(Non)iterativity and Input/Output Locality

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10 March 2023

"In general a major step in coming to understand something new consists in formulating it in terms of concepts and notations that we already understand:

Understanding is translation from the unknown to the known."

(Keenan and Moss, 2016, ix)

"In general a major step in coming to understand something new consists in formulating it in terms of concepts and notations that we already understand:

Understanding is translation from the unknown to the known."

- The unknown: phonological iterativity
- The known: strict locality

Theory-based definitions

Johnson (1972, 35): an iterative rule keeps applying until the string can no longer be changed.

(1) Sanskrit nasal retroflexion: targets /n/ before another sonorant when it is preceded by a retroflex continuant without an intervening coronal

uʂnataraanaam	uʂnataraanaam
uʂɳataraanaam	uʂɳataraaɳaam
uʂnataraaɳaam	uʂɳataraaɳaam

Theory-based definitions

- Alternatively, rules apply strictly left-to-right or right-to-left
- Linear rules (Johnson, 1972): direction is stipulated
- Directional rules (Howard, 1972): direction is determined by the rule's form (X __ or __ X)

Theory-based definitions

- In practice, iterative means ‘not simultaneous’ (Chomsky and Halle, 1968) or ‘reapplies to its own output’.

(2) [−cons] → [+nasal] / [+nasal] __

a. NVVV → NṼVV

b. NVVV → NṼṼṼ

Optimization and iteration

/NVVV/	*[+nas][−nas]	IDENT-NAS
[NVVV]	*!	
[NṼVV]	*!	*
[NṼṼV]	*!	**
☞[NṼṼṼ]		***

Emergent noniterativity

- Emergent Noniterativity Hypothesis (Kaplan, 2008): No formal entity in phonological grammars may require noniterativity.
- Noniterativity is always epiphenomenal and can be explained by other means.

(3) Lango (Western Nilotic; Noonan, 1992; Kaplan, 2008)

a.	/bɔŋɔ-ni/	[bɔŋoni]	'your dress'
b.	/amʊk-ni/	[amukki]	'your shoe'
c.	/mɔtɔka-e/	[mɔtɔkə-e]	'cars'

- Positional licensing: suffix [ATR] needs to be linked to the root.

‘True noniterativity’

- Not all cases of noniterativity can be reanalyzed as emergent (Ampofo and Rasin, 2021; McCollum and Kavitskaya, 2022).
- True noniterativity = counterexample to emergent noniterativity.

Extensions of rules

- Extension: {(NV, N$\tilde{V}$), (NVV, N$\tilde{V}$V), (NVVV, N$\tilde{V}$VV), ... }
- Intensional descriptions:

(4)

a. [−cons] → [+nasal] / [+nasal] __ (simultaneous/−iterative)

b. [−cons] → [+nasal] / [+nasal] __ (right-to-left)

c. [−cons] → [+nasal] / [+nasal, +cons] __ (left-to-right, right-to-left, simultaneous/−iterative)

Formal Language Theory

- In finite-state phonology, different application modes are implemented by matching the rule's context on either the input or output string (Kaplan and Kay, 1994; Hulden, 2009; Gorman and Sproat, 2021).

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A -> B || L _ R ;    simultaneous
A -> B \\ L _ R ;    right-to-left
A -> B // L _ R ;    left-to-right
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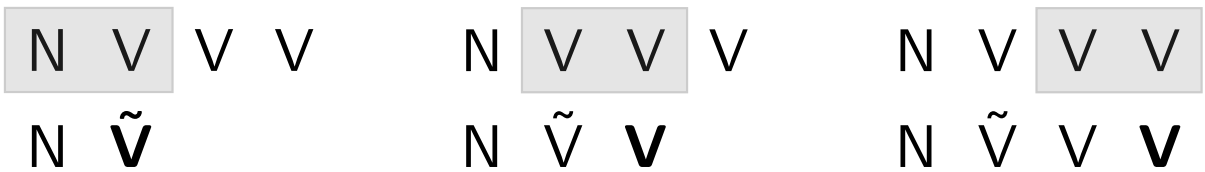
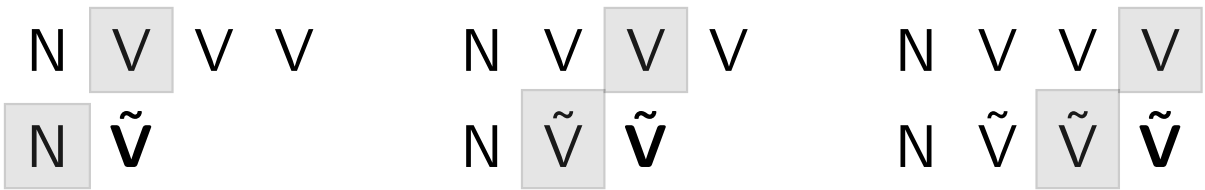
Matching context on input

