Representing (and not quite learning yet) Phonological Tiers

Adam Jardine

University of Delaware

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Introduction

- What is the character of constraints on non-linear representations?
- Work on applying the Subregular Hierarchy to phonology (Graf, 2010; Heinz, 2007, 2010; Rogers et al., 2013) gives us a constrained and explicit theory of *string* representations and how grammars operate over them
- This thinking can be brought to bear on non-linear representations by extending it from strings to *graphs*
- One interesting result: when the melody tier is bounded, the No-Crossing Constraint is *local*
- This will be illustrated with the case of tone in Tokyo Japanese

Computational bounds on phonology

- Thesis: there are non-trivial *computational* bounds on possible constraints (Heinz, 2007, 2010; Rogers et al., 2013) and maps (Chandlee, 2014) in natural language phonology
- Here, constraint means 'a statement describing the well-formed representations'
- These bounds can be measured by the expressive power of the constraints necessary to define a set of well-formed objects

(1) A set of strings (*formal language*)
$\{ab, abab, ababab, ...\}$

(2) A set of constraints for (1)
$\neg\#b \wedge \neg aa \wedge \neg bb \wedge \neg a\#$

Computational bounds on phonology

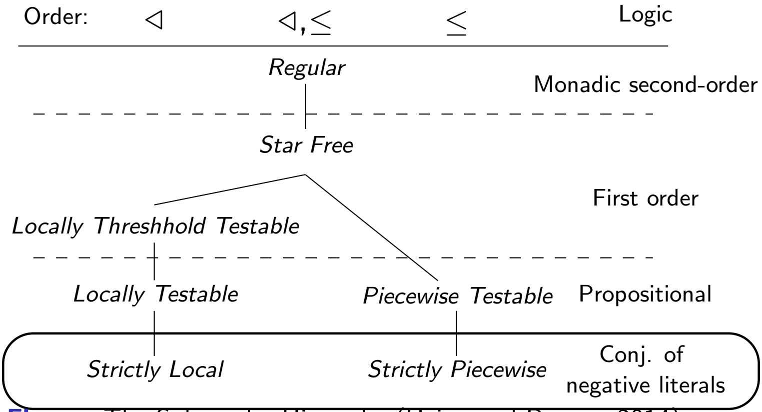


Figure: The Subregular Hierarchy (Heinz and Rogers, 2014)

Computational bounds on phonology

- This is consistent with the hypothesis that there is a *computational bound* on phonology
- There is an understanding that phonology uses *non-linear* representations, not only strings

Constraints on APRs

- Most agreed upon non-linear theory is autosegmental representations (APRs; Goldsmith, 1976)
- One constraint on APRs is the No-Crossing Constraint (NCC):

(3) Association lines do not cross.

- Coleman and Local (1991) point out that (3) is a constraint on *drawings*
- It does not distinguish among *representations*

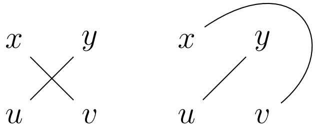


Figure: Two drawings of an APR

Constraints on APRs

- Goldsmith (1976)'s original formal definition (p. 28) *does* distinguish among representations
- Logically, (xy indicating association)

(NCC) $(\forall x, y, u, v)[(xu \wedge yv) \rightarrow (x \leq y \wedge u \leq v)]$

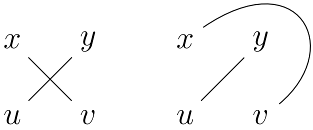


Figure: Two drawings of an APR

Constraints on APRs

(NCC) $(\forall x, y, u, v)[(xu \wedge yv) \rightarrow (x \leq y \wedge u \leq v)]$

- The NCC is monadic second order!
- This is in contrast with the intuition from the SRH work, which suggested that phonology uses restricted logic
- One answer: NCC is universal, so it doesn't matter
- This is problematic for theories using line crossing (c.f. Kimper, 2011) or phenomena which seem to contradict the NCC (Hyman, 2014)
- Is there a way to reduce the power of the NCC?

Proposal: APRs as graphs

- I propose to extend the logical model of the SRH to *graphs*
- APRs are a kind of graph (Goldsmith, 1976; Coleman and Local, 1991)

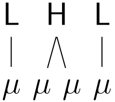


Figure: An APR

- In particular, a set of tier strings with their own precedence relations, connected to each other by association lines

Basics of APR graphs

- This information can be represented by a *labeled mixed graph* $\langle V, E, A, \ell \rangle$:
  - Undirected edges E = associations
  - Directed edges A = precedence ($\triangleleft$)
  - Node labeling ℓ = symbols

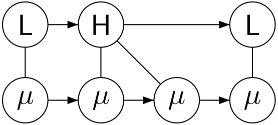


Figure: An APR graph of H and L tones associated to morae

Basics of APR graphs

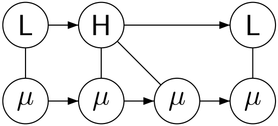


Figure: An APR graph

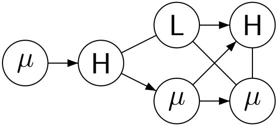


Figure: A non-APR graph

- Specifically, I assume for APR graphs:
  - A and ℓ divide nodes into string graphs (tiers) with disjoint alphabets
  - each edge in E has one end in the 'timing tier' string (a la Pulleyblank, 1986)

Basics of APR graphs

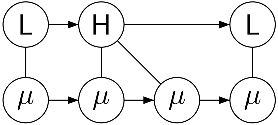


Figure: A surface APR graph

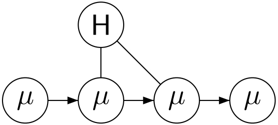


Figure: Not a valid surface APR

- For *surface* APR graphs:
  - Each node in the timing tier is associated to some node on each of the other tiers (i.e., it is *fully specified*—half of Goldsmith's WFC)

SL graph constraints

- What about other constraints?
- We can extend the SL idea of negative statements about sub*strings* to negative statements about sub*graphs*
- Let us call these *SL graph constraints*
- The Obligatory Contour Priniciple (Leben, 1973; McCarthy, 1986) is an SL graph constraint

(OCP) At the melodic level, adjacent identical elements are prohibited.

