

# Lexical Influences on Interword Variation

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## 1. Introduction

One observation that has emerged from the study of phonological acquisition is that a child may produce a target sound accurately in some but not all relevant words of the language. This has been referred to as *interword variation* (Ingram, 1979). Although interword variation has been well documented, it is not well understood. Previous accounts have focused on functional attributes of a child to explain this variation in production accuracy across words (Vihman, 1981; Vihman, Ferguson, & Elbert, 1986). An alternative to this functional account is a structural account. In the structural account, interword variation is attributed to the interaction between lexical and phonological representations in acquisition.

In the structural account, *lexical representations* correspond to the speaker's mental knowledge of word forms as a cohesive unit, whereas *phonological representations* correspond to the speaker's mental knowledge of individual sounds (Luce, Goldinger, Auer, & Vitevitch, 2000). For example, the lexical representation of 'sun' would be /sʌn/ and the phonological representation would be /s/, /ʌ/, /n/. A child who substitutes [ɾ] for target /s/ may associate the lexical representations of all target /s/-words with the phonological representation for /t/. This leads to subsequent incorrect production of all target /s/-words. As the child acquires phonology, he or she will eventually acquire an adult-like phonological representation for /s/. The new phonological representation then must establish associations with target lexical representations. This process is likely to occur gradually such that certain lexical representations will establish associations with the target sound first, leading to correct production of the target sound in certain words but continued incorrect production in other words.

Characteristics of lexical and phonological structure may predict which words and sounds are likely to establish associations first. That is, certain types of lexical representations may facilitate the formation of new associations. Thus, certain words may be more vulnerable to sound change than others. In complement, certain lexical representations may impede the formation of associations with new phonological representations. These words would be considered resistant to sound change. Furthermore, words vulnerable or resistant to sound change may vary depending on the characteristics of the sound acquired.

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A previous study by Gierut and Storkel (in press) addressed this issue (see also Gierut & Morrisette, 1998; Morrisette, 1999; Morrisette & Gierut, 2001). In this study, the influence of two lexical characteristics and three phonological characteristics were considered. The lexical characteristics were word frequency and neighborhood density. *Word frequency* refers to the number of occurrences of a given word in the language (Kučera & Francis, 1967). Words can be classified as occurring frequently or infrequently in a language. *Neighborhood density* is often defined as the number of phonetically similar counterparts of a given word based on a one phoneme addition, deletion or substitution (Luce & Pisoni, 1998), e.g., the neighbors of 'pit' include 'spit, it, bit, pat, pick.' Some words have many phonetically similar counterparts and are said to reside in dense neighborhoods. Other words have few phonetically similar counterparts and are considered to reside in sparse neighborhoods. The phonological characteristics were markedness of the child's presenting fricative inventory, markedness of the fricatives acquired, and context where sound change occurred. Studies of languages have shown that certain features are more common or universal than others. These features are claimed to be unmarked, whereas less common or more complex features are considered marked (Paradis & Prunet, 1991; Stemberger & Stoel-Gammon, 1991; Stoel-Gammon & Stemberger, 1994). Participating children presented with unmarked fricatives and acquire marked fricatives or presented with marked fricatives and acquire unmarked and/or marked fricatives. Furthermore, sound change could occur in prevocalic (i.e., word initial position) or postvocalic context (i.e., word medial or final position).

Results demonstrated a three way interaction between structural and featural markedness as well as context (Gierut & Storkel, in press). These results were based on an analysis of group data. Because of the small sample size, inferential statistics could not be used. The purpose of the current study was to reconsider the performance of individual children to determine whether the influence of lexical and phonological characteristics was consistent across participants.

