The life cycle of phonological processes and rule scattering

Ricardo Bermúdez-Otero
(*University of Manchester*)

Session ❻ (*History 1*)
in
Alternation types: computation, storage, history
Brugmann Fellow course, IGRA, Leipzig, July 2019

Introduction

§1 This session surveys the **life cycle of phonological processes**, showing that, in their diachronic evolution, sound patterns typically follow a unidirectional trajectory of change consisting of the following stages:

(i) **phonologization** — a mechanical phonetic effect is reanalysed as a cognitively controlled, language-specific, gradient process of phonetic implementation;

(ii) **stabilization** — this gradient process of phonetic implementation is reanalysed as a categorical phonological rule applying across the board at the phrase level;

(iii) **domain narrowing** — the phonological process thus born climbs from the phrase level to the word level, and thence to the stem level, as phonological properties generated in the output of a stratum *S* are reanalysed as already present in the input to *S*;

(iv) **morphologization** or **lexicalization** — finally, the phonological process ceases to operate, replaced either by a morphological rule of exponence or by a residue of listed allomorphy.

§2 Associated with this life cycle are two other diachronic phenomena of considerable importance:

(i) **rule generalization** — the scalar nature of the phonetic precursors of sound patterns may cause a series of related successive innovations, each giving rise to a more general version of the same phonological process;

(ii) **rule scattering** — the older ('lower') versions of a sound pattern often persist diachronically and coexist in the grammar with the newer ('higher') versions created by the life cycle.

§3 The life cycle of phonological processes, with its associated phenomena, is crucial to the theory of phonological alternation presented in this course (◄❶§1-§6, ❺§35-§38) for several reasons:

(i) the life cycle provides empirical support for a **stratal-cyclic architecture of phonology** (◄❶§7ff, ❷), since the latter obviously lays down the track for the former;

(ii) an understanding of rule scattering enables us to dispose of several putative counterinstances to **modularity** (◄❸§30, ❺§19), insofar as different synchronically copresent avatars of the same sound pattern are sensitive to different factors active in different components of the grammar;

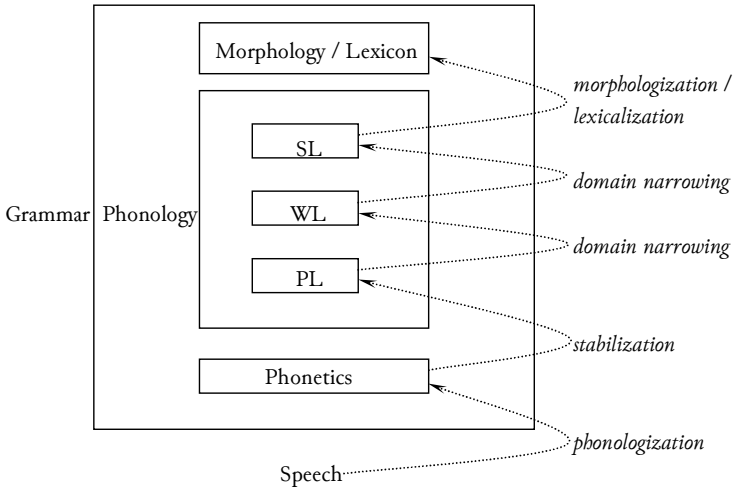
(iii) understanding the mechanisms causing domain narrowing is crucial to the as yet incomplete task of explaining the **historical genesis of stratal splits** in morphophonological systems (◄❹§35-§37, ►❼) and mapping **the diachronic life cycle of affixes** (►❼).

The life cycle of phonological processes

§4 The notion of the life cycle of phonological processes has a very long tradition:

- it can be traced back at least to the dawn of Structuralism with Kruszewski (1881) and Baudouin de Courtenay (1895) (◄❶§4);
- recent contributions include Kiparsky (1988, 1995, 2018), Bermúdez-Otero (2007, 2015), Bermúdez-Otero & Trousdale (2012), Ramsammy (2015, 2018), Turton (2016, 2017), Sen (2016), Bailey (under review).

§5 The life cycle in diagrammatic form (Bermúdez-Otero & Trousdale 2012: 700):



Overall, innovation propagates 'upwards', as representations at lower levels furnish the data for the acquisition of representations at higher levels (Bermúdez-Otero 1999: 102, 2003: §4.1).

Phonologization

§6 In phonologization, as defined here, a mechanical (physically or physiologically determined) phonetic pattern is reanalysed as a cognitively controlled, language-specific, gradient process of phonetic implementation.

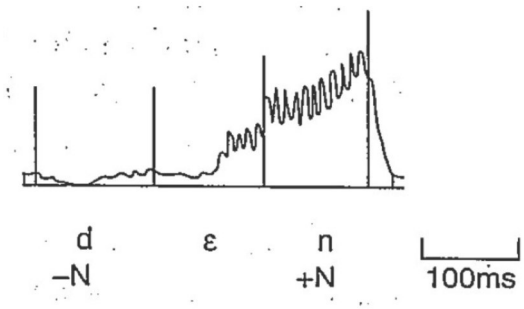
See Hyman (1976), Kiparsky (2015), and Ramsammy (2018). For an influential account of the mechanism of phonologization, see Ohala (1981, 1989).

§7 *Gradient nasalization in American English*

(i) The phonetic implementation of a [VN] target requires the velum to be lowered at the same time as an oral occlusion is formed at the V-to-N transition.

However, the velum is a relatively slow articulator (Bell-Berti 1993: 66), and this physiological fact causes the timing of maximum velar opening to deviate probabilistically from the achievement of oral closure.

(ii) In American English /C_0VN/ words like *den*, however, nasal airflow begins systematically early in the vowel: the effect has been **phonologized** (Cohn 1990, 1993).

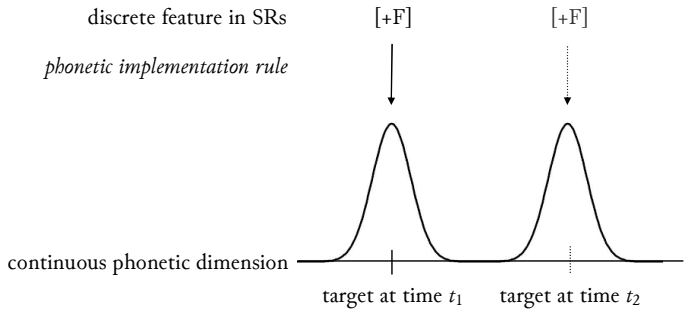


In this environment, however, nasalization remains **gradient**: the vowel is not specified as [+nasal] in the surface phonological representation (the output of the categorical phonology):

crucially, the nasalization pattern of the vowel involves **phonetic interpolation**, resulting in a cline-like contour which contrasts with the nasality plateau in cases of categorical nasalization like *dent* (cf. §16 below).

