Advanced Phonological Theory B – Lecture 10: Implementing Functional Constraints

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March 23, 2005

The grounding problem

- Both dispersion theory and the quantal theory hypothesise that inventories are subject to constraints that derive from perceptual and/or articulatory considerations
- However, neither Lindblom (1986) nor Stevens (1989) are very precise about how knowledge about perception and/or articulation end up in grammars
- The same applies to other theories that make claims about the (ultimate) functional nature of phonological devices (e.g., J. Beckman 1997; Kaye 1989)

Grounded phonology

- One recent school of thought (Flemming, 1995, 2001; Steriade, 1997, 2001; Boersma, 1998; Kirchner, 1998) suggests that synchronic phonological grammars are grounded through (direct) access to phonetic knowledge (Kingston & Diehl, 1994)

- This idea is typically implemented in terms of optimality-theoretic grammars composed of constraints referring to
  - Effort minimisation
  - Maximisation of the number of phonological contrasts
  - Maximisation of the phonetic distinctiveness of phonological categories ($\approx$ dispersion)

Grounded phonology

- Feature system for vowel height designed to reflect differences in F_1 (Flemming, 1995):

	[i]	[ɪ]	[e]	[ʌ]	[a]
Lowest F_1	+	-	-	-	-
Low F_1	+	+	-	-	-
High F_1	-	-	-	+	+
Highest F_1	-	-	-	-	+

Grounded phonology

- Feature system for vowel backness designed to reflect differences in F_2 (Flemming, 1995):

	[i]	[y]	[ɨ]	[ɯ]	[u]
Lowest F_2	+	-	-	-	-
Low F_2	+	+	-	-	-
High F_2	-	-	-	+	+
Highest F_2	-	-	-	-	+

Grounded phonology

- 2 families of constraints proposed by Flemming (1995) that refer to auditory features:

1. MAINTAIN n CONTRASTS ALONG DIMENSION x, where MAINTAIN $n \gg$ MAINTAIN $n+1$
   - Example: MAINTAIN 2 F_1 CONTRASTS: maintain 2 contrasts on the F_1 dimension (i.e., maintain at least 3 sounds that contrast in terms of F_1)
2. MINDIST$_x$ = Y (FEATURES), where MINDIST $n \gg$ MINDIST $n+1$
   - Example: MINDIST$_{F1}$ = 2: sounds that contrast in F_1 (e.g., vowel height) should have different values for at least two F_1 features

Direct grounding: dispersion

- MINDIST $n \gg$ MINDIST $n+1$ enforces peripheral vowels:

	MT 1 F_1-F_2	MD$_{F1-F2}$ = 2	MD$_{F1-F2}$ = 3	MT 2 F_1-F_2
[i, a]	*!			**
☞[i, a, u]				**
[i, a, o]			*!	**
[ɪ, ɐ, ʊ]			*!**	**
[i, e, a, o, u]			*!***	*
[i, e, a, o, u, ɨ]			*!*****	

Direct grounding: dispersion

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	MT 1 F_1-F_2	MD$_{F1-F2}$ = 2	MT 2 F_1-F_2	MD$_{F1-F2}$ = 3
[i, a]	*!		**	
[i, a, u]			*!*	
[i, a, o]			*!*	*
[ɪ, ɐ, ʊ]			*!*	***
[i, e, a, o, u]			*!	****
☞[i, e, a, o, u, ɨ]				******

Direct grounding: dispersion

- Note that constraints such as MINDIST$_{F1}$ = 2 and MAINTAIN 2 F$_1$ CONTRASTS are inherently relational: they evaluate (differences between) sets of candidate forms rather than single candidates

- Generalisation of the MINDIST and MAINTAIN CONTRAST constraint templates has to be limited by phonetic factors (another example of grounding)

- Otherwise it would have to be stipulated that e.g., MAINTAIN 16 F$_1$ CONTRASTS are universally ranked so low that they never have any visible effects

Direct grounding: dispersion

- Sicilian vowel reduction (data from Flemming 1995):

[vínni]	‘he sells’	[vɪnnímʊ]	‘we sell’
[véni]	‘he comes’	[vɪnímʊ]	‘we come’
[ávi]	‘he has’	[ʌvíti]	‘you have’
[móri]	‘he dies’	[mʊrímʊ	‘we die’
[úggyi]	‘he boils’	[uggyímʊ]	‘we boil’

Direct grounding: dispersion

- Tableau for Sicilian (vowel height only):

	*SHORT PER. VOWEL	MD_{F1} = 2	MT 2 F_1	MD_{F1} = 3
[ǐ, ĕ, ă]	*!*			**
[ĭ, ĕ, ǎ]		*!*		**
☞[ĭ, ǎ]			*	*
☞[í, é, á]				**
[í, á]			*!*	

