Modelling the evolution of lexical stress patterns in an agent-based simulation

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In English, word pairs like *ˈconcert*$_N$–*conˈcern*$_N$, *ˈconvoy*$_N$–*disˈmay*$_N$, *ˈconstant*$_A$–*conˈtent*$_A$ are stressed differently even though they are equivalent in terms of syllable structure, syllable weight, morphological composition, and syntactic category. A large body of research (e.g. Chomsky & Halle 1968, Liberman & Prince 1977, Kiparsky 1979, Hayes 1982, Giegerich 1985, Anderson 1986, Kager 1989, Burzio 1994, Halle 1998, Hyde 2007) has made obvious that this diversity cannot be derived from a single set of stress rules.

Our study addresses the question whether there are specific conditions under which stress pattern diversity as found in languages like English can be predicted to emerge and to remain (historically) stable. It builds on previous work (XXXXXXX XXXX), in which we hypothesised that words adopt those stress patterns which produce the most well-formed (i.e. alternating, see Selkirk 1982, Hayes 1984) rhythmic patterns in combination with other words in actual utterances. We modelled this hypothesis in terms of evolutionary game theory. Our model indicated that stress pattern diversity would become evolutionarily stable among polysyllables if the number of stressed monosyllables exceeded a certain threshold. This fit the historical development of English, where stress pattern diversity only became stable after Middle English, following a drastic increase in monosyllables due to the loss of unstressed syllabic inflections.

Although rigorous, our game-theoretic model required radical simplifications, so that the predictions derived from it remained general and mostly qualitative. To make up for these shortcomings, the present study addresses the question with an agent-based simulation, constructed in R (R Development Core Team). In this model, stable distributions of stress patterns evolve as a systemic response to individual interactions between lexemes (i.e. the ‘agents’). In each round of the simulation, a specified number of lexemes is selected to form a rhythmic phrase. The phrase is then evaluated regarding its rhythmic well-formedness, which in turn impacts the lexical agents’ likelihood of selection in a future round. Over time, the composition of the lexicon gradually adjusts to the rhythmic constraints by adjusting the proportions of different stress patterns. Initial results from our prototype corroborate our earlier findings that stress pattern diversity among polysyllables will become stable if the proportion of stressed monosyllables in the language is sufficiently high (Figure 1).

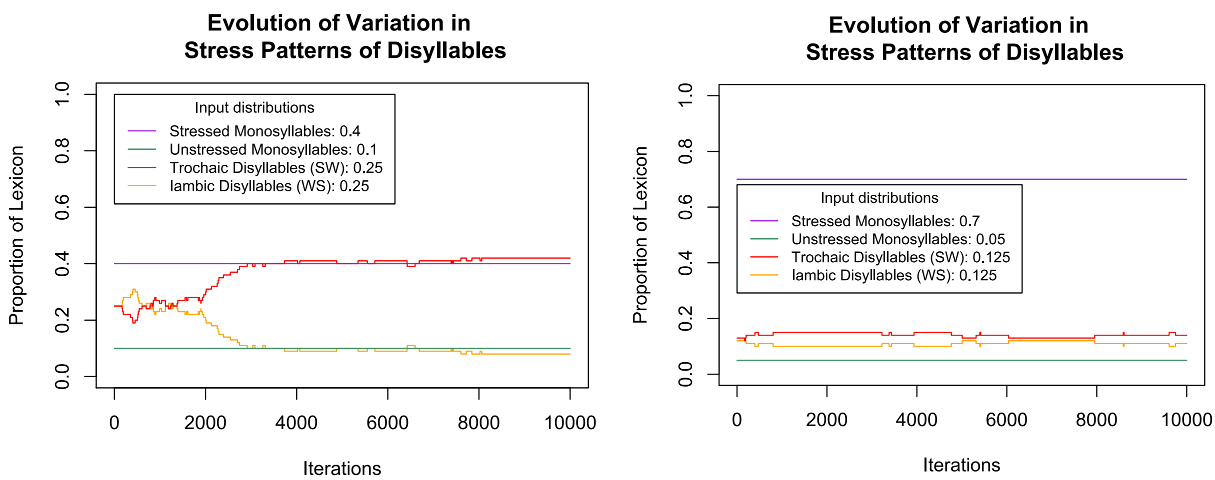

Figure 1: Evolution of stress pattern diversity. When stressed monosyllables are relatively rare, polysyllables (here: disyllables) will tend towards a single stress pattern (left). When stressed monosyllables are frequent, a relatively stable distribution of different stress patterns tends to emerge (right).

Unlike the game-theoretic model, the simulation allows us to investigate the effect of a larger set of parameters, which can be set individually, such as the initial distribution of stress types in the lexicon, the frequencies of disyllabic, trisyllabic and multisyllabic words, as well as syntactic restrictions on rhythmic phrases. This increases the realism of our model as the parameters can be set according to corpus data of real languages, allowing us to derive concrete quantitative predictions regarding stress pattern distributions in these languages.

In our talk, we present the simulation and discuss what it implies, not only for our research question, but also for the question how research in linguistics and in artificial intelligence can be profitably combined.

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