§8 Phonologization manifests itself diachronically as **neogrammarian change**, i.e. phonetically gradient, lexically regular change:

☞ neogrammarian change is change in the implementation rules assigning phonetic targets to discrete categories in surface representations.



An old idea: Paul (1886: 62), Bloomfield (1933: 364-5), etc. See Bermúdez-Otero (2015: 379-382).

§9 In line with the predictions of a **modular feedforward grammatical architecture** (Bermúdez-Otero 2007: 501-503, 2012: 45-49), new phonetic implementation rules are only sensitive to surface phonological information and are free from morphological and lexical effects.

For a review of the evidence from traditional historical linguistics, see Hill (2014).

§10 *Challenge 1: the role of lexical usage factors*

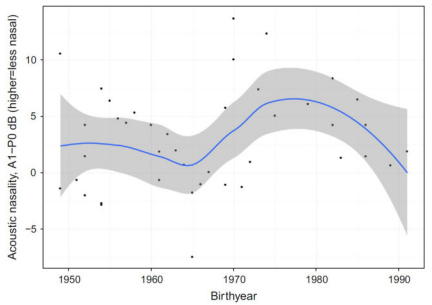
E.g. lexical token frequency (Bybee 2001): high-frequency words are relatively hypoarticulated

- shorter duration (Whalen 1991; Gahl 2008 on *time* vs *thyme*)
- more vowel centralization (Wright 2003, Dinkin 2008)
- more coarticulatory vowel nasalization (Zellou & Tamminga 2014)

Response: the effect of frequency is orthogonal and remains stable through change, giving rise to **constant rate effects** (Bermúdez-Otero et al. 2015; Kiparsky 2016: 482)

Observed for anticipatory vowel nasalization in American English (Zellou & Tamminga 2014):

- Mean vowel nasalization changes gradiently during the 20th century:



Acoustic nasality (*A1–P0*; small=more nasal) speaker means by speaker birthyear, from the trend sample, fit with a loess curve.

- And there is an effect of lexical frequency: frequent words show more nasalization.
- But this effect is constant across time: there is no significant interaction between speaker birthyear and lexical frequency.
- Hence, there is no need to record the outcome of gradient phonetic change in lexical representations: there is no continuous phonetic information in the lexicon.

The debate rumbles on: see e.g. Pierrehumbert (2001, 2002), Hay et al. (2015), Hay & Foulkes (2016), Bermúdez-Otero et al. (2017), Todd et al. (2019).

§11 *Challenge 2: putative morphologically conditioned phonetics*

Bybee (2001), Steriade (2000), etc. See Bermúdez-Otero (2010: §8), Kawahara (2011: §2.3.3), Morrison (2018), and Strycharczuk (forthcoming) for surveys of the literature.

E.g. English /l/-darkening and /uː/-retraction (Strycharczuk & Scobbie 2016)

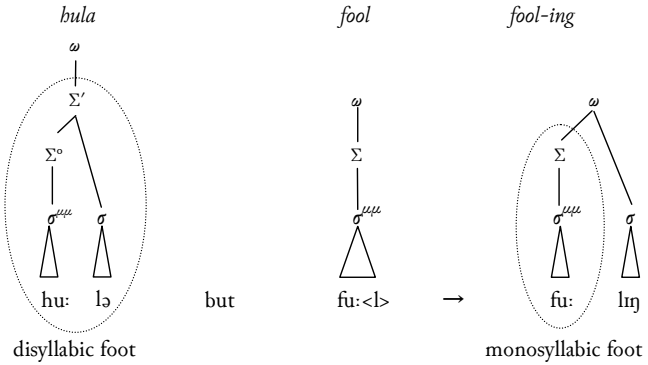
Some speakers show a gradient phonetic difference between

- monomorphemic *hu**l**a* [huːlə]

and • word-level *fool-ing* [fuːlɪŋ]

Response: a possible case of **prosodic bounding** (Bermúdez-Otero 2011: §4, ◀❶§14iii,§15iv)

- stem level (stress-affecting affixation) ⇨ exhaustive footing
- word level (stress-neutral affixation) ⇨ stray syllables attached directly to *ω*



Other apparent cases of apparently morphologically conditioned phonetics involve **rule scattering**: see §32-§40 below.

§12 *Challenge 3: putatively opaque phonetics (sensitive to nonsurface phonological information)*

See Fruehwald (2013, 2016) on English /aɪ/-raising and /t/-flapping: ◀❸§29ff.

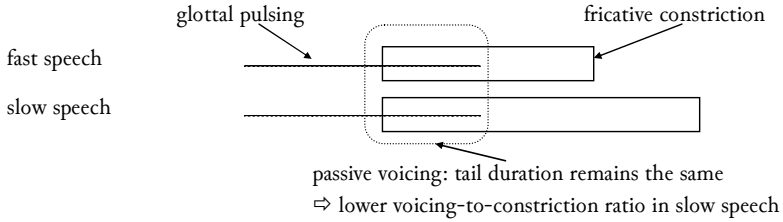
Stabilization

§13 In stabilization, a gradient process of phonetic implementation is reanalysed as a **categorical** phonological rule applying across the board at the **phrase level**.

