Anti-Paninian Rankings of Articulatory Constraints at the Phonetics-Phonology Interface

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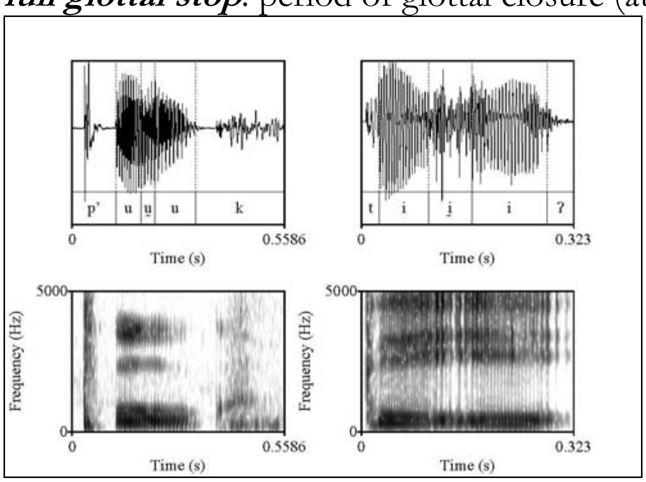
1. Proposal

- The phonetic patterns of production in language are best modeled by freely-rankable scalar articulatory constraints (following de Lacy 2002).
- This allows for anti-Paninian rankings, where a more general constraint dominates a less general constraint (see Prince 1997).
- The ranking values of articulatory constraints are language-specific and must be learned (*contra* Boersma 2006, Boersma and Hamann 2008).

2. Production and Perception of Glottalization in Yucatec Maya

- in Yucatec Maya, GLOTTALIZED vowels (/v́v̰/) are distinguished from HIGH TONE vowels (/v́v/) on the basis of pitch and glottalization
  - GLOTTALIZED vowels have ***higher initial pitch***, a ***larger pitch span*** (difference between minimum and maximum pitch), and ***more glottalization***
- see Frazier (2009) for full methodology, results, and discussion of production and perception experiments; only glottalization is discussed here
- I divide glottalization into four categories:
  - ***modal***: no glottalization; modal voice only
  - ***weak glottalization***: brief period of non-modal voice
  - ***creaky voice***: more substantial period of non-modal voice
  - ***full glottal stop***: period of glottal closure (at least 20 ms between glottal pulses)



weak glottalization vs. creaky voice

2.1 Production of Glottalization

- Percentage of times a given vowel shape is produced with a specific glottalization type:

	mod.	w.g.	cr.	g.s.
GLOTTALIZED	56%	15%	26%	2%
HIGH TONE	97%	1%	1%	0%

- GLOTTALIZED vowels are most often produced without glottalization. When glottalization is produced, there is a preference for creaky voice.
- HIGH TONE vowels are almost always produced without glottalization.

2.2 Perception of Glottalization

- Percentage of times a given vowel shape is heard on the basis of glottalization type:

	mod.	w.g.	cr.	g.s.
GLOTTALIZED	39%	55%	68%	93%
HIGH TONE	61%	45%	32%	7%

- A glottal stop is a really good cue for GLOTTALIZED vowel.
- Creaky voice is a decent cue for GLOTTALIZED vowels.
- Modal voice is a decent good cue for HIGH TONE vowels.
- Weak glottalization is not a good cue for this contrast.

➢ How does the grammar of Yucatec Maya account for the fact that GLOTTALIZED vowels are often produced with modal voice but that modal voice is not a good cue for GLOTTALIZED vowels?

3. The Grammar of Yucatec Maya

3.1 Model of Analysis

- Bidirectional Stochastic OT (Boersma 2006, 2007) is a parallel, multilevel model of phonetics and phonology; the production and perception grammar are defined by the same constraints with the same mean ranking values; stochastic evaluation accounts for variation
- our focus: the relation between a phonological surface form (/SF/) and an articulatorily and acoustically explicit phonetic form ([PF])
- in production, /SF/ is the input and candidate [PF]s are evaluated
  - *cue constraints* penalize particular /SF/, [PF] pairings
  - *articulatory constraints* penalize effortful [PF]s

/SF1/	*/SF1/, [PF2]	*/SF1/, [PF3]	*[PF1]
☞ [PF1]			*
[PF2]	*!		
[PF3]		*!	

