

Variables Governing Diffusion in Phonological Acquisition

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1. Introduction

Sound change in languages of the world takes place in one of two key ways: across-the-board or through lexical diffusion. *Across-the-board* change occurs when sound production changes abruptly in all relevant words at once. *Lexical diffusion* involves more gradual change in sound production with words changing on an individual case-by-case basis. Both types of change have been documented for fully-developed languages undergoing historical sound change (Chen & Wang, 1975; Labov, 1981) and for children acquiring the sound system of the ambient language (Dinnsen, 1996; Smith, 1973). In fully-developed and developing phonological systems, lexical diffusion is reportedly the more prevalent type of sound change.

For phonological acquisition, in particular, the process of lexical diffusion has been causally attributed to functional factors associated with children's unique learning styles or sound preferences (Ferguson & Farwell, 1975; Schwartz & Leonard, 1982), as well as structural factors associated with children's underlying representations (Dinnsen, 1984). Recent research suggests instead that four interrelated factors contribute to lexical diffusion in acquisition (Morrisette, 2000; Morrisette & Gierut, 2000b). These are the input, the implementation of sound change as either phonetic or phonemic, the manner class undergoing sound change, and the context of sound change.

In this brief report, we consider only the role of input as it governs lexical diffusion in phonological acquisition. The hypothesis being tested follows from standard principles of learning. Namely, if a child is exposed to sounds in words with specific characteristics, then lexical diffusion will take place in other words with these very same characteristics. The characteristics of primary interest are a word's frequency and its neighborhood density because these have been shown to be robust in spoken word recognition (e.g., Luce & Pisoni, 1998). *Word frequency* refers to the number of times a given word occurs in a language; whereas, *neighborhood density* is defined as the number of words that minimally differ in phonetic structure from a target word as based on one phoneme substitutions, deletions, or additions (e.g., 'cake,' 'ache,' and 'break' are all neighbors of 'rake'). The purpose of this study then was to determine if the frequency or neighborhood density of words presented to children in the input would influence the gradual emergence of sounds through lexical diffusion.

2. Methods

Longitudinal production data were obtained from eight children, ages 3;10 to 5;4. All of the children presented with functional phonological delays, as characterized by a severely reduced consonantal inventory in the absence of other associated linguistic, motor, cognitive, or social delays. These children were prime candidates for study because they exhibited gaps in the inventory that impacted their overall intelligibility, and consequently, warranted clinical treatment. The treatment was conducted as an experimental single-subject study whereby each child was taught one sound excluded from his or her pretreatment inventory in one of four randomly assigned conditions (Morrisette, 2000; Morrisette & Gierut, 2000a). The experimental conditions manipulated either the frequency or neighborhood density of words presented as the input in treatment. The period of treatment provided us the opportunity to systematically sample and document sound change through lexical diffusion because production data were regularly obtained. All sounds excluded from a child's pretreatment inventory (both treated and untreated) were monitored in relevant contexts and in multiple exemplars using conventional probe measures. Probes were balanced to include high and low frequency words from high and low density neighborhoods. Probe data were elicited in a picture-naming task, audio-recorded, and phonetically transcribed. Interjudge transcription reliability was calculated for approximately 20% of the data obtained, with 94% agreement across listeners.

In this post hoc investigation, sound change was operationalized as a change from an incorrect production of a sound in a word to a correct production of that same sound in that same word, as observed at any point in time. From this, it was possible to identify which words were susceptible to sound change and which other words were resistant to sound change. For example, an erred sound /r/ in the word 'read' would be defined as vulnerable to change if a child's incorrect output [wid] changed to the correct output [rid]. This same sound would be defined as resistant to change in another word 'run' if an incorrect output [wʌn] was maintained over time, or if one incorrect output [wʌn] changed to another [lʌn]. The word frequency and neighborhood density values of those words vulnerable to sound change were then compared to other words resistant to sound change. Word frequency values were obtained from Kučera & Francis (1967) and neighborhood density, from a computational database of 20,000 English words (Luce, 1986). Consistent with the purpose of this study, we were interested in determining whether lexical diffusion takes place in relatively high frequency words following exposure to high frequency words as input in treatment, with similar generalization patterns predicted for the alternate low frequency, and high/low density manipulations of the input. Given this, a priori definitions of 'high' or 'low' (frequency or density) were not imposed on the data; rather, the focus was on *relative* change.

From these data, it was possible to identify which sounds (either treated or untreated) changed in production from incorrect to correct, which words

supported these changes and which did not, and their frequency and density characteristics. These were the dependent measures by treatment condition in evaluation of the role of input in lexical diffusion.

