Learning OT grammars (introduction)

24.964—Fall 2004
Modeling phonological learning

Class 6 (14 Oct, 2004)

Agenda for today

- Discussion of Bailey & Hahn (from last time)
- Wrap-up of statistical approaches
- Intro to learning phonotactics with OT

Bailey & Hahn

(see Week 5 Overheads)

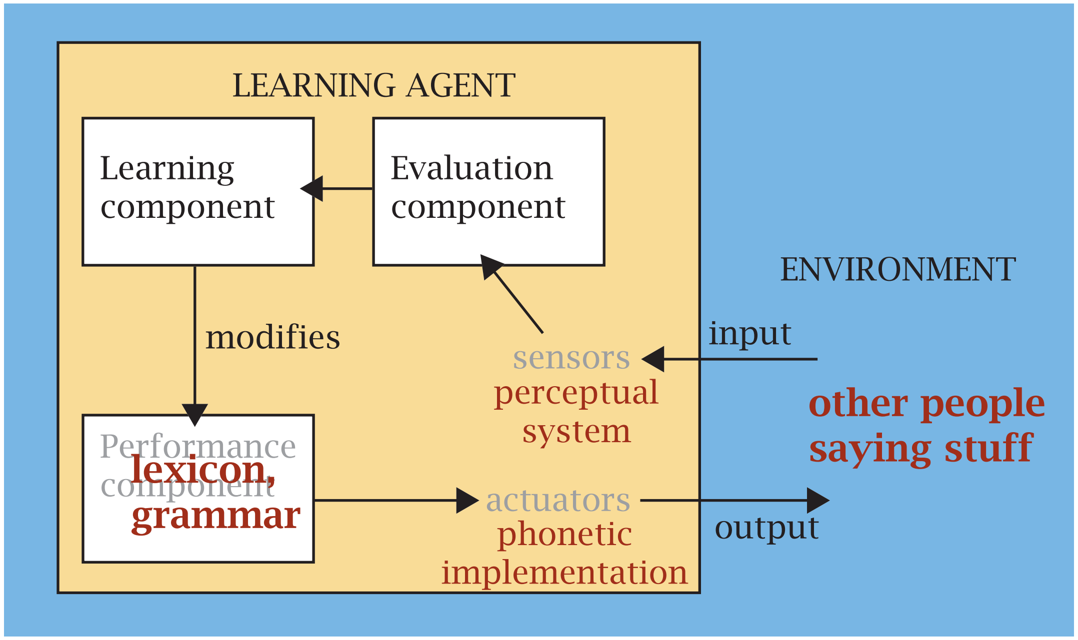
Statistical approaches to phonotactics

How would we characterize statistical approaches?

- Open/closed domain?
- Clean/noisy data?
- Hypothesis space?
- Batch/incremental learning?
- Supervised/unsupervised?
- Makes use of negative evidence?

Statistical approaches to phonotactics

Thinking back to the AI model:



(Where does most of the action lie in a statistical approach?)

A very different approach: OT

Tesar & Smolensky 1996 [2000]: Recursive Constraint Demotion

Goal: outline a learning algorithm which ranks constraints in such a way that they correctly derive the input data

- Target grammar should be able to derive observed surface forms from their corresponding UR's
- Grammar should also exclude forms that are not permissible in the target language
- (Not part of the goal: differentiate possible but unlikely forms from possible and likely forms)

Tesar & Smolensky (1996)

The OT architecture: (familiar parts)

- Lexicon
- GEN
- CON
- EVAL

(What is the learner's task?)

Tesar & Smolensky (1996)

The OT architecture: (familiar parts)

- Lexicon (language particular, must be learned)
- GEN (universal, and very generic)
- CON (universal, but must have particular form)
- EVAL (language particular ranking, procedure is universal)

Tesar & Smolensky (1996)

Some assumptions:

- The constraint set is fixed by UG (p. 4)
- Constraints are *total functions* from candidates
- Set of constraint rankings (dominance hierarchy) also total
- Competition between candidates consists of determining their harmonic ordering (winner is most harmonic)
- Learning = finding a ranking under which all desired winners are more harmonic than their respective losers
  - The relative order of losers does not matter

Tesar & Smolensky (1996)

