On the expressivity of Optimality Theory versus rules: An application to opaque patterns

Brian Buccola & Morgan Sonderegger
McGill University, Montréal, Canada
brian.buccola@mail.mcgill.ca | morgan.sonderegger@mcgill.ca

0 Overview

- **Longstanding intuition:** Some phonological patterns, in particular opaque patterns, are problematic for basic/classic/intuitive OT but not for rules (McCarthy, 2007; Baković, 2007; Pater, to appear; Kager, 1999, among others).
- **Question:** Problematic in what sense? Several possibilities:
  1. Opacity is totally inexpressible.
  2. Opacity is expressible in principle, but perhaps only with ad-hoc (but formally sound) constraints.
  3. A mix of the above.
- **Motivation:** Despite convincing informal demonstrations, it has never been proved that there is a pattern that is not expressible by any OT grammar of some fixed class.
- **Take-home:**
  - Formal result: There is a pattern (Canadian raising) that is expressible by rules but not by any OT grammar without faithfulness constraints that take context into account, i.e. that can "look ahead/behind."
  - More generally, environment opacity, is totally inexpressible without context-sensitive faithfulness constraints.
  - Chain shifts, and more generally focus opacity, is expressible, albeit with ad-hoc constraints that directly penalize the undesired IO mapping.
  - Thus, different types of opacity are problematic/"not doable" in OT in different ways.
- **Roadmap:**
  - 1–4: Classic analysis of counterbleeding on environment opacity; demonstration of OT's intuitive inadequacy.
  - 5–6: Formalization of basic OT; exclude context-sensitive faithfulness constraints that can "look ahead/behind" at other IO segments.
  - 7–8: Main result & proof: Canadian raising is inexpressible by basic OT, as defined here; proof technique works for any case of environment opacity.
  - 9–10: A look at other types of opacity.

1 Flapping

/ɡɹeitəɹ/ → [ɡɹeiɾəɹ] "greater"
/ɹaidəɹ/ → [ɹaiɾəɹ] "rider"

- Rule: t, d → ɾ / V __ V
- OT:

/ɹaidəɹ/	*V{t, d}V	Ident(sonorant)
a. ɹaidəɹ	1	0
→ b. ɹaiɾəɹ	0	1

2 Canadian Raising

/ɹait/ → [ɹʌit] "write"
/ɹaid/ → [ɹaid], *[ɹʌid] "ride"

- Rule: aɪ → ʌɪ / __ t
- OT:

/ɹait/	*aɪt	Ident(low)
a. ɹait	1	0
→ b. ɹʌit	0	1

3 Canadian Raising Opacity: Rule Interaction ✓

/ɹaitəɹ/ → [ɹʌiɾəɹ], *[ɹaiɾəɹ] "writer"

		Raise		Flap	
a.	/ɹaid/	→	ɹaid	→	[ɹaid] "ride"
b.	/ɹait/	→	ɹʌit	→	[ɹʌit] "write"
c.	/ɹaidəɹ/	→	ɹaidəɹ	→	[ɹaiɾəɹ] "rider"
d.	/ɹaitəɹ/	→	ɹʌitəɹ	→	[ɹʌiɾəɹ] "writer"
d′.	*[ɹaiɾəɹ]	←	ɹaiɾəɹ	←	/ɹaitəɹ/ "writer"

4 Canadian Raising Opacity: Constraint Interaction ✗

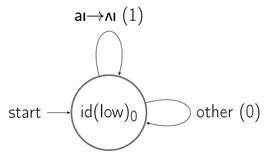
/ɹaitəɹ/ → [ɹʌiɾəɹ], *[ɹaiɾəɹ] "writer"

	/ɹaitəɹ/	*aɪt	*V{t, d}V	Ident(low)	Ident(son)
	a. ɹaitəɹ	1	1	0	0
	b. ɹʌitəɹ	0	1	1	0
→	c. ɹaiɾəɹ	0	0	0	1
	d. ɹʌiɾəɹ	0	0	1	1

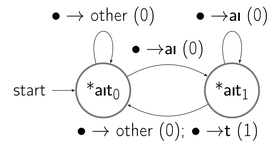
- Opaque pattern is inexpressible with these constraints.
- What about more and/or different constraints?
- What other constraints are intuitively allowable?

5 Example Constraints

- Formalize constraints as weighted finite state transducers (Riggle, 2004).



Ident(low): assign 1 violation to aɪ→ʌɪ.



*aɪt: assign 1 violation for each occurrence of [aɪt].
(• stands for any single segment.)

6 Defining Basic OT

- **Two levels of representation:**
  1. Underlying
  2. Surface
- **Two types of constraints:**
  1. Markedness: penalize certain sequences of output segments, with no reference to input segments.
  2. Single-state faithfulness: penalize certain single IO segments in correspondence, with no reference to other segments in the input or output.
- Multistate faithfulness constraints take context into account, e.g.:
  - penalize the IO segment pair $i \to o$ iff i precedes/follows i'.
  - penalize the IO segment pair $i \to o$ iff o precedes/follows o'.
- Such constraints are intuitively non-basic, i.e. not part of the basic OT grammars for which opacity is considered problematic.

7 Main Result

- There is no basic OT grammar, as defined here, in which both:
  1. [ɹaiɾəɹ] is the most optimal output of /ɹaidəɹ/.
  2. [ɹʌiɾəɹ] is the most optimal output of /ɹaitəɹ/.

