Local correspondence in phonological transformations

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Introduction

- Korean intervocalic voicing

[pap]	‘rice’
[pori-bap]	‘rice with barley’
[mat]	‘son’
[mad-aduɯl]	‘the first son’
[koŋ]	‘ball’
[sɛ-goŋ]	‘new ball’

(Kim-Renaud, 2009)

Introduction

- Korean intervocalic voicing

/ p a p /	/ p o l i - p a p /
↓ ↓ ↓	↓ ↓ ↓ ↓ ↓ ↓ ↓
[p a p]	[p o r i - b a p]
‘rice’	‘rice w. barley’

(McCarthy and Prince, 1995)

Introduction

- What is a possible correspondence?

p	p	* a
↓	↓	↓
p	b	p

- What is the nature of correspondence generalizations?

a	p	a	p	* a	p	a	p
↓	↓	↓	↓	↓	↓	↓	↓
a	b	a	p	a	p	a	p

Introduction

- Phonological transformations are largely *local* (Chandlee, 2014; Chandlee et al., 2014)
- We can study this through *banned substructure constraints* over correspondence graphs
- We can constrain correspondence through *concatenation* (Jardine and Heinz, 2015)

Introduction

- This is discludes ‘counting’ patterns predicted by optimization
- Correspondence is enforced locally, not through globally-evaluated constraints
- Opens up possibilities for learning transformations

Correspondences

- Inventory: {a, b, p}
- 4^2 possible symbol correspondences including ∅

∅	∅	∅	∅	a	a	a	a
↓	↓	↓	↓	↓	↓	↓	↓
∅	a	b	p	∅	a	b	p
p	p	p	p	b	b	b	b
↓	↓	↓	↓	↓	↓	↓	↓
∅	a	b	p	∅	a	b	p

Correspondences

- Inventory: {a, b, p}
- Languages will only use subset of these

∅	∅	∅	∅	a	a	a	a
↓	↓	↓	↓	↓	↓	↓	↓
∅	a	b	p	∅	a	b	p
p	p	p	p	b	b	b	b
↓	↓	↓	↓	↓	↓	↓	↓
∅	a	b	p	∅	a	b	p

Correspondences

$$C_{Sym} = \left\{ \begin{matrix} \varnothing \\ \downarrow \\ a \end{matrix}, \begin{matrix} \varnothing \\ \downarrow \\ b \end{matrix}, \begin{matrix} \varnothing \\ \downarrow \\ p \end{matrix}, \begin{matrix} a \\ \downarrow \\ \varnothing \end{matrix}, \begin{matrix} a \\ \downarrow \\ a \end{matrix}, \begin{matrix} p \\ \downarrow \\ \varnothing \end{matrix}, \begin{matrix} p \\ \downarrow \\ b \end{matrix}, \begin{matrix} p \\ \downarrow \\ p \end{matrix}, \begin{matrix} b \\ \downarrow \\ \varnothing \end{matrix}, \begin{matrix} b \\ \downarrow \\ b \end{matrix}, \begin{matrix} b \\ \downarrow \\ p \end{matrix} \right\}$$

- *Concatenation* can be extended from strings to graphs (Engelfriet and Vereijken, 1997; Jardine and Heinz, 2015)
- Concat. of symbol correspondences gives us set of *string* correspondences

$$C_{Str} = \left\{ \ldots, \begin{matrix} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\,a\,p\,a\,\# \end{matrix}, \begin{matrix} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\,a\,b\,a\,\# \end{matrix}, \begin{matrix} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\varnothing\varnothing\varnothing\# \end{matrix}, \begin{matrix} \#\,a\,p\,a\,p\,\# \\ \downarrow\downarrow\downarrow\downarrow \\ \#\,a\,p\,a\,p\,\# \end{matrix}, \ldots \right\}$$