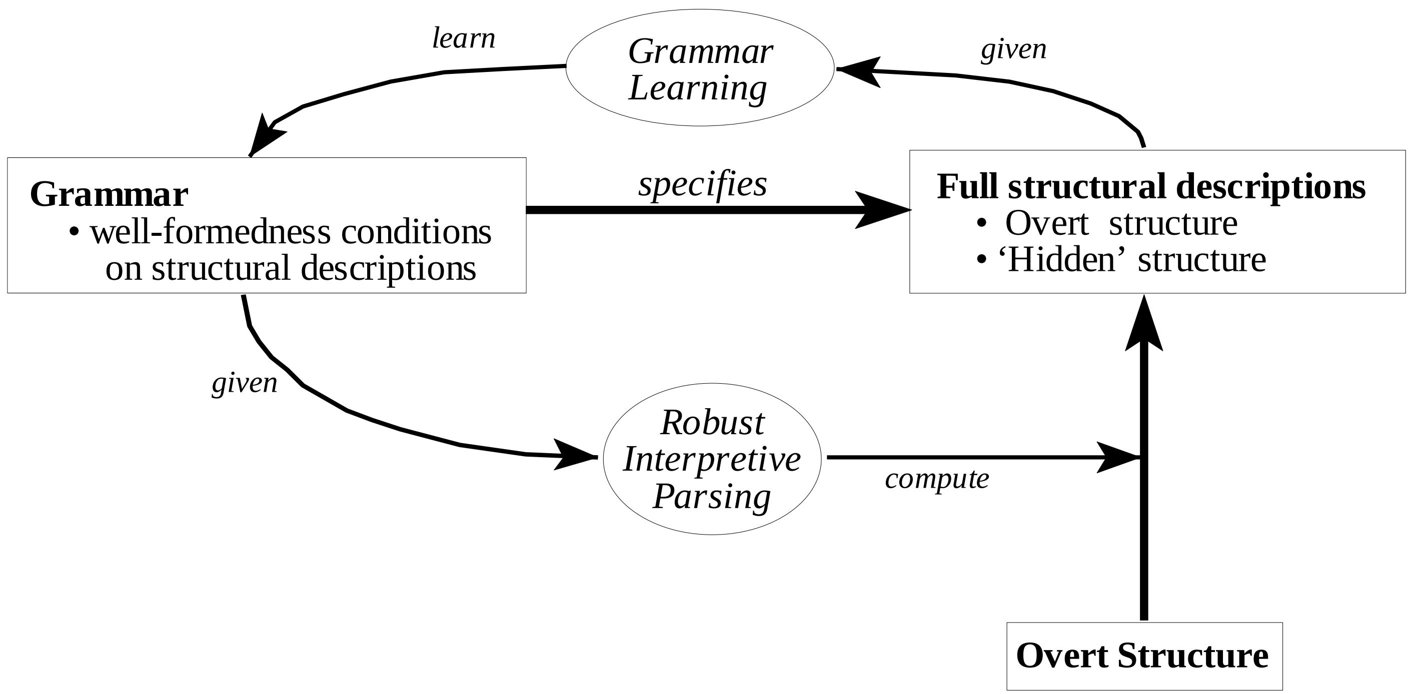
Another important distinction:

- *Full structural descriptions*: outputs of GEN, "including overt structure and input"
- *Overt structure*: the part of a description directly accessible to the learner

Example: /VCVC/ $\rightarrow \langle V \rangle$.CV.$\langle C \rangle \rightarrow$ [CV]

Tesar & Smolensky (1996)

The broader picture:



Tesar & Smolensky (1996)

The learning scenario:

- Learner hears overt structure: [CVC]
- Infer full structural description most likely to be associated with it, under the current grammar; e.g. .CVC.
  - Robust interpretive parsing
- Then flip around the problem: assume underlying form like overt form
- Attempt to learn grammar that derives correct structural description from assumed UR

Tesar & Smolensky (1996)

One other issue that arises:

- OT assumes that constraint rankings are *total*
- Yet there is often no evidence for ranking between particular pairs, because they do not conflict for the data at hand
- To avoid making unmotivated (and possibly wrong) commitments, the ranking algorithm produces *partial orderings* (*strata* of constraints) , consistent with numerous total rankings

Tesar & Smolensky (1996)

The ranking strategy:

1. Construct *mark-data pairs*
   - For each loser/winner pair, collect all violations
   - If both violate same constraint $\mathbb{C}$ an equal number of times, these marks cancel each other out
   - Identify $\mathbb{C}$ that assess uncancelled marks
2. Start with all $\mathbb{C}$ in a single stratum
3. Look for $\mathbb{C}$ that assign uncancelled marks to winners (that is, all constraints with L). Demote any such $\mathbb{C}$, unless it is already dominated by another constraint $\mathbb{C}'$ that has uncancelled *loser* marks (that is, a higher W)

4. Continue, creating subsequent strata, unless there are no uncancelled winner marks without higher-ranked uncancelled loser marks

Tesar & Smolensky (1996)

Example (6), p. 5

(6) Constraint Tableau for L_1

Candidates		ONSET	NOCODA	FILL^{Nuc}	PARSE	FILL^{Ons}
/VCVC/ →						
☞ *d.*	.□V.CV.⟨C⟩				*	*
b.	⟨V⟩.CV.⟨C⟩				* *	
c.	⟨V⟩.CV.C□́.			*	*	
a.	.V.CVC.	*	*			

Tesar & Smolensky (1996)

In *comparative tableau* form (Prince 2000, 2002)

/VCVC/ → .□V.CV.⟨C⟩	ONS	*CODA	DEP(V)	MAX	DEP(C)
d. ∼ a. ⟨V⟩.CV.⟨C⟩				W	L
d. ∼ b. ⟨V⟩.CV.C□.			W		L
d. ∼ c. .V.CVC.	W	W		L	L

Tesar & Smolensky (1996)

General principles:

- Constraints are ranked in as high a stratum as possible
- Constraints with L's can't be in the top stratum; they are placed immediately below the top stratum with a corresponding W
- Constraints are always demoted, never promoted

Tesar & Smolensky (1996)

Characterizing the RCD approach:

- Open/closed domain?
- Clean/noisy data?
- Hypothesis space?
- Batch/incremental learning?
- Supervised/unsupervised?
- Makes use of negative evidence?

Prince & Tesar (1999)

(Student-led discussion)

For next week

- Download this week's perlscripts file from the website, and "read" `RCD.pl` to understand how it implements Tesar & Smolensky 1996

- Try running it on the accompanying text files, to make sure it yields the "right" results for each (that is, understand why it yields what it yields)

- Modify `RCD.pl` to do ONE of the following:

  1. Incorporate the non-persistent "initial state" approach described by T&S, §4.4 ($\mathcal{M} \gg \mathcal{F}$)
  2. Calculate the r-measure of the final grammar

  ◦ HINT: you will need to modify the format of the input file to tell the learner which constraints are $\mathcal{M}$ vs. $\mathcal{F}$; there is no way for it to infer this

- Reading: Hayes (1999) Phonological Acquisition in OT