

The diachronic rise and synchronic representation of phonological opacity: a case study

Ricardo Bermúdez-Otero
University of Manchester

OVERVIEW

§1 */aɪ/-allophony in English: the received view*

- In many English dialects, notably including Canadian English, /aɪ/ exhibits allophonic behaviour like the following:

$$/aɪ/ \rightarrow \begin{cases} [aɪ] & \text{e.g. } \textit{sigh, sign, dive, side} \\ [\Delta i] & \text{e.g. } \textit{life, sight} \end{cases}$$

- The received view of this allophonic pattern is that it reflects the application of a context-sensitive process of /aɪ/-raising triggered by voiceless obstruents:

$aɪ \rightarrow \Delta i$ / ___[-voice] under certain prosodic conditions

E.g. Chambers (1973: 116, 1989: 79), Joos (1942: 141), Paradis (1980), among countless others.

- In this view, the overapplication of raising before flapped /t/ involves a counterbleeding interaction between raising and flapping (e.g. Halle 1962):

	/ɹaɪdɪtəl/	/ɹaɪtɪtəl/	/aɪdɪtəl/	/taɪtəl/
raising	—	ɹaɪtɪtəl	—	tɪtəl
flapping	ɹaɪrɪtəl	ɹaɪrɪtəl	aɪrɪtəl	tɪrɪtəl

§2 *Empirical challenges to the received view*

Recent research into /aɪ/-allophony raises three problems for the received view:

- /aɪ/-raising overapplies before /t/-flaps in all English dialects.
This is unexpected if transparency is the unmarked state of affairs.
- /aɪ/-raising overapplies before /t/-flaps even in its incipient, phonetically gradient stage.
Given that flapping is categorical, this is unexpected in modular feedforward frameworks where phonology serially precedes phonetics.
- /aɪ/-raising overapplies before /t/-flaps even in dialects where raising is younger than flapping.
This is unexpected in the light of the life cycle of phonological processes, according to which new sound patterns enter the grammar as transparent processes of phonetic implementation.

§3 *The solution: the enhancement-of-clipping hypothesis*

The puzzles in §2 disappear once we properly understand the relationship between /aɪ/-raising and prefortis clipping, the process that shortens English vowels before voiceless obstruents.

- Prefortis clipping is a categorical phonological process applying at the stem level.
- Clipping overapplies before /t/-flaps because it is stem-level, whereas flapping is phrase-level.
- /aɪ/-allophony starts its life cycle as a gradient process of offglide peripheralization that provides an additional acoustic cue to clipping.
- Hence, /aɪ/-raising is a transparent context-free process applying to categorically clipped tokens of /aɪ/, and not an opaque context-sensitive process; it is only clipping that is opaque and context-sensitive.

This analysis is consistent with

- (i) modular feedforward architectures,
- (ii) phonological stratification,
- and (iii) the life cycle of phonological process.

§4 *Supporting evidence*

This analysis correctly predicts the following facts:

- (i) /aɪ/-raising is sensitive to the categorical status of its target as clipped or unclipped, not to gradient duration;
- (ii) the distribution of raised [ɪ] is wider in Scottish dialects, where the Scottish Vowel Length Rule clips /aɪ/ before all consonants other than voiced continuants.

PROBLEMS FOR THE RECEIVED VIEW OF /aɪ/-RAISING

/aɪ/-raising overapplies before /t/-flaps in all English dialects

§5 *The myth of 'dialect B'*

- Joos (1942: 143-44):

dialect A *write* [ɪɹaɪt] ~ *writer* [ɪɹaɪɹɪ]

dialect B *write* [ɪɹaɪt] ~ *writer* [ɪɹaɪɹɪ] (allegedly extant in Ontario in the 1940s)

Further reports in Rudes (1976) and, indirectly, Picard (1977).

Picked up as an argument for extrinsic rule ordering by Halle (1962), subsequently echoed in Chomsky and Halle (1968: 342), Bromberger and Halle (1989: 58-60), and Kenstowicz (1994: 6-7), among others.

- But dialect B never existed.

Chambers (1973: 122): no dialect-B speakers in the 1970s.

Kaye (1990): if ever there were any, they all died young (transparency kills!)

§6 *No diachronic explanation for the absence of transparent dialects*

- If transparency is the unmarked state of affairs because opaque interactions are hard to learn (Kiparsky 1971: 632; cf. Baković 2011) then the absence of transparent dialects like ‘dialect B’ is unexpected.
- Possible diachronic explanation: there are no transparent dialects because...
 - in all dialects, /aɪ/-allophony is chronologically older than /t/-flapping
 - and there simply has been no reanalysis of opaque surface forms.
- Counterexample: Philadelphia English (Fruehwald 2013) see §9–§11 below.

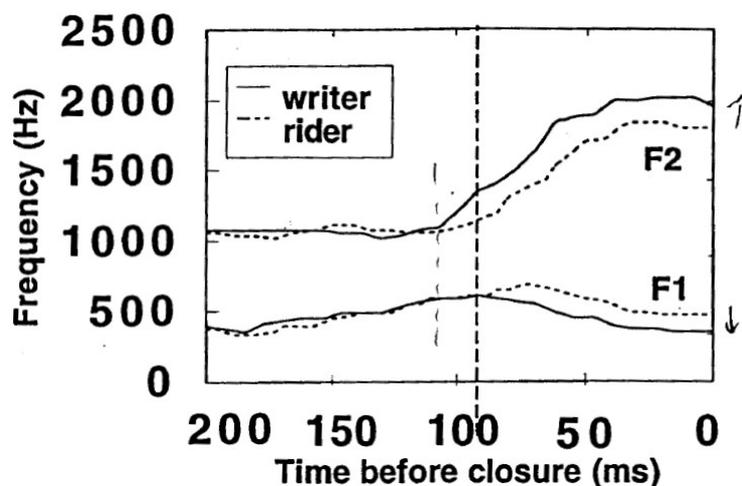
/aɪ/-raising overapplies before /t/-flaps even in its incipient, phonetically gradient stage

§7 *Gradient offglide peripheralization before flapped /t/*

- The phonetic precursor of nucleus raising is offglide peripheralization:

i.e. [Jaɪt] >peripheralization [Jaɪt] >raising [Jʌɪt]

See Thomas (1991, 2000), Moreton (2004), Gussenhoven (2007), Moreton and Thomas (2007).
- Offglide peripheralization is highly pervasive: all dialects investigated show it to some degree. See Kwong and Stevens (1999), Thomas (1991: §4; 2000), Moreton (2004).
- Offglide peripheralization applies before flapped /t/, even in dialects where the nucleus has not yet been affected by raising, and where peripheralization remains a small, apparently gradient effect.

