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Restrictiveness of constraint indexation
a case study on segmental contrast

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Introduction

- Indexed constraints often viewed as last-resort strategy (e.g., Becker 2009, Pater 2010) with few restrictions
  - Likewise for cophonologies (Inkelas & Zoll 2007)
- Argument: indexed constraint analyses are restrictive
  - Content of CON still restricts what patterns are expressible
  - Expressible patterns are not always discoverable/learnable
- Based on segmental contrast application of indexed constraints
  - Extra powerful and seemingly unrestricted version

Download:

https://alekseinazarov.org/papers/

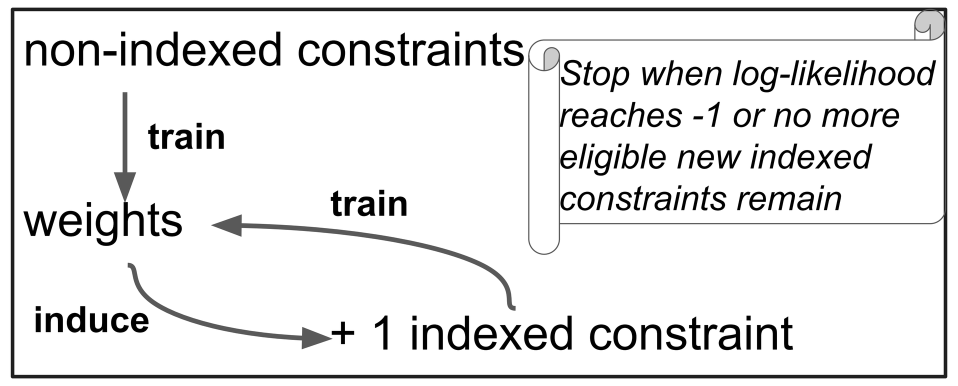
Segmental contrast indexed constraints

- Indexed constraints: defined phonologically & morphologically:
  - Pater (2000) et seq.: apply only to particular words/morphemes
  - Temkin-Martínez (2010), Round (2017): instead, apply only to particular **segments** in lexicon
- This encodes segmental **contrast** (e.g., Dresher 2009)
- Allows contrast-based (cf. Łubowicz 2012) account of **opacity** (Nazarov 2020)
- Still allows for modelling lexical **exceptions** (Pater 2000)

$/i_k s+e/$	$*[-hi]_k$	*s**i_k**	Harmony	*ʃ
☛ isi				
iʃi				*!
ise			*!	
ese	*!			
$/i_k s+i_k/$				
isi		*!		
☛ iʃi				*
ise	*!		*	
ese	*!*			

Contrast Indexation MaxEnt Learner (CIMEL)

- Premise (same as Becker 2009, Pater 2010):
  - Non-indexed constraints are universal (defined by user)
  - Indexed constraints induced as needed
- Novelty: combines two additional aspects
  - uses **MaxEnt** (Goldwater & Johnson 2003), see Nazarov & Smith (in prep)
  - finds **segmental contrast** indexed constraints, see Round (2017)
- Indexed constraints induced iteratively, one by one:
  - calculate gradients of constraint weights given individual segments in lexicon
  - pick constraint with greatest relative disagreement between segments
  - segments with positive gradient: associated with new indexed constraint



Weights trained using Byrd et al.'s (1995) algorithm within Staubs' (2011) implementation

- Non-indexed constraint induction (e.g., Hayes & Wilson 2008): possible extension of this model, not considered here

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T: Harmony before i-Pal: /is-e/ → isi → iʃi
O: i-Pal before Harmony: /is-e/ → ise → ise
E: /is/ does not undergo i-Pal across the board

Data

	T	O	E	R1	R2	R3
/es-e/	ese	ese	ese	uʃe	usu	eʃu
/is-e/	iʃi	**isi**	**isi**	iʃu	osi	ose
/is-i/	iʃi	iʃi	**isi**	ese	ufo	ife
/us-i/	uʃi	uʃi	uʃi	ufe	ufu	eso

