A Computational Account of Tone Sandhi Interaction

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Introduction

- Tianjin Chinese tone sandhi has received a lot of attention (Hung 1987, Zhang 1987, Tan 1987, Chen 2000, Lin 2008, Wee 2010, among others).
- Complex interaction among three rules that differ in directionality ("confused traffic").
- Will present a unified computational account: these rules share the property of being (Right) Output Strictly Local functions.

Rules/processes as maps

- Phonological generalizations (whether stated with rules or ranked constraints) can be viewed as maps (or functions) from an input string to an output string.
- Question of computational interest: how powerful/expressive do these maps have to be?
- Classification of phenomena in terms of *subregular* function classes: ISL and OSL

Input Strict Locality (ISL)

- Output is determined based on a ‘window’ of the most recent *input*.

✓ ISL

⋊	ɪ	N	p	ɑ	s	ə	b	l̩	⋉
	ɪ	λ	mp	ɑ	s	ə	b	l̩	

⋊	b	ɑː	d	⋉
	b	ɑː	λ	t

¬ ISL

⋊	s	ɑ	ɑ	ɑ	ʃ	⋉
	s	ɑ	ɑ	ɑ	s	

⋊	b	ɑː	d	⋉
	b	ɑː	λ	t

Output Strict Locality (OSL)

- Output is determine based on a ‘window’ of the most recent *output*.

Left-OSL							Right-OSL						
⋊	N	V	V	V	C	⋉	⋊	C	V	V	V	N	⋉
	N	Ṽ	Ṽ	Ṽ	C			C	Ṽ	Ṽ	Ṽ	N	

Rule application

ISL ≈ simultaneous application

⋊	N	V	V	V	C	⋉
	N	$\tilde{V}$	V	V	C	

OSL ≈ iterative application

⋊	N	V	V	V	C	⋉
	N	$\tilde{V}$	$\tilde{V}$	$\tilde{V}$	C	

Tianjin Tone Sandhi

- Four tones: L, H, R=LH, F=HL
- Sequences of 2 identical tones undergo sandhi (except for HH)

(1) a. FF $\mapsto$ LF
b. LL $\mapsto$ RL
c. RR $\mapsto$ HR

Tritonal strings

(1a) FF $\mapsto$ LF **(1b)** LL $\mapsto$ RL **(1c)** RR $\mapsto$ HR

- Apply right-to-left

(1a) F[FF] ↧ FLF (1b) L[LL] ↧ LRL

Tritonal strings

(1a) FF ↦ LF **(1b)** LL ↦ RL **(1c)** RR ↦ HR

- Applies left-to-right

	[RR]R
(1c)	↧
	H[RR]
(1c)	↧
	HHR

Rule-based accounts

Zhang (1987):

- FF rule feeds LL rule
- LL rule feeds RR rule

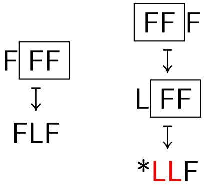
Rule	Direction	RLL	LFF
F→**L** / __**F**	right-to-left	–	LLF
L→**R** / __**L**	right-to-left	RRL	RLF
R→**H** / __**R**	left-to-right	HRL	–
		HRL	RLF

See also Tan (1987)

Rule-based accounts

Hung (1987):

- Rules apply freely subject to a phonotactic constraint against adjacent low tones (HH is okay).
- The constraint both ‘positively motivates’ and ‘negatively motivates’ FF $\mapsto$ LF and LL $\mapsto$ RL



Constraint-based accounts

- Ad hoc stipulation of directionality seems to be unavoidable in a rule-based approach (Chen 2000, Lin 2008, Wee 2010).
- With violable constraints, sandhi can be assumed to always apply left-to-right unless an OCP violation results.
  - HH is exempt

Constraint-based accounts

Derivational constraints (Chen 2000)

- Temporal Sequence: apply rules left to right
- $\text{OCP}_{\neg HH} \gg$ Temporal Sequence
- GEN produces candidates of the form:

R [LL]

↧

[RR] L

↧

HRL

Constraint-based accounts

- The use of derivational constraints recreates the duplication problem that motivated OT in the first place.
- Standard OT has issues with the opaque nature of left-to-right (Lin 2008, Wee 2010).
  - Overapplication: RRR $\mapsto$ HHR

Constraint-based accounts

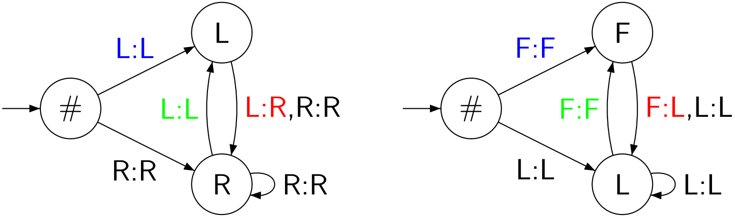
Lin (2008):

- IDENT-BO-T: Corresponding tones in prosodically related bases and outputs must be identical.
- OCP(L,F,R) $\gg$ IDENT-BO-T

$$\begin{array}{ccc} \text{(RR)} & & \text{((RR)R)} \\ \downarrow & & \downarrow \\ \text{(HR)} & \rightarrow & \text{((HH)R)} \\ & & \text{*((RH)R)} \end{array}$$

Computational account: FF and LL rules

- FF and LL rules are 1) regressive and 2) iterative
  - Right-OSL



UR:	#	L	L	L	#	UR:	#	F	F	F	#
SR:		L	R	L		SR:		F	L	F	

Computational account: RR rule

$R \rightarrow H$ / __ R

[RR]R	R[RR]
↧	↧
H[RR]	[RH]R
↧	↧
HHR	*RHR

Computational account: RR rule

R → H / __ R

- Direction actually doesn't matter.