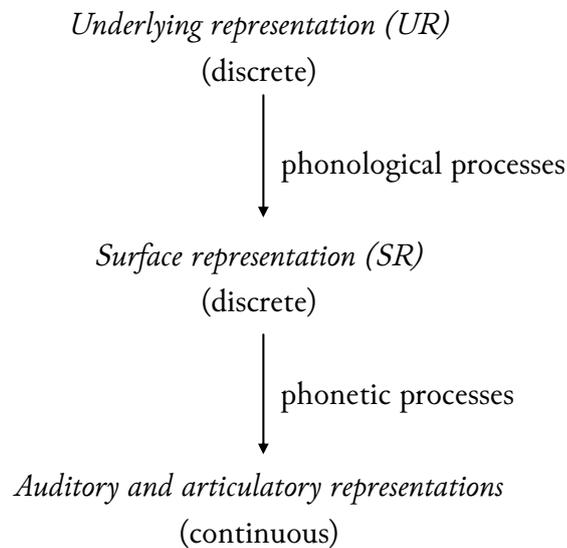


Time-normalized F1 and F2 trajectories for /aɪ/ in *writer* and *rider* uttered by a college-age American male. Note identical nuclei but peripheralized offglide in *writer*.

(Kwong and Stevens 1999: 8)

§8 *A puzzle for classical modular feedforward architectures*

- In such architectures, phonology serially precedes phonetics:

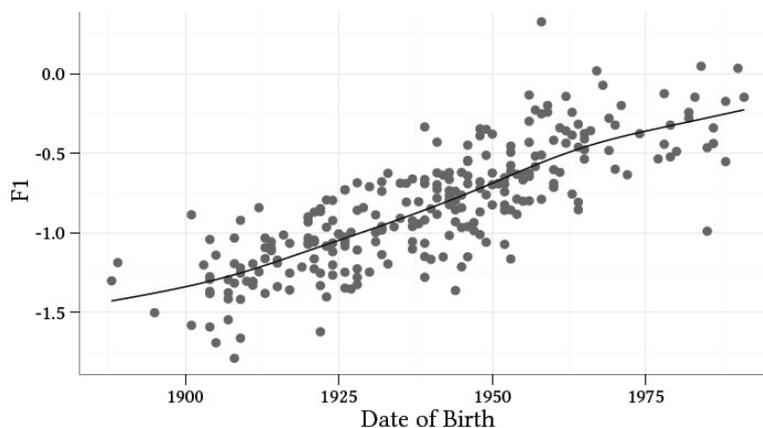


See Pierrehumbert (2002: 101-2), Bermúdez-Otero (2007: 502, 2014: §2.1), Bermúdez-Otero and Trousdale (2012: 693), among others.

- Hence, a gradient phonetic process like offglide peripheralization should never be made opaque by a categorical phonological process.
- Yet /t/-flapping is demonstrably categorical (Herd et al. 2010).

/aɪ/-raising overapplies before /t/-flaps even in dialects where raising is younger than flapping§9 */aɪ/-raising is a recent innovation in Philadelphia* (Fruehwald 2013)

- Implemented in a phonetically gradient fashion during the 20th century:

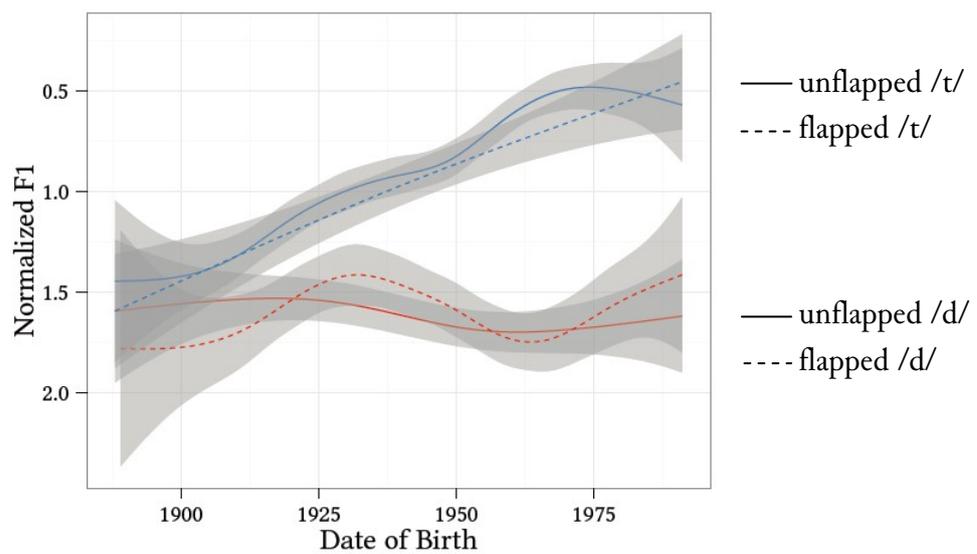


(Fruehwald 2013: 34)

- Data from the Philadelphia Neighbourhood Corpus (Labov and Rosenfelder 2013):
dots represent an individual speaker's mean F1 for the nucleus of /aɪ/ in canonical raising environments (see §23–§25 below).
- In other environments, nucleus F1 remains roughly flat: see e.g. Fruehwald (2013: 112).