## 2. Methods

Briefly, data from Gierut and Storkel (in press) consisted of fricative production by 19 children with functional phonological disorders. Children participated in empirical studies of phonological learning in which fricative production was monitored over time in untreated words. Children were placed into groups based on their pre- and post-treatment phonological inventories yielding three groups: children who presented with (1) unmarked fricative inventories /s z/ and acquired marked fricatives /f v θ ð ʃ/; (2) marked fricative inventories /f v/ and acquired marked fricatives /θ ð ʃ/; (3) marked fricative inventories /f v/ and acquired unmarked fricatives /s z/.

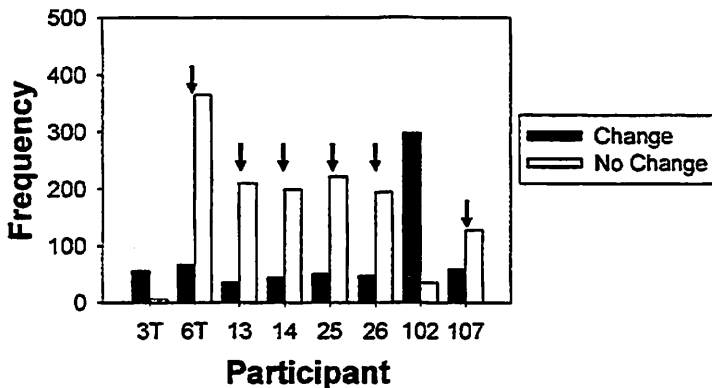
Pre-treatment speech samples were compared to post-treatment speech samples to determine the words that changed from incorrect to correct (i.e., words vulnerable to sound change) and those that remained incorrect over time (i.e., words resistant to sound change). Word frequency and neighborhood density values of each word type (change vs. no change) were noted. For this study, the words vulnerable to sound change were compared to those resistant to sound change for each child.

### 3. Results

Results are presented by context, postvocalic followed by prevocalic. Within each context, the influence of word frequency will be considered first, and then effects of neighborhood density will be described.

#### 3.1 Word frequency effects in postvocalic context

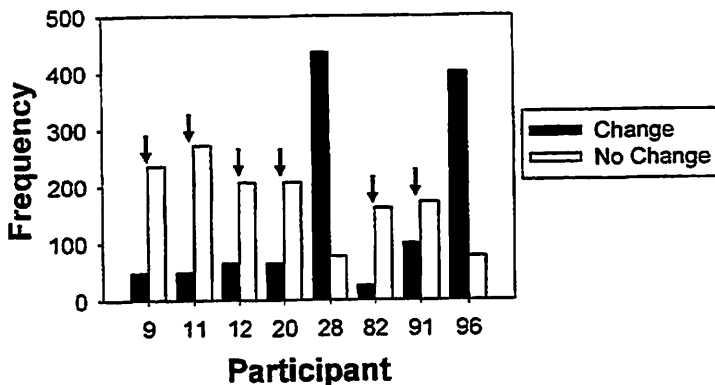
Figures 1, 2, and 3 show the frequency of the words that changed (black bar) compared to the words that did not change (clear bar) for each group of children. For children who presented with unmarked fricatives and acquired marked fricatives, a consistent effect of word frequency was observed in the postvocalic context. For 6 of the 8 children, the words that changed were less frequent than the words that did not change.



**Figure 1.** Mean frequency of words that changed versus did not change for children who presented with unmarked fricatives and acquired marked fricatives in the postvocalic context.

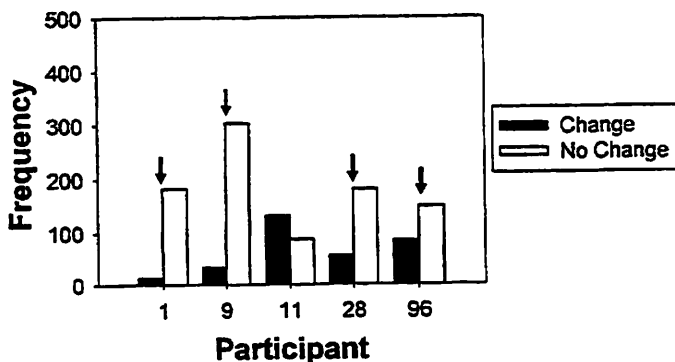
The results for children who presented with marked fricatives and acquired marked fricatives were similar. For 6 of the 8 children, the words

that changed were less frequent than the words that did not change. Again, relatively infrequent words appeared vulnerable to sound change.



