An agent-based simulation of constraint interaction in the evolution of word stress

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Conceptualizing languages as complex adaptive replicator systems (Beckner et al., 2009 (Croft, 2000; Dawkins, 1982; Dennett, 2018), we demonstrate an agent-based simulation that models the evolution of word stress patterns. We assume stress pattern evolution to reflect two distinct types of constraints. On the one hand, stress patterns of words of the same syntactic categories and the same syllabic structures, are under pressure to conform to one another, yielding predictable, 'regular' stress patterns (Chomsky & Halle, 1968; Anderson, 1986; Hayes, 1995; Burzio, 2005; Domahs et al., 2014). Such conformity facilitates the identification of words in speech and their acquisition. On the other hand, word stress patterns are constrained by preferences for utterances to be rhythmically well-formed, e.g. to minimize stress clashes and sequences of unstressed syllables, i.e. 'lapses' (Kelly, 1989; Breiss & Hayes, 2020).

The simulation models the evolutionary trajectories of lexical stress patterns predicted to arise on the basis of different (and controllable) assumptions about the relative strength of pressures selecting for 'regular' stress patterns, pressures selecting for rhythmically well-formed utterances, or pressures for stress and syllable weight to match. Additionally, one can control initial proportions of different lexical types, different stress patterns, as well as syntactic regularities governing word combination.

In each round, two polysyllables (the 'agents') are selected and combined in diverse contexts (reflecting the syntax of the modelled language). The likelihood of selecting a word type depends on its frequency in the lexicon. Stress patterns receive a 'payoff' reflecting the rhythmic quality of the formed sequence and their relative frequency with their class. This payoff then feeds back on that relative frequency. When the simulation reaches an equilibrium, the resulting distribution of stress patterns among word types is considered evolutionarily stable.

The simulation visualizes stress pattern evolution as trajectories of their proportions among polysyllabic nouns, adjectives, and verbs (Figure 1). It suggests that conformity pressures and rhythmic constraints conspire to stabilize regular stress patterns, contingent on a low proportion of monosyllables. Conversely, higher proportions stabilize stress pattern diversity.

Our talk discusses the adequacy of our simulation as a model of stress pattern dynamics in natural languages and reflects on the epistemic value of the method.

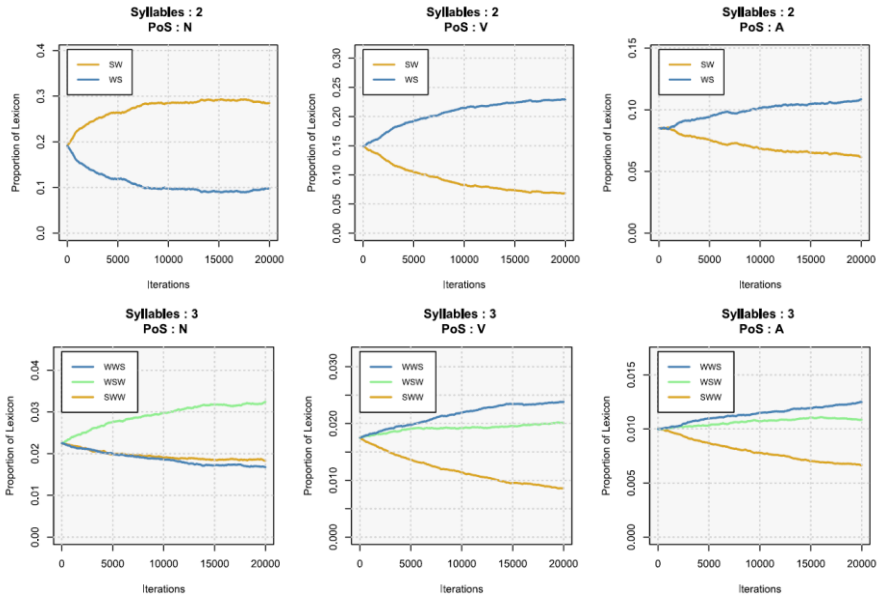

Figure 1: Stress patterns among polysyllabic nouns, adjectives and verbs

References

Anderson, John. 1986. Suprasegmental Dependencies. In Jacques Durand (ed.), *Dependency and Non-Linear Phonology* (Routledge Library Editions), 55–133. Boca Raton, FL: Routledge.

Beckner, Clay, Richard Blythe, Joan L. Bybee, Morten H. Christiansen, William Croft, Nick C. Ellis, John Holland, Jinyun Ke, Diane Larsen-Freeman & Tom Schoenemann. 2009. Language Is a Complex Adaptive System: Position Paper. *Language Learning* 59. 1–26.

Breiss, Canaan & Bruce Hayes. 2020. Phonological markedness effects in sentence formation. *Language* 96(2). 338–370.

Burzio, Luigi. 2005. *Principles of English stress* (Cambridge studies in linguistics 72). Cambridge: Cambridge Univ. Press.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English.* Cambridge, MA: MIT Press.

Croft, William. 2000. Explaining language change: an evolutionary approach. Harlow: Longman.

Dawkins, Richard. 1982. *The selfish gene.* New York: Oxford University Press.

Dennett, Daniel C. 2018. *From bacteria to Bach and back: The evolution of minds.* London: Penguin Books.

Domahs, Ulrike, Ingo Plag & Rebecca Carroll. 2014. Word stress assignment in German, English and Dutch: Quantity-sensitivity and extrametricality revisited. *The Journal of Comparative Germanic Linguistics* 17, http://www.jstor.org/stable/43549718. (12 January, 2024.)

Durand, Jacques (ed.). 1986. *Dependency and Non-Linear Phonology* (Routledge Library Editions). Boca Raton, FL: Routledge.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*.

Kelly, Michael H. 1989. Rhythm and language change in English. *Journal of Memory and Language* 28, https://www.sciencedirect.com/science/article/pii/0749596X89900041.