- in perception, [PF] is the input and candidate /SF/s are evaluated
  - *cue constraints* penalize particular /SF/, [PF] pairings

- *structural constraints* penalize ill-formed /SF/s

[PF1]	*/SF1/, [PF1]	*/SF2/, [PF1]	*/SF3/
/SF1/	*!		
/SF2/		*!	
☞ /SF3/			*

3.2 Constraints for the Analysis of Glottalization

- cue constraints penalize each possible pairing of an underlying form (/GLOTTALIZED/ or /HIGH TONE/) with a surface form ([modal voice], [weak glottalization], [creaky voice], [glottal stop])
- articulatory constraints penalize the production of [adducted vocal folds]
- scalar *[AVF] constraints (modeled after the markedness constraints of de Lacy (2002) and similar to the 'don't produce effort amount *x*' constraints in Boersma and Hamann (2008)):
  - *[AVF:{wg, cr, gs}]: penalizes weak glottalization, creaky voice, and a glottal stop
  - *[AVF:{cr, gs}]: penalizes creaky voice and a glottal stop
  - *[AVF:{gs}]: penalizes a glottal stop

3.3 Learning Strategies

- the ranking values of ***cue constraints*** are learned via "lexicon-driven perceptual learning" (Boersma 2006); the learner uses perception tableaux to test the interim grammar, and adjustments are made each time the grammar predicts an incorrect winner
  - example: speaker said [PF1] to mean /SF1/
  - learner checks that grammar predicts [PF1] to be mapped onto /SF1/:

	→	→		←	→	←
[PF1]	C_1	C_2	C_3	C_4	C_5	C_6
✋ /SF1/	*	*			*	
☞ /SF2/				*		*

✋ = the learning datum; ☞ = the winning candidate

  - the grammar has made an incorrect prediction, and so the constraints that distinguish the two candidates are adjusted, as denoted by the arrows
- the ranking values of ***articulatory constraints*** are based on effort and are (possibly) only lowered for practiced articulations (Boersma 2006, Boersma and Hamann 2008)
- If there is no language-specific learning or if the only language-specific ranking adjustments are those that lower the ranking values of constraints that penalize practiced articulations, we expect the ranking:

*[AVF:{gs}] »	*[AVF:{cr, gs}]	»	*[AVF:{wg, cr, gs}]
least general »	more general	»	most general

- Is this ranking able to account for the Yucatec Maya data?

3.4 Learning Simulation

- simulation run with PRAAT (Boersma and Weenink 2006)

- a GLA learner (Boersma and Hayes 2001) was trained on the production data associated with 685 tokens (337 with a GLOTTALIZED vowel and 348 with a HIGH TONE vowel) as spoken by Yucatec Maya speakers from Santa Elena, Yucatan, Mexico.
- learning strategy:
  - round one: initial state = all constraints have ranking value of 100
  - learner uses perception tableaux to test and adjust the rankings of cue constraints (= lexicon-driven perceptual learning)
  - round two: initial state = all cue constraints have ranking value reached at end of round one; all articulatory constraints have ranking value of 100
  - learner uses both perception and production tableaux to test and adjust the rankings of cue and articulatory constraints (= new method designed for the learning of articulatory constraints)

3.5 Results of the Learning Simulation

- ranking values learned for each constraint:

articulatory constraints		cue constraints			
*[AVF:{gs}]	103.23	*/GL/, [gs]	93.91	*/HI/, [gs]	109.32
*[AVF:{cr, gs}]	97.93	*/GL/, [cr]	91.49	*/HI/, [cr]	103.20
*[AVF:{wg, cr, gs}]	100.69	*/GL/, [wg]	99.00	*/HI/, [wg]	103.75
		*/GL/, [mod]	100.51	*/HI/, [mod]	98.78

- The articulatory constraints are in an anti-Paninian ranking; the more general *[AVF:{wg, cr, gs}] dominates the less general *[AVF:{cr, gs}].
- *[AVF:{wg, cr, gs}] conflates all categories of glottalization; lower-ranking constraints decide among the candidates (see de Lacy (2002) for importance of category conflation in phonology)