**Figure 2.** Mean frequency of words that changed versus did not change for children who presented with marked fricatives and acquired marked fricatives in the postvocalic context.

The third group, children who presented with marked fricatives and acquired unmarked fricatives, mirrored the first two. For 4 of the 5 children, the words that changed were less frequent than the words that did not change.

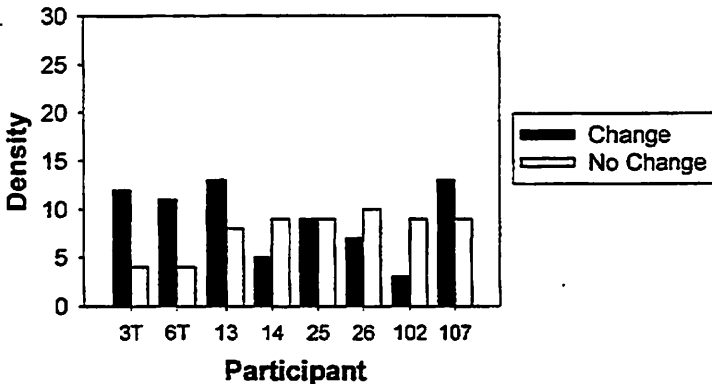


**Figure 3.** Mean frequency of words that changed versus did not change for children who presented with marked fricatives and acquired unmarked fricatives in the postvocalic context.

The influence of word frequency on sound change in postvocalic context was consistent. Across children who differed in the markedness of the presenting fricative inventory and in the markedness of the fricatives acquired, the words that changed were less frequent than the words that did not change.

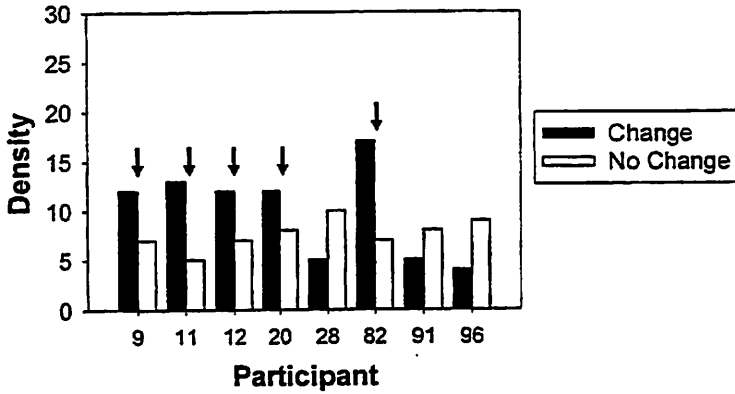
### 3.2 Neighborhood density effects in postvocalic context

Figures 4, 5, and 6 show the neighborhood density of the words that changed (black bar) compared to the words that did not change (clear bar) for each group. There was no consistent effect of neighborhood density for children who presented with unmarked fricatives and acquired marked fricatives. Four children showed change in words that were more dense than the words that did not change. In contrast, 3 children showed change in words that were less dense than the words that did not change. One child showed no difference in density between the words that changed compared to the words that did not change.



