Language and Computation

week 10, Tuesday, April 01

Tamás Biró
Yale University
tamas.biro@yale.edu
http://www.birot.hu/courses/2014-LC/

Practical matters

- **Post-reading:** JM 11
- `http://birot.hu/courses/2014-LC/readings.txt`
- Assignment 4 posted, due: 04/10.
- (To come(?): Viterbi and Forward-Backward – an example)

Today

- Phonology
- Finite-state phonology
- Optimality Theory (intro)

Next time: Computational aspects of Optimality Theory.

Phonetics vs. Phonology

Phonetics vs. Phonology

Phonetics: studying speech sounds.
Language-specific to a lesser degree.

- Production: how sounds made in human vocal tract.
- Acoustics: waveforms transmitted in the air.
- Perception: acoustic signal processed by ear.

Applications: speech synthesis and speech recognition.

Phonetics vs. Phonology

Phonology: studying sound patterns of specific languages, the sound system of specific languages.

- **Phoneme:** smallest contrastive unit in a sound system.
- Phoneme inventory: "alphabet" of the mental lexicon.
- **Allophones:** a phonetic variant of a phoneme.
- **Phonotactics:** permissible sound sequences.
- **Morpho-phonology:** sound changes due to morphology.

Phonology. . .

. . . deals with (among others):

- Sounds (phonemes, allophones, segments)
- Syllables
- Stress
- Tone and intonation
- Historical changes in the sound system of specific languages

Phonetics vs. Phonology

Phonetics	Phonology
physical	abstract
language-independent	language-specific
continuous	discrete representations

Phonology as computation

Language as computation
Example: SPE-style phonology

- Data structures, a.k.a. representations:
  segments: [a] or $\begin{bmatrix} +\text{ back} \\ -\text{ round} \\ -\text{ high} \\ +\text{ low} \end{bmatrix}$

  words: [t a m a: $\int$] or [ϵ p l]

