Raising and Flapping in Canadian English: grammar and acquisition

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AIMS

§1 This paper argues for *a stratal solution to the problem of phonological opacity in OT*. Stratal OT is shown to possess significant advantages over its competitors:

- Stratal OT imposes *tight formal restrictions on the space of possible opacity effects*: all opacity effects arise from the interaction between cycles; there is no cycle-internal opacity.
- In Stratal OT, therefore, the interaction between phonological processes can be *deduced from their morphosyntactic domain of application*.
- Because of this, Stratal OT supports a *learning model* that is capable of accounting for the acquisition of opacity effects even in nonalternating items.

§2 The advantages of Stratal OT are illustrated with a case study of the *classic counterbleeding interaction* between Diphthong Raising and Flapping in Canadian English:

- The relative order of Raising and Flapping need not be stipulated, but can be deduced from the fact that Raising is *stem-level,* whereas Flapping is *phrase-level*;
- The proposed learning model shows how children can use evidence from alternations such as *write* [ɹ**əit**] ~ *writer* [ɹ**əiɾ**ɚ] and *ride* [ɹ**aɪd**] ~ *rider* [ɹ**aɪɾ**ɚ] to assign correct underlying representations to the flaps in nonalternating items such as *mitre* [m**əiɾ**ɚ] and *spider* [sp**aɪɾ**ɚ].

THE PROBLEM OF PHONOLOGICAL OPACITY

Definition

§3 Kiparsky's (1982 [1971]: 75; 1973: 79) rule-based definition:

A rule $\mathcal{R}$ of the form $\alpha \rightarrow \beta \,/\, \gamma\_\_\delta$ is opaque if there are surface representations in the language having

either	(i)	α in the environment $\gamma\_\_\delta$	(*underapplication*)
or	(ii)	β derived by $\mathcal{R}$ in an environment other than $\gamma\_\_\delta$	(*overapplication*)

§4 Rule-ordering approach:

Rule $\mathcal{R}$ is ordered before another rule $\mathcal{S}$ such that

either	(i)	$\mathcal{S}$ creates the target of $\mathcal{R}$ (viz. $\gamma\alpha\delta$)	(*counterfeeding*)
or	(ii)	$\mathcal{S}$ destroys the environment of $\mathcal{R}$ (viz. $\gamma\_\_\delta$)	(*counterbleeding*)

The problem for OT

§5 A large set of phonological phenomena previously modelled by means of opaque rules cannot be described in the original version of OT (Prince & Smolensky 1993):

The signature of underapplication:
- a language has grammatical output forms containing [$\gamma\alpha\delta$],
- yet there is independent evidence requiring the ranking *$\gamma\alpha\delta$ » FAITH-α.

The signature of overapplication:
- a language has expressions where input /α/ is unfaithfully mapped onto output [β],
- yet there is no markedness constraint M ranked above FAITH-α such that the mapping /α/→[β] in these expressions increases harmony with respect to M.

How significant is the problem?

§6 Opacity is one of the clearest instances of *Plato's Problem* (Chomsky 1986) in phonology, as learners must acquire generalizations that are not true on the surface.

⇨ The ability to explain the acquisition of opaque grammars should be regarded as one of the main criteria by which generative theories of phonology are to be judged.

APPROACHES TO OPACITY IN OT: STRATAL OT

The common ground to the main approaches

§7 Opaque generalizations are true of some representation different from, but related to, the output.

§8 *Stratal OT* (e.g. Bermúdez-Otero 1999, 2003, etc.; Kiparsky 2000, 2002, etc.):

the opaque generalization holds true of a *phonological cycle associated with a subdomain of the expression*.

§9 *Transderivational correspondence*:

- paradigmatic opacity (e.g. *writer* [ɹəiɾɚ]) ⇨ OO-correspondence (e.g. Benua 1997) the opaque generalization holds true of the *output representation of a grammatically related expression* (e.g. *write* [ɹəit]);
- nonparadigmatic opacity (e.g. *mitre* [məiɾɚ]) ⇨ sympathy (McCarthy 1999, 2003) the opaque generalization holds true of the *output selected (for the same input) by a related constraint hierarchy*.