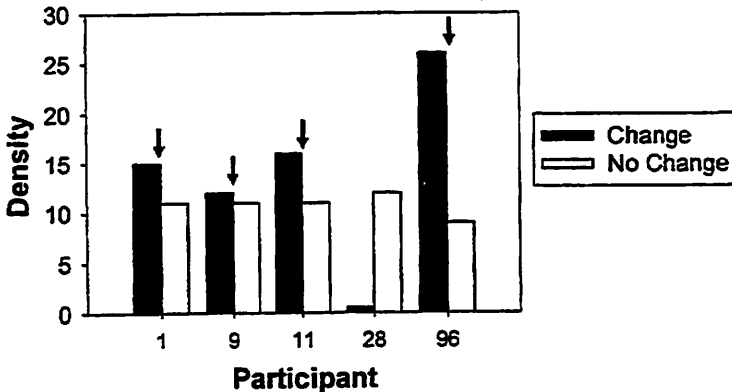
**Figure 4.** Mean neighborhood density of words that changed versus did not change for children who presented with unmarked fricatives and acquired marked fricatives in the postvocalic context.

A more consistent effect of density was observed for the children who presented with marked fricatives and acquired marked fricatives. For 5 of the 8 children, the words that changed were more dense than the words that did not change.



**Figure 5.** Mean neighborhood density of words that changed versus did not change for children who presented with marked fricatives and acquired marked fricatives in the postvocalic context.

Children who presented with marked fricatives and acquired unmarked fricatives paralleled the previous group. The words that changed were more dense than the words that did not change for 4 of the 5 children.



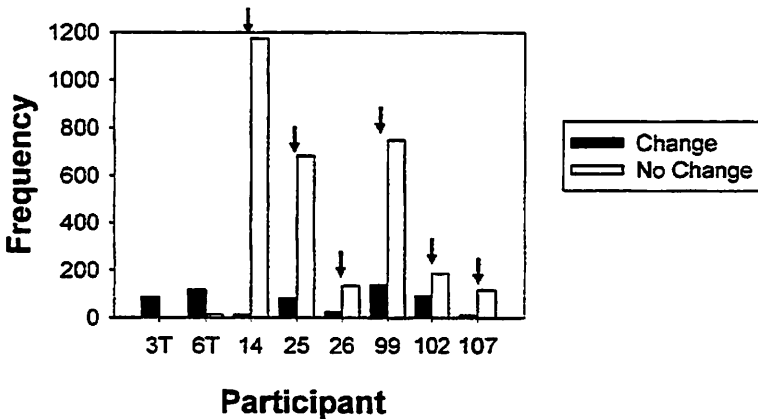
**Figure 6.** Mean neighborhood density of words that changed versus did not change for children who presented with marked fricatives and acquired unmarked fricatives in the postvocalic context.

For neighborhood density in postvocalic context, the markedness of the presenting inventory appeared to interact with density in predicting patterns of interword variation: marked structure aligned with dense neighborhoods.

Specifically, when children presented with marked fricatives, the words that changed tended to reside in neighborhoods that were denser than the words that did not change.

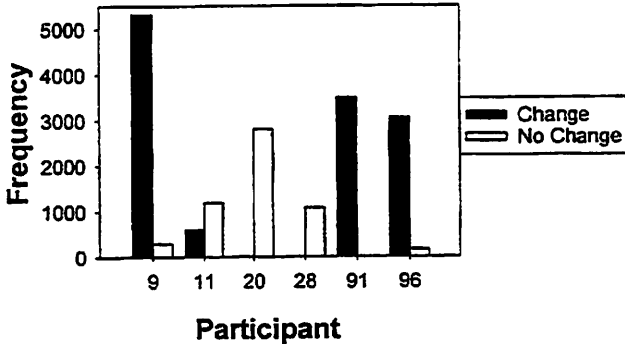
### 3.3 Word frequency effects in prevocalic context

Figures 7, 8, and 9 show the frequency of the words that changed (black bar) compared to the words that did not change (clear bar) in the prevocalic context for each group of children. Results from the children who presented with unmarked fricatives and acquired marked fricatives in the prevocalic context are considered first. For 6 of the 8 children, the words that changed were less frequent than the words that did not change. As in the prevocalic context, relatively infrequent words appeared vulnerable to change.