§10 /aɪ/ raised before flapped /t/, but not before flapped /d/, as in all dialects

/d/-flap	▶ no raising	{	<i>rider</i>	/ɹaɪd-əɪ/	→	[ɹaɪrəɪ]
			<i>idle</i>	/aɪdəl/	→	[aɪrəl]
/t/-flap	▶ raising	{	<i>writer</i>	/ɹaɪt-əɪ/	→	[ɹaɪrəɪ]
			<i>title</i>	/taɪtəl/	→	[taɪrəl]



(Fruehwald 2013: 121)

§11 In Philadelphia, /t,d/-flapping is chronologically older than /aɪ/-raising

- /t,d/-flapping already active before the inception of /aɪ/-raising:
i.e. [ɹ] in both *utter* and *udder* already in the 19th century.
- Puzzling diachronic evolution:

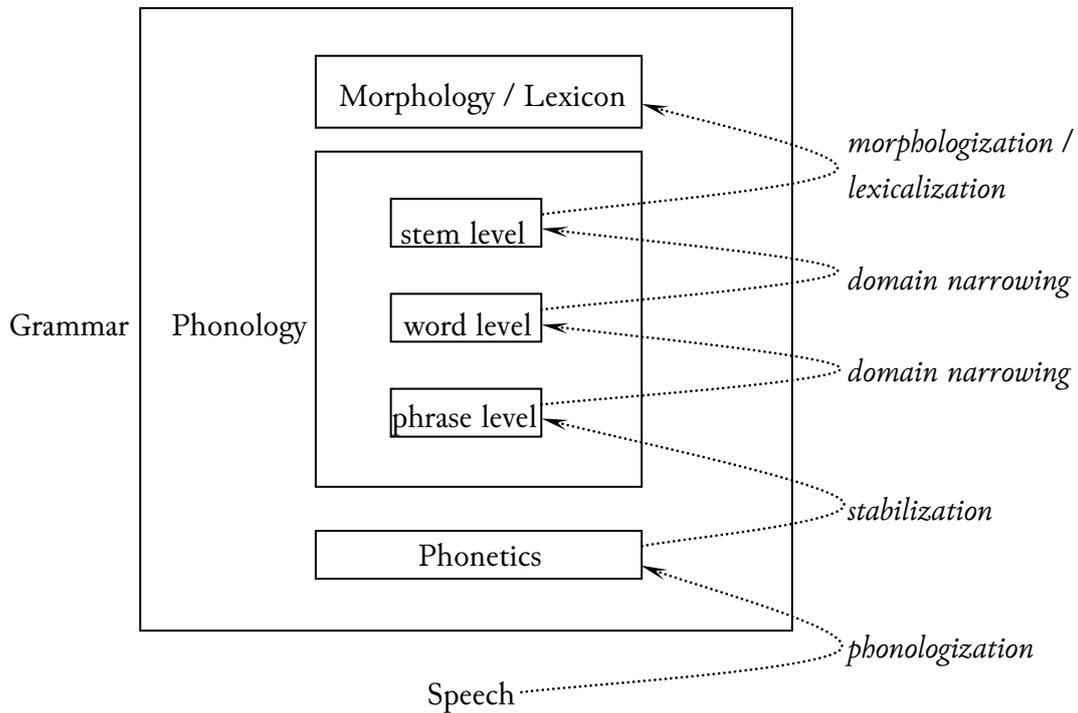
	<i>rider</i>	<i>writer</i>	<i>idle</i>	<i>title</i>
1900	[ɹaɪrəɪ]	[ɹaɪrəɪ]	[aɪrəl]	[taɪrəl]
2000	[ɹaɪrəɪ]	[ɹaɪrəɪ]	[aɪrəl]	[taɪrəl]

§12 More dialects like Philadelphia

Raised [aɪ] before flapped /t/ in dialects where /aɪ/-raising is a mid or late 20th century innovation:

- 3 informants in Rochester (upstate New York) in 1975 (Vance 1987: 202)
- 30 natives of Ann Arbor (Michigan) in 1995 (Dailey-O’Cain 1997: 110–11)

Neither upstate New York nor Michigan had raising in the 19th century (Thomas 1991: §2–§3).

§13 *A puzzle for the life cycle of phonological processes*

(Bermúdez-Otero and Trousdale 2012: 700)

- New sound patterns enter the grammar from below, as gradient processes of phonetic implementation (phonologization).
- These new processes apply transparently across the board.
They cannot be born opaque because they are not directly inserted in the middle of the grammar: there is no change by ‘rule insertion’ (King 1973, Gress-Wright 2011, Roberts 2011).
- Opacity emerges through aging, as older processes undergo stabilization and domain narrowing, and younger processes enter the grammar from below.

See e.g. Kiparsky (1988, 1995), Bermúdez-Otero (2007: 503ff; 2014), Bermúdez-Otero & Trousdale (2012: §2), Ramsammy (forthcoming).

Summary: the new puzzle of /aɪ/-raising and /t/-flapping

§14

In **all** English dialects that have /t,d/-flapping
and /aɪ/-allophony apparently conditioned by consonant voicing,
/aɪ/ followed by a /t/-flap behaves like /aɪ/ followed by a voiceless obstruent,
regardless of whether /aɪ/-allophony is young or old in the dialect,
or whether /aɪ/-allophony is gradient or categorical.