- Operations on these representations

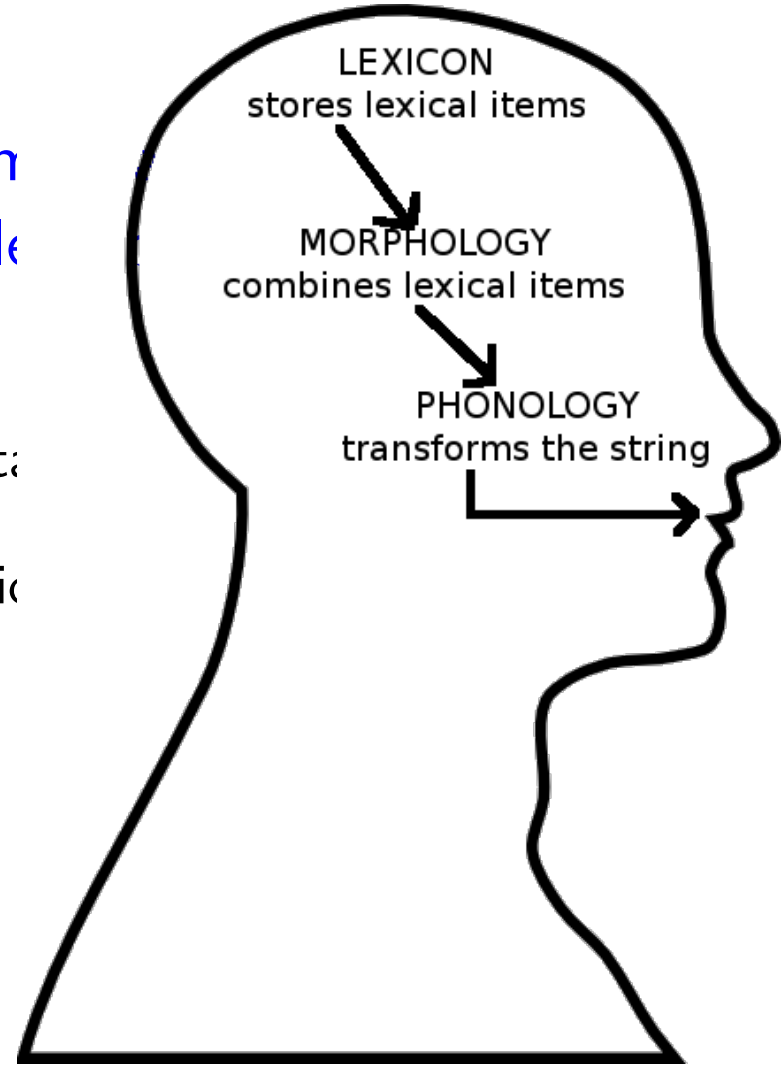
- Overall architecture

Language as computation
Example: SPE-style phonology

- Data structures, a.k.a. representations
- Operations on these representations: rewrite rules
  [a] $\rightarrow$ [o] or $\begin{bmatrix} + & \text{back} \\ - & \text{round} \\ - & \text{high} \\ + & \text{low} \end{bmatrix} \rightarrow \begin{bmatrix} + & \text{round} \\ - & \text{low} \end{bmatrix}$
- Overall architecture

Language as con
Example: SPE-style

- Data structures, a.k.a. represent
- Operations on these representati
- Overall architecture:



Computational approaches to phonology

Computational approaches to phonology

- Generative turn: "mind as a computer"
  $\rightarrow$ novel/better models of language for the linguist.
- Cognitive science connection: language as a window onto the mind.
- Contribution to speech and language techology?
- Computational questions raised by linguistic theories

Computational questions raised by linguistic theories

- Generative power
- Implementation
- Learnability
- etc.

David Marr's three levels

- Computational level
- Algorithmic level
- Implementational level

Architectures for phonology

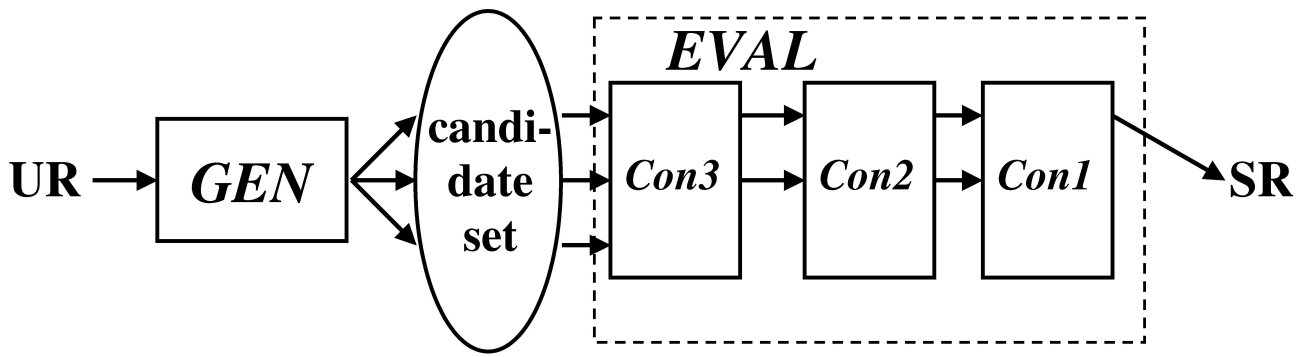
Architectures for phonology

SPE phonology:

- /Underlying form/ $\mapsto$ [surface form]
- via intermediate representations
- using a series of rewrite rules: $A \rightarrow B / C\_ D$
- seemingly context sensitive – is it?

Architectures for phonology

- Overall architectures: Optimality Theory



Optimality Theory

Simplified language **typology**:

- Stress on first syllable
- Stress on last syllable
- Stress on penultimate syllable
- No language with stress on second syllable as a rule

Optimality Theory

Simplified language **typology**:

- EARLY: stress as early as possible
- LATE: stress as late as possible
- NONFINAL: stress not on last syllable.

Optimality Theory

/σσσσ/	Early	Late	NonFinal
[s u u u]	0	3	0
[u s u u]	1	2	0
[u u s u]	2	1	0
[u u u s]	3	0	1

Optimality Theory

/σσσσ/	NonFinal	Late	Late
[s u u u]	0	3	0
[u s u u]	0	2	1
[u u s u]	0	1	2
[u u u s]	1	0	3

Optimality Theory

Simplified language **typology**:

- Stress on first syllable: Early $\gg$ Late, NonFinal
- Stress on last syllable Late $\gg$ Early, NonFinal
- Stress on penultimate syllable
  NonFinal $\gg$ Late $\gg$ Early
- No language with stress on second syllable as a rule:
  No such hierarchy.

See you on Thursday!