Bounded lookahead in quantity insensitive stress assignment

Nate Koser

Rutgers University

RULing XV

Introduction

- In iterative stress languages, stress is placed on every second or third syllable in the word

  $\sigma\sigma\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma$

- What is the best characterization of these kinds of patterns?

- What formal properties do they share?

Introduction

- Formal language theory (FLT) delineates classes of functions that serve as typological hypotheses for stress assignment

- Some previous "big-picture" FLT work on stress as a function (Hao & Andersson 2019; Koser & Jardine 2020)

- No treatment of iterative stress patterns in particular

Results

- Typological split among iterative patterns – less complex *output strictly local* (OSL) patterns[1] and more complex *subsequential* patterns[2]

- All more complex patterns share property of "look-ahead" despite surface differences

- If you separate the iteration of stress from the look-ahead, iterative patterns look the same

- More restrictive characterization of iterative stress

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[1] Chandlee & Heinz (2018)   [2] Mohri (1997)

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Why this matters

- A step closer to answering the question – what is the proper characterization of stress as a function?[1]

- Unites a group of patterns with surface differences based on their computational properties

- Bears on extrametricality[2] and non-finality[3]

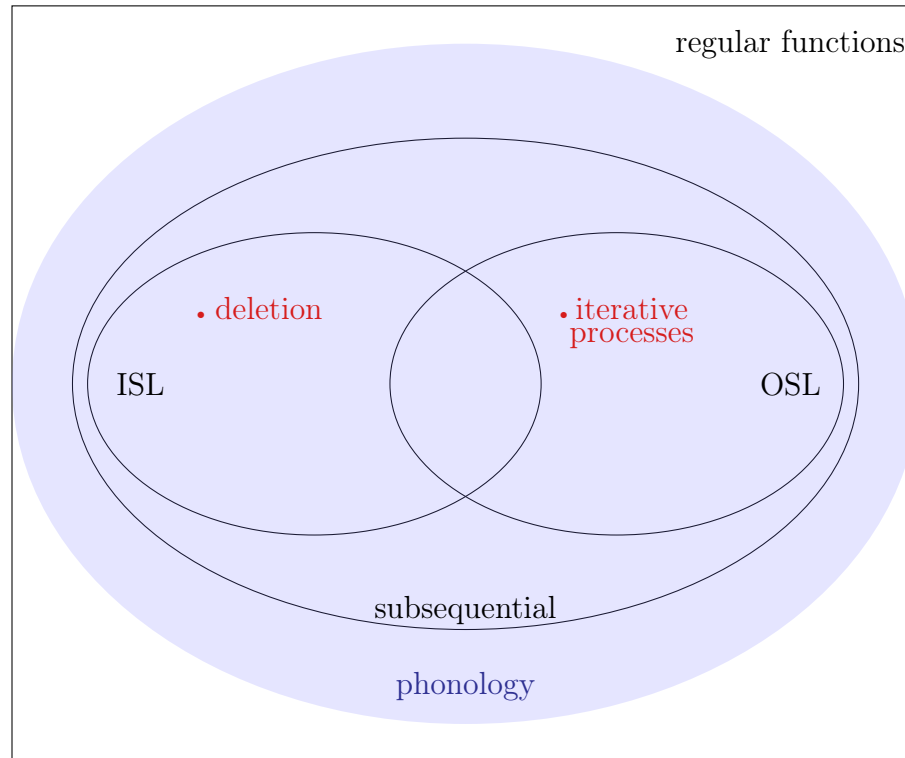- Informative with regard to decomposition of subsequential functions

[1] Koser & Jardine (2020)   [2] Liberman & Prince (1977)   [3] Prince & Smolensky (1993)

Plan

- Background (FLT, stress)

- Complexity of the patterns

- Address the more complex patterns

- Implications

Complexity

- FLT complexity classes divide space of possible functions based on expressive power of those functions

