Bedouin Arabic multiple opacity with indexed constraints in Parallel OT

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Introduction

- Phonological opacity:
  - Rule A is systematically made "exceptional" by Rule B
    underapplication: Bedouin Arabic /a/ → [i] before CV, except not before epenthetic V *(see panel on the right)*
    overapplication: Canadian English /aɪ/ → [ʌɪ] before $C_{[-voice]}$, except also before /t/ → [ɾ] (Chambers 1973)
    /ɹaɪt/ → [ɹʌɪt] 'write' /ɹaɪd/ → [ɹaɪd] 'ride' /ɹaɪt-ɚ/ → [ɹʌɪɾɚ] 'writer' /ɹaɪd-ɚ/ → [ɹaɪɾɚ] 'rider'
  - Motivation: Extrinstic ordering (Chomsky 1964, McCarthy 2007)? Morphology-phonology interaction (Bermúdez-Otero 2003)?
- Bedouin Arabic multiple opacity: Statal OT account difficult because of morphosyntactic domain facts (McCarthy 2007)
  - Incompatible with Turbidity (Goldrick 2001), Coloured Containment (Van Oostendorp 2008): too many levels required
  - Bidirectional Phonology (e.g., Boersma 2007) : difficult to analyze due to morphological domain facts
- Does this mean that phonological opacity is necessarily motivated by (arbitrary) extrinsic ordering?
  - I argue: no, opacity (incl. multiple opacity) can be motivated by the same mechanism as exceptionality

Connections: Opacity ↔ Exceptionality

- Both involve under/overapplication
- Both require language-specific non-phonetic conditioning
- Both pose a hidden structure learning problem to the learner (Nazarov 2016)
- Opaque rules have been reanalyzed as exceptional/lexically conditioned (Sanders 2003; Mielke et al. 2003) or as arising from language-specific constraints (also relevant for exceptionality) (Pater 2014)

Proposal: unifying mechanism behind both phenomena is constraint indexation (Pater 2000)

(Extended) Indexation

- Indexed constraints: only violated in domains (normally words/morphemes) that have the corresponding index
  - *[ai]$_i$: One violation for every sequence [ai], but only in (=overlapping with) a morpheme indexed *i* (Pater 2010)
    tamai: no violations [matai]$_i$: 1 violation taita-[i]$_i$: 1 violation
- *Extended indexation* (Nazarov 2019): indices are local to segments (Round 2017 and others) and binary (cf. Becker 2009)
  - Basically, like non-phonetic segmental features (cf. Chomsky and Halle 1968)
    $m_{[+i]}a_{[-i]}t_{[+i]}a_{[+i]}i_{[-i]}$
  - Consequence: we can use constraints of the shape *[+Feature, +Index] to make the realization of an indexed segment predictable
    - GEN may not change (+ values of) indices (cf. Pater 2000, 2010), therefore index influences segmental features
    - A process becomes opaque when it is dependent on indices, and the indices are realized in a predictable but non-uniform way *(see panels on the right)*

Implications for typology and learning

- Typology:
  - Opacity is not in the factorial typology of universal constraints (cf. Sanders 2003) – typological range of opaque phenomena restricted by learnability/discoverability more than by the availability of representations
  - Opacity requires language-specific induction of complex indexed constraints: predicts rarity of opacity
- Learning:
  - 2 steps: induce indexed Markedness constraint that motivates the process (any segment could be indexed), induce constraints that determine how the indexed segments are realized
  - Implies that learners acquiring opacity go through a stage of exceptionality (corroborated for Canadian Raising variants)

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Bedouin Arabic data

- 3 extrinsically ordered processes (Al-Mozainy 1981, McCarthy 2007)
  1) Syncope i → ∅ / __ CV /kitib-at/ → kitbat 'it$_F$ was written' /kitib/ → ktib 'it$_M$ was written'
  2) Raising a → [+high] / __ CV /katab/ → kitab 'he wrote' /samiʕt/ → simiʕt 'I heard'
  3) Epenthesis ∅ → i / _CC$_{[+son]}$# /gabl/ → gabil 'before' /libn/ → libin 'clay'

