and only later acquire the more marked segments (i.e., those less frequently attested in the world's languages). Jakobson thought that those segments most commonly found crosslinguistically (e.g., /p/, /n/, and /a/) would be the easiest to perceive and produce, and would therefore be the first to be acquired. Although Jakobson's claims have never been substantiated at the segmental level, markedness proposals for explaining developmental learning paths have

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received renewed attention with the advent of Optimality Theory (Prince & Smolensky, 1993). OT provides a framework for investigating linguistic structures in terms of constraint interactions rather than rules. This provides a means for addressing acquisition issues at higher levels of structure such as the syllable and the prosodic word, as well as the interaction between segments and these prosodic structures. For example, Demuth (1995, 1996a, 1996b) and Demuth & Fee (1995) showed that children's early words take the unmarked form of a minimal word, or binary foot. Gnanadesikan (1996) showed that children's first syllables take the unmarked form of core syllables, or CV, also exhibiting a preference for the least marked onsets (i.e., segments with the least sonority). Pater (1997) extended these findings, showing that, when children truncate early words containing an initial unstressed syllable, they have a tendency to preserve the consonant that is least marked (less sonorant) in onset position. Thus, although some children truncate *banana* to ['nænə], others select the word-initial stop (the least marked onset) to fill the onset of their truncated form ['bænə]. Thus, there is ample evidence that children at early stages of acquisition produce unmarked syllable and prosodic word structures, and that segments are included in this process.

During this time researchers also began to discover that children are sensitive to the high-frequency linguistic structures of the language(s) to which they are exposed. Some of these findings have come from the area of infant speech perception, where researchers have shown that English-learning infants are finely tuned to the statistics of the ambient language, showing an early sensitivity to high-frequency word structures (Jusczyk, Cutler & Rendanz, 1999; Morgan, 1996) and segmental contrasts (e.g., Anderson, Morgan & White 2003; Maye, Werker & Gerken, 2002). Other research has shown similar sensitivities in the early production. For example, Kirk & Demuth (2003) showed that English-learning children tend to acquire coda clusters before they acquire onset clusters. Coda clusters are much more frequent in English than onset clusters. Furthermore, the first coda clusters to be acquired are also the highest frequency stop + s,z clusters, as in *box* [baks]. In addition, metathesis errors turned the lower frequency s,z + stop clusters (e.g., *wasp* [wasp]) into the higher frequency stop + s,z clusters (e.g., [waps]). Thus, not only the course of language acquisition, but some of the errors made along the way, show an early preference for high frequency phonological structures in children's productions. This runs counter to claims by Chomsky (1965) and Brown (1973) that frequency effects cannot explain the course of language development.

Early sensitivity to the frequency of phonological structures is also found crosslinguistically. For example, Spanish-learning children tend to acquire initial weak (unfooted) syllables several months before English-learning children. Conversely, English-learning children acquire coda consonants several months before Spanish-learning children (Demuth, 2001). Roark & Demuth (2000) showed that the earlier acquired structures in each language are much higher in frequency relative to other word and

syllable structures. Thus, children tend to produce higher-frequency syllable shapes and prosodic word shapes before they produce lower frequency prosodic structures.

Findings consistent with these claims are reported in Levelt, Schiller & Levelt's (2000) study of Dutch-speaking children's development of syllable structure. The syllable shapes that are highest in frequency are acquired first, and the syllable shapes that are lowest in frequency are acquired last. Interestingly, however, these children exhibited individual variation in the learning path when the frequency of two syllable structures was the same, some opting for increased complexity in the onset first (CCVC), and others exhibiting increased complexity in the coda first (CVCC). This suggests that we should expect to find individual variation when two comparable structures have equal frequency.

Note, however, that the first acquired and highest frequency syllable shapes in Dutch are also core syllables, or CV – the least marked syllable shape crosslinguistically. And, as one might expect, the last acquired and least frequent syllable structures were also the most marked, exhibiting consonant clusters in both onset and coda positions (CCVCC). Thus, the frequency of these different syllable shapes coincides with markedness. Although Levelt, et al. (2000) suggest that the Dutch children are sensitive to the frequency of different syllable shapes, perhaps they are also sensitive to the markedness of these syllables. Or, perhaps learning is facilitated when frequency and markedness coincide.