Correspondences

$$C_{Str} = \left\{ \ldots, \begin{array}{c} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\,a\,p\,a\,\# \end{array}, \begin{array}{c} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\,a\,b\,a\,\# \end{array}, \begin{array}{c} \#\,a\,p\,a\,\# \\ \downarrow\downarrow\downarrow \\ \#\varnothing\varnothing\varnothing\# \end{array}, \begin{array}{c} \#\,a\,p\,a\,p\,\# \\ \downarrow\downarrow\downarrow\downarrow \\ \#\,a\,p\,a\,p\,\# \end{array}, \ldots \right\}$$

- C_{Str} is similar to, but distinct from, OT's GEN
  - *All* inputs are considered
  - Input-output correspondence constrained by concatenation
- Language specific tranformations are subsets of C_{Str}

Constraining correspondences

- *Banned substructure constraints* are a restrictive way of specifying sets of well-formed objects (Heinz, 2010; Rogers et al., 2013; Jardine and Heinz, in press)

$$\neg s_1 \wedge \neg s_2 \wedge \ldots \wedge \neg s_n$$

Constraining correspondences

- To specify subsets of C_{Str}, ban substructures of string correspondences

$$\neg\,\text{a} \;\wedge\; \neg\,\text{p} \;\wedge\; \neg\,\text{b} \quad (=\textsc{Max})$$
$$\downarrow \qquad \downarrow \qquad \downarrow$$
$$\varnothing \qquad \varnothing \qquad \varnothing$$

$$*\#\ \text{a}\ \ \text{p}\ \ \text{a}\ \ \#$$
$$\downarrow\ \downarrow\ \downarrow$$
$$\#\ \text{a}\ \ \varnothing\ \ \text{a}\ \ \#$$

$$\#\ \text{a}\ \ \text{p}\ \ \text{a}\ \ \#$$
$$\downarrow\ \downarrow\ \downarrow$$
$$\#\ \text{a}\ \ \text{p}\ \ \text{a}\ \ \#$$

- Constraints interact through *conjunction* ($\wedge$), not through optimization

$$\textsc{Max} \wedge \textsc{Dep}$$

Constraining correspondences

- Banned substructure constraints are thus *inviolable* and *language-specific*
- They are *local* because well-formedness is dependent entirely on well-formedness of substructures (Rogers and Pullum, 2011; Rogers et al., 2013)
- They are *efficiently learnable* by remembering well-formed substructures (García et al., 1990; Heinz, 2010, 2011; Jardine and Heinz, 2016)

Intervocalic voicing analysis

- Main banned substructure:

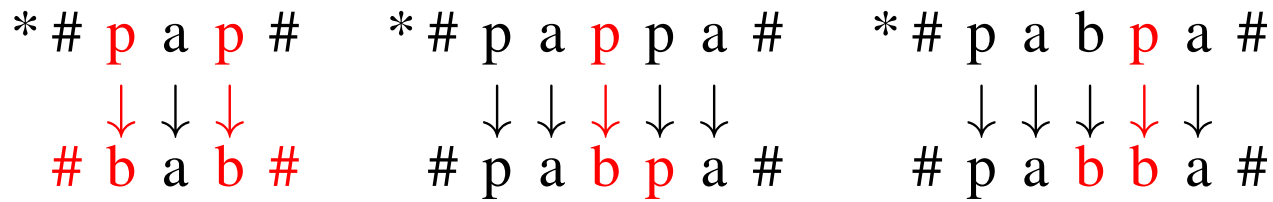
$$*\text{apa} = \neg\ \text{p} \quad (\text{p} \downarrow \text{a p a})$$

# a p a p #	* # a p a p #
↓ ↓ ↓ ↓	↓ ↓ ↓ ↓
# a b a p #	# a p a p #

- Adding MAX∧DEP ensures that voicing is the correct repair

Intervocalic voicing analysis

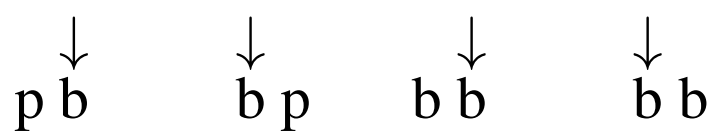
- We also need to forbid *over*-repairing