3. Results

3.1. High Frequency Condition

Figure 1 displays the relative mean frequency of the words that did, and did not, undergo productive sound change following children's exposure to high frequency words as input in treatment. Change/no change is plotted for both treated and untreated sounds. For treated sounds, the mean frequency of words vulnerable to sound change was 97 (per million) as compared to 220 for words resistant to change. For untreated sounds, the mean frequency of words vulnerable to sound change was 486 versus 264 for words resistant to change. These data lend only partial support for the hypothesis that high frequency words as input will induce lexical diffusion in other high frequency words, but only when associated with untreated sounds.

3.2. Low Frequency Condition

Figure 2 displays the results following exposure to low frequency words as input in treatment. For treated sounds, the words that underwent productive change had a mean frequency of 68, as compared to 98 for those words that resisted change. For untreated sounds, the mean frequency of words that changed was 108 as opposed to 235 for words that did not change. In full support of the hypothesis, low frequency words as input triggered lexical diffusion in other low frequency words, and this occurred consistently for both treated and untreated sounds.

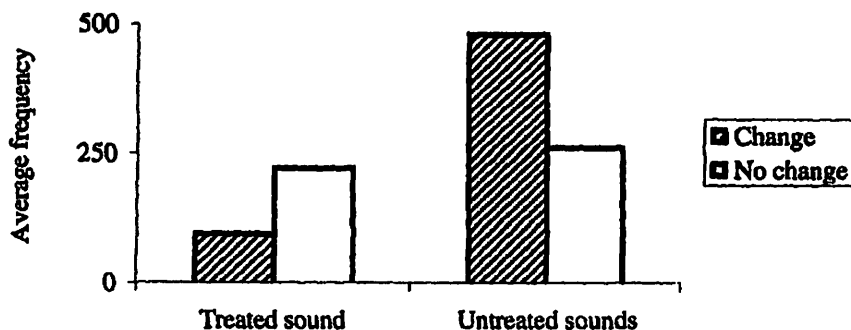


Figure 1. High frequency words as input

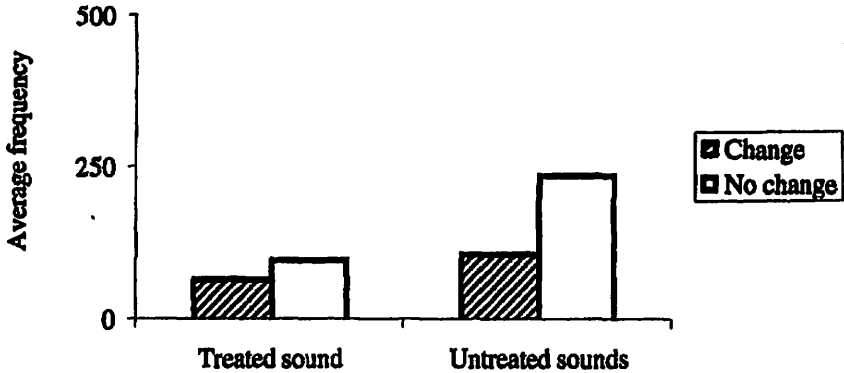


Figure 2. Low frequency words as input

3.3. High Density Condition

Figure 3 shows the results following children's exposure to words from high density neighborhoods as input in treatment. In terms of treated sounds, the words that were susceptible to productive change had an average of 13 phonetically similar neighbors, whereas words resistant to change had 17 neighbors. Untreated sounds evidenced productive change in words with an average of 14 neighbors, with the same number of neighbors also observed for words that did not change. There were no differences then between the characteristics of words vulnerable versus resistant to lexical diffusion for untreated sounds. Taken together, these data do not lend support to the hypothesis that words from high density neighborhoods as input will promote lexical diffusion in other words from relatively dense neighborhoods.

3.4. Low Density Condition

Figure 4 presents the results following children's exposure to words from low density neighborhoods as input in treatment. For treated sounds, the mean neighborhood density of words that did versus did not change was 15 and 16 respectively. For untreated sounds, the mean neighborhood density showed similarly equivalent patterns, with the density values of words that did and did not change being 15 and 14 respectively. Thus, there was no differential effect of low density words as input on the process of lexical diffusion.