Sympathy is invoked where an analysis based on OO-correspondence is not available.

Stratal OT

§10 *Cyclic application*

Given a linguistic expression *e* with a phonological input representation *I*, the phonological function *P* applies recursively from the inside out within a nested hierarchy of phonological domains associated with the morphosyntactic constituent structure of *e*:

i.e. if $I = [[x][[y]z]]$, then $P(I) = P(P(x),P(P(y),z))$.

§11 *Level segregation*

The phonology of a language does not consist of a single function *P*, but of a set of distinct functions or 'levels' $\{P_1, P_2, \ldots, P_n\}$, such that the specific function P_i applying to domains of type δ_i is determined by the type of morphosyntactic construction associated with δ_i.

Bermúdez-Otero (in preparation) and Kiparsky (2000, 2003, etc.) acknowledge three levels (the *stem level*, *word level*, and *phrase level*), roughly corresponding to the cyclic, postcyclic, and postlexical strata of classical ruled-based Lexical Phonology.

§12 *Cycle-internal transparency*

Each cycle involves a single pass through *Gen* and *Eval*:

i.e. $P_i(\delta_i) = Eval_i(Gen(\delta_i))$

Within cycles, computation is parallel; seriality only arises from the interaction between cycles.

§13 *Key predictions*

- Within each cycle, the input-output mapping is transparent; *opacity arises only from the serial interaction between cycles.*
- The complexity of opacity effects is bounded by the *number of cycles*, which is in turn independently constrained by the *morphosyntactic structure* of the linguistic expression.
- The only criterion that determines the level ascription of a phonological process (i.e. a ranking of constraints) is the *morphosyntactic domain where the process applies*: e.g. a process cannot be assigned to the word level if it does not apply transparently in word-level domains.

RAISING AND FLAPPING IN CANADIAN ENGLISH: GRAMMAR

A classic case of opacity

§14 • *Raising* /aɪ, ɑʊ/ → [əi, ʌʊ] / __ [-voice] under certain prosodic conditions

• *Flapping* /t, d/ → [ɾ] / $\left\{\begin{matrix}\text{ɹ} \\ \text{V}\end{matrix}\right\}$ __ V under certain prosodic conditions

• Flapping *counterbleeds* Raising, so that Raising appears to *overapply*.

	writing	*riding*	*mitre*	*spider*
UR	/ɹaɪt-ɪŋ/	/ɹaɪd-ɪŋ/	/maɪtəɹ/	/spaɪdəɹ/
Raising	ɹəitɪŋ	—	məitər	—
Flapping	**ɹəiɾ**ɪŋ	ɹaɪɾɪŋ	**məiɾə**ɹ	spaɪɾəɹ

For discussion, see Joos (1942), Chomsky (1964: 74), Chomsky & Halle (1968: 342), Bromberger & Halle (1989: 58-61), Kenstowicz (1994: 6-7), Hayes (1999: §8).

§15 The opacity effect is psychologically real: evidence from repetition-priming experiments in Luce *et al.* (1999: 1892):

> Our results suggest that — at least in the recognition of flapped items in American English — recovery processes do indeed map the surface manifestation of the flap onto representations in which underlying abstract voicing categories are well specified.