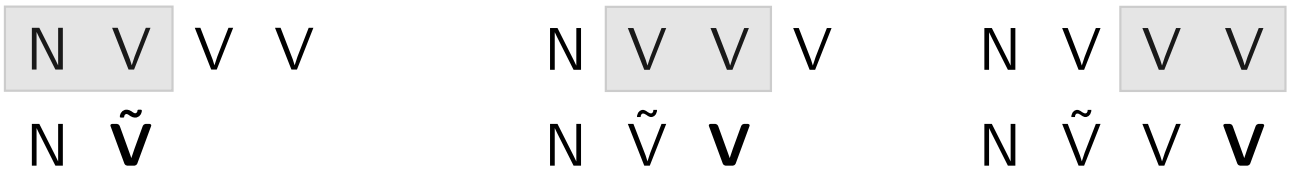


Matching context on output

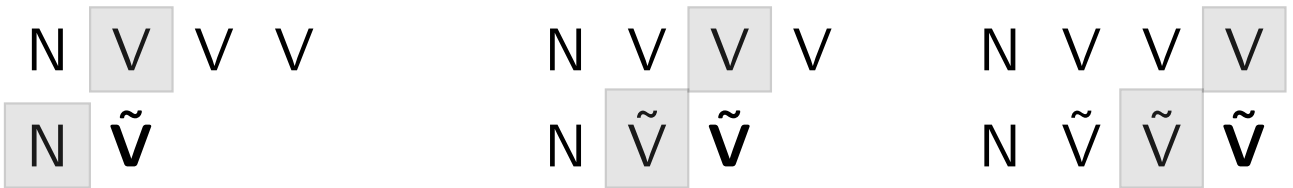


Strictly local functions

Input Strictly Local



Output Strictly Local

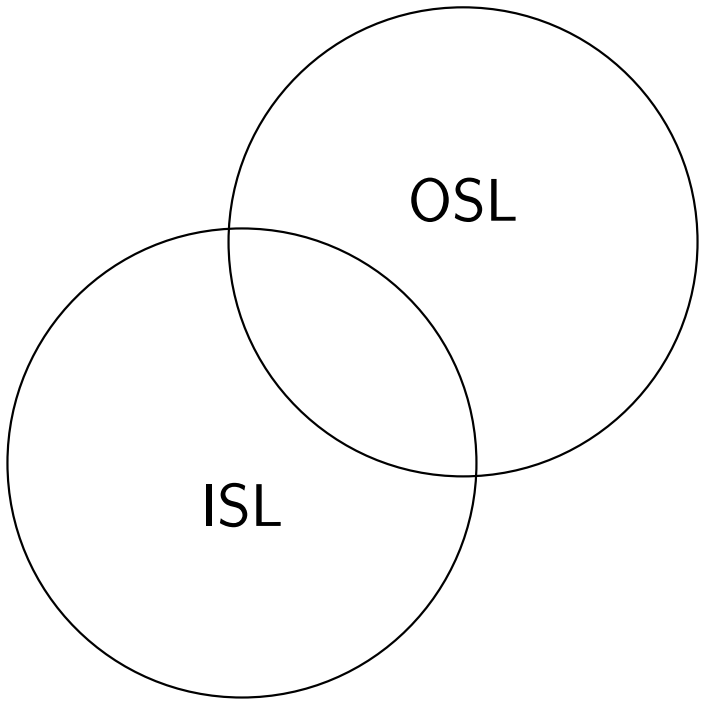


(Berstel, 1982; Vaysse, 1986; Lind and Marcus, 1995; Sakarovitch, 2009; Chandlee, 2014)