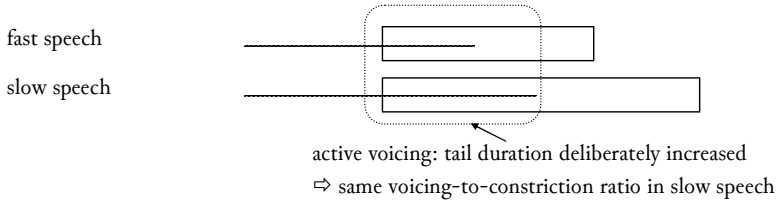
§14 *Stabilization of voicing in word-final prevocalic /s/ in Quito Spanish*

(Strycharczuk 2012: ch. 6; Strycharczuk et al 2014; ◀❶§2ii)

(i) Stage 1: phonologization (gradient voicing) *más alto* /mas alto/ [ma.s̬a̤l̤.t̪o] ‘taller’

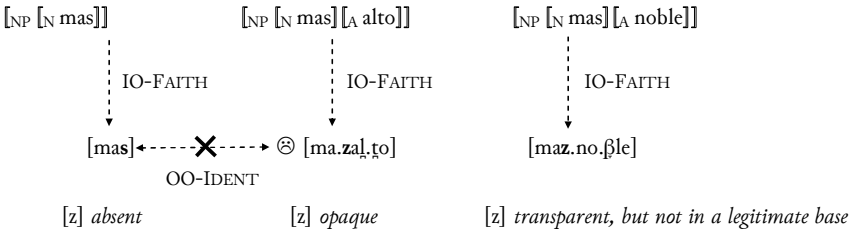


(ii) Stage 2: stabilization (categorical voicing) *más alto* /mas alto/ [ma.**z**a̤l̤.t̪o] ‘taller’



§15 Being able to diagnose stabilization may be crucial to arguments about the architecture of phonology:

e.g. Quito Spanish /s/-voicing provides a counterexample to OO-correspondence, in that the voicing of word-final prevocalic /s/ in the onset is opaque and cannot be generated by transderivational identity with related surface forms (Bermúdez-Otero 2011: §6)

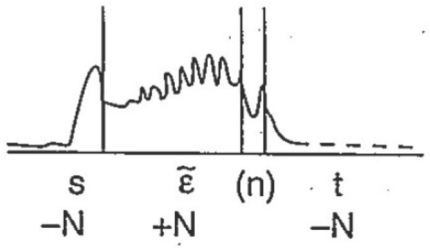


But the argument only goes through if /s/-voicing is categorical (cf. e.g. Colina 2009).
For the stratal analysis of this pattern, ◀❷§9-§11.

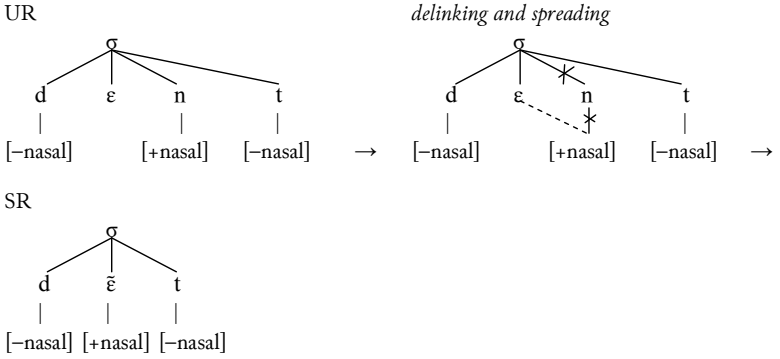
§16 *Categorical nasalization in American English*

Unlike words like *den* (§7), American English /C_0VNT/ words like *dent* exhibit **categorical** nasalization (Cohn 1990, 1993):

- the vowel is specified as [+nasal] on the surface, and the underlying /N/ is deleted;
- phonetically, the vowel shows a plateau-like contour of nasal airflow.



§17 Categoricity via autosegmental delinking and spreading:



§18 The contrast between gradient nasalization in American English *den* and categorical nasalization in *dent* illustrates an important phenomenon in sound change, plausibly grounded in the scalar nature of its phonetic precursors:

Rule generalization (Bermúdez-Otero 2015: §22.3.1)

- Typically, phonologization and stabilization first take place in a relatively specific, highly phonetically favourable environment.
- Thereafter, further rounds of phonologization and stabilization may create new versions of same process applying in more general, less phonetically favourable environments.
- The successive versions of the process (older relatively specific vs younger relatively general ones) may go through their life cycles separately.

See also Vennemann (1972: 186–187), Kiparsky (1988: §14.3.1), and §28–§29 below.

Domain narrowing

§19 Once stabilized as a phrase-level phonological process, the cyclic domain of a sound pattern may undergo narrowing:

utterances > grammatical words > sublexical domains

Concomitantly, the process climbs up in the stratal hierarchy:

phrase level > word level > stem level

§20 *A textbook example of domain narrowing: the history of English postnasal plosive deletion*

(Garrett & Blevins 2009: 527–528; Bermúdez-Otero 2011: §3; Bermúdez-Otero & Trousdale 2012: §2.3; Bailey 2018)

- Postnasal plosive deletion: ɡ → ∅ / ŋ__ σ]
  N.B. the deletion of postnasal /ɡ/ is opaque in the onset, i.e.when a vowel follows.
- Domain narrowing since Early Modern English:

	Diachronic stage			
	0	1	2	3
*elo**ng**ate*	ŋɡ	ŋɡ	ŋɡ	ŋɡ
*prolo**ng**-er*	ŋɡ	ŋɡ	ŋɡ	ŋ
*prolo**ng** it*	ŋɡ	ŋɡ	ŋ	ŋ
*prolo**ng*** ‖	ŋɡ	ŋ	ŋ	ŋ

0	Early Modern English	deletion not yet stabilized	
1	Elphinston's formal register	PL /ɡ/-deletion	transparent
2	Elphinston's colloquial register	WL /ɡ/-deletion	overapplication in phrasal domains
3	Present-day English	SL /ɡ/-deletion	overapplication in word *and* [phrase domains

§21 *Recurrent input restructuring*

level	deletion?	*elongate*	*prolonging* ‖	*prolong it*	*prolong* ‖
a. *Stage 0: Early Modern English*					
SL	no	[iː.lɒŋ.geɪt]	[prə.lɒŋ][ɪŋ]	[prə.lɒŋ][ɪt]	[prə.lɒŋ]
WL	no	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ]	[prə.lɒŋ][ɪt]	[prə.lɒŋ]
PL	no	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ]	[prə.lɒŋ.gɪt]	[prə.lɒŋ]
b. *Stage 1: Elphinston's formal register*					
SL	no	[iː.lɒŋ.geɪt]	[prə.lɒŋ][ɪŋ]	[prə.lɒŋ][ɪt]	[prə.lɒŋ]
WL	no	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ]	[prə.lɒŋ][ɪt]	[prə.lɒŋ]
PL	yes	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ~~ɡ~~]	[prə.lɒŋ.gɪt]	[prə.lɒŋ~~ɡ~~]