Raising

§16 Raising is triggered by a following *voiceless segment* (henceforth C̥):

e.g. *write* [ɹəit] cf. *ride* [ɹaɪd]
knife [nəif] cf. *knives* [naɪvz]

§17 Raising is bounded by the *prosodic word* (ω):

e.g. *high school* [$_{\omega'}$ [$_{\omega}$ ˈhaɪ][$_{\omega}$ ˌskuːl]] cf. univerbated [$_{\omega}$ ˈhəiˌskuːl]
tie shop [$_{\omega'}$ [$_{\omega}$ ˈtaɪ][$_{\omega}$ ˌʃɑp]]

§18 Within ω, the trigger C̥ may belong to a following weaker foot:

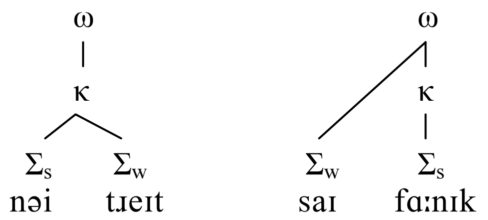
e.g. *nitrate* [$_{\omega}$ [$_{\Sigma}$ ˈnəi][$_{\Sigma}$ ˌtɹeɪt]]

But the trigger C̥ must not belong to a stronger foot:

e.g. *syphonic* [$_{\omega}$ [$_{\Sigma}$ ˌsaɪ][$_{\Sigma}$ ˈfɑːnɪk]]
citation [$_{\omega}$ [$_{\Sigma}$ ˌsaɪ][$_{\Sigma}$ ˈteɪʃn]]

Possible analysis: the prosodic domain of Raising is the *colon* (κ), defined as a sequence of a (strong) foot plus any weaker feet following it within ω:

e.g.



§19 Raising *underapplies before word-level suffixes* (Bermúdez-Otero 2003):

e.g. *eyeful* [aɪfʊl], *[əifʊl] cf. *Eiffel* [əifəl]
Fraușhip [fɹaʊʃɪp], *[fɹʌʊʃɪp]

Implication: Raising applies at the stem level.

Why not pursue a prosodic, rather than morphophonological, analysis?

e.g. *eyeful* [$_{\omega'}$ [$_{\omega}$ aɪ] fʊl] ?

Because there is no independent phonetic evidence for an ω-boundary intervening between a word-level suffix and its base:

e.g. sensitivity of gradient duration rules to boundaries (Sproat 1993: 178)

> [...F]or no speaker is it the case that the + [e.g. +*ic*; RB-O] or # [e.g. #*ing*; RB-O] boundary contexts show a significant difference from each other or from the no-boundary context (0). On the other hand, for every speaker […] the difference between the compound boundary cases and the other lexical cases [sc. 0, +, #; RB-O] is significant. […W]hile there is no evidence of sensitivity to weaker lexical boundaries (+ and #), duration rules are sensitive to the edges of other domains, including compound boundaries.

Raising and Prefortis Clipping

§20 A connection between Canadian Raising and Prefortis Clipping has long been surmised (e.g. Trudgill 1986, McMahon 2000).

Strong position: *the environments of Canadian Raising and Prefortis Clipping are in fact identical*.

§21 Evidence:

- Prefortis Clipping *underapplies before word-level suffixes*:

e.g.	*awe-some*	Wells (1990) /ˈɒː səm/	i.e. [ɒːsəm], *[ɒsəm]
	law-ful	Wells (1990) /ˈlɒː fᵊl/	i.e. [lɒːfl̩], *[lɒfl̩]
cf.	*gruesome*	Wells (1990) /ˈgruːs əm/	i.e. [gɹusəm], *[gɹuːsəm]
	waffle	Wells (1990) /ˈwɑːf ᵊl/	i.e. [wɑfl̩], *[wɑːfl̩]

- Prefortis Clipping *overapplies* before flapped /t/, i.e. is *counterbled by Flapping*:

e.g.	*utter*	*udder*
UR	/ʌtəɹ/	/ʌdəɹ/
Clipping	ʌ̆təɹ	—
Flapping	ʌ̆ɾəɹ	ʌɾəɹ
SR	[**ʌ̆ɾ**ɚ]	[ʌɾɚ]

[Phonetic evidence (Zue & Laferriere 1979, Patterson & Connine 2001, etc.):
(i) no significant difference in mean duration between flapped /d/ and flapped /t/;
(ii) on average, vowels 9ms longer before flapped /d/ than before flapped /t/;
(iii) near merger —difference maintained in production but not exploited in lexical recognition.
⇨ A gradient, nonneutralizing phonetic process of durational adjustment reduces, but does not eliminate, the categorical length difference between clipped and unclipped vowels before flaps.]