THE SOLUTION: /aɪ/-RAISING TARGETS CATEGORICALLY CLIPPED ALLOPHONES

Key ideas

- §15 Prefortis clipping... • is categorical,
• applies at the stem level,
• is therefore counterbled by phrase-level /t/-flapping in dialects that have the latter.
- §16 /aɪ/-raising... • is a context-free process targeting categorically clipped allophones of /aɪ/,
• is therefore transparent (it is clipping that is opaque),
• starts out as a gradient enhancement of clipping, though it can be stabilized later (as happened already long ago in Ontario).
- §17 Therefore, the correct statement of /aɪ/-raising, at least in its incipient stages, is
not aɪ → ʌi / __[-voice] under certain prosodic conditions (context-sensitive)
but ǎi → ʌi (context-free)
- §18 Derivations in early 20th-century Philadelphia:
- | | | | | | |
|--------------|------------|--------------|---------------|-------------|--------------|
| | | <i>rider</i> | <i>writer</i> | <i>idle</i> | <i>title</i> |
| Stem level | (clipping) | ˌaɪd | ˌaɪt | aɪdəl | tʌɪtəl |
| Word level | | ˌaɪpɪɹ | ˌaɪtɪɹ | aɪdəl | tʌɪtəl |
| Phrase level | (flapping) | ˌaɪrɪɹ | ˌaɪrɪɹ | aɪrəl | tʌɪrəl |
| Phonetics | (raising) | ˌaɪrɪɹ | ˌɛɪrɪɹ | aɪrəl | tʌɪrəl |

The relative order of processes...

- was fully determined by their stratal affiliation,
- unproblematically reflected the sequence of corresponding historical innovations.

Prefortis clipping is categorical

§19 *A long-standing question*

“[W]hat is the status of vowel length before voiced sounds in English, *bead* [bi:d] versus *beat* [bit]? The difference is greater than observed in many other languages (Keating 1985), but does it count as phonological?”

(Cohn 2006: 26)

For discussion of the general approach to categoricity and gradience I adopt here, see Bermúdez-Otero and Trousdale (2012: 694-96) and Strycharczuk (2012: 45-7).

§20 *Key points*

- The magnitude of the durational difference between clipped and unclipped allophones in English is extreme
(Chen 1970; see Sóskuthy 2013: 196-99 for a review of later literature).
- Prefortis clipping suffices to cue the laryngeal contrast by itself
(Denes 1955, Klatt 1976, Port and Dalby 1982, among many others).
- Prefortis clipping is itself not sensitive to the magnitude of other phonetic cues to the laryngeal contrast:
crucially, in English dialects with anticipatory assimilation in voicing/voicelessness, vowel duration remains unaffected by assimilation (Jansen 2004: 142).

§21 *If prefortis clipping is categorical, how is it represented in the phonology?*

- A simple proposal:
- voiceless obstruents share the skeletal unit of the preceding vocoid;
 - skeletal attachments iconically reflect durational trade-offs.

<i>bid</i>	<i>bit</i>	<i>bead</i>	<i>beat</i>	<i>bide</i>	<i>bite</i>
X X	X X	X X X	X X X	X X X	X X X
	\	∨	∨ \		\ \
ɪ d	ɪ̥ t	i: d	i̥ t	a ɪ d	ä ɪ t

On durational trade-offs in prefortis clipping, see Kluender et al. (1988).

On 'mora sharing', see Maddieson (1993), Maddieson and Ladefoged (1993), Hubbard (1995a,b), and Broselow et al. (1997).

A similar application of mora sharing to the analysis of Canadian raising has been independently proposed by Onosson (forthcoming).

Prefortis clipping and /aɪ/-raising are found in exactly identical environments

§22 *The evidence of Canadian English*

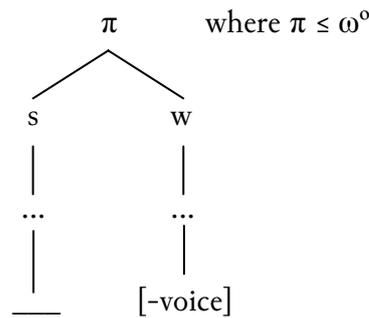
Canadian data are particularly valuable because the environment of /aɪ/-raising in places like Philadelphia is very similar to the environment of Canadian raising,

but Canadian raising is...

- exhaustively described
- categorical
- old already established in the late 19th century;
- sociolinguistically stable no significant difference in application between the 1970s and today, aside from variation in respect of fronting of the nucleus; remarkably uniform application across Canada.

See e.g. Chambers (1973, 1989, 2006), Chambers and Hardwick (1986), Rosenfelder (2007), Thomas (1991).

§23 *The prosodic environment of Canadian raising*



- Raising is triggered by a following voiceless consonant (C_0):

e.g. *write* [ʌɪt] cf. *ride* [ʌɪd]
 knife [nɪɪf] cf. *knives* [nɪɪvz]

- Raising does not apply across prosodic word boundaries (ω):

e.g. *high school* [ω' [ω 'hɑɪ] [ω ,sku:l]] cf. *univerbated* [ω 'hɪɪ,sku:l]
 tie shop [ω' [ω 'tɑɪ] [ω ,ʃɑp]]

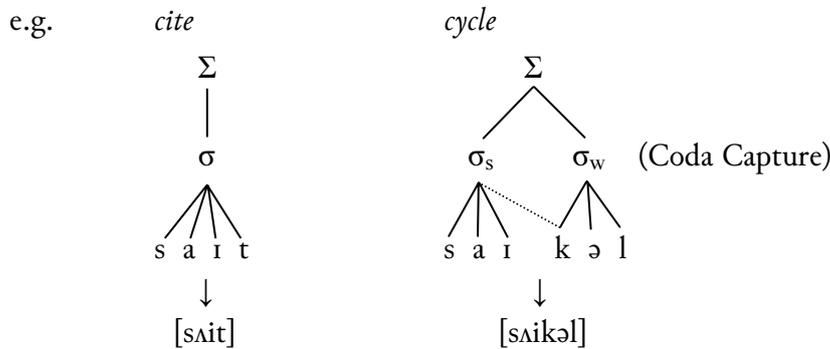
Idsardi (2006: 26) reports that, in his idiolect, raised [ɪɪ] is acceptable in *Don't lie to me*. I have been unable to find another Canadian speaker who concurs with this introspective judgment.

