

Advanced Phonological Theory B – Lecture 10: Implementing Functional Constraints

Wouter Jansen
wouter.jansen@kuvik.net
<http://wouter.jansen.kuvik.net/>

March 23, 2005

Lecture 10: Implementing Functional Constraints

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](#))

Lecture 10: Implementing Functional Constraints

1

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)

Lecture 10: Implementing Functional Constraints

2

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	-	-	-	-	+

Lecture 10: Implementing Functional Constraints

3

Grounded phonology

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

	[i]	[y]	[ɨ]	[u]	[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 $_{F_1} = 2$: 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 $_{F_1-F_2} = 2$	MD $_{F_1-F_2} = 3$	MT 2 F_1-F_2
[i, a]	*!			**
⊗ [i, a, u]				**
[i, a, o]			*!	**
[i, e, ʊ]			*!*	**
[i, e, a, o, u]			*!***	*
⊗ [i, e, a, o, u, ɨ]			*!*****	

Direct grounding: dispersion

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

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

Direct grounding: dispersion

- Note that constraints such as $\text{MINDIST}_{F_1} = 2$ and $\text{MAINTAIN } 2 F_1 \text{ CONTRASTS}$ 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., $\text{MAINTAIN } 16 F_1 \text{ CONTRASTS}$ 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'	[vinnímʊ]	'we sell'
[véni]	'he comes'	[vinímʊ]	'we come'
[ávi]	'he has'	[ʌvítʰi]	'you have'
[móri]	'he dies'	[mʊríʊ]	'we die'
[úggyi]	'he boils'	[uggyímʊ]	'we boil'

Direct grounding: dispersion

- Tableau for Sicilian (vowel height only):

	*SHORT PER. VOWEL	$\text{MD}_{F_1} = 2$	$\text{MT } 2 F_1$	$\text{MD}_{F_1} = 3$
[í, ě, ã]	*!*			**
[í, ě, ʌ]		*!*		**
[í, ʌ]			*	*
[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

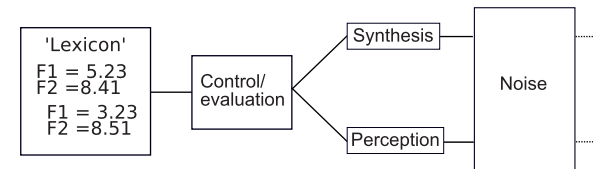
- Speech communication is simulated in the shape of imitation games, which proceed as follows:
 1. A randomly selected agent a transmits one of the vowels in its lexicon
 2. The signal is received by a randomly selected agent b , which matches it against the vowels in its own lexicon, and transmits the 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 'successful' 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

References

- Archangeli, D. & D. Pulleyblank (1994) *Grounded Phonology* Cambridge MA: MIT Press.
- Beckman, J. (1997) positional faithfulness, positional neutralisation and Shona height harmony. *Phonology* 14: 1-46.
- Boersma, P. (1998) *Functional Phonology*. PhD dissertation, University of Amsterdam.
- Briscoe, E. (2000) Grammatical acquisition: inductive bias and coevolution of language and the language acquisition device. *Language* 76: 245-296.

- de Boer, B. (2000) Self organization in vowel systems. *Journal of Phonetics* 28: 441-465.
- de Boer, B. (2001) *The Origins of Vowel Systems*. Oxford: Oxford University Press.
- Flemming, E. (1995) *Auditory features in phonology*. PhD dissertation, UCLA.
- Flemming, E. (2001) Scalar and Categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18: 7-44.
- Kaye, J. (1989) *Phonology: A Cognitive View*. Hillsdale, NJ: Erlbaum.

- Kingston, J. & R. Diehl (1994) Phonetic knowledge. *Language* 70: 419-454.
- Kirby, S. (1999) *Function, Selection, and Innateness: The Emergence of Language Universals*. Oxford: OUP.
- Kirchner, R. (1998) *An Effort-Based Approach to Consonant Lenition*. PhD dissertation, UCLA, and Rutgers Optimality Archive.
- Kochetov, A. (2003) Positional Markedness as a by-product of the learning situation: a simulation. Paper presented at the *29th meeting of the Berkeley Linguistics Society*, February 2003.
- Lindblom, B. (1986) Phonetic universals in vowel systems.

- In J. Ohala & J. Jaeger (eds.) *Experimental Phonology*. Orlando: Academic Press, 13-44.
- Lindblom, B., P. MacNeilage, & M. Studdert-Kennedy (1983) Self-organizing processes and the explanation of language universals. In: B. Butterworth, B. Comrie, & O. Dahl (eds) *Explanations for language universals*. The Hague: Mouton.
- Steriade, D. (1997) *Phonetics in phonology: the case of laryngeal neutralization*. Ms., UCLA.
- Steriade, D. (2001) Directional asymmetries in place assimilation: a perceptual account. In E. Hume &

K.Johnson (eds.) *Perception in Phonology*. New York:
Academic Press.

Stevens, K. (1989) On the quantal nature of speech. *Journal
of Phonetics* 17: 3-45.