§22 Conclusions: <u>Raising applies at the stem level to clipped diphthongs</u>.

§23 Rankings for Raising:

- CLEARDIPH » IDENT[mid],
- CLIPDIPH » IDENT[low],

and
- CLIPDIPH » CLEARDIPH,

where

- **CLEARDIPH**
  Maximize the distance between diphthongal elements.
  ⇨ *əi, *ʌʊ.

- **CLIPDIPH**
  In clipped diphthongs, minimize the distance between elements.
  ⇨ *aɪt, *ɑʊt.

- **IDENT[mid]**
  Let α be an input segment, and let β be its output correspondent; if α is [mid], then β is [mid].
  ⇨ /əi, ʌʊ/ *→ [aɪ, ɑʊ].

- **IDENT[low]**
  Let α be an input segment, and let β be its output correspondent; if α is [low], then β is [low].
  ⇨ /aɪ, ɑʊ/ *→ [əi, ʌʊ].

Flapping

§24 I assume the Kiparsky-Jensen analysis:

- Stops are tensed at the word level if foot-initial (in certain dialects, if colon-initial); otherwise, they are lax.
- At the phrase level, lax [t] and lax [d] are flapped between in the environment V/ɹ__V.

§25 Flapping must be phrase-level because *its domain straddles word boundaries*:

e.g.	*He hit Ann*	[hi hɪ̆ɾ æn]	cf. *hit* [hɪ̆t]
	He hid Ann	[hi hɪɾ æn]	cf. *hid* [hɪd]

Support for Stratal OT

§26 The counterbleeding interaction between Raising and Flapping follows, as predicted by the theory, from their *level ascription*, which is independently determined by their *morphosyntactic domain*:

<u>Raising precedes Flapping because Raising is stem-level and Flapping is phrase-level</u>.

LEARNABILITY

Restrictiveness ≠ learnability

§27 • If two theories of grammar T_1 and T_2 define the grammar spaces S_1 and S_2 respectively, and if both S_1 and S_2 are too large for convergence to be guaranteed by brute-force searching, then the prime determinant of learnability will be the *relative efficiency of the learning algorithms associated with T_1 and T_2*, rather than the *relative size of S_1 and S_2* (Tesar & Smolensky 2000: 2-3).

- <u>A phonological model cannot achieve explanatory adequacy in respect of opacity simply by restricting the space of possible opaque effects; one must show that the learner is able to search that space effectively</u>.

The acquisition of opacity in Sympathy Theory

§28 • There is, at present, no algorithm for acquiring sympathy-theoretic grammars (McCarthy 1999: 340).

• *Proposal*: Assume a ❀O-IDENT » IO-FAITH bias (Dinnsen *et al.* 2000).
Problem: Historically, opaquely derived surface properties are reanalysed as underlying, not vice versa.

• Conclusion: Sympathy Theory cannot account for the acquisition of opacity.

The acquisition of opacity in Stratal OT

§29 *Iterative stratum construction*

input to level *n* = output of level *n−1*

URs = input to stem level
↑
Stem-level hierarchy
↑
output of stem level = input to word level
↑
Word-level hierarchy
↑
output of word level = input to phrase level
↑
Phrase-level hierarchy
↑
output of phrase level =SRs

§30 *Emergence of opacity*

• Let a process *p* apply at level *n* and become opaque at level *n+1*.
• Assume an ordinary constraint ranking algorithm that *only acquires output-true rankings.*

Then:

• Ex hypothesi, *p* is not output-true at *n+1*. Accordingly, the ranking algorithm will not set up the hierarchy for *p* at *n+1*.