- Phonology is *regular* (Johnson 1972; Kaplan & Kay 1994)

- In fact, most is subregular (Rogers et al. 2013; Heinz 2018)

FLT and phonology

- Classes correspond to different phonological patterns; different information

- Input strictly local (ISL) functions[1] - bounded information in the input

    - Ex: initial stress: $\#\sigma\sigma\sigma\sigma \rightarrow \#\acute{\sigma}\sigma\sigma\sigma$

- Output strictly local (OSL) functions[2] - bounded information in the output

    - Ex: binary stress: $\#\sigma\sigma\sigma\sigma\sigma \rightarrow \#\acute{\sigma}\sigma\grave{\sigma}\sigma\grave{\sigma}$

- Subsequential functions[3] - information up to current input symbol, more powerful

    - Ex: LHOR stress: $\text{LLHL} \rightarrow \text{LL\acute{H}L}$ $\text{LLLLL} \rightarrow \text{LLLL\acute{L}}$

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[1] Chandlee (2014)   [2] Chandlee & Heinz (2018)   [3] Mohri (1997)

Stress

- Iterative binary quantity insensitive (QI) stress

    - binary: Murinbata[1]: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}...$

    - non-finality: Pintupi[2]: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\sigma...$

    - clash; Ojibwe:[3]: $\sigma\acute{\sigma}, \sigma\acute{\sigma}\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\acute{\sigma}...$

    - internal lapse: Garawa[4]: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma$

- What is the complexity of different iterative stress?
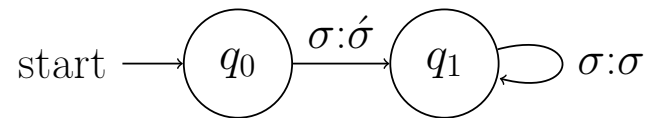
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[1] Street & Mollinjin (1981)   [2] Hansen & Hansen (1969)   [3] Kaye (1973)   [4] Furby (1974)

Stress

- Given iterative patterns are OSL, adopt it as null hypothesis

- Stress as string-to-string mapping from input to output with finite state transducers (FST)

- Function classes have well-understood FST properties

Stress

- Properties of FSTs make properties of the function apparent

start $\longrightarrow$ (q_0) $\xrightarrow{\sigma:\acute{\sigma}}$ (q_1) $\circlearrowright$ $\sigma:\sigma$

initial stress:

$$\sigma\sigma \rightarrow \acute{\sigma}\sigma$$
$$\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\sigma$$
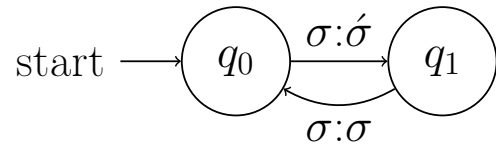$$\sigma\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\sigma\sigma$$
$$\sigma\sigma\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\sigma\sigma\sigma$$
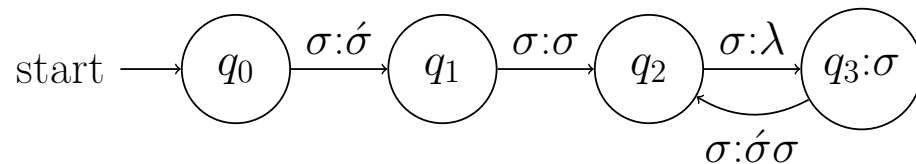$$... \rightarrow ...$$

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Binary: OSL

- Murinbata: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}...$

- Placement of stress determined based on output, OSL

start $\longrightarrow$ q_0 $\xrightarrow{\sigma:\acute{\sigma}}$ q_1
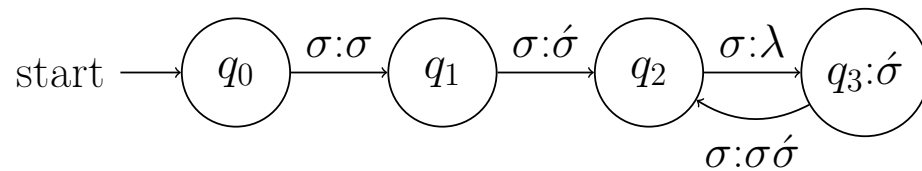
$\sigma:\sigma$

Non-finality: non-OSL

- Pintupi: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\sigma...$

- Binary stress would stress final

- Every odd syllable, needs to know – am I at the end of the word?