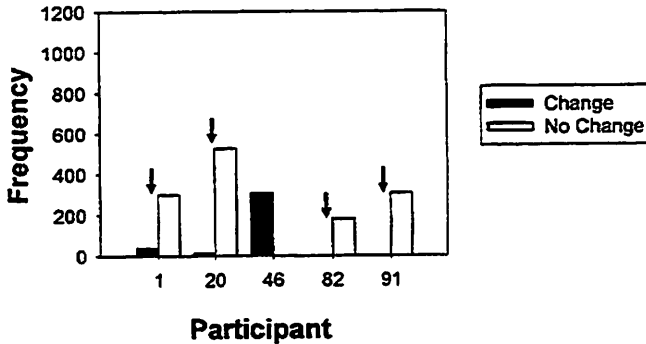
**Figure 7.** Mean frequency of words that changed versus did not change for children who presented with unmarked fricatives and acquired marked fricatives in the prevocalic context.

Children who presented with marked fricatives and learned marked fricatives showed individual variation in the effects of word frequency in the prevocalic context. Three children demonstrated change in words that were less frequent than the words that did not change. The remaining 3 children showed the opposite pattern: change in words that were more frequent than the words that did not change.



**Figure 8.** Mean frequency of words that changed versus did not change for children who presented with marked fricatives and acquired marked fricatives in the prevocalic context.

A consistent pattern was observed for the children who presented with marked fricatives and acquired unmarked fricatives. For 4 of the 5 children, the words that changed were less frequent than the words that did not change.



**Figure 9.** Mean frequency of words that changed versus did not change for children who presented with marked fricatives and acquired unmarked fricatives in the prevocalic context.

In the prevocalic context, the markedness of both the presenting fricative inventory and the fricatives acquired appeared to influence the effect of word frequency on sound change: unmarked features aligned with infrequent words. Specifically, the words that changed tended to be less frequent than the words that did not change when the presenting inventory was unmarked or when unmarked fricatives were acquired. In contrast, when the presenting inventory was marked and marked fricatives were acquired, no clear effect of frequency was observed.



### 3.4 Neighborhood density effects in prevocalic context

Figures 10, 11, and 12 show the neighborhood density of the words that changed (black bar) compared to the words that did not change (clear bar) in the prevocalic context for each group. No clear pattern emerged for any group. Across groups, 9 of the 19 children showed change in words that were more dense than the words that did not change, whereas another 9 children showed the opposite pattern. The words that changed were equally likely to be more or less dense than the words that did not change.

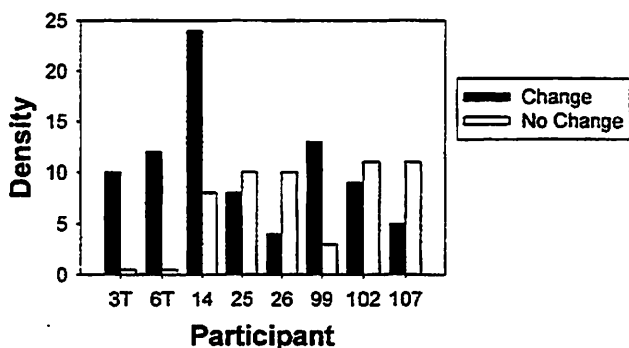


Figure 10. Mean neighborhood density of words that changed versus did not change for children who presented with unmarked fricatives and acquired marked fricatives in the prevocalic context.