The Dutch findings raise several interesting questions for further research. First, they suggest that at least some forms of individual variation may arise where the frequency (or markedness) of related structures is equivalent. Second, they suggest that children's phonologies may not be as unconstrained as Ferguson & Farewell (1975) proposed, but show a finite set of learning paths, where both markedness and frequency play a role. Markedness and frequency coincide in the Dutch data; what happens when they differ? Perhaps some learners are more sensitive to markedness, and others more sensitive to frequency. If so, this might account for some of the individual variation reported in children's early grammars. The challenge, however, in testing this hypothesis, would be to identify a context where markedness and frequency do not coincide. One of the contexts where this occurs is that of English coda consonants. We turn to a discussion of these issues below.

## **2. The Markedness and Frequency of English Coda Consonants**

The CV syllable is widely acknowledged to be the least marked syllable shape cross-linguistically (Clements & Keyser, 1983). Many languages do not permit codas (e.g., Sesotho, Hawaiian), and those that do also permit CV syllable structures (e.g., English). These crosslinguistic findings led Clements (1990) to propose that CV is the optimal syllable shape, where sonority rises sharply toward the peak (or nucleus) of the syllable, and falls minimally toward the end. That is, less sonorant

consonants are the least marked in onsets (cf. Gnanadesikan (1996) and Pater (1997) findings above), and more sonorant consonants are the least marked for codas. The Sonority Hierarchy, and the sonority of different consonants, are given in (1).

(1) Sonority Hierarchy (Ladefoged 1982)

Glides > Liquids > Nasals > Fricatives > Stops

*more sonorant*  
*less marked codas*

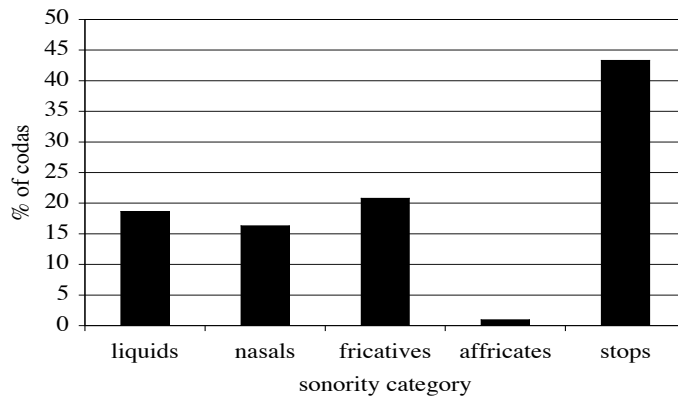
*less sonorant*  
*more marked codas*

Languages that permit codas often restrict them to sonorant consonants (e.g., Japanese allows only nasal codas), whereas languages that allow less sonorant consonants tend to also allow more sonorant consonants (e.g., English allows all sonority categories in codas). The handling of loan-words in languages with a restricted set of codas provides additional evidence that these syllable-based sonority constraints are non-accidental. For example, in the Beijing dialect of Chinese, in which only /r/, /n/, and /ŋ/ are allowed in coda position, less sonorant codas in loanwords are resyllabified as onsets to a following syllable (Blevins, 1995). Thus, sonorant codas are the least marked (most widely attested) coda type cross-linguistically. Furthermore, there is an implicational hierarchy whereby those languages that permit the most marked/least sonorant codas (i.e., stops) will also permit less marked/more sonorant codas (e.g., liquids, nasals), as in English.

Since English permits coda consonants at all points along the sonority hierarchy, we were interested to see how frequent each of these coda types were, and if sonority/markedness and frequency would differ. To determine the frequency of the different English coda consonant types that a typical English-learning child would hear, we examined coda consonants in a sample of child-directed speech. This included 284,976 word tokens drawn from the Adam, Eve and Sarah files on the CHILDES database (MacWhinney, 1995), and 136,214 word tokens of child-directed speech from our own corpora. The adult speech samples were spoken to children between the ages of 0;11.25 and 5;1.6, and were written orthographically. All words containing singleton codas in final stressed position were then extracted, phoneticized using the Carnegie Mellon North American English pronouncing dictionary, and categorized by sonority. This resulted in 184,220 words with final codas in stressed syllables, where affricates comprised only 0.95% of all codas, liquids, nasals, and fricatives comprised 18.65%, 16.30%, and 20.78% of codas respectively, and stops comprised 43.31% of codas. Stops are therefore the most frequent type of word-final coda in English child-directed speech (see Figure 1).