c. *Stage 2: Elphinston's casual register*

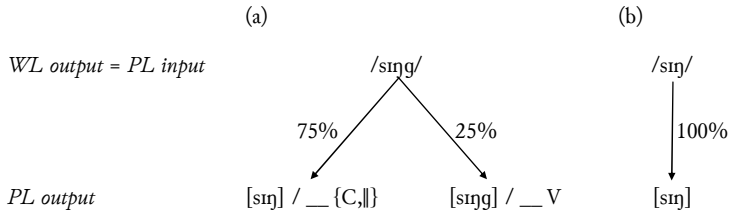
SL	no	[iː.lɒŋ.geɪt]	[pɹə.lɒŋg] [ɪŋg]	[pɹə.lɒŋg] [ɪt]	[pɹə.lɒŋg]
WL	yes	[iː.lɒŋ.geɪt]	[pɹə.lɒŋ.gɪŋ̈]	[pɹə.lɒŋ̈] [ɪt]	[pɹə.lɒŋ̈]
PL	yes (vacuously)	[iː.lɒŋ.geɪt]	[pɹə.lɒŋ.gɪŋ]	[pɹə.lɒ.ŋɪt]	[pɹə.lɒŋ]

d. *Stage 3: present-day RP*

SL	yes	[iː.lɒŋ.geɪt]	[pɹə.lɒŋ̈] [ɪŋ̈]	[pɹə.lɒŋ̈] [ɪt]	[pɹə.lɒŋ̈]
WL	yes (vacuously)	[iː.lɒŋ.geɪt]	[pɹə.lɒ.ŋɪŋ]	[pɹə.lɒŋ] [ɪt]	[pɹə.lɒŋ]
PL	yes (vacuously)	[iː.lɒŋ.geɪt]	[pɹə.lɒ.ŋɪŋ]	[pɹə.lɒ.ŋɪt]	[pɹə.lɒŋ]

§22 *The role of alternant distribution in input restructuring*

- In the conservative grammar (stage 1 in §20 and §21), the word *sing* was represented as /sɪŋg/ in the input to the phrase-level phonology. Surface tokens lacking [g] in preconsonantal and prepausal environments were derived by means of an unfaithful phrase-level mapping: see (a) below.
- Such tokens, however, occurred approximately three times more frequently than faithful prevocalic ones (Bybee 1998: 73). Learners who took them at face value replaced /sɪŋg/ with /sɪŋ/ in the phrase-level input: see (b) below.



§23 *The role of the Anti-Alternation Bias*

The quantitative distribution of alternants on the surface is not enough to explain domain narrowing.

- Crucially, the restructuring /$_{WL}$ sɪŋg/ > /$_{WL}$ sɪŋ/ gives rise to tokens of onset [ŋ] on the surface:

before input restructuring	/$_{WL}$ sɪŋg/ + /$_{WL}$ ɪt/	→	[$_{PL}$ sɪŋ.gɪt]
after input restructuring	/$_{WL}$ sɪŋ/ + /$_{WL}$ ɪt/	→	[$_{PL}$ sɪ.ŋɪt]

- Thus, domain narrowing is accompanied by the demotion of the markedness constraint *[$_{\sigma}$ŋ in the phrase-level phonology, even though this constraint is unviolated in the learner's data.

Q. If, after pure phonotactic learning over surface forms, *[$_{\sigma}$ŋ is undominated in the phrase-level hierarchy, why does this ranking fail to prevent domain narrowing?

A. Because, after pure phonotactic learning is over, during the acquisition of alternations, an **Anti-Alternation Bias** (◄5§34ii, ►7) takes precedence over the Subset Principle, and so the M≫F ranking bias ceases to hold:

⇨ a learner who has only encountered preconsonantal and prepausal tokens of *sing,* i.e. [sɪŋ], and who consequently assigns to it the word-level representation /$_{WL}$ sɪŋ/, will avoid the unfaithful mapping /$_{WL}$ sɪŋ/ + /$_{WL}$ ɪt/ → [$_{PL}$ sɪŋ.**g**ɪt] since it generates a novel alternant [sɪŋ**g**] that she has not encountered before: in consequence, she will demote *[$_{\sigma}$ŋ below DEP-[g] in the phrase-level hierarchy.

Unlike implementations in OO-correspondence (McCarthy 1998; Hayes 2004; Tessier 2006, 2016; Do 2013, 2018), this approach to the Anti-Alternation Bias does not incorrectly predict that innovative sound changes will show cyclic misapplication effects from the outset: cf. §11.

Morphologization and lexicalization

§24 In the final stages of its life cycle, a phonological process may
- be reanalysed as a morphological operation of exponence,

or
- be reanalysed as a nongenerative via-rule linking stored allomorphs (◄5§29-§34).

§25 *Morphologization as a rule of exponence: the development of Germanic* s*-stems in Old High German*

The story as told by Anderson (1988: 324-336)

- Proto-Germanic:

	sg.	*pl.*
nom./acc.	lamb-iz	lamb-iz-ō
gen.	lamb-iz-aza	lamb-iz-om
dat.	lamb-iz-ai	lamb-iz-omoz

- Pre-Old High German:

  As a result of various changes (including rhotacism), the paradigm below results.

  At this stage, the relevant nouns take the ending /-ir-/ throughout the paradigm, but a set of phonological rules deletes /-ir-/ in a non-initial syllable word-finally:

  phonological rule(s): ir → ∅ / σ_1 ___ #

	sg.	*pl.*
nom./acc.	lamb	lamb-ir-u
gen.	lamb-ir-as	lamb-ir-o
dat.	lamb-ir-a	lamb-ir-um

- Early Old High German:

  A further rule is added to the grammar, deleting final short /u/. This causes the rule deleting word-final /-ir-/ to become opaque, as there is word-final [-ir-] on the surface in the nom./acc.pl.

	sg.	*pl.*
nom./acc.	lamb	lamb-**ir**
gen.	lamb-ir-as	lamb-ir-o
dat.	lamb-ir-a	lamb-ir-um

  As a consequence, the behaviour of /-ir-/ is reanalysed: instead of being deleted in a phonological context, viz. word-finally, it is analyzed as being inserted in a morphological context, viz. in oblique (cases other than nom. and acc.) or plural forms.

morphological rule:

$$\varnothing \rightarrow \text{-ir-} \;/\; \text{Stem}_{[s\text{-class}}\; \underline{\quad\quad} \begin{Bmatrix} [+\text{oblique}] \\ [+\text{plural}] \end{Bmatrix}$$