#	R	R	R	#
	H			

#	R	R	R	#
			R	

#	R	R	R	#
	H	H		

#	R	R	R	#
		H	R	

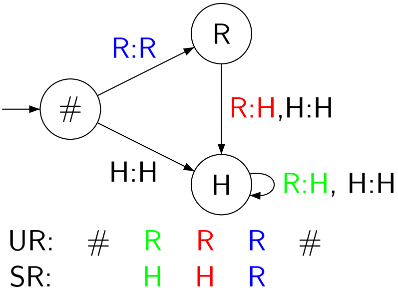
#	R	R	R	#
	H	H	R	

#	R	R	R	#
	H	H	R	

- This is also simultaneous application: so ISL?

Computational account: RR rule

- It is ISL, but it's also Right-OSL.



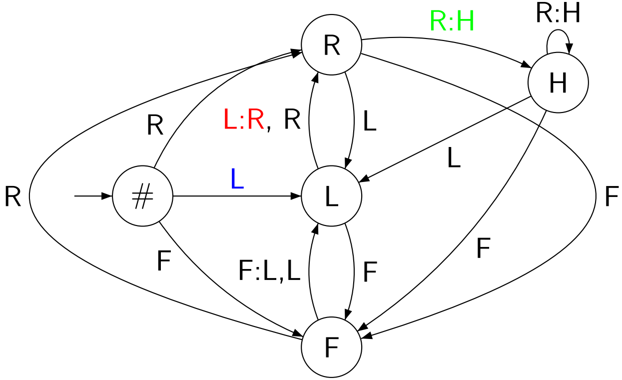
What's going on?

- ISL (unlike OSL) can model rules with two-sided contexts.
- When the rule has a one-sided context, the ISL/OSL distinction sometimes collapses.
- Conjecture (for simultaneous application):
  - A → B / __ D (ISL = ROSL)
  - A → B / C __ (ISL = LOSL)
- Dissimilation only?

3-in-1

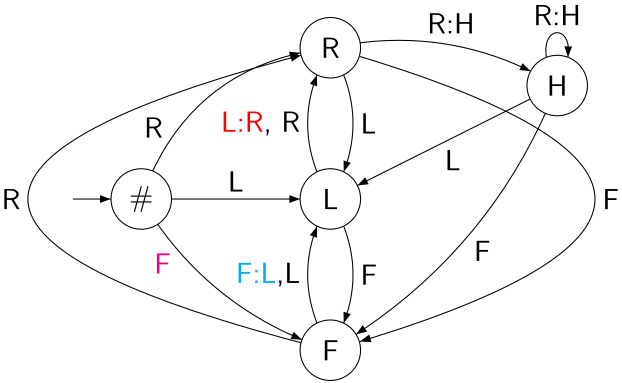
- Since they all have the same property (ROSL), the rules can actually be modeled with a single ROSL function.
- Advantage: all three can be learned by the OSL learning algorithm (Chandlee, Eyraud, Heinz 2015).

3 rules, single 2-ROSL function



R	L	L
		L
R	L	L
	R	L
R	L	L
H	R	L

3 rules, single 2-ROSL function



L	F	F
		F
L	F	F
	L	F
L	F	F
R	L	F

How many rules?

- The assumption of 3 rules originally simplified the rule-based analyses.
- "There is an implicit assumption in Chen's [1986] analysis...that there is only one tone sandhi rule in Tianjin, albeit with four subrules, and the four subrules behave identically with respect to the domain and mode of application, with no ordering among them" (Zhang 1987, p. 251).

Summary

- As originally defined, ISL = simultaneous application and OSL = iterative application, but it's more nuanced than that.
    - Under certain conditions, OSL can model either mode of application.
- A unified analysis of Tianjin Tone Sandhi is possible: all three rules are ROSL.
    - Exceptionality of the RR rule is only apparent.
    - Though it is still *distinct* in *also* being ISL.

Conclusion

- Tone sandhi provides useful case studies for the computational nature of different modes of application:
  - Strings of identical targets (RRR, FFF, LLL)
  - Target/trigger overlap among rules.
- Are there other cases of sandhi interaction in which the rules are (necessarily) computationally distinct?

References

- Chandlee, Jane, Rémi Eyraud, and Jeffrey Heinz. (2015). Output strictly local functions. *Proceedings of the 14th MOL.*
- Chen, Matthew Y. (1986). The paradox of Tianjin tone sandhi. CLS 22. 98-114.
- Chen, Matthew Y. (2000). *Tone sandhi: Patterns across Chinese dialects*. Cambridge: Cambridge UP.
- Hung, Tony T.N. (1987). Tianjin tone sandhi: Towards a unified approach. *Journal of Chinese Linguistics 15*(2), 274-305.
- Lin, Hui-Shan. (2008). Variable directional applications in Tianjin tone sandhi. *Journal of East Asian Linguistics 17*(3), 181-226.
- Tan, Fu. (1987). Tone sandhi in the Tianjin dialect. *Journal of Chinese Linguistics 15*(2), 228–246.
- Wee, Lian-Hee. (2010). A percolative account of Tianjin tone sandhi. *Language and Linguistics, 11*(1):21–64.
- Zhang, Zheng Sheng. (1987). The paradox of Tianjin: Another look. *Journal of Chinese Linguistics 15*(2), 247-273.