Stop codas are marked cross-linguistically, and yet these are the most frequent coda type in English child-directed speech. Thus, English stop codas are a case where markedness and frequency conflict. English coda consonants therefore provide an ideal test ground for determining

learnability preferences: if learners are sensitive to *markedness*, they should acquire more sonorant consonants before stops. However, if learners are sensitive to *frequency*, they should acquire stop codas before more sonorant codas. In the next section we turn to the acquisition data, examining two English-speaking children's development of coda consonants.



**Figure 1. The relative frequency of word-final stressed coda consonant types in English child-directed speech.**

### 3. The Study

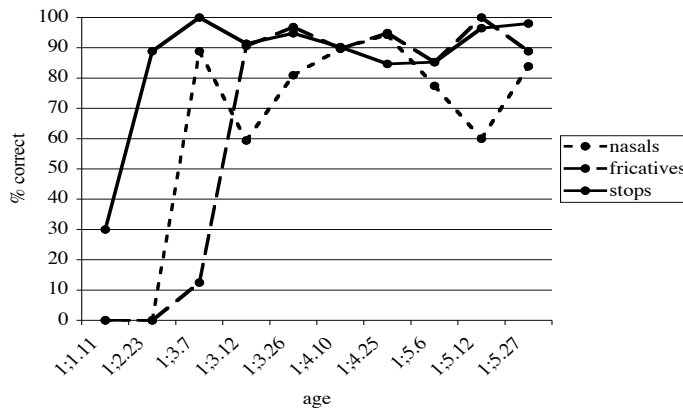
This study analyzed longitudinal spontaneous speech samples collected from two children from southern Massachusetts and Rhode Island, Child N (a girl) and Child W (a boy). Each child was audio and video recorded every two weeks for one hour in the home while interacting with their parents. The recordings for this study were drawn from the onset of the children's first words until the reliable production of coda consonants (i.e., over 80% target codas produced in three or more consecutive sessions). Child N's sessions therefore ranged from age 1;1.10 to 1;4.25, and Child W's sessions from age 1;4.10 to 1;11.14. Recordings were phonetically transcribed in CHAT format (cf., MacWhinney, 1995).

From these speech samples, target words containing singleton codas in word-final stressed positions were extracted and examined. Since liquid codas are generally acquired late, and the children in this study were exposed to an *r*-less dialect, we decided to omit liquid codas from the study. Affricate coda targets were extremely rare (cf. the low frequency of adult affricate coda targets in Figure 1); we therefore also omitted affricates from the study.

Our analysis then examined the children's acquisition of nasal, fricative, and stop codas in word-final stressed syllables. During the period examined Child N targeted 1115 codas (including 22 plural morphemes), and Child W targeted 629 (including 12 plural morphemes and a copula). Any session with less than 15 tokens was collapsed with the following

session, resulting in a range of 16 to 259 codas per session. A coda was counted as correctly produced if it was realized identically to the target (*dog* > [dɑg]) (64% of the data), or as a consonant of the same sonority class (*dog* > [dad]) (10% of the data). This was done to control for possible problems of place or voicing, and to address any issues of segmental gaps. Codas were counted as incorrectly produced if they were deleted (*dog* > [dɑ]) (20% of the data), or substituted with a consonant of a different sonority class (*dog* > [dɑŋ]) (6% of the data).

