Lexicons and phonologies co-evolve under pressure from incremental word processing

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Over the last century, much evidence has accumulated suggesting that language structures evolve under pressure to maintain a balance between effort and communication accuracy. However, both 'effort' and 'accuracy' are constrained by the particular processes involved in encoding and decoding the speech signal. The work described here concerns adaptations of the lexicon and phonology of a language to the fact that listeners process the phonetic signal incrementally. When listeners hear the beginning of a word, they begin narrowing down hypotheses about what word they are hearing from the very first segment, rather than waiting until the end of the word. As a consequence of this incremental processing, early segments contribute more disambiguating information than later segments. Independent evidence suggests that speakers hyperarticulate phonetic cues that distinguish them from near lexical neighbors [1]. Putting these two facts together, we expect lexicons should evolve so that informative segments are concentrated early in words, because that is where they can do the most work in disambiguation. Conversely, less effortful combinations of sounds - which are often less informative - should be more common near ends of words because there, expenditure of greater effort does little to increase information transmission accuracy. Recent evidence shows that this is the case [2].

Turning to phonology, we expect that the ability of early phonemes in a word to provide more disambiguating information should inhibit the development phonological rules that reduce information word-initially. As a way to investigate this general hypothesis, we assembled a set of geneologically and areally balanced set of 50 languages and asked whether contrast-neutralizing rules are significantly more common at word ends than beginnings. For example, a common type of neutralizing rule is 'word-final obstruent devoicing', in which the voicing contrast in obstruents is neutralized at the ends of words. We find that indeed, neutralizing rules are significantly more frequent word-finally than word-initially (Figure 1). This pattern was found in every language family and in every language area in the dataset, as we would expect if the asymmetry is due to a basic fact about human language processing [3].

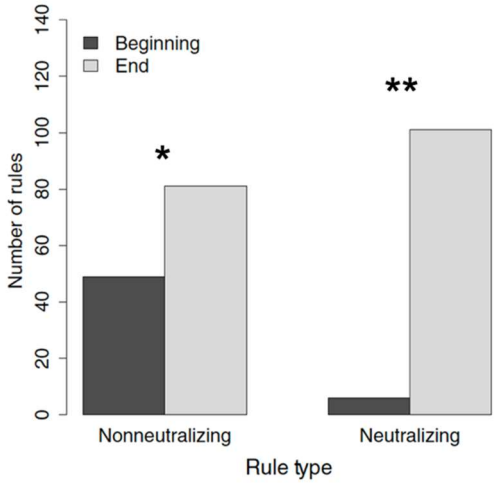
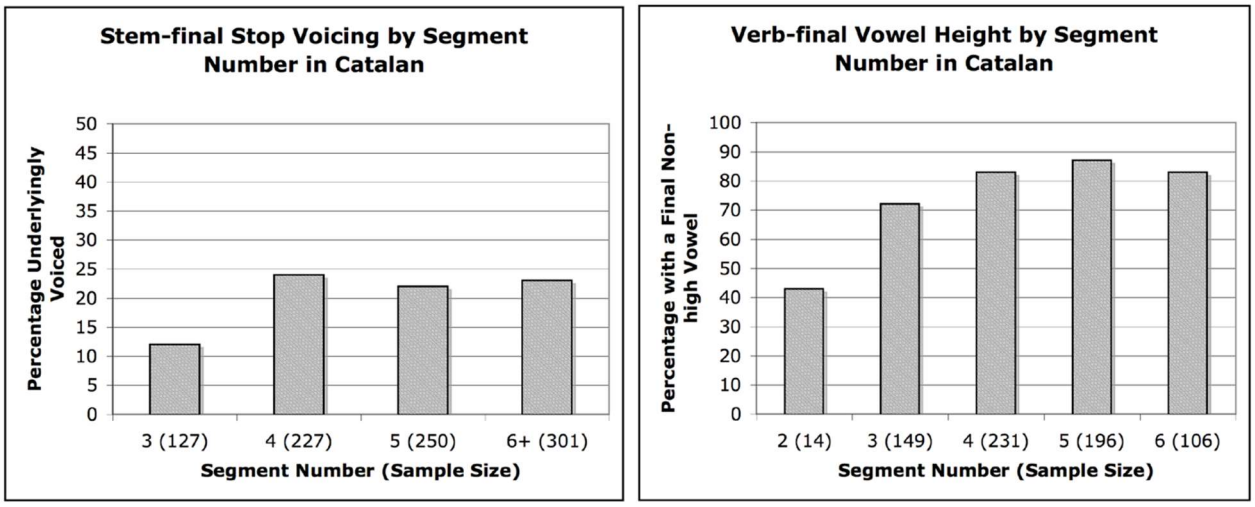


Figure 1. The left pair of bars shows the number of non-neutralizing rules in the dataset that apply to word beginnings versus ends. Non-neutralizing rules are ~2 times more likely to apply to the ends of words than the beginnings. The right pair of bars shows the number of neutralizing rules applying to word beginnings versus ends. Neutralizing rules are ~20 times more likely to apply to word ends. This word-edge difference is significantly greater than the difference for non-neutralizing rules.

Recall that we think that neutralization rules are more common word-finally because segment contrast late in the word is less informative. But what about very short words? In short words the end of the word is very close to the beginning, so final segments are more informative. Given that a language has a final-neutralization rule in its phonology, how might the lexicon evolve to respond? A way that a word can avoid the effects of a final-neutralization rule in the phonology

is to end with a segment that does not alternate. In new data expanding on [4] we focus on neutralizing phoneme pairs in which one neutralizes to the other, as in final obstruent devoicing. In this dataset we find that short words are less likely to end with the alternating member of a final neutralization, exemplified below with Catalan, which shows both final devoicing and vowel-height neutralization in unstressed syllables.

Figure 2. The first panel shows the percentage of stems in Catalan with underlyingly voiced word-final obstruents by word length. The second panel shows the percentage of stems that have in a non-high vowel in the final syllable, by word length. In Catalan, non-high vowels neutralize to a higher vowel in unstressed syllables; for example /e, o/ neutralize to [i, u]. In both cases, shorter stems are significantly less likely to end with a phoneme whose surface form neutralizes to that of another phoneme.



These observations suggest that phonologies and lexicons co-evolve under pressure from incremental processing, and further under pressure from each other. Here, we show data consistent with a model in which incremental processing in concert with relative hyperarticulation of high-information cues inhibits the development of word-initial neutralization rules. In turn the lexicon evolves such that most short words end in word-final segments that do not alternate, which has the effect of localizing word-final neutralization in longer words where word-final segments are least informative.

References

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