- Within ω° , the trigger C_0 must be in a weak branch of the lowest prosodic node dominating both trigger and target:

i.e.	in the coda	<i>cite</i>	[sɪɪt]
	in the a onset of a following weak syllable	<i>cycle</i>	['sɪɪ.kəl]
	in the onset of a following weaker foot	<i>nitrate</i>	[ω [Σ 'nɪɪ] [Σ ,tɪɪɪt]]
but not	in the onset of a following stronger foot	<i>citation</i>	[ω [Σ ,sɪɪ] [Σ 'tɪɪʃən]]

§24 *Excursus: against the ambisyllabic analysis*

- Paradis (1980) and Chambers (1989: §2) propose that raising is triggered by a tautosyllabic C_0 . Key assumption: ambisyllabicity à la Kahn (1976).



- This analysis incurs a fatal paradox:

(i) In the dialect described by Chambers, raising applies to *nitràte* [nɪɪtɪɪt].

Therefore, the /t/ of *nitràte* must be ambisyllabic.

Therefore, secondary stress on the following syllable must not block Coda Capture.

(ii) If secondary stress on the following syllable does not block Coda Capture, then intervocalic /t/ is ambisyllabic in words like *phótòn* [fɒtən].

But, in the Kahnian approach to English syllabification, intervocalic /t/ flaps if ambisyllabic.

Therefore, the ambisyllabic approach to Canadian raising predicts that the /t/ of *phótòn* flaps.

☞ This prediction is incorrect: the /t/ of *phótòn* never flaps.

§25 *Canadian raising underapplies before word-level suffixes* (Bermúdez-Otero 2003)

E.g. *eye-ful* ['aɪfʊl], *['ɹɪfʊl] cf. *Eiffel* ['ɹɪfəl]
Frau-ship ['fɹaʊʃɪp], *['fɹaʊʃɪp]

∴ The conditions of application for Canadian raising are determined at the stem level.

- Not an effect of secondary stress on the affix: cf. *nítràte* ['nɪ,ɹɛɪt].
- Not an effect of an ω-boundary between stem and affix: see Bermúdez-Otero (2011: §4).
 Cf. e.g. Szpyra (1989: 178-200), Hammond (1999: 322-329), Raffelsiefen (2005).
- For the absence of cyclic reapplication, see Bermúdez-Otero (2012: 31-40).

§26 *The environment of prefortis clipping: the testimony of Wells (1990, 2008)*

Instrumental studies of the effects of secondary stress and word-level suffixation on prefortis clipping are sadly lacking.

However, through the syllabification conventions of the *Longman pronunciation dictionary*, Wells (1990, 2008) reports (presumably introspective) judgements on the incidence of prefortis clipping.

Strikingly, as first observed by Bermúdez-Otero (2004: §21),

the environment of prefortis clipping as reported by Wells
 is exactly identical with

the environment of Canadian raising as reported by Chambers (see §23-§25)!

- | | | | |
|------------------|------------------------------------------|--------------------|-----------------|
| • Clipping... | before coda ɔ̣ | <i>cite</i> | [sɹɪt] |
| | before onset ɔ̣ in an unstressed σ | <i>cycle</i> | ['sɹɪ.kəl] |
| | before onset ɔ̣ in a weaker stressed σ | <i>nítràte</i> | ['nɹɪ,ɹɛɪt] |
| • No clipping... | before onset ɔ̣ in a stronger stressed σ | <i>cítàtion</i> | [,sɹɪ.'tɛɪ.ʃən] |
| | across ω-boundaries | <i>hígh schòol</i> | ['hɑɪ,skʊ:l] |
| | before word-level suffixes | <i>éyeful</i> | ['aɪ.fʊl] |
| | | but <i>Éiffel</i> | ['ɹɪ.fəl] |

∴ Prefortis clipping is stem-level.

(See §25.)

Stem-level clipping is counterbled by phrase-level flapping

§27 I assume Kiparsky's (1979: 437) analysis of flapping (see also Jensen 2000):

hit Ann

i.e.

/hit/

- at the word level, obstruents become [lax] if not foot-initial

hit^[lax]

- at the phrase level, lax [t] or [d] flap between in the environment {V,ɹ}__V

hiræŋ

Flapping must be phrase-level because its domain straddles word boundaries.

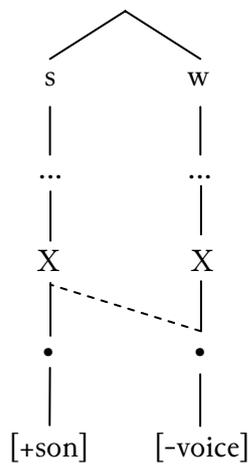
See e.g. Kaisse and Shaw (1985: 4), among many others.

∴ Stem-level clipping applies before phrase-level flapping.

Descriptive summary

§28 *Prefortis clipping*

π where $\pi \leq \omega^0$ (stem level)



/aɪ/-raising

ǎi → ǎi

CORROBORATING EVIDENCE

/aɪ/-allophony is sensitive to allophonic categories, not to continuous duration

§29 *The incomplete neutralization of the clipped/unclipped distinction before flaps*

Median duration (ms) of /aɪ/ in Philadelphia _____ (Fruehwald 2013: 117)

unflapped /d/ (e.g. *ride*) 237 unflapped /t/ (e.g. *write*) 144

flapped /d/ (e.g. *rider*) 156 flapped /t/ (e.g. *writer*) 111

§30 *Analysis*

- /aɪ/ is longer in *rider* than in *writer*.