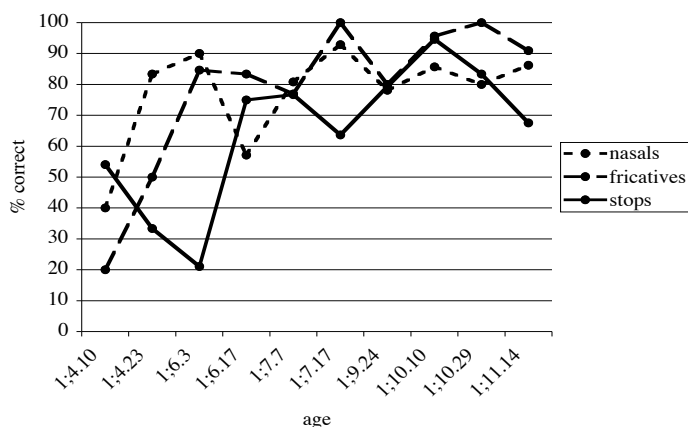
Consider Child N's coda productions in Figure 2. From the age of 1;2.23 onwards, Child N correctly produced over 80% of targeted stop codas. Two weeks later (1;3.7) she began to produce nasal codas. She did not produce fricatives with over 80% accuracy until a week after that (1;3.12), and was still not producing nasal codas consistently two months later (i.e., with over 80% accuracy in three consecutive sessions). Thus, Child N acquired stop codas first, showing a strong preference for frequency over markedness. In contrast, she showed variability with respect to the acquisition of the less marked fricative and nasal codas, nasals appearing first, but reaching criterion later.



**Figure 2. Child N's production of word-final stressed coda consonants.**

Child W's course of coda acquisition is less obvious, but he clearly demonstrates a different pattern of development from Child N (Figure 3). His production of nasal and fricative codas increases during the first three sessions. This contrasts with his production of stop codas, which do not increase until the fourth session, two months later (1;6.17). By 1;7.17 both nasals and fricatives are consistently produced at above 80% in accuracy. In contrast, his stops continue to show variability. Child W is therefore less

sensitive to the frequency of coda types than Child N, showing an earlier preference for less marked nasal and fricative codas.



**Figure 3. Child W's production of word-final stressed coda consonants.**

Could these apparent differences in learning strategies be merely an artifact of the particular lexical items the child was attempting during these sessions? If so, we might expect to find many stop codas in Child N's targets, but fewer stop codas attempted by Child W. However, this is not the case: both children's attempted stop codas constituted 48-49% of their attempted coda targets – very similar to the attested frequency of stop codas in child-directed speech (Figure 1). Further post-hoc analyses of the data suggest that type/token effects also played little role in influencing the results. In one analysis we controlled for type by weighting each target word (type) equally, regardless of the number of times it was attempted in a session. Thus, if a child attempted a target once and produced it, that the accuracy for that target would be weighted as 1/1, while if a child attempted a target twice and produced it only once, the accuracy for that target accuracy would be 1/2. This analysis produced results very similar to those in Figures 2 and 3. We then considered possible input effects by examining the child-directed speech for each child. This included 12,631 words with final codas for Child N, and 13,561 for Child W. There were no significant differences in the frequency of input coda types for the two children. Thus, neither lexical effects in the input nor in the child's attempted targets can account for the different developmental patterns found.

In a second analysis we looked at the children's onsets consonants to determine if their coda acquisition patterns might be due to different abilities with different classes of segments. However, there were no restrictions on onsets produced, suggesting that the sonority effects found in this study were coda-specific. This also bears on representational issues:

Goad & Brannen (2003) suggest that final consonants in English may actually be syllabified as onsets to empty-headed nuclei. This hypothesis makes two predictions: 1) that codas will exhibit restricted sonority profiles, whereas word-final onsets will not (e.g., French), and 2) word-final codas will be acquired piecemeal, whereas word-final onsets should all be acquired at the same time (e.g., Rose, 2000). It therefore appears that the word-final consonants in our study are codas, and not onsets to empty-headed syllables.

In sum, Child N showed an early preference for frequent rather than unmarked codas, and Child W showed the reverse, indicating two different types of language learning strategies. Other factors, such as possible lexical, segmental, and representational explanations of the data cannot account for these different patterns of development. Thus, some of the individual variation reported in the literature may be due to different learning strategies of this type. In the following section we discuss some of the theoretical implications of these findings.

#### **4. Discussion**

In the foregoing section we showed that Child N and Child W display two different strategies in acquiring English coda consonants: Child N is sensitive to frequency, whereas Child W is sensitive to markedness. This difference in learning strategies has significant implications for our understanding of how language is learned, explaining some of the individual variation across children, as well as variability in the productions of a individual child. However, the possibility that different children might exhibit different 'learning algorithms' raises several learnability questions.