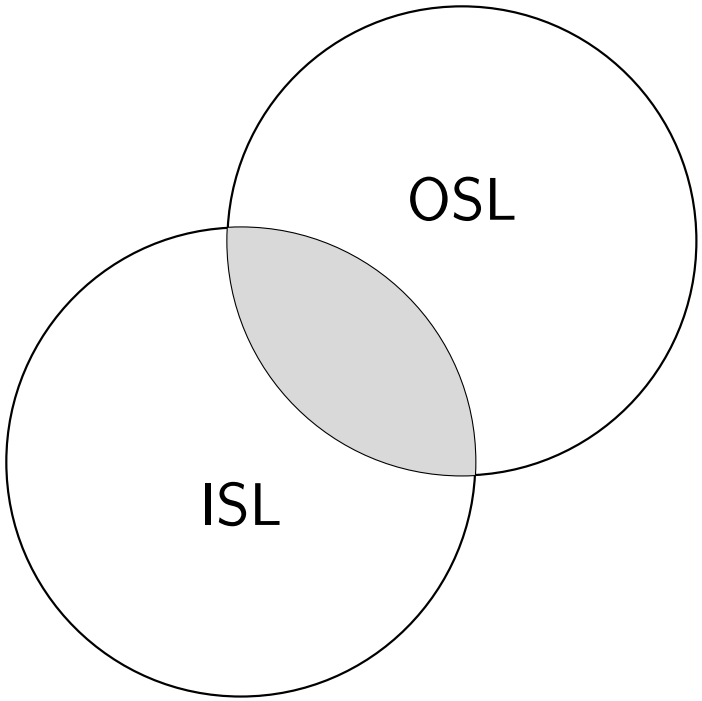
Previously...

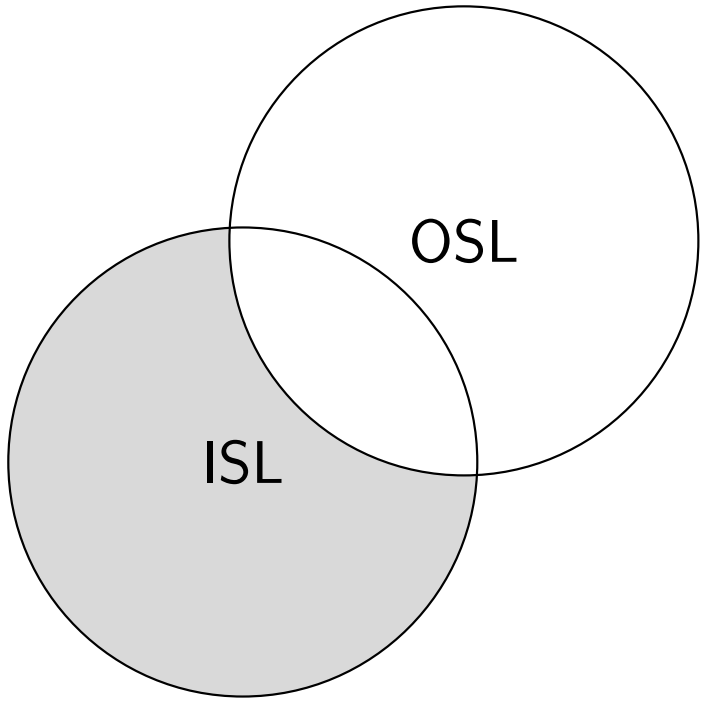
- 94% of the processes in P-Base (Mielke, 2008) are Input Strictly Local (ISL) for some k (Chandlee, 2014, p. 138).
- OSL is available if you need to iterate.

Incomparable but not disjoint



An ISL classification is ambiguous





ISL vs. OSL vs. ISL ∩ OSL

- Proposal: recast 'noniterative' as *necessarily* ISL and 'iterative' as *necessarily* OSL.
- Most(?) maps are in the intersection.
  - Gorman and Sproat (2021, p. 53): 'directionality of application has no discernable effect for perhaps the majority of rules, and can often be ignored'.

Results

	ISL	ISL ∩ OSL	OSL
substitution (one-sided)	output-nondistinct single target	output-distinct	output-nondistinct multiple targets
dissimilation (one-sided)	identical span	single target	alternating pattern
deletion (one-sided)	anchored single target	overlap	anchored multiple targets
epenthesis (one-sided)		everything	
epenthesis (two-sided)	both contexts longer than 1	at least one context of length 1	
other two-sided	everything		

Deletion maps

(5) $V \rightarrow \varnothing \; / \; \# \_\_$

- Simultaneous and right-to-left application: VVVC → VVC
- Left-to-right application: VVVC → C