• Assume that the learner assigns input representations correctly at *n+1*; see §32 and §33 below. Now, input to *n+1* = output of *n*. Ex hypothesi, *p* is output-true at *n*. Accordingly, the ranking algorithm sets up the hierarchy for *p* at *n*.

§31 *Constraint ranking by pure phonotactic learning under the identity map*

• To find the constraint hierarchy of a level *n*, given output forms:

(i) assume the identity map (I = O),
(ii) assume a MARKEDNESS » FAITHFULNESS bias,
(iii) demote markedness constraints and promote faithfulness constraints just enough to derive the output from identical input.

See e.g. Prince & Tesar (1999), Hayes (1999).

- Alternations normally conspire to bring collocations in line with output phonotactics (Kisseberth 1970).

  Accordingly, *purely distributional evidence* will normally suffice to find the constraint rankings driving not only phonotactics but also alternations.

§32 *Input assignment (I): alternations prompt departures from the identity map*

- Learners only depart from the identity map when faced with *alternations* (Yip 1996; cf. Alderete & Tesar 2002).

  In line with *Input Optimization* (Prince & Smolensky 1993: §9.3), departures from the identity map are minimal.

- **Input optimality** (Bermúdez-Otero in preparation)
  An input representation is optimal iff it has no competitor that
  (i) generates an identical set of output alternants,
  and (ii) generates all output alternants no less efficiently,
  and (iii) generates some output alternant more efficiently
  [where efficiency = satisfaction of high-ranking faithfulness constraints].

- Where more than one input representation is optimal, follow one of the following heuristics:
  (i) **Hale's heuristic** (after Hale 1973: 420)
  Prefer inputs that are well-formed outputs.
  (ii) **Heuristic for asymmetric paradigms**
  In an asymmetric paradigm, prefer those inputs that generate the morphologically unmarked member most efficiently.

§33 *Input assignment (II): Archiphonemic Prudence*

Dealing with opacity in non-alternating items:

- Let the following situation of *contextual neutralization* obtain at level *n*:

$$\begin{tikzcd}[column sep=small] & /\alpha/ \arrow[dl] \arrow[dr] & & /\beta/ \arrow[dl] \arrow[dr] & \\ [\alpha]_e & & [\gamma]_f & & [\beta]_e \end{tikzcd}$$

$\{\alpha, \beta\} \rightarrow \gamma$ / $[\_\_]_f$ level *n*

- If the *archiphonemic string* $[\gamma]_f$ occurs in the output representation of a non-alternating item *i* level n, then

  (i) assume that, in *i* too, either $\begin{array}{c}/\alpha/\\ \downarrow\\ [\gamma]_f\end{array}$ or $\begin{array}{c}/\beta/\\ \downarrow\\ [\gamma]_f\end{array}$

  (ii) put the two possible input representations for *i* at level *n* in '*quarantine*' by excluding them from the data set triggering acquisition at level *n−1*;

  (iii) when the constraint hierarchy for *n−1* is known, discard any input representation for *i* at level *n* that is not a well-formed output at level *n−1.*

§34 *Interim evaluation of the model*

- It makes the most of the *assets of the synchronic theory*, fully exploiting the serial interaction between strata (§29) and the intimate connection between the domain of a process and its stratal ascription (§30).

- It adopts independently motivated solutions to the problem of acquiring constraint rankings (§31) and input representations for alternating items (§32).
- Only stipulation: Archiphonemic Prudence (§33).

RAISING AND FLAPPING IN CANADIAN ENGLISH: ACQUISITION

Acquiring the phrase-level cophonology

§35 *Constraint rankings*

- Flapping is output-true ⇨ The ranking for Flapping is set up by pure phonotactic learning.
- Raising misapplies ⇨ The ranking for Raising is not established:

Datum	*Triggered ranking*
məiɾɚ ≻ maɪɾɚ 'mitre' ɹəiɾɪŋ ≻ ɹaɪɾɪŋ 'writing'	IDENT[mid] » CLEARDIPH
aɪfʊl ≻ əifʊl 'eyeful'	CLEARDIPH » CLIPDIPH

§36 *Input assignment for alternating items*

- [hɪ**t**] *hit* ~ [hɪ**ɾ** æn] *hit Ann*
  optimal input: /hɪt/
- [hɪ**d**] *hid* ~ [hɪ**ɾ** æn] *hid Ann*
  optimal inputs: /hɪd/ and */hɪɾ/; Hale's heuristic and the heuristic for asymmetric paradigms select /hɪd/.