First, what does it mean to prefer frequency over markedness? Much of the recent acquisition of phonology literature has suggested that children's initial production (and perceptual) grammars have markedness constraints ranked more highly than faithfulness constraints (Markedness >> Faithfulness) (cf. Demuth, 1995; Gnanadesikan, 1996; Pater, 1997; Smolensky, Davidson & Jusczyk, in press). That is, children's early perceptual preferences and productions are not necessarily faithful to the target form. Thus, some learners seem to permit target inappropriate outputs for several years. As Roark & Demuth (2000) show, this can happen even when a particular (syllable, word) structure occurs with some non-trivial frequency (e.g., Spanish coda consonants occur on 25% of syllables, yet are acquired much later than English codas, often only after the age of 2) (e.g., Lleó, 2003). Thus, some children persist in being unfaithful to the target for extended periods of time. However, the fact that coda consonants are much more frequent in English (occurring on 60% of all syllables), and are also acquired earlier than in Spanish, suggests that language learners quickly become faithful to the high-frequency structures of the language to which they are exposed. The early mapping high frequency structures into early output forms can be thought of as being more faithful, showing fewer constraint violations. We can therefore recast the different learning strategies

of the two children in this study in terms of the following constraint rankings, where Child N demoted frequently violated constraints first, and Child W demoted the least marked constraints first:

(2) Two different learning paths/constraint rankings

Child N: Frequency: \*nas/coda , \*fric/coda >> \*obstr/coda  
Child W: Markedness: \*obstr/coda >> \*fric/coda >> \*nas/coda

As we study additional children we may discover that more are faithful to higher-frequency structures earlier than originally thought. Child N seems to be one of the children, acquiring most of her coda consonants by age of 1;2.24. (See also Salidis & Johnson's (1997) study of a child who produced coda consonants along with his first words at 10 months).

If children do have different learning strategies, we might expect to see evidence of this at different levels of linguistic structure. This raises a host of research questions. For example, will language learners who show early sensitivity to frequency effects in one linguistic domain (e.g., syllable structure) also show this in other domains (e.g., prosodic word structures)? Or will frequency effects only occur in contexts where there is a certain frequency threshold? Obviously these issues will need to be examined more closely after identifying those linguistic structures where frequency and markedness do not coincide.

The variable ranking of markedness and frequency/faithfulness constraints will obviously not handle all forms of individual variation. However, careful analysis of the actual input individual children hear may provide further support for the importance of frequency effects on children's early outputs. For example, Wijnen, Kirkhaar & Den Os (1994) suggested that early individual variation in the word shapes two Dutch-speaking children used (e.g. CVC versus CVCV) might have been due to different input frequency: one of the mothers apparently used many more diminutives, resulting in a greater number of CVCV words in the input that particular child heard. Thus, although children's grammars may have a tendency to exhibit unmarked structures early in acquisition, this might be attenuated to the extent that more marked structures are more frequent, as we have shown here. Alternatively, it may often be the case that unmarked structures are also the most frequent (e.g. prosodic words as binary feet in English), resulting in early and stable acquisition patterns across learners (e.g., Demuth 1996b).

## 5. Conclusion

This study examined the early stages of word-final coda consonant acquisition in two English-speaking children between the ages of 1 and 2. It found that one child acquired the more marked but more frequent stop codas first, whereas the other child acquired the less marked but also less frequent nasal and fricative codas first. Taken together, these findings suggest that

both markedness and frequency may play a role in determining the course of language development, but also that some children may be more frequency-based learners, and others may be more markedness-based learners. These findings also predict that acquisition should proceed quickly and show less individual variation when unmarked structures are extremely frequent. Some independent evidence for this later claim comes from the study of adult speech production errors (e.g., Goldrick, 2002). This raises questions about the role of frequency and markedness in both developing and mature grammars. Further research will be needed to determine the nature of the statistics different learners use in different linguistic domains (Boersma & Hayes, 2001; Boersma & Levelt, 1999; Goldwater & Johnson, 2003), and the potential impact this has on their developing grammatical systems.