Opaque process	Interaction	Inducing process	Underapplication	"Proper" application
Syncope	underapplies due to	Raising	/samiʕt/ → simiʕt	*smiʕt
Syncope	underapplies due to	Epenthesis	/libn/ → libin	*lbin
Raising	underapplies due to	Epenthesis	/gabl/ → gabil	*gibil

Analysis with indexed constraints

/k i$_{[-L]}$ t i$_{[-L]}$ b/	*V$_{[-L]}$CV$_{[+V]}$	*aCV$_{[+V]}$	*CC#	Dep	Max(V)	Ident(V)
ki$_{[-L]}$ ti$_{[-L]}$ b	*!					
☞ k∅$_{[-L]}$ ti$_{[-L]}$ b					*	
ki$_{[-L]}$**t** ti$_{[-L]}$ b				*!		
/k a$_{[+L]}$ t a$_{[+L]}$ b/						
ka$_{[+L]}$ ta$_{[+L]}$ b		*!				
☞ ki$_{[+L]}$ ta$_{[+L]}$ b						*
k∅$_{[+L]}$ ta$_{[+L]}$ b					*!	
/g a$_{[+L]}$ b l/						
ga$_{[+L]}$ b∅$_{[-V]}$ l			*!			
☞ ga$_{[+L]}$ bi$_{[-V]}$ l				*		
gi$_{[+L]}$ bi$_{[-V]}$ l				*		*!
g∅$_{[+L]}$ bi$_{[-V]}$ l				*	*!	

- High vowels undergo syncope because they are [-L]
  - Syncope constraint *V$_{[-L]}$CV$_{[+V]}$ only refers to [-L], not [+high]
- Low vowels undergo raising and not syncope because they are [+L]
  - Raising constraint *aCV$_{[+V]}$ applies
  - Syncope constraint *V$_{[-L]}$CV$_{[+V]}$ irrelevant
- Epenthesis in CC# clusters due to *CC#
  - Epenthetic vowels are [-V] (see below)
  - Do not match second V position in raising and syncope constraints

Richness of the Base: only [+L] 'behaves as low'

/b a$_{[-L]}$ t a$_{[-L]}$/	*V$_{[-L]}$CV$_{[+V]}$	*aCV$_{[+V]}$	Max(V)	*[-lo]$_{[+L]}$	*[+lo]$_{[-L]}$	Id(V)
ba$_{[-L]}$ ta$_{[-L]}$	*!					
b∅$_{[-L]}$ ta$_{[-L]}$			*		*!	
☞ b∅$_{[-L]}$ ti$_{[-L]}$			*			*
/t i$_{[+L]}$ k i$_{[+L]}$/						
ti$_{[+L]}$ ki$_{[+L]}$				**!		
ta$_{[+L]}$ ka$_{[-L]}$		*!				**
☞ ti$_{[-L]}$ ka$_{[-L]}$				*		*

- Any vowel indexed [-L,+V] deletes before CV, comes out as [i] elsewhere
- Any vowel indexed [+L, +V] raises to [i] before CV, comes out as [a] elsewhere

Richness of the Base: only [+V] 'behaves as underlying V'

/b i$_{[-L]}$ k i$_{[+L]}$/	*V$_{[-L]}$CV$_{[+V]}$	*CC#	Dep	*V$_{[-V]}$	Max(V)	*[-lo]$_{[+L]}$	Id(V)
bi$_{[+V]}$ ki$_{[-V]}$				*!			
☞ bi$_{[+V]}$ k∅$_{[-V]}$					*		
/t k/							
t∅ k		*!					
☞ ti$_{[-L,-V]}$ k			*	*			

- Underlying vowels indexed [-V]: deleted
  - All overt underlying vowels condition raising
- Inserted vowels always [-L, -V]
  - GEN cannot insert/change [+L], [+V]
  - Inserted vowels do not trigger raising

Concluding remarks

- Multiple opacity like in Bedouin Arabic possible without extrinsic ordering as long as grammars allow for extended indexation
- Implications: opacity not in typology of universal constraints (hard to learn); learning opacity implies learning exceptionality

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