- Later Old High German:

  Morphologization is confirmed by the fact /-ir-/ insertion is now reduced to a subset of morphological environments, viz. in the plural:

	sg.	*pl.*
nom./acc.	lamb	lemb-**ir**
gen.	lamb-es	lamb-**ir**-o
dat.	lamb-e	lamb-**ir**-um

morphological rule: $\varnothing \rightarrow$ -ir- / $\text{Stem}_{[s\text{-class}]}$ ____ [+plural]

§26 *Lexicalization as a via-rule: umlaut plurals in Englis*h

In pre-Old English, umlauted plurals were the result of a phonological rule:

e.g. o: → ø: / ___ C_0 i

	sg.	pl.
UR	/fo:t/	/fo:t-iz/
SR	[fo:t]	[fø:tiz]
	'foot'	'feet'

In present-day English, they are undoubtedly stored irregular forms, at best linked by by a via-rule:

e.g. $[_{Nsg} \ldots V^{[+hi,+bk]} C_1] \sim [_{Npl} \ldots i{:}C_1]$

foot	*feet*
goose	*geese*
tooth	*teeth*

EMERGENT SYNCHRONIC PATTERNS

§27 The doctrine of the life cycle predicts that, *ceteris paribus,* older processes are 'higher' and apply in narrower cyclic domains than younger processes;

though see Bermúdez-Otero & Trousdale (2012: 699) and Bermúdez-Otero (2015: 392) for more nuanced, qualified statements.

This prediction accounts for some remarkable synchronic patterns.

§28 *Specific high, general low:* o*-lowering in Swiss German*

Bermúdez-Otero (2015: 392), after Kiparsky (1965: 2-25ff) and Robinson (1976)

- The older, specific rule: *pre-*r o*-lowering* (see §18 above on **rule generalization**)

$$\begin{bmatrix} \text{V} \\ \text{-high} \\ \text{+back} \end{bmatrix} \rightarrow [+\text{low}] \;/\; \overset{\mu}{\underset{|}{\underline{\quad\quad}}} \begin{bmatrix} +\text{son} \\ +\text{cor} \\ -\text{nas} \\ -\text{lat} \end{bmatrix} \qquad \text{i.e.} \quad \breve{o} \rightarrow \breve{ɔ} \,/\, \underline{\quad} \; r$$

- The younger, general rule: *general* o*-lowering*

$$\begin{bmatrix} \text{V} \\ \text{-high} \\ \text{+back} \end{bmatrix} \rightarrow [+\text{low}] \;/\; \overset{\mu}{\underset{|}{\underline{\quad\quad}}} \begin{bmatrix} +\text{cor} \\ -\text{nas} \\ -\text{lat} \end{bmatrix} \qquad \text{i.e.} \quad \breve{o} \rightarrow \breve{ɔ} \,/\, \underline{\quad} \; \{r, t, d, \ldots\}$$

§29 Both pre-*r o*-lowering and general *o*-lowering go through the normal life cycle, undergoing domain narrowing from the word to the stem level.

If both rules are present in a dialect and they apply separately (Schaffhausen), the older, more specific rule has a narrower cyclic domain.

	'thorn' $[_{WL}\,[_{SL}$ torn$]]$	'thorns' $[_{WL}\,[_{SL}$ torn$]^{[-bk]}]$	'floor' $[_{WL}\,[_{SL}$ bodə$]]$	'floors' $[_{WL}\,[_{SL}$ bodə$]^{[-bk]}]$
Stage I				
SL	—	—	—	—
WL umlaut	—	tørn	—	bødə
Surface	torn	tørn	bodə	bødə
Stage II				
SL	—	—	—	—
WL umlaut	—	tørn	—	bødə
pre-*r* lowering	tɔrn	—	—	—
Surface	tɔrn	tørn	bodə	bødə

Stage III (St. Galler Rheintal)

SL pre-*r* lowering	tɔrn	tɔrn	—	—
WL umlaut	—	tœrn	—	bødə
Surface	tɔrn	tœrn	bodə	bødə

Stage IV (Schaffhausen)

SL pre-*r* lowering	tɔrn	tɔrn	—	—
WL umlaut	—	tœrn	—	bødə
general lowering	(vacuous)	—	bɔdə	—
Surface	tɔrn	tœrn	bɔdə	bødə

Stage V (Kesswil)

SL general lowering[1]	tɔrn	tɔrn	bɔdə	bɔdə
WL umlaut	—	tœrn	—	bœdə
Surface	tɔrn	tœrn	bɔdə	bœdə

[1] Subsuming pre-*r* lowering.

§30 *Mild high, drastic low: liquid lenition in English*

Bermúdez-Otero (2011: 2034-7), Bermúdez-Otero and Trousdale (2012: 702-4).

In a long-term lenition trajectory,

milder, older process ↔ synchronically higher stratum (narrower domain)
more drastic, younger process ↔ synchronically lower stratum (wider domain)

E.g. (i) /ɹ/-lenition trajectory

ɹ >lenition ɻ >deletion ∅

/ɹ/-lenition is older than /ɹ/-deletion.

(ii) /l/-lenition trajectory:

l >darkening ɫ >vocalization ɤ̈ (>deletion ∅)

/l/-darkening is older than /l/-vocalization.

∴ /ɹ/-lenition, /l/-darkening: older ⇨ higher stratum (narrower domain)
/ɹ/-deletion, /l/-vocalization: younger ⇨ lower stratum (wider domain)

§31 • Word-level processes (overapply to word-final prevocalic Cs):

/ɹ/-lenition does apply in *car alarm*
/l/-darkening does apply in *seal it*

• <u>Phrase-level processes (do **not** overapply to word-final prevocalic Cs)</u>:

/ɹ/-deletion does **not** apply in *car alarm*
/l/-vocalization does **not** apply in *seal it*

RULE SCATTERING AND MODULARITY

§32

> RULE SCATTERING (after Robinson 1976):
> Diachronic change often introduces a new avatar of an existing pattern into a higher component of the grammar by reanalysis, while the old avatar remains *in situ*.

See Bermúdez-Otero (2007: 506; 2010; 2015: 387-392).

Rule scattering at the phonology-phonetics interface

§33 A perfectly ordinary stage of affairs:

two cognate rules, one gradient, one categorical, representing different stages in the diachronic life cycle of the same sound pattern, coexist within the same grammar.