## References

- Anderson, Jennifer, James L. Morgan, and Katherine S. White. 2003. A statistical basis for speech sound discrimination. *Language and Speech*, 46,155-182. (Special Issue on Phonological Acquisition).
- Barlow, Jessica A. 1997. *A constraint-based account of syllable onsets: Evidence from developing systems*. Unpublished doctoral dissertation. Bloomington: Indiana University.
- Blevins, Juliette. 1995. The syllable in phonological theory. In J. A. Goldsmith (Ed.), *The Handbook of Phonological Theory*, 206-244. Oxford: Blackwell Publishers.
- Bloom, Lois. 1970. *Language development: Form and function in emerging grammars*. Cambridge, MA: MIT Press.
- Boersma, Paul, and Bruce Hayes. 2001. Empirical tests of the gradual learning algorithm *Linguistic Inquiry* 32, 45-86.
- Boersma, Paul, and Clara Levelt. 1999. Gradual Constraint-Ranking Learning algorithm predicts acquisition order. *Proceedings of the 30<sup>th</sup> Child Language Research Forum*, 229-237. Stanford: CSLI.
- Brown, Roger. 1973. *A first language: The early stages*. Cambridge, MA: Harvard University Press.
- Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge: MIT Press.
- Clements, George N. 1990. The role of the sonority cycle in core syllabification. In John Kingston & Mary Beckman, (Eds.), *Papers in Laboratory Phonology I*, 283-333. Cambridge: Cambridge University Press.
- Clements, George. N. & S. Jay Keyser. 1983. *CV Phonology*. Cambridge, MA: MIT Press.
- Demuth, Katherine. 1995. Markedness and the development of prosodic structure. In Jill Beckman (ed.), *Proceedings of the North East Linguistic Society* 25, 13-25. Amherst, MA: GLSA, University of Massachusetts.
- Demuth, Katherine. 1996a. Alignment, stress and parsing in early phonological words. In *Proceedings of the International Conference on Phonological Acquisition*, Barbara Bernhardt, John Gilbert, and David Ingram (eds.), 113-124. Somerville, MA: Cascadilla Press.
- Demuth, Katherine. 1996b. The prosodic structure of early words. In James Morgan and Katherine Demuth (eds.), *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, 171-184. Mahwah, N.J.: Laurence Erlbaum Associates.

- Demuth, Katherine. 2001. Prosodic constraints on morphological development. In *Approaches to Bootstrapping: Phonological, Syntactic and Neurophysiological Aspects of Early Language Acquisition*, Jürgen Weissenborn and Barbara Höhle (eds.), 3-21. Amsterdam: John Benjamins. *Language Acquisition and Language Disorders Series 24*.
- Demuth, Katherine, and E. Jane Fee. 1995. Minimal prosodic words in early phonological development. Ms, Brown University and Dalhousie University.
- Fee, E. Jane. 1996. Syllable structure and minimal words. In *Proceedings of the International Conference on Phonological Acquisition*, Barbara Bernhardt, John Gilbert, and David Ingram (eds.), 85-98. Somerville, MA: Cascadilla Press.
- Ferguson, Charles A. & C. B. Farwell. 1975. Words and sounds in early language acquisition. *Language* 51, 419-439.
- Fikkert, Paula. 1994. On the acquisition of prosodic structure. Doctoral dissertation, University of Leiden, The Netherlands.
- Gnanadesikan, Amalia. 1996. Markedness and faithfulness constraints in child phonology. Ms., University of Massachusetts, Amherst.
- Goad, Heather, and Kathleen Brannen. 2003. Phonetic evidence for phonological structure in syllabification. In *The phonological spectrum*, Vol. 2, Joost van de Weijer, Vincent J. van Heuven and Harry van der Hulst (eds.), 3-30. Amsterdam: John Benjamins.
- Goldrick, Matthew. 2002. *Patterns of sound, patterns in mind: Phonological regularities in speech production*. PhD dissertation, Johns Hopkins University.
- Goldwater, Sharon, and Mark Johnson. 2003. Learning OT constraint rankings using a maximum entropy model. In *Proceedings of the Workshop on Variation within Optimality Theory*, Jennifer Spenader, Anders Eriksson, and Östen Dahl (eds.), 111-120. Stockholm: Stockholm University.
- Ingram, David. 1978. The role of the syllable in phonological development. In A. Bell & J. Hooper (eds.), *Syllables and Segments*, Elsevier-North Holland, New York.
- Jakobson, Roman. 1941/68. *Child language, aphasia and phonological universals*. The Hague & Paris: Mouton.
- Jusczyk, Peter, Anne Culter, and Nancy J. Rendanz. 1993. Infant's preferences for the predominant stress patterns of English words. *Child Development* 64,675-687.
- Kirk, Cecilia, and Katherine Demuth. 2003. Onset/coda asymmetries in the acquisition of clusters. In *Proceedings of the 27th Annual Boston University Conference on Language Development*, Barbara Beachley, Amanda Brown, and Frances Conlin (eds.), 437-448. Somerville, MA: Cascadilla Press.
- Ladefoged, Peter. 1982. *A course in phonetics*. New York: Harcourt Brace Javanovich.
- Lleó, Conxita. 2003. Prosodic licensing of codas. *Probus* 15, 257-281.
- Levelt, Clara C., Niels O. Schiller, and Willem J. Levelt. 2000. The acquisition of syllable types. *Language Acquisition* 8, 237-264.
- MacWhinney, Brian. 1995. *The CHILDES project: Tools for analyzing talk* (2<sup>nd</sup> ed.). Hillsdale, NJ: Erlbaum.
- Maye, Jessica, Janet F. Werker, and LouAnn Gerken. 2002. Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, 82, B101-B111.

