How constraints refer to nothing:
The correct notion of substructure for phonology
Nick Danis[1,3], Jeffrey Heinz[2], and Adam Jardine[3]

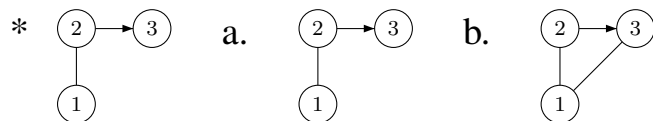[1]*Princeton University*, [2]*Stony Brook University, and* [3]*Rutgers University*

Overview

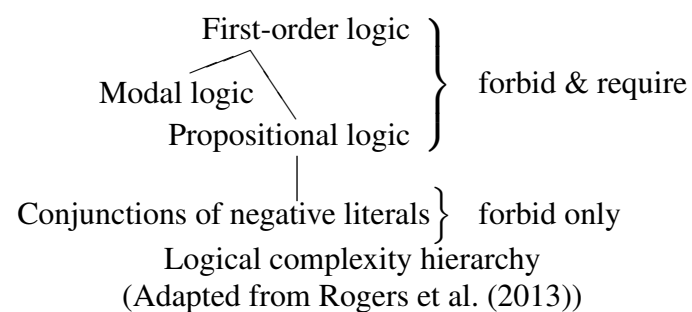- Many markedness constraints identify illicit **substructures** of a representation
  Ex., *NC̥, *CODA, *[voice]

- The **superstructure problem**: a pattern in which a well-formed structure is a **superstructure** of an ill-formed one (Jardine and Heinz, in press; Jardine, 2016; Danis, 2017)

- We propose a strong (and mathematically natural) definition of substructure from **logic** and **model theory** that can capture these cases in a unified way and maintains a restrictive, **negative** conception of markedness

Negative Markedness

- From a logical perspective, the most restrictive constraints can only **forbid substructures** (Jardine and Heinz, in press)

First-order logic
Modal logic
Propositional logic
} forbid & require

Conjunctions of negative literals } forbid only

Logical complexity hierarchy
(Adapted from Rogers et al. (2013))

- Example of first-order:

$$\forall x, \exists y [+\text{nasal}](x) \rightarrow [-\text{voice}](y)$$

"If there is a nasal, there must be a voiceless segment (somewhere in the word)"

- Example negative (string) literal:

$$\neg *NC̥$$

"Don't contain a *NC̥ sequence"

The Superstructure Problem

- Given non-linear representations, some constraints appear to **require** structure

- **Aghem** (Hyman, 2014)

  - When H tone is followed by L, it spreads to the right:
    a. /é - nòm/ → [é - nôm] 'to be hot'
    b. /fú - kìa/ → [fú - kîa] 'your sg. rat'
    c. e-nom → e-nom [é - nôm] 'to be hot'
       | | | |
       H L   H L

  - Constraint: "H must spread to a following L-toned mora"
  - The well-formed structure includes the ill-formed structure

  *H L   ✓ H L
  | | \|
  σ   σ   σ σ

- **CODACOND** (Ito 1986, Ito and Mester, 1994)

  * C]σC   ✓[CVC]σCV
 | |
   place   place

- Other examples:
  - Ngbaka coocurrence restrictions on complex consonants (Sagey 1986, Danis 2017)
  - Spreading in Tingrinya and other languages (Hayes 1986)

Defining Substructure

- **Substructure:** For two structures A and B in $\mathcal{S}$, A is a substructure of B iff there is a mapping h from D^A to D^B such that
  - for every unary relation R_i, $d^A \in R_i$ in A **iff** $h(d^A) \in R_i$ in B, and
  - for every binary relation R_j, $(d_1^A, d_2^A) \in R_j$ in A **iff** $(h(d_1^A), h(d_2^A)) \in R_j$ in B

- This definition is standard in logic and model theory (Libkin, 2004)

- This **strong definition** differs from earlier (for phonology) **weak definition**, which uses **if** instead (Hayes, 1986; Jardine and Heinz, in press; Jardine, 2017)

Aghem Tone Spreading
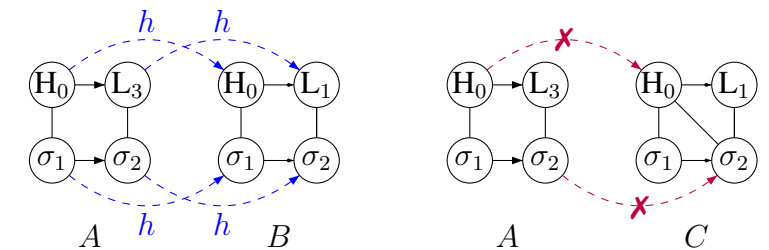
- The mapping h from A to B satisfies the definition, but there is no such mapping from A to C
- Thus, B is not grammatical for Aghem, but C is.

Discussion

- The strong definition is more expressive than the weak, but still **negative**
- Constraints like SPEC-T ("Syllables must be specified for tone"; Yip, 2002)) are different; they warrant further study
- The right formal definitions of markedness and representations can unify distinct phenomena.
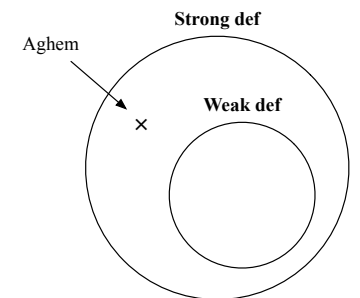
Select References

Danis, Nick (2017). *Complex place and place identity*. PhD thesis, Rutgers University.
Hayes, Bruce (1986). Assimilation as spreading in Toba Batak. *LI*, 17(3):467–499.
Hyman, Larry (2014). How autosegmental is phonology? *The Linguistic Review*, 31:363–400.
Jardine, Adam (2016). *Locality and non-linear representations in tonal phonology*. PhD thesis, University of Delaware.
Jardine, Adam (2017). The local nature of tone-association patterns. *Phonology*, 34:385–405.
Jardine, Adam and Heinz, Jeffrey (in press). Markedness constraints are negative: an autosegmental constraint definition language. In *Proceedings of CLS 51*.
Libkin, Leonid (2004). *Elements of Finite Model Theory*. Berlin: Springer-Verlag.
Rogers, James, Heinz, Jeffrey, Fero, Margaret, Hurst, Jeremy, Lambert, Dakotah, and Wibel, Sean (2013). Cognitive and sub-regular complexity. In *Formal Grammar*, volume 8036 of *Lecture Notes in Computer Science*, pages 90–108. Springer.
Yip, Moira (2002). *Tone*. Cambridge University Press.

Author emails: ndanisprinceton.edu, jeffrey.heinzsbu.edu, adam.jardinerutgers.edu