Examples: • Philadelphia *æ*-tensing (Labov 1994) §35-§36 below
• Pre-yod /s/-palatalization (Zsiga 1995) §37-§39 below

§34 Why is this stage of affairs common? Presumably because of the mechanics of *stabilization* (i.e. of the diachronic process of reanalysis whereby tokens of a gradient rule of phonetic implementation are reinterpreted as involving a categorical distinction):

the reanalysed tokens give rise to a new categorical rule, whilst the nonreanalysed tokens preserve the gradient rule *in situ* (Bermúdez-Otero 2015: 387-388).

§35 *Philadelphia æ-tensing: a categorical default stem-level rule…*

- categorical opposition between lax [æ] and tense [æː]
- the phonetic realizations of [æ] and [æː] occupy largely nonoverlapping regions in auditory space (Labov 1989: 8-10)
- default pattern: *æ* is normally tense before coda /m, n, f, θ, s/ (Labov 1994: 430)
- counterbled by resyllabification before word-level suffixes:
  e.g. *m*[æː]*n, m*[æ]*nner*, *m*[æː]*nn-ing* (Labov 1994; 430-31)
- outright lexical exceptions: [æː] in mad, bad, glad; but [æ] in *sad*, *fad*, *lad*
  [æ] in strong verbs like *began*, *ran*, *swam*

§36 *…overlaid with a gradient phonetic process*

the precise formant values of the acoustic realization of [æː] are exquisitely sensitive to the phonetic environment

	effect on height
following nasal	158
preceding nasal	99
preceding obstruent plus /l/	–210
two following syllables	–410
etc.	

(coefficients in Labov 1994: 466)

§37 *Pre-yod /s/-palatalization: A neutralizing stem-level morphophonological process…*

confe/s/+/j/*on* → *confe*[ʃ]*on* [ʃ] realized with same pattern of linguopalatal consonant as underlying /ʃ/

§38 *…coexisting with gradient gestural overlap across word-boundaries*

pre/s/ # /j/*ou* → *pre*[s̻j̻]*ou* [s̻j̻] arises from the superposition of the patterns of linguopalatal contact for /s/ and /j/

§39 But the same diachronic origin! Cf. Chaucer's *confe*/si.u:n/.

§40 The rule systems created by scattering exhibit phonetic gradience and morphological sensitivity in the same grammar without violating modularity (cf. §11 above):

- the old phonetic process exhibits gradience;
- the new categorical process exhibits morphological sensitivity.

E.g. /s/-reduction in New York Spanish (Erker 2012)

(i) categorical [s]-absence → sensitive to morphemic status (e.g. inflectional or not)

(ii) gradient reduction of [s]-duration → insensitive to morphology

Rule scattering at the morphology-phonology interface

§41 The effect of contextual factors upon phonological variation decreases in magnitude for high-frequency, apparently exceptional items:

e.g. final /t,d/ deletion in New Zealand English

		and	other words
context	__C	88%	58%
	__V	75%	10%
range		13%	48%

small contextual effect *big contextual effect*

Same result for final /s/ deletion in El Salvador Spanish (*entonces, digamos, pues* vs other words).

§42 Guy's explanation: variable allomorphy + variable phonology

- AND has two allomorphs: *and* and *an'*; other words have a single UR.
- Selection of *an'* pre-empts variable /t,d/-deletion, and so attenuates the effect of factors governing the phonological process.

See also Mackenzie (2013) on English auxiliaries.

Again, this is outcome of diachronic **rule scattering**: the allomorphic pattern and the variable phonological rule have the same historical origin. The resulting two-process system is **modular** in that the phonological rule of /t,d/-deletion is blind to lexical identity.

References

Anderson, Stephen R. 1988. Morphological change. In Frederick J. Newmeyer (ed.), *Linguistics: The Cambridge Survey*, 324-362. Cambridge: Cambridge University Press.

Bailey, George. 2018. *Variation and change in Northern English velar nasals: production and perception*. PhD thesis, University of Manchester.

Bailey, George. under review. Insertion and deletion in Northern English (ng): interacting innovations in the life cycle of phonological processes. Available at https://tinyurl.com/yysxz7le, pp. 77-111.

Baudouin de Courtenay, Jan Niecisław. 1895. *Versuch einer Theorie phonetischer Alternationen: ein Kapitel aus der Psychophonetik*. Straßburg: Trübner. Available in English (1972), 'An attempt at a theory of phonetic alternations', in Edward Stankiewicz (ed.), *A Baudouin de Courtenay anthology: the beginnings of structural linguistics* (Indiana University Studies in the History and Theory of Linguistics), Bloomington: Indiana University Press, 144-212.

Bell-Berti, Fredericka. 1993. Understanding velic motor control: studies of segmental context. In Marie K. Huffman & Rena A. Krakow (eds.), *Nasals, nasalization, and the velum* (Phonetics and Phonology 5), 63-85. San Diego: Academic Press.

Bermúdez-Otero, Ricardo. 1999. *Constraint interaction in language change: quantity in English and Germanic [Opacity and globality in phonological change]*. Doctoral dissertation, University of Manchester and Universidad de Santiago de Compostela. Available at http://www.bermudez-otero.com/PhD.pdf.

Bermúdez-Otero, Ricardo. 2003. The acquisition of phonological opacity. In Jennifer Spenader, Anders Eriksson & Östen Dahl (eds.), *Variation within Optimality Theory: Proceedings of the Stockholm Workshop on 'Variation within Optimality Theory'*, 25-36. Stockholm: Department of Linguistics, Stockholm University. Expanded version available as ROA-593-0403 at the Rutgers Optimality Archive, http://roa.rutgers.edu.

Bermúdez-Otero, Ricardo. 2007. Diachronic phonology. In Paul de Lacy (ed.), *The Cambridge handbook of phonology*, 497-517. Cambridge: Cambridge University Press.

Bermúdez-Otero, Ricardo. 2010. Morphologically conditioned phonetics? Not proven. Paper presented at On Linguistic Interfaces II, Belfast, 2 December 2010. Handout available at http://www.bermudez-otero.com/Belfast_handout.pdf.

Bermúdez-Otero, Ricardo. 2011. Cyclicity. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, vol. 4: *Phonological interfaces*, 2019-2048. Malden, MA: Wiley-Blackwell.

Bermúdez-Otero, Ricardo. 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), 8-83. Oxford: Oxford University Press.