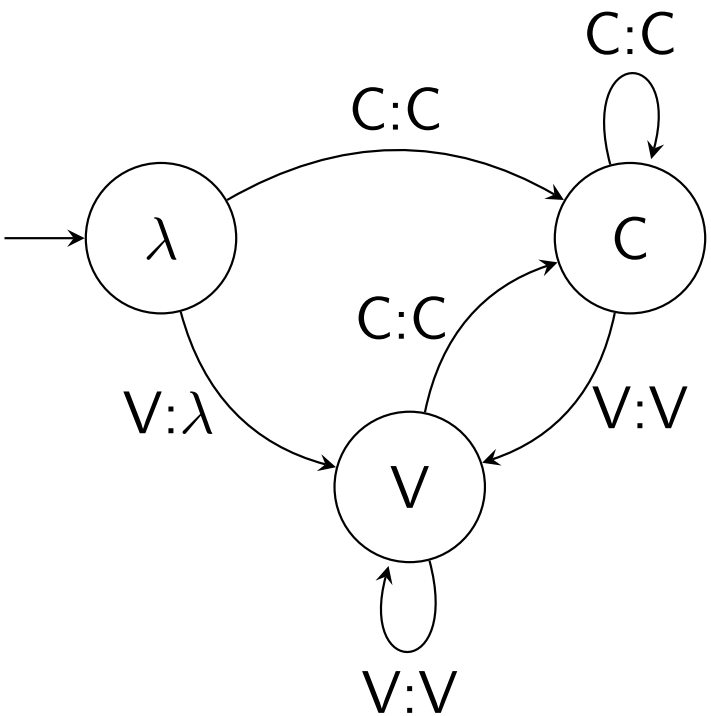
Deletion maps

(6) $V \rightarrow \varnothing \; / \; V \_\_$

Simultaneous:	aeiou → a
Left-to-right:	aeiou → aiou → aou → au → a
Right-to-left:	aeiou → aeio → aei → ae → a