An alternative paradigm: emergent structure

- In a sense, a generalisation of Ohala's 'innocent misperception'
- Key hypothesis: all (or part of) linguistic structure emerges, or self-organises through the interplay of a range of factors, e.g.
  - (Development of) cognitive and motor abilities: articulation, perception, categorisation, memory
  - Communicative interaction
  - Population dynamics

An alternative paradigm: emergent structure

- Key references: Lindblom et al. (1983) (concepts) Kirby (1999); Briscoe (2000) (syntax) de Boer (2000, 2001); Kochetov (2003) (phonology)

- Implication (as with Ohala's account of place assimilation): phonological representation and constraints are redundant as sources of explanations

An alternative paradigm: emergent structure

- Key methodology: construct formal models that represent populations of speakers endowed with relevant elements of cognition
- As these models are complex and contain probabilistic factors, predictions are derived by implementing them as computer programs

An alternative paradigm: emergent structure

- The model of de Boer (2000, 2001) represents a speech community of a number of agents
- Agents are endowed with ‘lexicons’ containing phonetic representations of vowels, as well as means to transmit and receive these phonetic representations

An alternative paradigm: emergent structure

- Speech communication is simulated in the shape of imitation games, which proceed as follows:

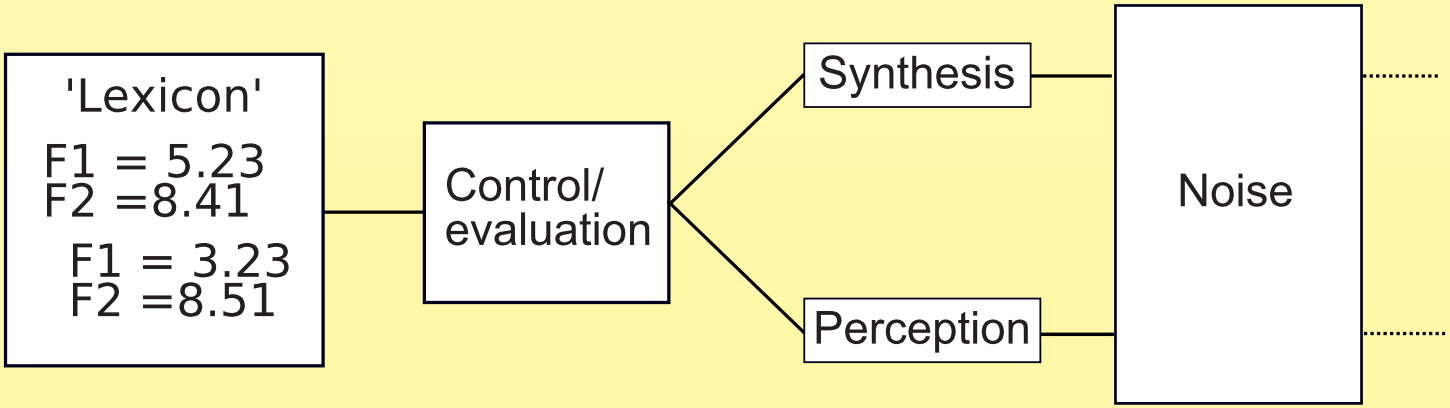
  1. A randomly selected agent a transmits one of the vowels in its lexicon
  2. The signal is received by a randomly selected agent b, which matches it against the vowels in its own lexicon, and transmits the best match back to agent a
  3. If the signal returned to a corresponds closely enough to the original vowel transmitted by a, the agent increases the success rate of this original vowel

An alternative paradigm: emergent structure

- Two further key features of the model
  - Agents periodically drop vowels that yield persistently low communicative success: this generates a bias towards (roughly) similar vowel inventories across the population of agents
  - A certain amount of noise is added to the transmission process: combined with the favouring of 'sucessful' vowels, this skews the model towards dispersed vowel inventories

An alternative paradigm: emergent structure

- Partial architecture of the agents (simulated speaker-listeners) of de Boer (2000, 2001)



An alternative paradigm: emergent structure

- De Boer's model is able to generate (some) realistic-looking vowel systems without reference to phonological features or explicit constraints on the configuration of inventories

- In principle models of this sort can be used to derive predictions about sound inventories and other facets of phonology

An alternative paradigm: emergent structure

- But de Boer's model simplifies real speech communities to a great extent and uses devices that it is hard to find real-life analogies for
  - For example, the (average) number of vowels in the agents' lexicons is directly proportional to the amount of noise added to the transmission process
- It would therefore seem that in this instance, predictions of the model should be treated with a great deal of caution

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