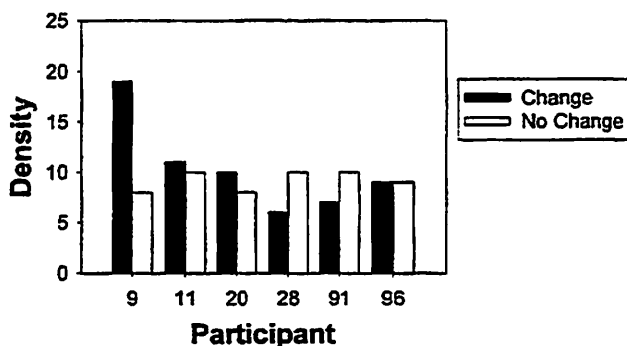
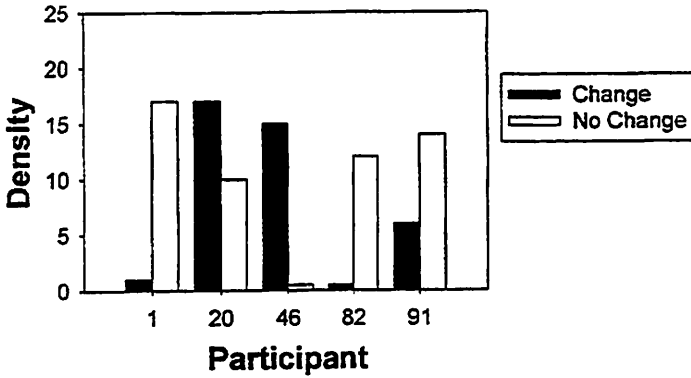


Figure 11. Mean neighborhood density of words that changed versus did not change for children who presented with marked fricatives and acquired marked fricatives in the prevocalic context.



**Figure 12.** Mean neighborhood density of words that changed versus did not change for children who presented with marked fricatives and acquired unmarked fricatives in the prevocalic context.

#### 4. Discussion

In postvocalic context a consistent relationship between the lexical characteristics of word frequency and sound change was observed. Across children differing in the markedness of the presenting inventory and the markedness of the fricatives acquired, change occurred in infrequent words. The effect of density on interword variation in postvocalic context was dependent on the markedness of the presenting inventory. Marked presenting inventories were associated with change in words from dense neighborhoods. In contrast, unmarked presenting inventories were associated with variability in the density of the words that changed. In prevocalic context, a different pattern was observed. The markedness of both the presenting inventory and the sounds acquired interacted with word frequency. Unmarked elements were associated with change in infrequent words. In contrast, marked elements were associated with variability in the frequency of words that changed. In addition, there was no consistent relationship between density and sound change in prevocalic context.

Given these results, it is proposed that word frequency and neighborhood density may reflect different dimensions of lexical representations. Word frequency may reflect the strength of the underlying lexical representation, whereas neighborhood density may be associated with the level of detail in the lexical representation. Word frequency may indicate the likelihood that a lexical representation will change. In particular, infrequent words may have more malleable representations making these words more vulnerable to sound change. In contrast, frequent words may

have more rigid lexical representations making these words more resistant to sound change. This hypothesis is supported by the current data as well as findings from speech errors. In adults, infrequent words are more likely to be produced in error than frequent words (Vitevitch, 1997). Thus, infrequent words seem to be prone to permanent as well as temporary changes in sound production. This general tendency may be modified in cases when marked structures are present initially and also acquired in the prevocalic context accounting for the variability observed in the current study.

Neighborhood density may be a sign of the level of detail in the underlying lexical representation. Words from dense neighborhoods appear to have more segmentally detailed representations than words from sparse neighborhoods (Garlock, Walley, & Metsala, 2001; Metsala & Walley, 1998; Storkel, in press). Segmentally detailed representations may facilitate sound change because these representations are more adult-like. Specifically, words in dense neighborhoods may be more likely to have lexical representations that mirror the adult target (e.g., /sʌn/ as the lexical representation of 'sun'). In contrast, words in sparse neighborhoods may be more likely to have lexical representations that mirror the child's production (e.g., /tʌn/ as the lexical representation of 'sun'). Segmentally detailed or adult-like representations may facilitate formation of an association between an existing lexical representation and a new phonological representation. This account of the effect of neighborhood density on interword variation may also explain the interaction between density and context. In particular, there is evidence that the lexical representation of prevocalic context may be segmentally detailed regardless of neighborhood density. In contrast, the representation of postvocalic context may be more dependent on density (Storkel, in press). Therefore, density may only predict the words vulnerable to change when change occurs in postvocalic position because it is in this position that density distinguishes lexical representations that are segmentally detailed from those that are not segmentally detailed.