- Requires lookahead (seen as "waiting" λ)

- Lookahead not OSL, is subsequential

start $\longrightarrow$ q_0 $\xrightarrow{\sigma:\acute{\sigma}}$ q_1 $\xrightarrow{\sigma:\sigma}$ q_2 $\xrightarrow{\sigma:\lambda}$ $q_3{:}\sigma$, with return edge $\sigma:\acute{\sigma}\sigma$

Clash: non-OSL

- Ojibwe: $\sigma\acute{\sigma}, \sigma\acute{\sigma}\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}, \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\acute{\sigma}...$

- Binary stress would *miss* final stress

- Not OSL, is subsequential

start $\longrightarrow$ q_0 $\xrightarrow{\sigma:\sigma}$ q_1 $\xrightarrow{\sigma:\acute{\sigma}}$ q_2 $\underset{\sigma:\sigma\acute{\sigma}}{\overset{\sigma:\lambda}{\rightleftarrows}}$ $q_3{:}\acute{\sigma}$

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Internal lapse: non-OSL

- Garawa: $\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma, \acute{\sigma}\sigma\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma$

- Binary stress (right to left) would stress penult

- Not OSL, is subsequential

Taking stock

- Non-fin, clash, internal lapse patterns all subsequential

- All share property of lookahead

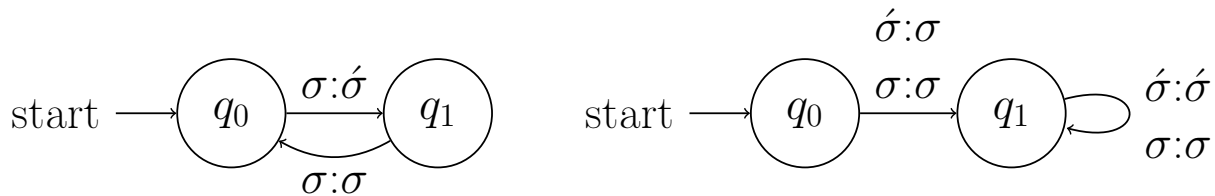- Despite surface differences, similar computational properties

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Two functions

- Capture the similarity by separating the iteration of stress from the lookahead

- One OSL function that blindly iterates binary stress

- One ISL function that acts like lookahead by "cleaning up"

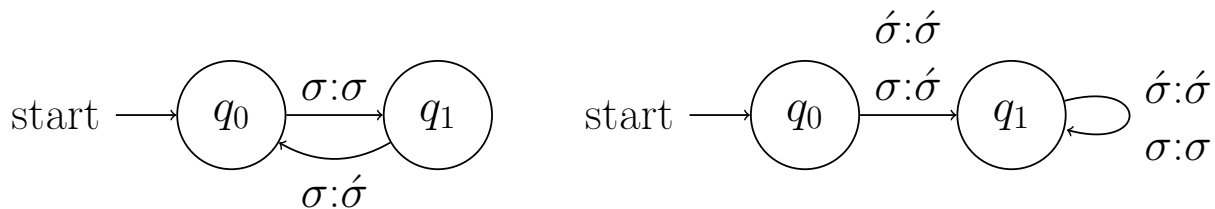- Output of OSL is input of ISL, like rule ordering

Two functions: Non-fin

- $\sigma\sigma\sigma\sigma \quad \rightarrow \quad \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma} \quad \rightarrow \quad \acute{\sigma}\sigma\acute{\sigma}\sigma\sigma$
  $\sigma\sigma\sigma\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma \rightarrow \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma$