Bermúdez-Otero, Ricardo. 2015. Amphichronic explanation and the life cycle of phonological processes. In Patrick Honeybone & Joseph C. Salmons (eds.), *The Oxford handbook of historical phonology*, 374-399. Oxford: Oxford University Press.

Bermúdez-Otero, Ricardo, George Bailey, Maciej Baranowski & Danielle Turton. 2017. The phonological lexicon, usage factors, and rates of change: evidence from Manchester English. Paper presented at ConSOLE XXV, Leipzig, 4 January 2017. Slides available at http://www.bermudez-otero.com/CRE.pdf.

Bermúdez-Otero, Ricardo, Maciej Baranowski, George Bailey & Danielle Turton. 2015. A constant rate effect in Manchester /t/-glottalling: high-frequency words are ahead of, but change at the same rate as, low-frequency words. Paper presented at 2nd Edinburgh Symposium on Historical Phonology, 3 December 2015.

Bermúdez-Otero, Ricardo & Graeme Trousdale. 2012. Cycles and continua: on unidirectionality and gradualness in language change. In Terttu Nevalainen & Elizabeth Closs Traugott (eds.), *The Oxford handbook of the history of English*, 691-720. New York: Oxford University Press.

Bloomfield, Leonard. 1933. *Language*. New York: Holt.

Bybee, Joan. 1998. The phonology of the lexicon: evidence from lexical diffusion. In Michael Barlow & Suzanne Kemmer (eds.), *Usage-based models of language*, 65-85. Stanford: CSLI Publications.

Bybee, Joan. 2001. *Phonology and language use*. Cambridge: Cambridge University Press.

Cohn, Abigail. 1990. Phonetic and phonological rules of nasalization. *UCLA Working Papers in Phonetics* 76, 167-216.

Cohn, Abigail. 1993. Nasalisation in English: phonology or phonetics. *Phonology* 10, 43-81.

Colina, Sonia. 2009. Sibilant voicing in Ecuadorian Spanish. *Studies in Hispanic and Lusophone Linguistics* 2 (1), 1-18.

Dinkin, Aaron J. 2008. The real effect of word frequency on phonetic variation. In Joshua Tauberer, Aviad Eilam & Laurel MacKenzie (eds.), *Proceedings of the 31st Annual Penn Linguistics Colloquium* (University of Pennsylvania Working Papers in Linguistics 14.1), 97-106. Philadelphia: Penn Linguistics Club. Available at http://repository.upenn.edu/pwpl/vol14/iss1/8/.

Do, Young Ah. 2013. *Biased learning of phonological alternations*. Doctoral thesis, MIT.

Do, Young Ah. 2018. Paradigm uniformity bias in the learning of Korean verbal inflections. *Phonology* 35 (4), 547-575.

Erker, Daniel. 2012. Of categories and continua: relating discrete and gradient properties of sociophonetic variation. *University of Pennsylvania Working Papers in Linguistics* 18 (Issue 2, *Selected papers from NWAV 40*), 11-20. Available at http://repository.upenn.edu/pwpl/vol18/iss2/3.

Fruehwald, Josef. 2013. *The phonological influence on phonetic change*. Doctoral dissertation, University of Philadelphia.

Fruehwald, Josef. 2016. The early influence of phonology on a phonetic change. *Language* 92 (2), 376-410.

Gahl, Susanne. 2008. *Time* and *thyme* are not homophones: the effect of lemma frequency on word durations in spontaneous speech. *Language* 84 (3), 474-496. CITE ALSO GAHL 2009 AND LOHMANN 2018.

Garrett, Andrew & Juliette Blevins. 2009. Analogical morphophonology. In Kristin Hanson & Sharon Inkelas (eds.), *The nature of the word: essays in honor of Paul Kiparsky*, 527-545. Cambridge, MA: The MIT Press.

Hay, Jennifer B., Janet B. Pierrehumbert, Abby J. Walker & Patrick LaShell. 2015. Tracking word frequency effects through 130 years of sound change. *Cognition* 139, 83-91.

Hay, Jennifer & Paul Foulkes. 2016. The evolution of medial /t/ over real and remembered time. *Language* 92 (2), 298-330.

Hayes, Bruce. 2004. Phonological acquisition in Optimality Theory: the early stages. In René Kager, Joe Pater & Wim Zonneveld (eds.), *Constraints in phonological acquisition*, 158-203. Cambridge: Cambridge University Press.

Hill, Nathan W. 2014. Grammatically conditioned sound change. *Language and Linguistics Compass* 8 (6), 211-229.

Hyman, Larry. 1976. Phonologization. In Alphonse Juilland, A. M. Devine & Laurence D. Stephens (eds.), *Linguistic studies offered to Joseph Greenberg on the occasion of his sixtieth birthday* (Studia Linguistica et Philologica 4), 407-418. Saratoga, CA: Anma Libri.

Kawahara, Shigeto. 2011. Experimental approaches in theoretical phonology. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, vol. 4: *Phonological interfaces*. Malden, MA: Wiley-Blackwell.

Kiparsky, Paul. 1965. *Phonological change*. Doctoral dissertation, MIT.

Kiparsky, Paul. 1988. Phonological change. In Frederick J. Newmeyer (ed.), *Linguistics: the Cambridge survey*, vol. 1, *Linguistic theory: foundations*, 363-415. Cambridge: Cambridge University Press.

Kiparsky, Paul. 1995. The phonological basis of sound change. In John A. Goldsmith (ed.), *The handbook of phonological theory*, 640-670. Oxford: Blackwell.

Kiparsky, Paul. 2015. Phonologization. In Patrick Honeybone & Joseph C. Salmons (eds.), *The Oxford handbook of historical phonology*, 563-582. Oxford: Oxford University Press.

Kiparsky, Paul. 2016. Labov, sound change, and phonological theory. *Journal of Sociolinguistics* 20 (4), 464-488.

Kiparsky, Paul. 2018. Accent and ablaut: emergent cyclicity. In David M. Goldstein, Stephanie W. Jamison & Brent Vine (eds.), *Proceedings of the 28th Annual UCLA Indo-European Conference November 11th and 12th, 2016*. Bremen: Hempen.

Kruszewski, Mikołaj. 1881. *Ueber die Lautabwechslung*. Kazan: Universitätsbuchdruckerei. Available in English (1995), 'On sound alternation', translated by Robert Austerlitz, in *Writings in general linguistics* (Amsterdam Classics in Linguistics 11), edited by Konrad Koerner, Amsterdam: John Benjamins, 3-34.