### Endnotes

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### References

- Garlock, Victoria M., Walley, Amanda C., & Metsala, Jamie L. (2001). Age-of-acquisition, word frequency, and neighborhood density effects on spoken word recognition by children and adults. *Journal of Memory and Language*, 45, 468-492.

- Gierut, Judith A., & Morrisette, Michele L. (1998). Lexical properties in implementation of sound change. In A. Greenhill, M. Hughes, H. Littlefield, & H. Walsh (Eds.), *Proceedings of the 22nd Annual Boston University Conference on Language Development* (pp. 257-268). Somerville, MA: Cascadilla Press.
- Gierut, Judith A., & Storkel, Holly L. (in press). Markedness and the grammar in lexical diffusion of fricatives. *Clinical Linguistics & Phonetics*.
- Ingram, David. (1979). Cross-linguistic evidence on the extent and limit of individual variation in phonological development. *Proceedings of the 9th International Congress of Phonetic Sciences*, 2, 150-154.
- Kučera, H., & Francis, W. N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University.
- Luce, Paul A., Goldinger, Steve D., Auer, Edward T., & Vitevitch, Michael S. (2000). Phonetic priming, neighborhood activation, and PARSYN. *Perception & Psychophysics*, 62, 615-625.
- Luce, Paul A., & Pisoni, David B. (1998). Recognizing spoken words: The neighborhood activation model. *Ear & Hearing*, 19, 1-36.
- Metsala, Jamie L., & Walley, Amanda C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: Precursors to phonemic awareness and early reading ability. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy* (pp. 89-120). Mahwah, NJ: Lawrence Erlbaum Associates.
- Morrisette, Michele L. (1999). Lexical characteristics of sound change. *Clinical Linguistics & Phonetics*, 13, 219-238.
- Morrisette, Michele L., & Gierut, Judith A. (2001). Variables governing diffusion in phonological acquisition. In A. H.-J. Do, L. Dominguez, & A. Johansen (Eds.), *Proceedings of the 25th Annual Boston University Conference on Language Development* (Vol. 2, pp. 534-541). Somerville, MA: Cascadilla Press.
- Paradis, C., & Prunet, J. F. (Eds.). (1991). *Phonetics and phonology, Vol. 2: The special status of coronals: Internal and external evidence*. San Diego, CA: Academic Press.
- Stemberger, Joseph P., & Stoel-Gammon, Carol. (1991). The underspecification of coronals: Evidence from language acquisition and performance errors. In C. Paradis & J.-F. Prunet (Eds.), *Phonetics and phonology, Vol. 2: The special status of coronals* (pp. 181-199). San Diego, CA: Academic Press.
- Stoel-Gammon, Carol, & Stemberger, Joseph P. (1994). Consonant harmony and phonological underspecification in child speech. In M. Yavas (Ed.), *First and second language phonology* (pp. 63-80). San Diego, CA: Singular.
- Storkel, Holly L. (in press). Restructuring similarity neighborhoods in the developing mental lexicon. *Journal of Child Language*.
- Vihman, Marilyn M. (1981). Phonology and the development of the lexicon: Evidence from children's errors. *Journal of Child Language*, 8, 239-264.
- Vihman, Marilyn M., Ferguson, Charles A., & Elbert, Mary. (1986). Phonological development from babbling to speech: Common tendencies and individual differences. *Applied Psycholinguistics*, 7, 3-40.
- Vitevitch, Michael S. (1997). The neighborhood characteristics of malapropisms. *Language and Speech*, 40, 211-228.