Strictly Local Phonological Processes

Jane Chandlee

University of Delaware

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Main objectives

- Propose a tighter computational characterization of phonological processes that apply locally.
- Define the class of Strictly Local functions, which can be shown to model such processes.
- Promote locality from a tendency to a defining property of many phonological processes.

Phonological mappings

- Final devoicing: (ba:d, ba:t)
- -son $\Rightarrow$ -voice / __#
- *[-son, +voice]# >> IDENT(voice)

Phonological mappings

- (CAD, CBD)
- A ⇒ B / C __ D
- *CAD >> FAITH(A⇒B) (Baković 2013)
- Locality as a property of the *mapping*.
- Tesar (to appear): phonological maps are output-driven

Overview

1. Strictly Local Languages and Phonotactics
2. Strictly Local Functions and Processes
3. Learning SL
4. Exclusions and Extensions

Strictly Local Languages

- Class of formal languages describable with grammars of k-factors (= substrings of length $\leq k$)
- A string is in the language iff its own k-factors are a subset of the grammar.

McNaughton & Papert (1971), Rogers & Pullum (2011), Rogers et al. (2012)

SL languages and phonotactics

(1) Words can't end in a voiced obstruent.

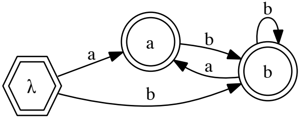
- SL-2 grammar that omits the 2-factor D#, where D = {b, d, g, v, z, ʒ, dʒ}

Strictly Local Languages

(2) Suffix Substitution Closure (Rogers & Pullum 2011): A language is SL iff there is some k such that for any string x of length $k-1$ and strings u_1, v_1, u_2, v_2 (of any length), if $u_1 x v_1$ and $u_2 x v_2$ are in the language, then $u_1 x v_2$ must also be in the language.

Strictly Local Languages

- Canonical FSA for a SL-k language has $Q = \Sigma^{\leq k-1}$.
- Transitions defined such that $q =$ the most recent symbols of the input.



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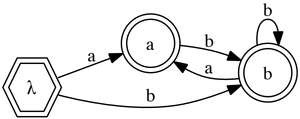
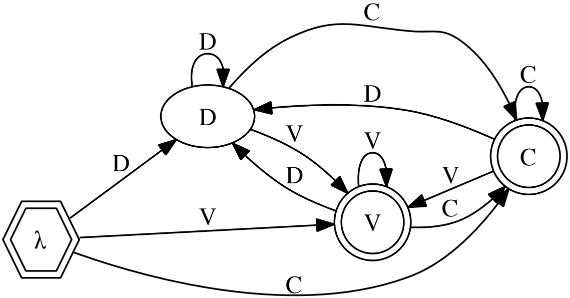


$\overline{\Sigma^* aa \Sigma^*}$

SL languages and phonotactics



From sets to functions

Phonotactics

*b#

*d#

*g#

SL if the restriction is against a contiguous substring of bounded length (Heinz 2010).

From sets to functions

Phonotactics	Processes
*b#	$\mapsto$ p#
*d#	$\mapsto$ t#
*g#	$\mapsto$ k#

From sets to functions

(3) $x_i \Rightarrow y_i$ / U __ V

Phonotactics	Processes
$*ux_1v$	$\mapsto uy_1v$
$*ux_2v$	$\mapsto uy_2v$
$*ux_3v$	$\mapsto uy_3v$

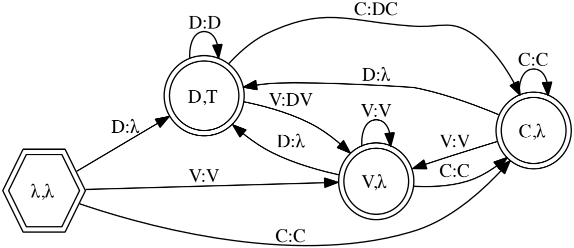
SL if there is an upper bound on the strings in UXV.

Automata-theoretic characterization

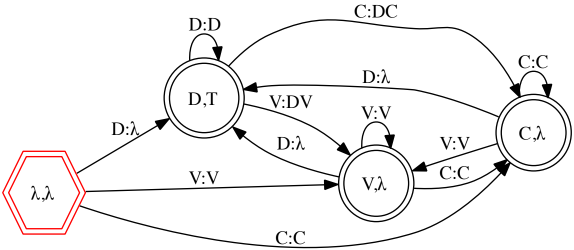
- The SL functions are believed to be a proper subset of the subsequential functions, which are those describable with subsequential finite state transducers (SFSTs).
- These FSTs are deterministic on the input and include a final output function that maps each state to a string, which is appended to the output if the input ends in that state (all states are final) (Mohri 1997).