Labov, William. 1989. Exact description of the speech community: short *a* in Philadelphia. In Ralph W. Fasold & Deborah Schiffrin (eds.), *Language change and variation*, 1-57. Amsterdam: John Benjamins.

Labov, William. 1994. *Principles of linguistic change*, vol. 1: *Internal factors*. Oxford: Blackwell.

MacKenzie, Laurel. 2013. Variation in English auxiliary realization: a new take on contraction. *Language Variation and Change* 25 (1), 17-41.

McCarthy, John J. 1998. Morpheme structure constraints and paradigm occultation. In M. Catherine Gruber, Derrick Higgins, Kenneth Olson & Tamra Wysocki (eds.), *CLS 32, Part 2: The Panels*, 123-150. Chicago, IL: Chicago Linguistic Society.

Morrison, Donald Alisdair. 2018. Vowel nasalisation in Scottish Gaelic: the search for paradigm uniformity effects in fine-grained phonetic detail. In Gillian Gallagher, Maria Gouskova & Sora Yin (eds.), *Proceedings of the 2017 Annual Meeting on Phonology*. Washington, DC: Linguistic Society of America.

Ohala, John J. 1981. The listener as a source of sound change. In Carrie S. Masek, Roberta A. Hendrick & Mary Frances Miller (eds.), *Papers from the parasession on language and behavior* (Chicago Linguistic Society 17), 178-203. Chicago: Chicago Linguistics Society.

Ohala, John J. 1989. Sound change is drawn from a pool of synchronic variation. In Leiv Egil Breivek & Ernst Håkon Jahr (eds.), *Language change: contributions to the study of its causes*, 173-198. Berlin: Mouton de Gruyter.

Paul, Hermann. 1886. *Principien der Sprachgeschichte*, 2nd edn. Halle: Max Niemeyer. 1st edn 1880.

Pierrehumbert, Janet B. 2001. Exemplar dynamics: word frequency, lenition and contrast. In Joan L. Bybee & Paul Hopper (eds.), *Frequency and the emergence of language structure*, 137-157. Amsterdam: John Benjamins.

Pierrehumbert, Janet B. 2002. Word-specific phonetics. In Carlos Gussenhoven & Natasha Warner (eds.), *Laboratory Phonology 7*, 101-139. Berlin: Mouton de Gruyter.

Ramsammy, Michael. 2015. The life cycle of phonological processes: accounting for dialectal microtypologies. *Language and Linguistics and Language Compass* 9 (1), 33-54.

Ramsammy, Michael. 2018. The phonology-phonetics interface in constraint-based grammar: gradience, variability, and phonological change. In S.J. Hannahs & Anna R. K. Bosch (eds.), *The Routledge handbook of phonological theory*. Abingdon: Routledge.

Robinson, Orrin Warner. 1976. A "scattered" rule in Swiss German. *Language* 52 (1), 148-162.

Sen, Ranjan. 2016. Examining the life cycle of phonological processes: considerations for historical research. *Papers in Historical Phonology* 1, 5-36.

Steriade, Donca. 2000. Paradigm uniformity and the phonetics-phonology boundary. In Michael B. Broe & Janet B. Pierrehumbert (eds.), *Papers in laboratory phonology V: acquisition and the lexicon*, 313-334. Cambridge: Cambridge University Press.

Strycharczuk, Patrycja. 2012. *Phonetics-phonology interactions in pre-sonorant voicing*. PhD thesis, University of Manchester. Available at http://ling.auf.net/lingbuzz/001645.

Strycharczuk, Patrycja. forthcoming. Phonetic detail and gradience in morphophonological alternations. In Mark Aronoff (ed.), *Oxford Research Encyclopedia of Linguistics*. Oxford: Oxford University Press.

Strycharczuk, Patrycja & James M. Scobbie. 2016. Gradual or abrupt? The phonetic path to morphologisation. *Journal of Phonetics* 59, 76-91.

Strycharczuk, Patrycja, Marijn Van 't Veer, Martine Bruil & Kathrin Linke. 2014. Phonetic evidence on phonology-morphosyntax interactions: sibilant voicing in Quito Spanish. *Journal of Linguistics* 50 (2), 403-452.

Tessier, Anne-Michelle. 2006. *Biases and stages in phonological acquisition*. Amherst, MA: Doctoral dissertation, University of Massachusetts. Available as ROA-883-1106, Rutgers Optimality Archive, http://roa.rutgers.edu.

Tessier, Anne-Michelle. 2016. *Phonological acquisition: child language and constraint-based grammar*. London: Palgrave.

Todd, Simon, Janet B. Pierrehumbert & Jennifer Hay. 2019. Word frequency effects in sound change as a consequence of perceptual asymmetries: An exemplar-based model. *Cognition* 185, 1-20.

Turton, Danielle. 2016. Synchronic stratum-specific rates of application reflect diachronic change: morphosyntactic conditioning of variation in English /l/-darkening. *Papers in Historical Phonology* 1, 130-165.

Turton, Danielle. 2017. Categorical or gradient? An ultrasound investigation of /l/-darkening and vocalization in varieties of English. *Laboratory Phonology* 8 (1), art. 13.

Vennemann, Theo. 1972. Phonetic analogy and conceptual analogy. In Theo Vennemann & Terence H. Wilbur (eds.), *Schuchardt, the neogrammarians, and the transformational theory of phonological change: four essays* (Linguistische Forschungen 26), 181-204. Frankfurt am Main: Athenäum Verlag.

Whalen, D. H. 1991. Infrequent words are longer in duration than frequent words. *The Journal of the Acoustical Society of America* 90 (4), 2311.

Wright, Richard. 2003. Factors of lexical competition in vowel articulation. In John Local, Richard Ogden & Rosalind Temple (eds.), *Phonetic interpretation: Papers in Laboratory Phonology VI*, 75-87. Oxford: Oxford University Press.

Zellou, Georgia & Meredith Tamminga. 2014. Nasal coarticulation changes over time in Philadelphia English. *Journal of Phonetics* 47, 18-35.

Zsiga, Elizabeth C. 1995. An acoustic and electropalatographic study of lexical and postlexical palatalization in American English. In Bruce Connell & Amalia Arvaniti (eds.), *Phonology and phonetic evidence: papers in laboratory phonology IV*, 282-302. Cambridge: Cambridge University Press.