∴ The two vowels have different representations in the output of the phonology:

categorically unclipped [aɪ] in *rider*,
 categorically clipped [ǎɪ] in *writer*.

This effect has been replicated in a large number of studies (Fox and Terbeek 1977, Zue and Laferriere 1979, Patterson and Connine 2001, Herd et al. 2010).

It is observable both in real words and in nonce items (Braver forthcoming).

- /aɪ/ is longer in *ride* than in *rider*, and in *write* than in *writer*.

∴ There is a gradient phonetic process that reduces the duration of all vowels before flaps, without categorically neutralizing the clipped/unclipped distinction.

An old observation: “The real point is that vowels before flaps become shortened to some fraction of their original length” (Fox and Terbeek 1977: 33).

For a recent formal implementation, see Braver (2013: 149).

§31 *The phonetic origins of /aɪ/-allophony: an enhancement of clipping*

- Nucleus raising is a knock-on effect of offglide peripheralization (see refs in §7).
- In turn, offglide peripheralization is an enhancement of clipping (Gussenhoven 2007):
 - ↳ learners observe that a peripheralized offglide creates a percept of reduced nucleus duration;
 - ↳ learners reanalyse offglide peripheralization as an acoustic cue realizing a clipped target.

§32 *Correct prediction 1*

Offglide peripheralization and nucleus raising are acoustic cues to a clipped category, and **not** coarticulatory effects.

∴ /aɪ/-allophony tracks the categorical status of a vowel as clipped or unclipped, and **not** its duration.

	<i>writer</i> <i>write</i>	<i>rider</i>	<i>ride</i>
raising tracks.....surface category	[ǎɪ] [ǎɪ]	[aɪ]	[aɪ]
not duration	111ms 144ms 156ms		237ms

This answers a question raised in Fruehwald (2013, 2014).

CONCLUSION

§36 At first glance, the interaction between /aɪ/-allophony and /t/-flapping across English dialects appears to challenge both the life cycle of phonological processes (§13) and classical modular feedforward architectures of grammar (§8).

However, the hypothesis that /aɪ/-allophony originates as an enhancement of categorical distinctions created by clipping effectively answers those challenges, while correctly predicting

- (i) the independence of /aɪ/-allophony from gradient duration
- and (ii) the difference in the distribution of raised allophones between Scottish English and other dialects.

The evidence of /aɪ/-allophony in English is thus consistent with phonological frameworks where,

- (i) diachronically, new sound patterns enter the grammar from below as transparent processes of gradient phonetic implementation;
- (ii) synchronically, phonology serially precedes phonetics;
- and (iii) synchronically, phonological processes with narrow morphosyntactic domains serially precede phonological processes with wide morphosyntactic domains.

REFERENCES

- Agutter, Alex (1988). 'The not-so-Scottish Vowel Length Rule', in John M. Anderson and Norman Macleod (eds), *Edinburgh studies in the English language*. Edinburgh: John Donald, 120-32.
- Aitken, A.J. (1981). 'The Scottish Vowel-length Rule', in Michael Benskin and M.L. Samuels (eds), *So many people longages and tonges: philological essays in Scots and mediaeval English presented to Angus McIntosh*. Edinburgh: The Middle English Dialect Project, 131-57.
- Baković, Eric (2011). 'Opacity and ordering', in John A. Goldsmith, Jason Riggle, and Alan Yu (eds), *The handbook of phonological theory* (2nd edn). Oxford: Blackwell, 40-67.
- Bermúdez-Otero, Ricardo (2003). 'The acquisition of phonological opacity', in Jennifer Spenader, Anders Eriksson, and Östen Dahl (eds), *Variation within Optimality Theory: Proceedings of the Stockholm Workshop on 'Variation within Optimality Theory'*. Stockholm: Department of Linguistics, Stockholm University, 25-36. Expanded version (2003) available at <http://www.bermudez-otero.com/stockholm.pdf>, and as ROA-593-0403 at the Rutgers Optimality Archive, <http://roa.rutgers.edu>.
- (2004). 'Raising and Flapping in Canadian English: grammar and acquisition'. Paper given at the CASTL Colloquium, University of Tromsø, Tromsø, 2 November 2004. Available at www.bermudez-otero.com/tromsoe.pdf.
- (2007). 'Diachronic phonology', in Paul de Lacy (ed.), *The Cambridge handbook of phonology*. Cambridge: Cambridge University Press, 497-517.
- (2011). 'Cyclicity', in Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume, and Keren Rice (eds), *The Blackwell companion to phonology* (vol. 4: *Phonological interfaces*). Malden, MA: Wiley-Blackwell, 2019-48.