Final devoicing

(4) $\text{D} \Rightarrow \text{T} \;/\; \_\_ \,\#$

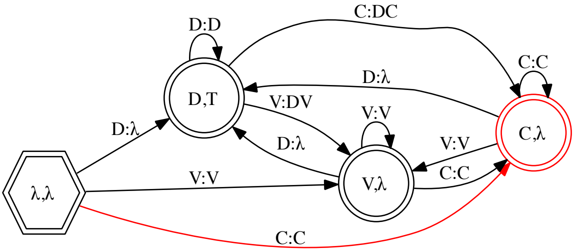


Final devoicing



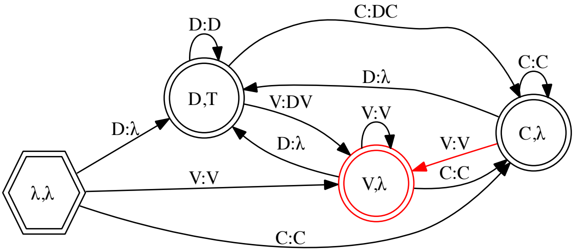
Input:		C	V	D
State:	λ			
Output:				

Final devoicing



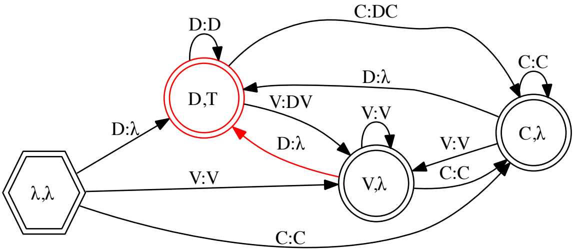
Input:			C	V	D
State:	λ	$\Rightarrow$ C			
Output:			C		

Final devoicing



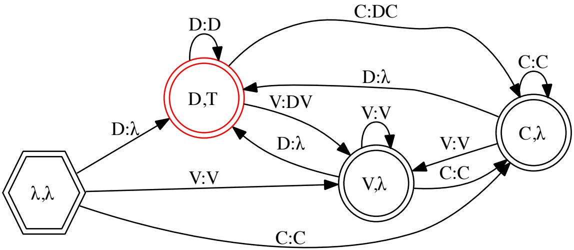
Input:			C		V	D
State:	λ	$\Rightarrow$	C	$\Rightarrow$	V	
Output:			C		V	

Final devoicing



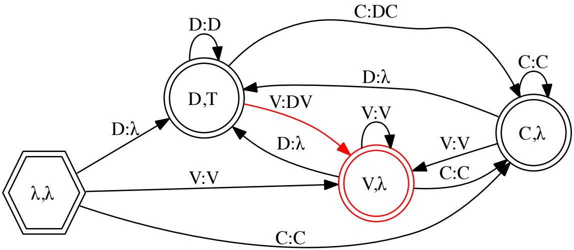
Input:			C		V		D
State:	λ	$\Rightarrow$	C	$\Rightarrow$	V	$\Rightarrow$	D
Output:			C		V		λ

Final devoicing



Input:			C		V		D	
State:	λ	$\Rightarrow$	C	$\Rightarrow$	V	$\Rightarrow$	D	
Output:			C		V		λ	T

Final devoicing



Input:		C	V	D	V	
State:	λ	$\Rightarrow$ C	$\Rightarrow$ V	$\Rightarrow$ D	$\Rightarrow$ V	
Output:		C	V	λ	DV	λ

Mode of rule application

(5) $a \Rightarrow b \;/\; a \_\_ a$

	Simultaneous	Left-to-right	Right-to-left
aaaa	$\mapsto$ abba	$\mapsto$ abaa	$\mapsto$ aaba

(Kaplan & Kay 1994)

Strictly Local Functions

Definition

A function f is Strictly Local iff there is some k such that f can be described with a SFST for which $Q = \Sigma^{\leq k-1}$, and