- Morgan, James L. 1996. A rhythmic bias in preverbal speech segmentation. *Journal of Memory and Language* 35, 666-688.
- Nelson, Keith, E. 1981. Individual differences in language development: Implications for development and language. *Developmental Psychology*, 17, 170-87.
- Pater, Joe. 1997. Minimal violation and phonological development. *Language Acquisition* 6, 201-253.
- Pater, Joe, and Jessica Barlow. 2002. A typology of cluster reduction: conflicts with sonority. In *Proceedings of the 26th Annual Boston University Conference on Language Development*, Barbora Skarabela, Sarah Fish, and Anna J.-J. Do (eds.), 533-544. Somerville, MA: Cascadilla Press.
- Peters, Ann, and Lise Menn. 1993. False starts and filler syllables: ways to learn grammatical morphemes. *Language* 69, 742-777.
- Prince, Alan, and Paul Smolensky. 1993. Optimality Theory: Constraint Interaction in Generative Grammar. Cambridge: Technical report TR-2. Rutgers Center for Cognitive Science, Rutgers University.
- Roark, Brian, and Katherine Demuth. 2000. Prosodic constraints and the learner's environment: A corpus study. In *Proceedings of the 24th Annual Boston University Conference on Language Development*, S. Catherine Howell, Sarah A. Fish, and Thea Keith-Lucas (eds.), 597-608. Somerville, MA: Cascadilla Press.
- Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Doctoral dissertation, McGill University, Montréal.
- Smith, Niel V. 1973. *The Acquisition of Phonology*. Cambridge: Cambridge University Press.
- Smolensky, Paul, Lisa Davidson, and Peter Jusczyk. In press. The initial and final states: Theoretical implications and experimental explorations of the richness of the base. In P. Smolensky & G. Legendre (eds), *The harmonic mind: From neural competition to optimality theoretic grammars*. Cambridge, MA: Blackwell.
- Stoel-Gammon, C. arol. 1985. Phonetic inventories, 15-14 months: A longitudinal study. *Journal of Speech and Hearing Research*, 28, 505-512.
- Vihman, Marilyn M., and Mel Greenlee. 1987. Individual differences in phonological development: ages one and three years. *Journal of Speech and hearing Research*, 30, 503-521.
- Vihman, Marilyn M. 1993. Variable paths to early word production. *Journal of Phonetics*, 21, 61-82.
- Vihman, Marilyn M., Marlys A. Macken, Ruth Miller, H. Simmons, and J. Miller. 1985. From babbling to speech: a reassessment of the continuity issues. *Language* 61, 395-443.
- Wijnen, Frank, Evelien Krikhaar, and Els den Os. 1994. The (non)realization of unstressed elements in children's utterances: Evidence for a rhythmic constraint. *Journal of Child Language* 21, 59-83.