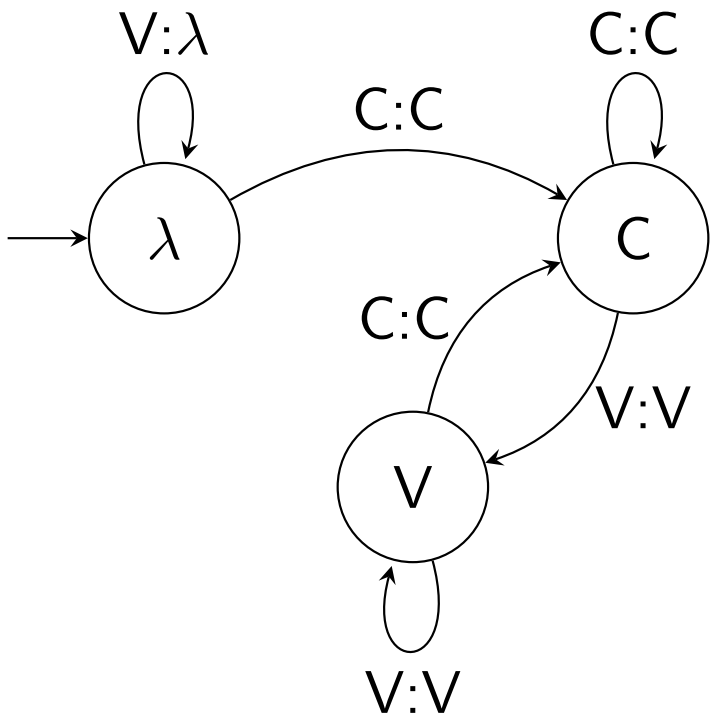
‘Anchored’ deletion

(7) $V \rightarrow \varnothing \; / \; \# \_\_$



ISL

VVVC → VVC

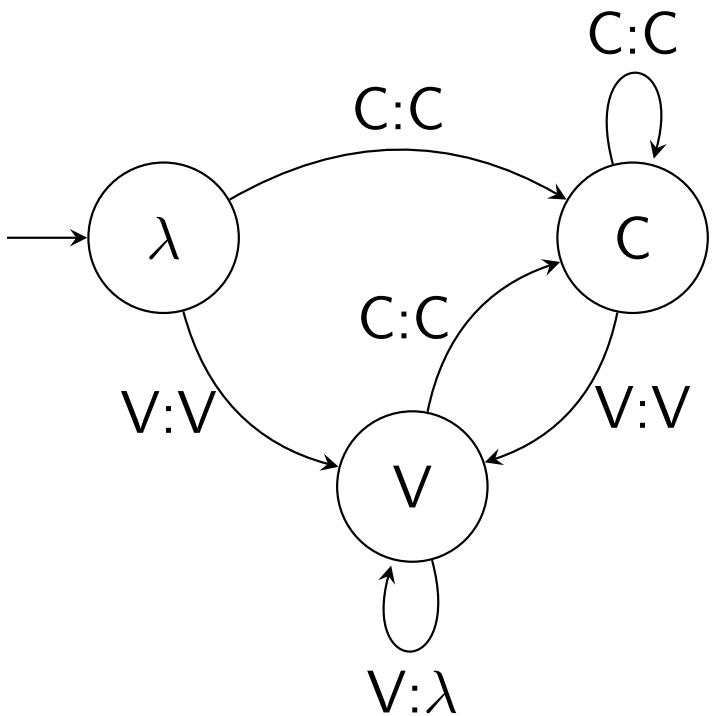


OSL

VVVC → C

‘Overlap’ deletion

(8) $V \rightarrow \varnothing \ / \ V \_\_$



ISL ∩ OSL

Anchored deletion

(9) $V \rightarrow \varnothing \; / \; \# \_\_$

/VVVC/	*#V	MAX
[VVVC]	*!	
[VVC]	*!	*
[VC]	*!	**
☞[C]		***

Overlap deletion

(10) $V \rightarrow \varnothing \; / \; V \_\_$

/VVVV/	*VV	Max
[VVVV]	*!**	
[VVV]	*!*	*
[VV]	*!	**
☞[V]		***

Deletion (summary)

ISL	ISL ∩ OSL	OSL
anchored single target	overlap	anchored multiple targets
noniterative		iterative

Theoretical implications

- For rule-based theories, we have a prediction for when the non-default application mode will be required.

	Default	Other mechanism
SPE	simultaneous	parenthesis-star
Linear rules	iteration	reverse direction
Directional rules	iteration	simultaneous
Parameterized rules	+iterative	−iterative

(Chomsky and Halle, 1968; Johnson, 1972; Howard, 1972; Archangeli and Pulleyblank, 1994)

Deletion (summary)

ISL	ISL ∩ OSL	OSL
anchored single target	overlap	anchored multiple targets
noniterative		iterative

Deletion (summary)

ISL	ISL ∩ OSL	OSL
anchored single target	overlap	anchored multiple targets
noniterative	iterative	

Theoretical implications

- For constraint-based theories, the category of 'necessarily ISL' offers a principled means of deciding when to relax the otherwise output-oriented assumptions of markedness.
- Noniterativity, but also opacity:
  - McCarthy (1996): markedness constraints are specified as holding at the underlying or surface level (or either).
  - Hyman (2021): HTS - A syllable following an input /H/ should be followed by H in the output.

Computational implications

- *Most* maps are in the intersections of ISL and OSL.
  - Only under certain conditions does the difference matter, and even then it may be difficult to observe.
- The three-way partition matters—ISL, OSL, or ISL $\cap$ OSL—for our understanding of the computational nature of maps.