- (2012). ‘The architecture of grammar and the division of labour in exponence’, in Jochen Trommer (ed.), *The morphology and phonology of exponence* (Oxford Studies in Theoretical Linguistics 41). Oxford: Oxford University Press, 8-83.
- (2014). ‘Amphichronic explanation and the life cycle of phonological processes’, in Patrick Honeybone and Joseph C. Salmons (eds), *The Oxford handbook of historical phonology*. Oxford: Oxford University Press.
- Bermúdez-Otero, Ricardo and Graeme Trousdale (2012). ‘Cycles and continua: on unidirectionality and gradualness in language change’, in Terttu Nevalainen and Elizabeth Closs Traugott (eds), *The Oxford handbook of the history of English*. New York: Oxford University Press, 691-720.
- Braver, Aaron (2013). *Degrees of incompleteness in neutralization: paradigm uniformity in a phonetics with weighted constraints*. Doctoral dissertation, Rutgers, New Brunswick, New Jersey.
- (forthcoming). ‘Imperceptible incomplete neutralization: production, non-identifiability, and non-discriminability in American English flapping’, *Lingua*.
- Bromberger, Sylvain and Morris Halle (1989). ‘Why phonology is different’, *Linguistic Inquiry* 20: 51-70.
- Broselow, Ellen, Su-I Chen, and Marie Huffman (1997). ‘Syllable weight: convergence of phonology and phonetics’, *Phonology* 14 (1): 47-82.
- Chambers, J. K. (1973). ‘Canadian Raising’, *Canadian Journal of Linguistics* 18: 113-35.
- (1989). ‘Canadian Raising: blocking, fronting, etc’, *American Speech* 64 (1): 75-88.
- (2006). ‘Canadian Raising: retrospect and prospect’, *Canadian Journal of Linguistics* 51: 105-18.
- Chambers, J. K. and Margaret F. Hardwick (1986). ‘Comparative sociolinguistics of a sound change in Canadian English’, *English World-Wide* 7 (1): 23-46.
- Chen, Matthew (1970). ‘Vowel length variation as a function of the voicing of the consonant environment’, *Phonetica* 22: 129-59.
- Chomsky, Noam and Morris Halle (1968). *The sound pattern of English*. New York: Harper & Row.
- Cohn, Abigail C. (2006). ‘Is there gradient phonology?’ in Gisbert Fanselow, Caroline Féry, Matthias Schlesewsky, and Ralf Vogel (eds), *Gradience in grammar: generative perspectives*. Oxford: Oxford University Press, 25-44.
- Dailey-O’Cain, Jennifer (1997). ‘Canadian raising in a midwestern U.S. city’, *Language Variation and Change* 9: 107-210.
- Denes, P. (1955). ‘Effect of duration on the perception of voicing’, *Journal of the Acoustical Society of America* 27 (4): 761-64.
- Fox, Robert A. and Dale Terbeek (1977). ‘Dental flaps, vowel duration and rule ordering in American English’, *Journal of Phonetics* 5: 27-34.
- Fruehwald, Josef (2013). *The phonological influence on phonetic change*. Doctoral dissertation, University of Philadelphia.
- (2014). ‘The early influence of phonology on a phonetic change’. Ms.: University of Edinburgh.
- Gress-Wright, Jonathan (2011). ‘Rule insertion revisited’. Paper given at the Penn Linguistics Colloquium 35, Philadelphia, 20 March 2011. Abstract available at http://www.ling.upenn.edu/Events/PLC/PLC35/abstracts/4b_GressWright.pdf.
- Gussenhoven, Carlos (2007). ‘A vowel height split explained: compensatory listening and speaker control’, in Jennifer Cole and José Ignacio Hualde (eds), *Laboratory phonology 9*. Berlin: Mouton de Gruyter, 145-72.
- Halle, Morris (1962). ‘Phonology in generative grammar’, *Word* 18: 54-72.
- Hammond, Michael (1999). *The phonology of English: a prosodic optimality-theoretic approach* (The Phonology of the World’s Languages). Oxford: Oxford University Press.
- Herd, Wendy, Allard Jongman, and Joan Sereno (2010). ‘An acoustic and perceptual analysis of /t/ and /d/ flaps in American English’, *Journal of Phonetics* 38 (4): 504-16.

- Hubbard, Kathleen (1995a). 'Morification and syllabification in Bantu languages', *Journal of African Languages and Linguistics* 16: 137-55.
- (1995b). "'Prenasalised consonants" and syllable timing: evidence from Runyambo and Luganda', *Phonology* 12: 235-56.
- Idsardi, William J. (2006). 'Canadian Raising, opacity, and rephonemicization', *Canadian Journal of Linguistics* 51 (2/3): 21-28.
- Jansen, Wouter (2004). *Laryngeal contrast and phonetic voicing: a laboratory phonology approach to English, Hungarian, and Dutch*. Doctoral dissertation, University of Groningen.
- Jensen, John T. (2000). 'Against ambisyllabicity', *Phonology* 17: 187-235.
- Joos, Martin (1942). 'A phonological dilemma in Canadian English', *Language* 18 (2): 141-44.
- Kahn, Daniel (1976). *Syllable-based generalizations in English phonology*. Doctoral dissertation, MIT, Cambridge, MA.
- Kaisse, Ellen M. and Patricia A. Shaw (1985). 'On the theory of Lexical Phonology', *Phonology Yearbook* 2: 1-30.
- Kaye, Jonathan (1990). 'What ever happened to dialect B?' in Joan Mascaró and Marina Nespor (eds), *Grammar in progress: GLOW essays for Henk van Riemsdijk* (Studies in Generative Grammar 36). Dordrecht: Foris, 259-63.
- Keating, Patricia (1985). 'Universal phonetics and the organization of grammars', in Victoria A. Fromkin (ed.), *Phonetic linguistics: essays in honor of Peter Ladefoged*. Orlando: Academic Press, 115-32.
- Kenstowicz, Michael (1994). *Phonology in generative grammar*. Oxford: Basil Blackwell.
- King, Robert D. (1973). 'Rule insertion', *Language* 49 (3): 551-78.
- Kiparsky, Paul (1971). 'Historical linguistics', in W. O. Dingwall (ed.), *A survey of linguistic science*. College Park: University of Maryland Linguistics Program, 579-642. Reprinted in Paul Kiparsky (1982), *Explanation in phonology*. Dordrecht: Foris, 57-80.
- (1979). 'Metrical structure assignment is cyclic', *Linguistic Inquiry* 10 (3): 421-41.
- (1988). 'Phonological change', in Frederick J. Newmeyer (ed.), *Linguistics: the Cambridge survey* (vol. 1, *Linguistic theory: foundations*). Cambridge: Cambridge University Press, 363-415.
- (1995). 'The phonological basis of sound change', in John A. Goldsmith (ed.), *The handbook of phonological theory*. Oxford: Blackwell, 640-70.
- Klatt, Dennis H. (1976). 'Linguistic uses of segmental duration in English: acoustic and perceptual evidence', *The Journal of the Acoustical Society of America* 59 (5): 1208-21.
- Kluender, Keith R., Randy L. Diehl, and Beverley A. Wright (1988). 'Vowel-length differences before voiced and voiceless consonants: an auditory explanation', *Journal of Phonetics* 16: 153-69.
- Kwong, Katherine and Kenneth N. Stevens (1999). 'On the voiced-voiceless distinction for *writer/rider*', *Speech Communication Group Working Papers (Research Laboratory of Electronics at MIT)* 11: 1-20.
- Labov, William and Ingrid Rosenfelder (2013). *The Philadelphia Neighbourhood Corpus*. Philadelphia: University of Pennsylvania Phonetics Laboratory.
- Maddieson, Ian (1993). 'Splitting the mora', *UCLA Working Papers in Phonetics* 83: 9-18.
- Maddieson, Ian and Peter Ladefoged (1993). 'Phonetics of partially nasal consonants', in Marie K. Huffman and Rena A. Krakow (eds), *Nasals, nasalization, and the velum* (Phonetics and Phonology 5). San Diego: Academic Press, 251-301.
- McMahon, April M. S. (1991). 'Lexical phonology and sound change: the case of the Scottish vowel length rule', *Journal of Linguistics* 27: 29-53.
- Moreton, Elliott (2004). 'Realization of the English postvocalic [voice] contrast in F_1 and F_2 ', *Journal of Phonetics* 32 (1): 1-33.