§37 *Input assignment for non-alternating items*

- The analysis of alternations shows that there is an archiphonemic string [ɾ] with two possible input correspondents /t/ or /d/.
- Accordingly, by Archiphonemic Prudence:

Quarantined item		*Phrase-level input candidates*
[məiɾɚ]	'mitre'	/məitəɹ/, /məidəɹ/
[spaɪɾɚ]	'spider'	/spaɪtəɹ/, /spaɪdəɹ/
[rəiɾɪŋ]	'writing'	/ɹəitɪŋ/, /ɹəidɪŋ/
[raɪɾɪŋ]	'riding'	/ɹaɪtɪŋ/, /ɹaɪdɪŋ/

Acquiring the word-level cophonology

§38 *Constraint rankings (I)*

- Raising does not overapply in the output of the word level:
  (i) surface [məiɾɚ] 'mitre' is under quarantine;
  (ii) at the phrase level, [ɹəiɾ ʌp]←/ɹəit ʌp/ 'write up'.
- Raising underapplies in the output of the word level:
  e.g. [aɪfʊl] *eyeful*.

- Triggered ranking: Ident[low] » ClipDiph » ClearDiph » Ident[mid].

§39 *Quarantine lifting (I)*

		Ident[low]	ClipDiph	ClearDiph	Ident[mid]
məidəɹ	məidəɹ			*!	
	maɪdəɹ 💣				*
məitəɹ ☜	məitəɹ ☜			*	
	maɪtəɹ		*!		*
ɹəidɪŋ	ɹəidɪŋ			*!	
	ɹaɪdɪŋ 💣				*
ɹəitɪŋ ☜	ɹəitɪŋ ☜			*	
	ɹaɪtɪŋ		*!		*

§40 *Constraint ranking (II)*

Flapping does not apply in the new word-level outputs [məitəɹ] and [ɹəitɪŋ]
⇨ The constraint ranking for Flapping is blocked.

§41 *Input assignment*

Trivial (no alternations): [aɪ] *eye* ~ [aɪfʊl] *eyeful* ← /aɪ-/ *eye*
[ɹəit] *write* ~ [ɹəitɪŋ] *writing* ← /ɹəit-/ *write*

Acquiring the stem-level cophonology

§42 *Constraint ranking*

- Raising does not overapply in the output of the stem level. Recall that surface [məiɾəɹ] *mitre* and [ɹəiɾɪŋ] *writing* have been correctly assigned the phrase-level input representations /məitəɹ/ and /ɹəitɪŋ/ by Archiphonemic Prudence.
- Raising does not underapply in the output of the stem level:
  [aɪfʊl] ← /aɪ-/+/-fʊl/ at the word level
- The normal application of Raising triggers the ranking {ClearDiph » Ident[mid]}, {ClipDiph » Ident[low]}, and {ClipDiph » ClearDiph}; see §23 above.

§43 *Quarantine lifting (II)*

		ClipDiph	ClearDiph	Ident[low]	Ident[mid]
spaɪtəɹ	spaɪtəɹ	*!			
	spəitəɹ 💣		*	*	
spaɪdəɹ ☜	spaɪdəɹ ☜				
	spəidəɹ		*!	*	
ɹaɪtɪŋ	ɹaɪtɪŋ	*!			
	ɹəitɪŋ 💣		*	*	
ɹaɪdɪŋ ☜	ɹaɪdɪŋ ☜				
	ɹəidɪŋ		*!	*	

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