- NoInitVoic= ¬ p

- NoFinVoic= ¬ p

- NoCCVoic= ¬ p ∧ ¬ p ∧ ¬ p ∧ ¬ p



Intervocalic voicing analysis

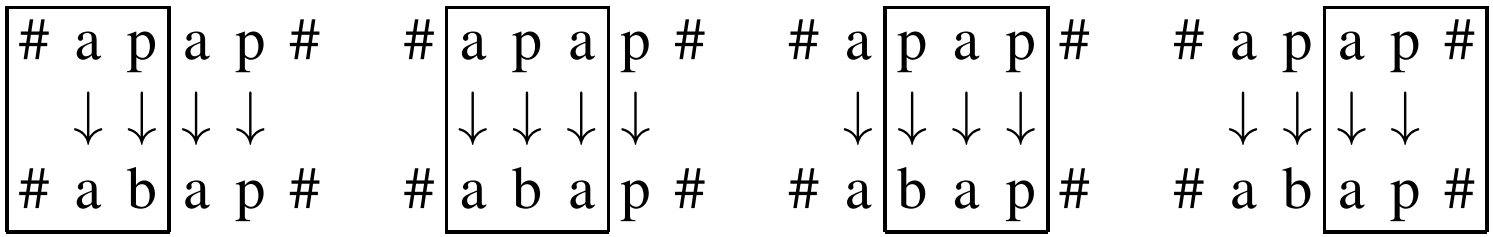
- The following describes the subset of C_{Str} representing intervocalic voicing:

$$*\text{apa} \wedge \textsc{Max} \wedge \textsc{Dep} \wedge \textsc{NoInitVoic} \wedge \textsc{NoFinVoic} \wedge \textsc{NoCCVoic}$$

- Banned substructure constraints can be a *theory* of transformations
- They capture the *local* nature of phonological transformations

Learning

- Learning model ‘scans’ through input structures (Jardine and Heinz, 2016)



- Correct because learner will never see *apa, MAX, NOINITVOIC, etc.
- Concatenation and symbol correspondence primitives may help with learning URs from SRs

Comparison to OT

- Many OT MARKEDNESS and FAITHFULNESS are local in the same way
- MAX, DEP, *apa, *CCC, etc.
- Optimization is not local

Comparison to OT

Optimization counts (Gerdemann and Hulden, 2012)

	aaaappp	DEP	*ap	MAX
	aaaappp		*!	
	aaaabppp	*!		
	∅∅∅∅ppp			*!***
☞	aaaa∅∅∅			***

	aaaappppp	DEP	*ap	MAX
	aaaappppp		*!	
	aaaabppppp	*!		
☞	∅∅∅∅ppppp			****
	aaaa∅∅∅∅∅			*!****

Comparison to OT

- This behavior also produces Majority Rules patterns (Lombardi, 1999; Baković, 2000; Heinz and Lai, 2013)
- Provably, counting patterns *cannot* be described with banned substructure constraints

Conclusions

- Concatenation of symbol correspondences yields a restrictive notion of input/output correspondence
- Banned substructure constraints over string correspondences yields a restrictive, learnable, *local* theory of transformations

Conclusions

- How does this theory compare to automata-theoretic notions of locality (Chandlee, 2014; Chandlee et al., 2015)?
- We can incorporate long-distance versions of banned substructure constraints (Heinz, 2010; Heinz et al., 2011)
- How can banned substructure corresondence constraints be extended to non-string structures? (Jardine, 2016)?

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Appendix: Metathesis

- Metathesis
  - Analyze it as deletion + epenthesis (Blevins and Garrett, 2004; Chandlee and Heinz, 2012)

    a p ∅
    ↓ ↓ ↓
    ∅ p a
  - Include a finite set of metathesis primitives

    a p
    ⤫
    p a

    (metathesis is bounded: Chandlee et al., 2012; Chandlee and Heinz, 2012)
- Otherwise, we need non-local LINEARITY constraint(s)