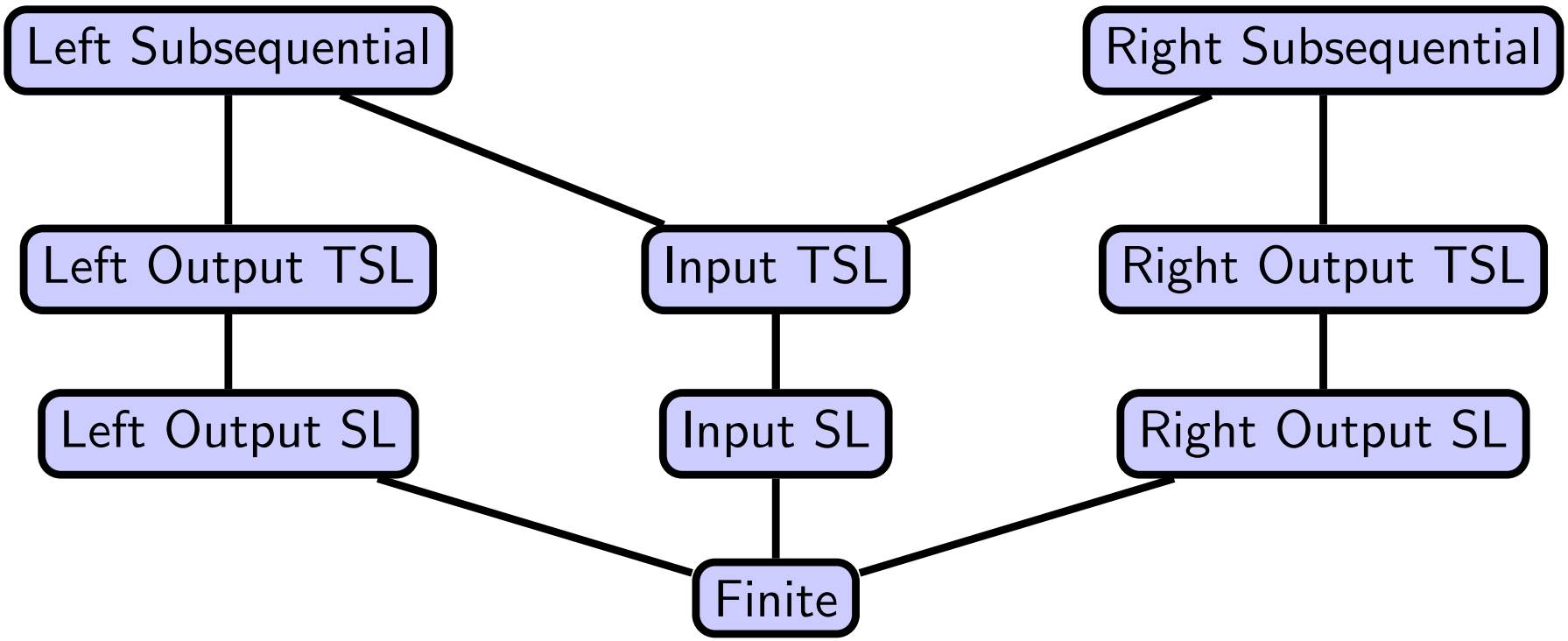
Locality and iterativity

- Why local functions?
- Locality and iterativity are inextricably linked.

Locality and iterativity

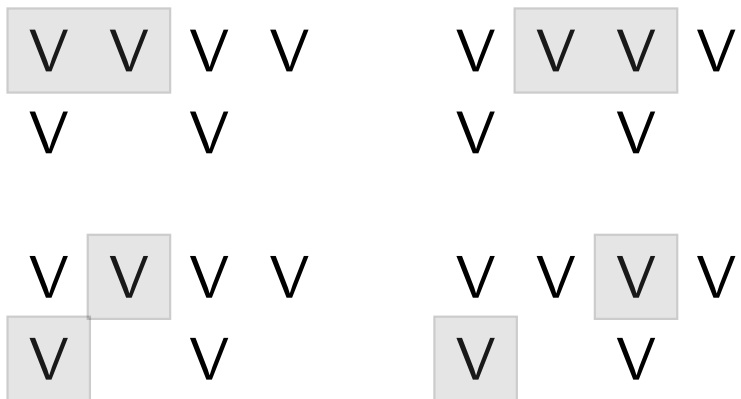
- Search and Copy model of vowel harmony (Mailhot and Reiss, 2007; Nevins, 2010).
- e.g., Turkish back harmony:
  - Searching left-to-right, find the first vowel that is specified for the feature back. Copy that vowel's specification for back to the suffix vowel.
- Relativized locality ("find the first") = no formal difference between local and long-distance maps.
- Each 'recipient' initiates its own search for a donor = no iteration.