  (assuming that both [ɹaiɾəɹ] and [ɹʌiɾəɹ] are output candidates for both inputs)
- Any OT grammar in which those candidates are optimal must contain at least one multistate faithfulness constraint, e.g. "Ident(low) before /d/," which penalizes the mapping /aɪ/→[ʌɪ] but only when /aɪ/ immediately precedes /d/.

8 Proof Overview

Proof by contradiction (simplified here): assume there is such a basic OT grammar.

- There must be constraints c_j, c_k (possibly the same) such that:
  1. c_j assigns fewer violations to [ɹaiɾəɹ] than to [ɹʌiɾəɹ] for /ɹaidəɹ/.
  2. c_k assigns fewer violations to [ɹʌiɾəɹ] than to [ɹaiɾəɹ] for /ɹaitəɹ/.

$$\left\{ \begin{array}{l} \langle \underline{\text{ɹaidəɹ}}, \text{ɹaiɾəɹ} \rangle \\ \langle \text{ɹaidəɹ}, \underline{\text{ɹʌiɾəɹ}} \rangle \\ \\ \langle \underline{\text{ɹaitəɹ}}, \text{ɹaiɾəɹ} \rangle \\ \langle \text{ɹaitəɹ}, \underline{\text{ɹʌiɾəɹ}} \rangle \end{array} \right\} \subseteq \text{Gen}$$

- underline = c_j's preference
- wavy line = c_k's preference

- c_j must be either:
  1. a markedness constraint, e.g. *ʌɪr.
  2. a 1-state faithfulness constraint, e.g. Ident(low).
- c_k must be either:
  1. a markedness constraint, e.g. *aɪr.
  2. a 1-state faithfulness constraint, e.g. AntiIdent(low).

- $\Rightarrow c_j \neq c_k$
- $\Rightarrow c_j \gg c_k$ or $c_k \gg c_j$
- Case 1 ($c_j \gg c_k$): then [ɹaiɾəɹ] is more optimal than [ɹʌiɾəɹ] for /ɹaitəɹ/. ✗
- Case 2 ($c_k \gg c_j$): then [ɹʌiɾəɹ] is more optimal than [ɹaiɾəɹ] for /ɹaidəɹ/. ✗

9 Counterfeeding on Focus Opacity (Chain Shifts)

- Western Basque (de Rijk, 1970):
  - /alaba+a/ → [alabe+a]
  - /seme+e/ → [semi+a]
- Rules:
  1. /e/ → [i]
  2. /a/ → [e]

  (⇒ /a/ ↛ [i])
- OT: suffices to posit an undominated 1-state faithfulness constraint *a→i that penalizes mapping /a/ to [i].

10 Counterbleeding on Focus Opacity

- Low German (Kiparsky, 1968; Kenstowicz and Kisseberth, 1979):
  - /taːg/ → [taːx]
  - /taːg+ə/ → [taːɣ+ə]
  - /hauz/ → [haus]
- Rules:
  1. Spirantization: [−son, +voi] → [+cont] / V __
  2. Devoicing: [−son] → [−voi] / __ #

  (⇒ /taːg/ ↛ [taːk])
- OT: suffices to posit an undominated 1-state faithfulness constraint *g→k that penalizes mapping /g/ to [k].

11 Conclusion

- Different types of opacity pose different problems for basic OT.
- Focus opacity: expressible in principle, albeit with intuitively ad-hoc constraints.
- Environment opacity: formally inexpressible without context-sensitive (multistate) faithfulness constraints, which can "look ahead/behind" at other IO segments.
- **Open questions:**
  - Context-sensitive faithfulness has already been proposed to account for other phenomena, e.g. positional faithfulness (Beckman, 1998). Is it possible to capture all cases of opacity using only constraints that are formally similar to those already proposed for non-opaque patterns?
  - Is it possible to express all phonological patterns using only two-state faithfulness constraints, i.e. faithfulness constraints that look only one segment to the left/right?

12 Selected References

Baković, Eric. 2007. A revised typology of opaque generalizations. *Phonology* 24:217–259

Beckman, Jill. 1998. Positional faithfulness. Doctoral Dissertation, University of Massachusetts Amherst

Kager, René. 1999. *Optimality Theory*. Cambridge University Press

Kenstowicz, Michael, and Charles Kisseberth. 1979. *Generative phonology: Description and theory*. Academic Press

Kiparsky, Paul. 1968. Linguistic universals and language change. In *Universals in linguistic theory*, ed. Emmon W. Bach and Robert T. Harms, 170–202. Holt, Reinhart, & Winston

McCarthy, John. 2007. *Hidden generalizations: Phonological opacity in Optimality Theory*. Equinox Publishing Ltd

Pater, Joe. to appear. Canadian raising with language-specific weighted constraints. *Language*

Riggle, Jason. 2004. Generation recognition and learning in finite state Optimality Theory. Doctoral Dissertation, UCLA

de Rijk, Rudolph. 1970. Vowel interaction in Bizcayan Basque. *Fontes Linguae Vasconum* 2:149–167

13 Acknowledgments

For many helpful comments, we thank Heather Goad, Michael Wagner, and the audiences at the Toronto-Ottawa-Montreal phonology workshop and at Formal Grammar 2013.