- OSL function stresses every odd syllable left-to-right

- ISL function removes final stress if present
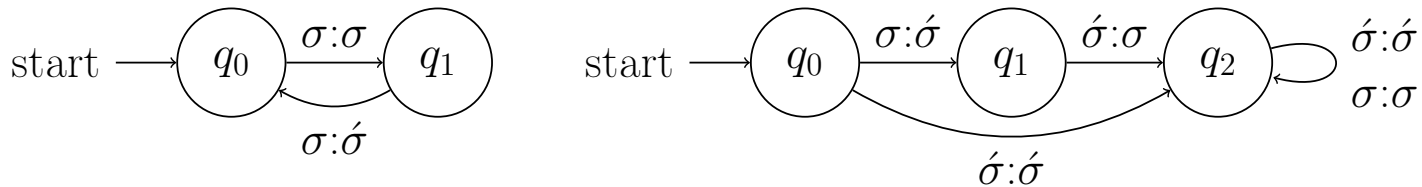
- Iteration is like Murinbata

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Two functions: Clash

- $\sigma\sigma\sigma\sigma\sigma \quad \rightarrow \quad \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma \quad \rightarrow \quad \sigma\acute{\sigma}\sigma\acute{\sigma}\acute{\sigma}$
  $\sigma\sigma\sigma\sigma\sigma\sigma \quad \rightarrow \quad \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma} \quad \rightarrow \quad \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}$

- Every even syllable

- *Add* final stress if not present

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Two functions: internal lapse

- $\sigma\sigma\sigma\sigma\sigma \rightarrow \sigma\acute{\sigma}\sigma\acute{\sigma}\sigma \rightarrow \acute{\sigma}\sigma\sigma\acute{\sigma}\sigma$
  $\sigma\sigma\sigma\sigma\sigma\sigma \rightarrow \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma \rightarrow \acute{\sigma}\sigma\acute{\sigma}\sigma\acute{\sigma}\sigma$

- Every even syllable (right-to-left)

- Add initial stress if not present *and* delete peninitial stress if present

start $\longrightarrow$ q_0 $\quad \sigma{:}\sigma \quad$ q_1 $\qquad\qquad$ start $\longrightarrow$ q_0 $\quad \sigma{:}\acute{\sigma} \quad$ q_1 $\quad \acute{\sigma}{:}\sigma \quad$ q_2 $\quad$ $\acute{\sigma}{:}\acute{\sigma}$, $\sigma{:}\sigma$

$\sigma{:}\acute{\sigma}$ $\qquad\qquad\qquad\qquad\qquad$ $\acute{\sigma}{:}\acute{\sigma}$

Summary

- Separating the lookahead from the iteration highlights underlying similarity in patterns with surface differences

- Creates mini typology: some delete, some add, some delete and add

Further Issues

- ISL function is not just any arbitrary ISL function; only ever needs one or two input symbols (similar for OSL function)

- State some restriction on them. Restriction on the interaction ala McCollum et al. (2018)?

- Restrictions very important – otherwise difference with subsequential function is unclear

- Without restrictions, can *any* subsequential function be broken down in this way?

Further Issues

- Similar in spirit to extrametricality[1] and non-finality[2] analyses

- More like non-finality, all syllables remain in computation

- Obviates need for function reattaching extrametrical syllables – trade off

- Neither of the above apply to clash or internal lapse cases

[1] Liberman & Prince (1977)   [2] Prince & Smolensky (1993)

Further Issues

- Can this be extended somehow to othe stress cases?

    - bidirectional: Cahuilla[1]: Stress every other syllable in both directions, starting at the root-initial syllable

    - ternary?

    - quantity sensitive languages?

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[1] Seiler (1977)

Thanks

Thanks to the Adams for their helpful comments, and thank you for listening!

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