Hierarchy of functions



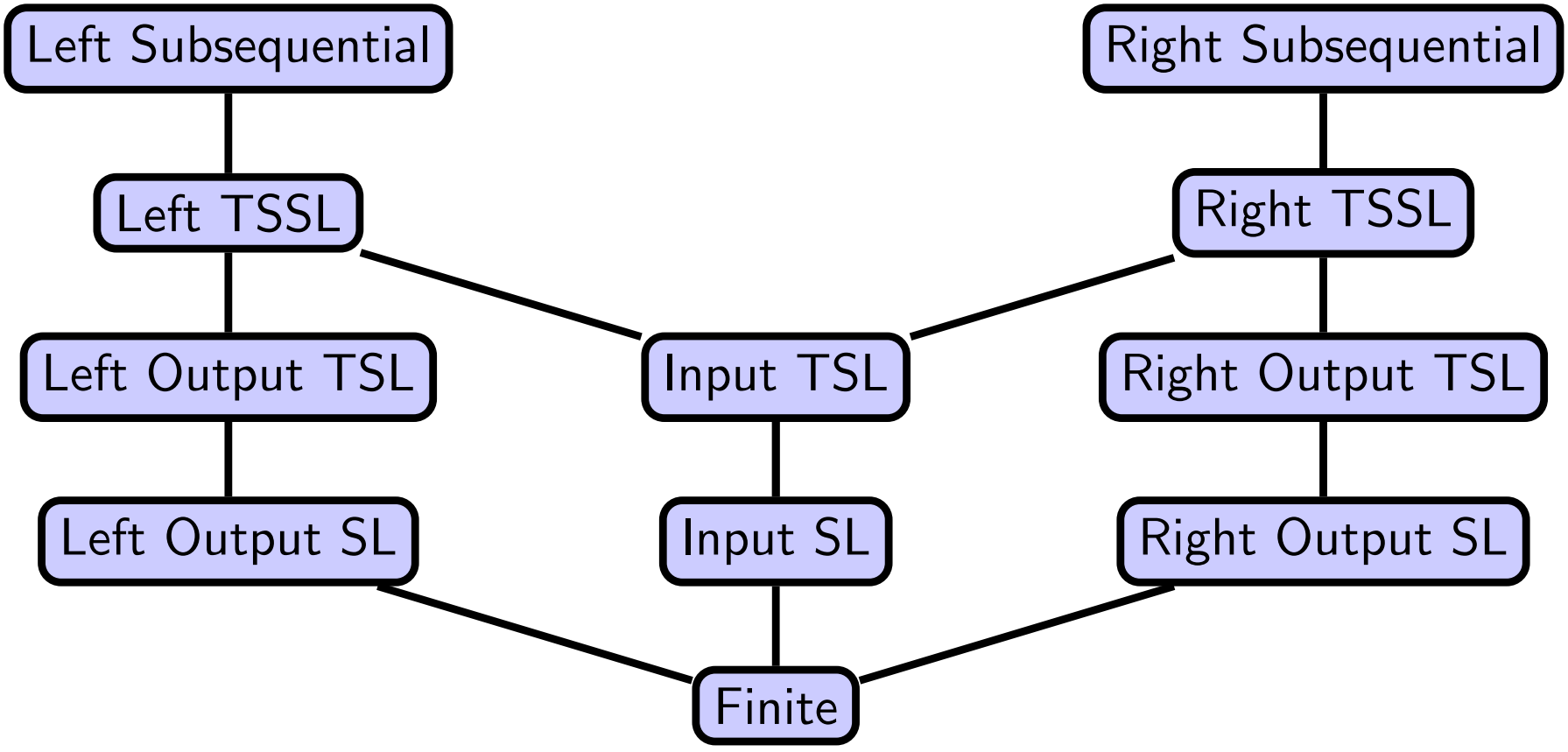
Current work: Rhythmic syncope

- Deletion of every other vowel (often schwa)
- This map is not tier-based strictly local (Hao and Bowers, 2019; Bowers and Hao, 2020).



- (This is just overlap deletion again: $V \rightarrow \varnothing$ / V __)
- To preserve locality, they introduce the tier-based synchronized strictly local (TSSL) functions.

Hierarchy of functions



However, (part 1)

- If we don't ignore the consonants, they can be used to distinguish vowel targets from non-targets.
- 3-OSL

However, (part 2)

- This only works if the deletion rule has a left **or** right context, not both.

(11)
a. $V \rightarrow \varnothing$ / VC __
b. $V \rightarrow \varnothing$ / __ CV
c. $V \rightarrow \varnothing$ / VC __ CV

- OSL (needed for iteration) cannot model rules with both contexts.

Conclusions

- Recasting *noniterative* and *iterative* as requiring access to input or output structure, respectively, enables the use of these terms as properties of maps rather than grammars.
- A theory of phonology that embraces the notion of locality must deal with both of these categories one way or another.

Thank you!

Substitution (non-dissimilatory)

Let TRIGGERS be the set of segments that trigger a process, and let OUTPUTS be the set of segments that result from that process.

A phonological map is

1. *output-nondistinct* if $\text{OUTPUTS} \cap \text{TRIGGERS} \neq \varnothing$.
2. *output-distinct* if $\text{OUTPUTS} \cap \text{TRIGGERS} = \varnothing$.