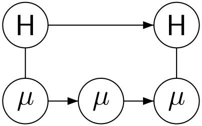


Figure: An APR graph

$\neg$ H→H $\wedge$ $\neg$ L→L

Figure: OCP as SL constraints

Tone in Tokyo Japanese

- A (simplified) description of surface tone patterns of Tokyo Japanese (TJ) based on Haraguchi (1977):
- In TJ, the first mora is generally pronounced low (L), followed by high toned morae (H)

(4)

a. kawa 'river' LH
b. atama 'head' LHH
c. miyako 'capital' LHH
d. sentaku 'laundry' LHHH

- There can be a drop from H to L, but it never goes back up to H.

(5)

a. o-tegami 'letter' LHLL
b. tanosii 'fun' LHHL
c. *LHLH, *LHLLH, ...

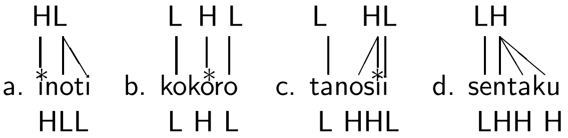
- A word may start H if monomoraic or all following morae are L

(6)

a. e 'picture' H
b. kyoo 'today' HL
c. inoti 'life' HLL

Tone in Tokyo Japanese

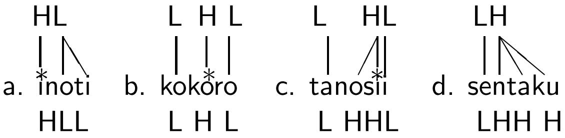
(7)



- AP analysis: words with drop have an accent (∗) (Haraguchi, 1977) to which an HL melody associates. Words without accent have H melody
- Words without a word-initial drop get an initial L tone
- H and second L (if present) associate to other morae, obeying NCC

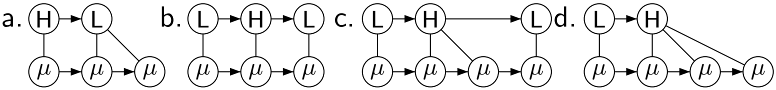
Tone in Tokyo Japanese

(7)



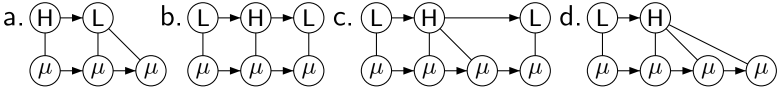
- We're concerned with the surface associations here, so we'll bypass the accent in favor of associating an HL melody
- The set of well-formed APRs in TJ, then, is those with an (L)HL or LH melody associated to morae according to the rules just described

(8)



TJ as an APR graph set

(8)

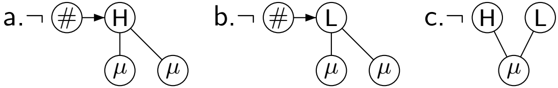


- How do we capture this graph set?
- First, SL constraints for the melody tier

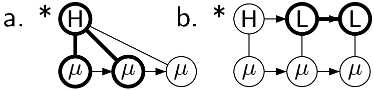
(9) a. ¬ # → L → #   b. ¬ L → L   c. ¬ H → H   d. ¬ H → L → H

- Then, constraints on association

(10)

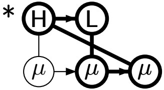
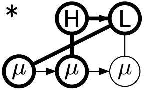
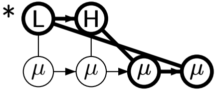


(11)

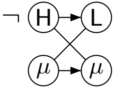
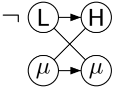
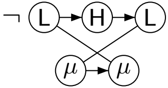


TJ as an APR graph set

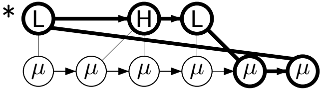
- The following are also not well-formed TJ APRs

(12) a.  b.  c. 

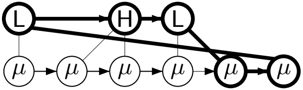
- We can also state SL constraints on no line-crossing

(13) a.  b.  c. 

- Assuming full specification and bound on length of the melody tier, these hold no matter length of the timing tier

(14) 

Discussion: the NCC as an SL graph constraint

(14) * 

- Due to full specification and bound melody tier, all tone nodes are within a bound number of edges to any mora nodes
- This means that with full specification, for any language with a bounded melody tier, the NCC is SL
- This is *not* true when either of the assumptions do not hold

Discussion: the NCC as an SL graph constraint

- What does this mean?
- The NCC, which earlier looked MSO, can be for these cases described with negative literals
- Empirical question: Are there truly unbounded melodic tiers (in tone, at least)?
- Can the NCC *in general* be made local with some other assumptions?

Conclusion

- This talk outlined a method for rigorously investigating non-linear representations in phonology
- One interesting result: in some cases, the NCC is local
- Only talked about static representations — don't know enough yet about constraints on *transformations* on representations
- (Method for studying that — Engelfriet and Hoogeboom (2001))
- Future work can also study inferring SL graph constraints from positive data

Acknowledgments

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