- (simultaneous) $\forall q \in Q, a \in \Sigma, (q, a, o, \text{Suff}_{k-1}(qa)) \in \delta$
- (left-to-right) $\forall q \in Q, a \in \Sigma, (q, a, o, \text{Suff}_{k-1}(qo)) \in \delta$

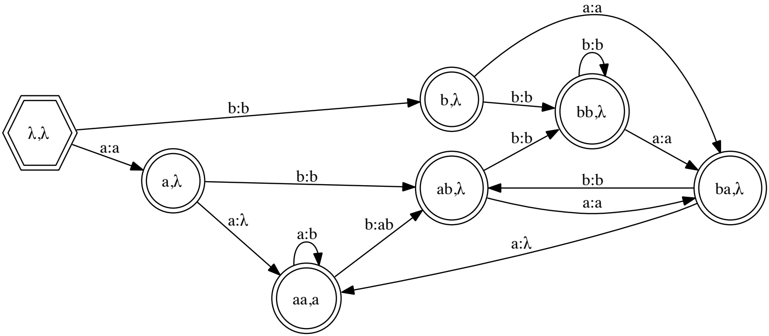
Strictly Local Functions

Right-to-left (cf. Kaplan & Kay 1994, Hulden 2009, Heinz & Lai 2013, Chandlee 2014)

Simultaneous application

(6) a ⇒ b / a ___ a

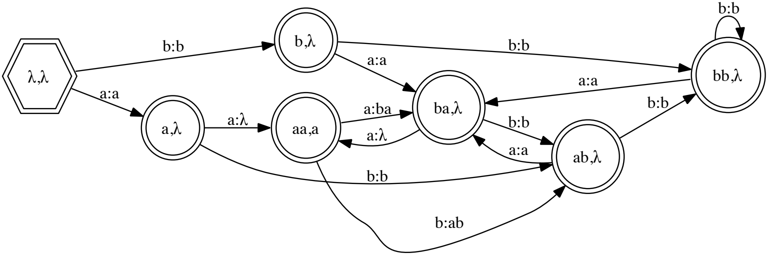
aaaa ↦ abba



Left-to-right application

(7) $\quad$ a $\Rightarrow$ b / a ___ a

aaaa $\mapsto$ abaa



Strictly Local Phonological Processes

What kinds of processes are SL?

1. Substitution
2. Deletion

   (8) $x_i \Rightarrow \lambda$ / U ___ V

3. Epenthesis

   (9) $\lambda \Rightarrow y$ / U ___ V

4. 'Bounded' metathesis

Metathesis

- Metathesis = Delete ∘ Copy (Blevins & Garrett 1998, Heinz 2005, Chandlee & Heinz 2012)

(10) Rotuman (Churchward 1940)

a. $VCV\# \mapsto VVC\#$

b. Copy: $\lambda \Rightarrow V_1$ / V __ $CV_1\#$

c. Delete: $V_1 \Rightarrow \lambda$ / VV_1C __#

Metathesis

- 'Long-distance' metathesis

(11) Cuzco Quechua (Davidson 1977)

a. yuraq ⇒ ruyaq, 'white'

b. aBc ↦ cBa

- Still bounded if the length of all $b \in$ B is bounded.

Strictly Local Phonological Processes

What kinds of processes are SL?

1. Substitution
2. Deletion
3. Epenthesis
4. ‘Bounded’ metathesis
5. Local partial reduplication/affixation

Local partial reduplication

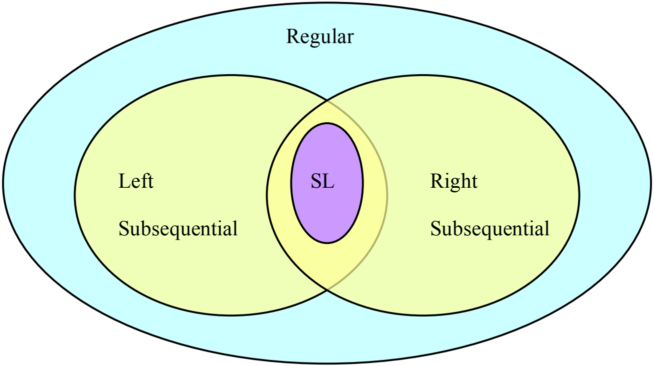
(12) a. Local prefixation: CV$x \mapsto$ CV-CVx
b. Local suffixation: xCV $\mapsto$ xCV-CV
c. Local infixation: $C_1VCx \mapsto C_1VC_1Cx$

(13) a. General prefixation: *un*-x
b. General suffixation: x-*ing*

What does this get us?