Bengali ATR harmony

{ɛ, ɔ} → {e, o} before a high vowel (Mahanta, 2007).

kɔt^{h}a	'spoken words'	kɔlpo	'resembling'
kot^{h}ito	'uttered'	kolpito	'invented'
kɔthoniyo	'speakable'	kɔlponiyo	'imaginable'

/ɔɔi/ → [ɔoi]

Bengali ATR harmony

- $\textsc{Triggers} = \{\text{i, u}\}$ (only high vowels can trigger harmony)
- $\textsc{Outputs} = \{\text{e, o}\}$
- Output-distinct
- ISL $\cap$ ROSL

Akan serial verbs

[+ATR] spreads leftward to the next vowel, but no further (Ampofo and Rasin, 2021).

/tɔ fa di/	[tɔ fæ di]	‘buy, take, and eat’
/tɔ fa bɔ di/	[tɔ fa bo di]	‘buy, take, crack, and eat’
/tɔ di su/	[to di su]	‘buy, eat, and cry’

Akan serial verbs

- $\textsc{Triggers} = \textsc{Outputs} = \{$i, e, æ, o, u$\}$
- Output-nondistinct
- ISL only

Back to results

Dissimilation

(12) $\mathrm{L} \rightarrow \mathrm{R} \;/\; \mathrm{L} \_\_$

- ISL (and simultaneous application): LLLL → LRRR
- LOSL (and iterative application): LLLL → LRLR

Tianjin tone sandhi

$$R \rightarrow H \;/\; \_\_\; R \qquad RRR \rightarrow HHR$$

$$F \rightarrow L \;/\; \_\_\; F \qquad FFF \rightarrow FLF$$

$$L \rightarrow R \;/\; \_\_\; L \qquad LLL \rightarrow LRL$$

(Chen, 1986; Zhang, 1987; Tan, 1987; Hung, 1987; Chen, 2000; Wee, 2010)

Rhythmic law

(13) $V\text{ː} \rightarrow V \;/\; V\text{ː}\ C_0\ \_\_$

Slovak (Indo-European; Slovakia)

/čiːt-aːm/	[čiːt-am]	‘read-1S’
/čiːt-aːv-aːm/	[čiːt-av-am]	(frequentive)

Githabal (Australian)

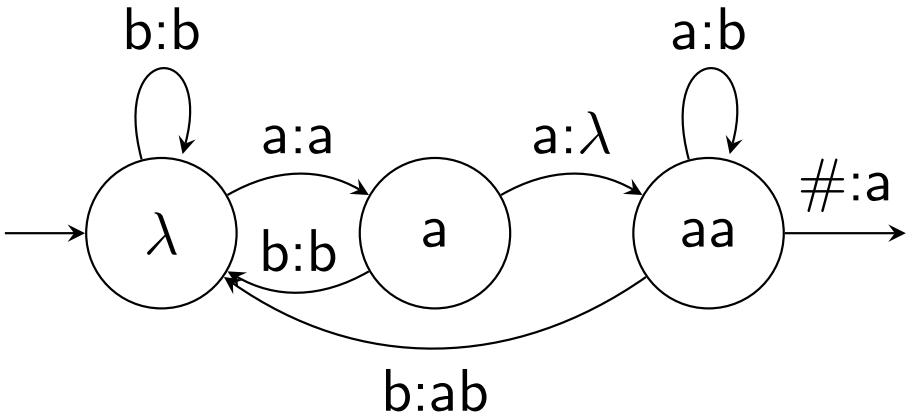
/nuːn-daːŋ/	[nuːn-daŋ]	‘too hot’
/djalum-baː-daːŋ-beː/	[djalum-baː-daŋ-beː]	‘is certainly right on the fish’

(Kenstowicz and Kisseberth, 1979)

Back to results

Rules with two-sided contexts

(14) $a \rightarrow b \;/\; a \_\_ a$



aaaa → abba

Rules with two-sided contexts

- These rules are necessarily ISL, but do they ever iterate?
- Survey of PBase (Mielke, 2008):

	Potentially iterative	Total
Substitution	8	672
Deletion	37	207
Epenthesis	—	287

Potentially iterative

(15) Mundari (Austro-Asiatic; India; Cook, 1965, pg. 61)

a. {u, o} → [w] / V __ V

b. /kiŭa/ [kiwa] 'chin'

c. /heŏa/ [hewa] 'accustom'

- Need to see what happens to /euua/

Back to results

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