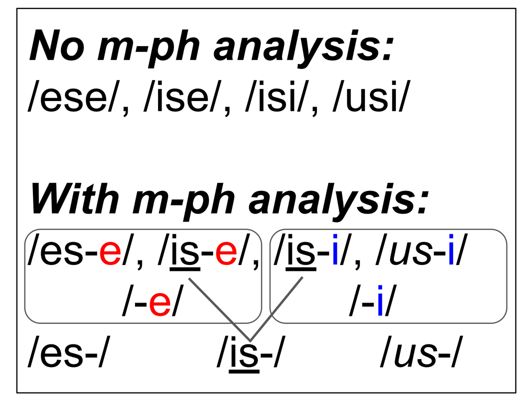
- Data: 6 toy langs based on Prickett & Jarosz (2021)
  - 8 stems: {eoiu} followed by {fs}, e.g., of-, es-, is-. us-
  - 3 suffixes: -e, -i, -u
- 3 non-random languages:
  - V height harmony + Transparent i-Palatalization (**T**) — *requires indexation for contrast*
  - V height harmony + Opaque i-Palatalization (**O**) — *requires indexation for contrast and opacity*
  - V height harmony + Exceptional i-Palatalization (**E**) — *requires indexation for contrast and exceptions*
- 3 random languages (**R1**, **R2**, **R3**):
  - Random output candidate picked for every input
- Constraints provided:

Context-free:	*ʃ	***[+cor]**	***[+hi]**	***[+bk]**	***[-cor]**	etc.
Pro-palatalization:	***si**	***si**				
Pro-height harmony:	***[+hi]**[-hi]	*[+hi]**[-hi]**	***[-hi]**[+hi]	*[-hi]**[+hi]**		
Pro-backness harmony:	***[+bk]**[-bk]	*[+bk]**[-bk]**	***[-bk]**[+bk]	*[-bk]**[+bk]**		
Faithfulness, if active:	**Ident**					

Bold = "focus" of constraint (amenable to indexation)

Learning scenarios

- Two stages in phonological acquisition (Hayes 2004):
  - Phonotactic stage (learn possible words)
  - Morphophonological stage (learn alternations)
- Morphophonological acquisition requires:
  - Access to morphological analysis (find words that share morphemes)
  - Access to faithfulness constraints
- Here: three scenarios considered:
  1. Fully phonotactic stage (no morphophonological analysis, no faithfulness constraints)
  2. Transitional stage (morphophonological analysis, no faithfulness)
  3. Full morphophonological stage (morphophonological analysis & faithfulness)



Results

- CIMEL run 5× for each language × learning scenario
- Testing of resulting weights and indexed constraints:
  - Log-likelihood of training data ≥ -1?
  - Generalization: Richness of the Base (ROTB) test
    - For segments of /is-e/, consider all possible index assignments
    - Always ≥95% probability on some attested form?

Averaged log-likelihood for all conditions

Scenario	T	O	E	R1	R2	R3
1.	-.002	-.01	-.005	-24	-24	-23
2.	-.01	-.01	-.01	-44	-45	-43
3.	-.003	-.002	-.002	-44	-44	-40

Shaded cells: passed log-likelihood and ROTB tests

Discussion and conclusion

- Random languages (R1-3) not learned:
  - Available pressures (pro-palatalization, pro-harmony etc.) not sufficient to model these patterns
- Non-random languages learned, but only pass ROTB test under scenario 2. (Transitional stage):
  - Scenario 1: does not allow learner to generalize between instances of same morpheme
  - Scenario 3: Faithfulness reduces motivation to induce contrast-based constraints
    - A Markedness-over-Faithfulness bias (Hayes 2004, Prince & Tesar 2004) might help
- Indexed constraints may not be as robust and unrestrictive as they seem:
  - Indexed constraints are only as strong as the possibilities of their non-indexed counterparts
  - Learner must have enough knowledge and motivation to discover the correct indexed constraints