- Moreton, Elliott and Erik R. Thomas (2007). 'Origins of Canadian Raising in voiceless-coda effects: a case study in phonologization', in Jennifer Cole and José Ignacio Hualde (eds), *Laboratory phonology 9*. Berlin: Mouton de Gruyter, 37-63.
- Onosson, D. S. (forthcoming). 'The prosodic structure of Canadian Raising', *2014 CLA Conference Proceedings*. Canadian Linguistic Association. http://cla-acl.ca/?page_id=845.
- Paradis, Carole (1980). 'La règle de Canadian Raising et l'analyse en structure syllabique', *Canadian Journal of Linguistics* 25 (1): 35-45.
- Patterson, David and Cynthia M. Connine (2001). 'Variant frequency in flap production: a corpus analysis of variant frequency in American English flap production', *Phonetica* 58 (4): 254-75.
- Picard, Marc (1977). 'Canadian raising: the case against reordering', *Canadian Journal of Linguistics* 22 (2): 144-55.
- Pierrehumbert, Janet (2002). 'Word-specific phonetics', in Carlos Gussenhoven and Natasha Warner (eds), *Laboratory Phonology 7*. Berlin: Mouton de Gruyter, 101-39.
- Port, Robert and Jonathan Dalby (1982). 'Consonant/vowel ratio as a cue for voicing in English', *Attention, Perception, and Psychophysics* 32 (2): 141-52.
- Raffelsiefen, Renate (2005). 'Paradigm uniformity effects versus boundary effects', in Laura J. Downing, T. Alan Hall, and Renate Raffelsiefen (eds), *Paradigms in phonological theory*. Oxford: Oxford University Press, 211-62.
- Ramsamy, Michael (forthcoming). 'The life cycle of phonological processes: accounting for dialectal microtypologies', *Linguistics and Language Compass*.
- Roberts, Philip (2011). 'A proposed Latin rule insertion revisited in OT'. Paper given at the 85th Annual Meeting of the Linguistic Society of America (LSA), Pittsburgh, 6 January 2011. Handout available at <http://users.ox.ac.uk/~wolf2469/LSA-85-handout-Roberts.pdf>.
- Rosenfelder, Ingrid (2007). 'Canadian Raising in Victoria, B.C. An acoustic analysis', *Arbeiten aus Anglistik und Amerikanistik* 32 (2): 257-84.
- Rudes, Blair (1976). 'Lexical representation and variable rules in natural generative phonology', *Glossa* 20 (111-150).
- Scobbie, James M., Nigel Hewlett, and Alice Turk (1999). 'Standard English in Edinburgh and Glasgow: the Scottish vowel length rule revealed', in Paul Foulkes and Gerard J. Docherty (eds), *Urban voices: accent studies in the British Isles*. London: Arnold, 230-45.
- Sóskuthy, Márton (2013). *Phonetic biases and systemic effects in the actuation of sound change*. PhD thesis, University of Edinburgh.
- Strycharczuk, Patrycja (2012). *Phonetics-phonology interactions in pre-sonorant voicing*. PhD thesis, University of Manchester. Available at <http://ling.auf.net/lingbuzz/001645>.
- Szpyra, Jolanta (1989). *The phonology-morphology interface: cycles, levels and words* (Croom Helm linguistics series). London: Routledge.
- Thomas, Erik R. (1991). 'The origins of Canadian Raising in Ontario', *Canadian Journal of Linguistics* 36: 147-70.
- (2000). 'Spectral differences in /ai/ offsets conditioned by voicing of the following consonant', *Journal of Phonetics* 28 (1): 1-25.
- Vance, Timothy J. (1987). '“Canadian Raising” in some dialects of the northern United States', *American Speech* 62 (3): 195-210.
- Wells, J. C. (1990). 'Syllabification and allophony', in Susan Ramsaran (ed.), *Studies in the pronunciation of English: a commemorative volume in honour of A.C. Gimson*. London: Routledge, 76-86.
- (2008). *Longman pronunciation dictionary* (3rd edn). Harlow: Longman.
- Zue, Victor W. and Martha Laferriere (1979). 'Acoustic study of medial /t,d/ in American English', *Journal of the Acoustical Society of America* 66 (4): 1039-50.

CONTACT DETAILS

Ricardo Bermúdez-Otero
Linguistics and English Language
University of Manchester
Oxford Road
Manchester M13 9PL
United Kingdom

r.bermudez-otero@manchester.ac.uk
www.bermudez-otero.com