- Empirical coverage: at least 96% of the approx. 5500 processes in P-Base (v1.95, Mielke 2008) are Strictly Local
- Learning: SL functions can be learned with a modified OSTIA (Oncina et al. 1993) that uses strict locality as a learning bias (Chandlee & Jardine 2013, Chandlee & Koirala 2014)

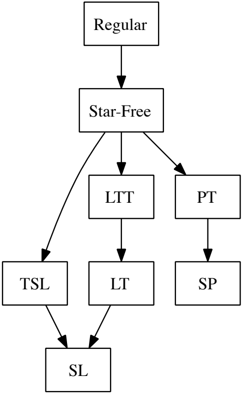
Learning SL



What *isn't* SL?

- Displacement/diachronic metathesis (Blevins & Garrett 1998, Buckley 2011, Chandlee et al. 2012, Chandlee & Heinz 2012)
- Nonlocal partial reduplication (Riggle 2003)
- Vowel harmony with transparent vowels (Nevins 2010, Gainor et al. 2012, Heinz & Lai 2013)
- Consonant harmony (Hansson 2001, Rose & Walker 2004, Luo 2013)
- Dissimilation (Suzuki 1998, Bennett 2013, Payne 2013)
- Some tonal patterns (Jardine 2013)

Future work



(McNaughton & Papert 1971, Rogers & Pullum 2011, Heinz et al. 2011, Rogers et al. 2012)

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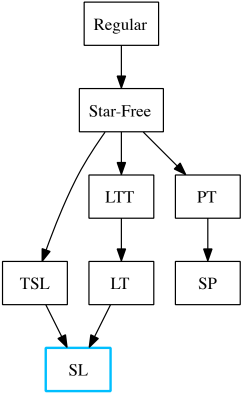

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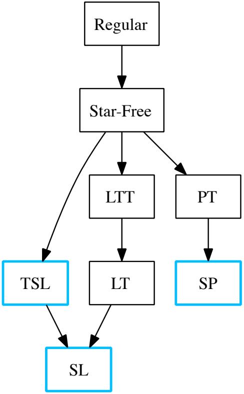

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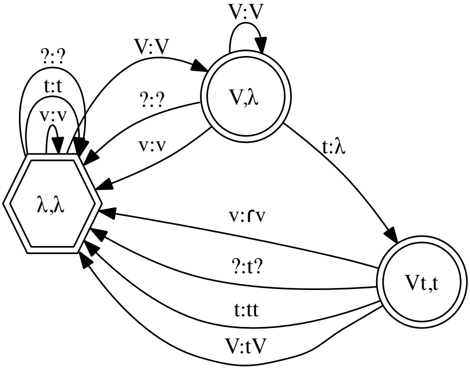
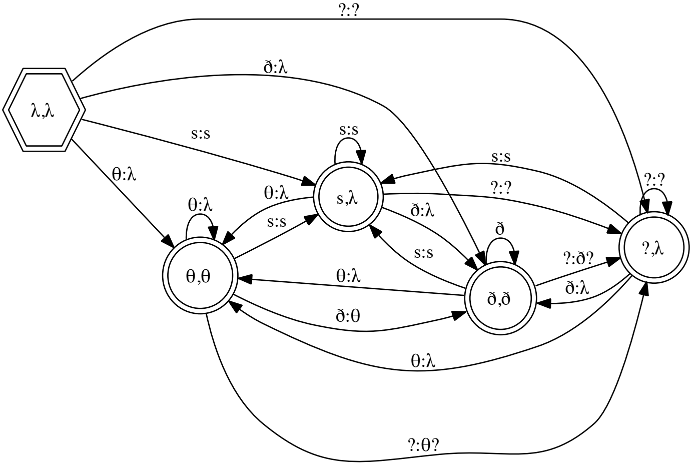
English flapping

(14) $\quad$ t ⇒ ɾ / V́ __ V ($k = 3$)



Greek fricative deletion (Joseph & Philippaki-Warburton 1987)

(15) $\{\theta, ð\} \Rightarrow \lambda$ / ___ $\{s, \theta\}$ $(k = 2)$



Dutch schwa epenthesis (Warner et al. 2001)

(16) $\lambda \Rightarrow$ ə / {l, r} __ [-coronal] ($k = 3$)