4. Why the Anti-Paninian Ranking is Necessary for Yucatec Maya

- high-ranking */GL/,[mod] accounts for the fact that modal voice is not a good cue for the perception of GLOTTALIZED vowels; high-ranking *[AVF:{wg,cr,gs}] accounts for the fact that GLOTTALIZED vowels are often produced with modal voice
- when *[AVF:{wg, cr, gs}] » */GL/,[mod], GLOTTALIZED vowels are produced with modal voice; when */GL/,[mod] » *[AVF:{wg, cr, gs}], GLOTTALIZED vowels are produced with some form of glottalization
- if the constraints are ordered according to their mean ranking value, a GLOTTALIZED vowel (/GL/) is produced with [modal voice]:

/GL/	*[AVF: {gs}]	*[AVF: {wg, cr, gs}]	*/GL/, [mod]	*/GL/, [wg]	*[AVF: {cr, gs}]	*/GL/, [gs]	*/GL/, [cr]
(56%)☞[mod]			*				
[wg]		*!		*			
[cr]		*!			*		*
[gs]	*!	*			*	*	

- if, due to stochastic evaluation, *[AVF:{wg, cr, gs}] falls below */GL/, [mod], the winning candidate is determined by the ranking of */GL/,[wg] and *[AVF:{cr, gs}]:

/GL/	*[AVF: {gs}]	*/GL/, [mod]	*[AVF: {wg, cr, gs}]	*/GL/, [wg]	*[AVF: {cr, gs}]	*/GL/, [gs]	*/GL/, [cr]
[mod]		*!					
(15%)☞[wg]			*	*(!)			
(26%)☞[cr]			*		*(!)		*
[gs]	*!		*		*	*	

- if there is no language specific learning with regard to articulatory constraints, *[AVF:{wg, cr, gs}] must be ranked below *[AVF:{cr, gs}]:

/GL/	*[AVF: {gs}]	*/GL/, [mod]	*/GL/, [wg]	*[AVF: {cr, gs}]	*[AVF: {wg, cr, gs}]	*/GL/, [gs]	*/GL/, [cr]
(56%)☞[mod]		*(!)					
(15%)☞[wg]			*(!)		*		
(26%)☞[cr]				*(!)	*		*
[gs]	*!			*	*	*	

- here, the ranking of */GL/,[mod]; */GL/, [wg]; and *[AVF:{cr, gs}] determines the winning candidate
- in order for [mod] to be the winner 56% of the time, */GL/,[mod] must be ranked below both */GL/,[wg] and *[AVF:{cr, gs}]
- but low-ranking */GL/,[mod] would negatively affect the perception grammar by making modal voice a good cue to GLOTTALIZED vowels (and making it an even better cue than weak glottalization!)
- the analysis of pitch in Yucatec Maya also requires anti-Paninian rankings (see Frazier 2009: ch. 5)

5. Why the Anti-Paninian Ranking Matters for Phonological Theory

- ***learning***: the ranking values of articulatory constraints are language-specific and not solely tied to the quantification of effort
  - de Lacy's claims about markedness in phonology cannot be applied to articulatory constraints if Boersma's assumptions about the learning of articulatory constraints is correct; these assumptions predict that articulatory constraints are not freely rankable and that category conflation is not necessary in production grammars
  - learning models must account for the ranking values of articulatory constraints and allow for anti-Paninian rankings
- ***defining articulatory constraints***: anti-Paninian rankings cannot be mimicked with MINIMIZEEFFORT, a type of weighted articulatory constraints introduced by Flemming (2001)
  - a MINEFF constraint penalizes some effortful phonetic dimension
  - the penalty assigned by this constraint equals the weight of the constraint times (some quantified value of) the amount of effort produced
  - more effort always equates with a larger penalty
  - a grammar that uses MINEFF-style articulatory constraints cannot account for Yucatec

Maya

6. Conclusions

- Anti-Paninian rankings of articulatory constraints are necessary to account for phonetic patterns of production.
- The ranking values of articulatory constraints are language-specific and must be learned.
- MINIMIZEEFFORT articulatory constraints undergenerate.

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