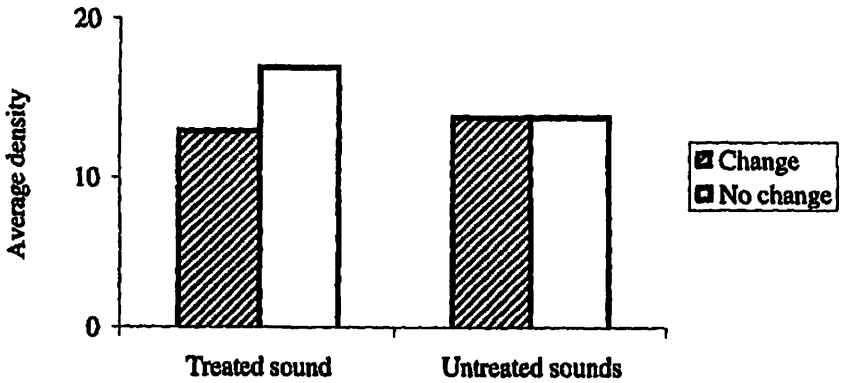


Figure 3. Words from high density neighborhoods as input

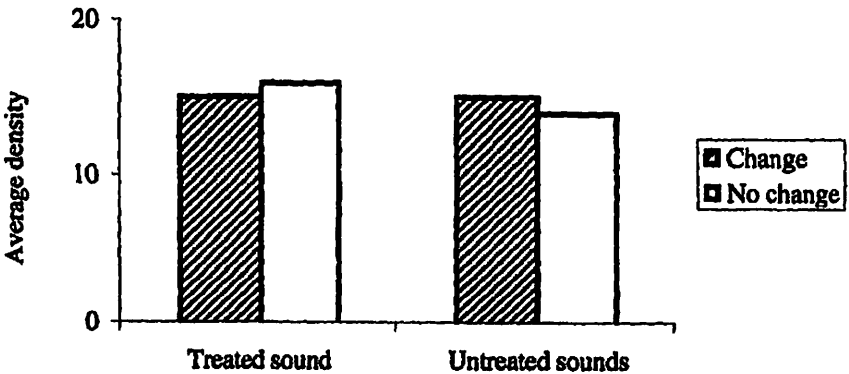


Figure 4. Words from low density neighborhoods as input

4. Discussion

This study considered the role of input in lexical diffusion by examining whether the words children were exposed to in treatment would induce productive sound change in other words with comparable frequency and density characteristics. The collective results are summarized in Table 1.

Table 1. Summary of lexical diffusion

Input	Treated sound	Untreated sounds
High frequency	Low frequency	High frequency
Low frequency	Low frequency	Low frequency
High density	Low density	No difference
Low density	No difference	No difference

We first address the influence of the input as associated with a word's frequency on the process of lexical diffusion in acquisition. From Table 1, it can be seen that low frequency words as input provided full support for the hypothesis being tested. Both treated and untreated sounds conformed to the predicted pattern of diffusion to other low frequency words, consistent with the input. The hypothesis that input governs lexical diffusion was also supported by frequency data from untreated sounds. When either high or low frequency words were presented as input, changes in production of untreated sounds were promoted in like kinds of words. Productive change in treated sounds, however, consistently occurred in low frequency words despite the corresponding word frequency of the input. One implication is that low frequency words may be particularly vulnerable to treated sound change. This finding is consistent with other production data from adults (Phillips, 1984; Vitevitch 1997a, b). Historically, low frequency words are the first to undergo phonemic implementation of sound change. Low frequency words are also most prone to speech errors involving malapropisms or segmental slips. Thus, it seems that low frequency words may be predisposed to productive sound change, albeit in acquisition, in historical sound change, or in slips of the tongue.

Turning to neighborhood density, lexical diffusion did not appear to be influenced by this characteristic of the input. For the most part, there was no difference in the density values of words that evidenced sound change, as compared to those other words that did not undergo sound change. This was the case despite the neighborhood density of words presented as input, and whether productive change occurred in treated or untreated sounds. One suggestion is that neighborhood density is not as salient a factor in lexical diffusion as word frequency. Other experimental treatment studies involving children with phonological delays further support this proposal (Gierut et al., 1999; Morrisette, 2000; Morrisette & Gierut, 2000a). Treatment that employed words with many phonetically similar rhyming counterparts was not efficacious in promoting phonological learning and generalization. Neighborhood density thus may be less critical or facilitory in phonological acquisition and change.

In conclusion, this descriptive study provides partial evidence that input is a factor governing lexical diffusion in phonological acquisition. A word's frequency is particularly predictive of which words will undergo lexical diffusion and which will not. Input alone, however, cannot account for the full range of sound change observed in acquisition. Consequently, a conjunction of input, functional, featural, and contextual variables must be examined in tandem for a cohesive view of lexical diffusion in phonological acquisition.

Endnotes

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