Visualising vowel harmony decay in Old Norse manuscripts

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There is a working paper out in relation to today's talk: http://journals.ed.ac.uk/pihph/article/view/4417

- all recommendations, corrections, suggestions are welcome!

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Vowel harmony decay in Old Norwegian

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Abstract

Vowel harmony involves the systematic correspondence between vowels in some domain for some phonological feature. Though harmony represents one of the most natural and diachronically robust phonological phenomena that occurs in human language, how and why harmony systems emerge and decay over time remains unclear. Specifically, what motivates harmony decay and the pathways by which harmony languages lose harmony remains poorly understood since no consistent historical record in any single language has yet been identified which displays the full progression of this rare sound change (McCollum 2015, 2020; Kavitskaya 2013, Bobaljik 2018). In this paper, I explore the progression and causation of vowel harmony decay in Old Norwegian (*c* 1100–1350). Using a grapho-phonologically tagged database of a sample of 13th- to 14th-century manuscripts, I present novel corpus methods for tracking and visualising changes to vowel co-occurrence patterns in historical records, demonstrating that the Old Norwegian corpus provides a consistent and coherent record of harmony decay. The corpus distinguishes categorical pre-decay harmony, probabilistic intermediate stages, and post-decay non-harmony. Across the Old Norwegian manuscripts, we observe a variety of pathways of harmony decay, including increasing harmony variability via the collapse of harmony classes introduced by vowel mergers, the lexicalisation of historically harmonising morphemes, and trisyllabic vowel reductions which limit harmony iterativity. This paper provides the first detailed corpus study of the full spectrum and causation of this rare sound change in progress and provides valuable empirical diagnostics for identifying and analysing harmony change in contemporary languages.

1 Introduction

1.1 Vowel harmony and harmony decay

This paper explores the causes and progression of a rarely attested sound change: vowel harmony decay or the loss of vowel harmony. Very

Outline

- Dynamic sound change
  - vowel harmony decay
- New corpus study
  - Old Norwegian vowel harmony decay
- Motivations and pathways

- collapse of harmony classes introduced by vowel mergers
- increasing harmony optionality
- lexicalisation of historically harmonising morphemes
- vowel reductions in trisyllabic positions which limit harmony iterativity

1 Background

1.1 Vowel harmony basics

Very generally defined, **vowel harmony** is a process in which vowels in a word show systematic correspondence for some feature.

- an example of labial or rounding harmony is provided in (1)

(1) **Rounding harmony in Yakut** (Siberian-Turkic; Krueger 1962: pp. 46–53)
  a. kel-el-ler 'come'-3.PRES.-PL.
  b. kør-øl-lør 'see'-3.PRES.-PL.
  c. kele-ɣin 'come'-2.SG.
  d. døjø-ɣyn 'grow quiet'-2.SG.

Vowel harmony typology

Any segmental feature may serve as the basis for a harmony system

Chewa (Bantu) height harmony (Downing & Mtenje 2017)
  [+high] phík-il 'cook'-APPL.
  [−high] tsék-el 'close'-APPL.
Finnish (Finno-Ugric) backness harmony (Ringen 1975)
  [+back] pouta-na 'fine weather'-ESS.
  [−back] pöytnä-nä 'table'-ESS.
Yoruba (Atlantic-Congo) tongue root harmony (Ọla Orie 2001; 2003)
  [+ATR] ògèdè 'incantations'
  [−ATR] ɔ̀gɛ̀dɛ̀ 'banana, plantain'

Prevalence and motivations for harmony

Harmony systems are considered to be among the most natural phonological processes

- articulatorily and perceptually motivated,
  - eases articulation, makes sequences more predictable, enhances perceptually weak cues, etc. (Suomi 1983; Gallagher 2010; Walker 2005)
- easy to learn and acquired early

  - few to no harmony violations by ca. 2;6 years (MacWhinney 1978; Leiwo, Kulju & Aoyama 2002; Altan 2007)

- cross-linguistically very common and diachronically robust
  - e.g. millenia old backness harmony in Turkic languages (Harrison, Dras & Kapicioglu 2006)

1.2 Vowel harmony decay

Despite the stability of harmony systems, diachronic and/or cross-dialectal correspondences with historical and existing harmony languages show that harmony systems do decay.

- e.g. Turkish vs. Uzbek (Turkic; Csató & Johanson 1998; Sjoberg 1963).

(2) **Turkic backness harmony lost in Uzbek**

BACK	dost-lar		'friend'-PL.		do'st-lar		'friend'-PL.
	kul-lar		'slave'-PL.		qul-lar		'slave'-PL.
FRONT	et-ler	*et-lar	'meat'-PL.		et-lar	*et-ler	'meat'-PL.
	diş-ler	*diş-lar	'tooth'-PL.		tish-lar	*tish-ler	'tooth'-PL.

(a) Turkish – [-lar] / [-ler] **(b)** Uzbek – [-lar]

Question: If harmony is so natural and beneficial, what motivates **harmony decay** and how do harmony processes die?

1.3 Sources of evidence

We know currently little about the causes and nature of harmony decay

- no historical record has been shown to demonstrate harmony decay in progress.

Currently, we can examine harmony decay using:

- comparisons between harmonic/non-harmonic dialects
  - Crimean Tatar (Turkic; Kavitskaya 2013)
- diachronic comparisons before and following harmony decay
  - e.g. Chaghatai (Bodrogligeti 2002; Eckmann 1966) and its descendant Uzbek (Sjoberg 1963; Harrison, Dras & Kapicioglu 2006); see also Kazakh (Turkic; McCollum 2015); Itelmen (Chukotko-Kamchatkan; Bobaljik 2018)

- agent-based computational modelling of potential trajectories of vowel harmony evolution/decay
  - e.g. Harrison, Dras & Kapicioglu (2006); Mailhot (2010)

From these studies, we have a number of suspected causes of harmony decay:

- changes in vowel inventories (mergers/splits),
- emergence of disharmonic morphemes,
- vowel reduction,
- language contact (i.e. via the influx of disharmonic foreign loanwords)

Problem: We lack empirical evidence

- ☞ crucial missing link in the typological record: the transition from a harmonic to non-harmonic language.
- ☞ unclear how and why these factors might converge on the loss of harmony

2 Corpus study

2.1 Old Norwegian vowel harmony

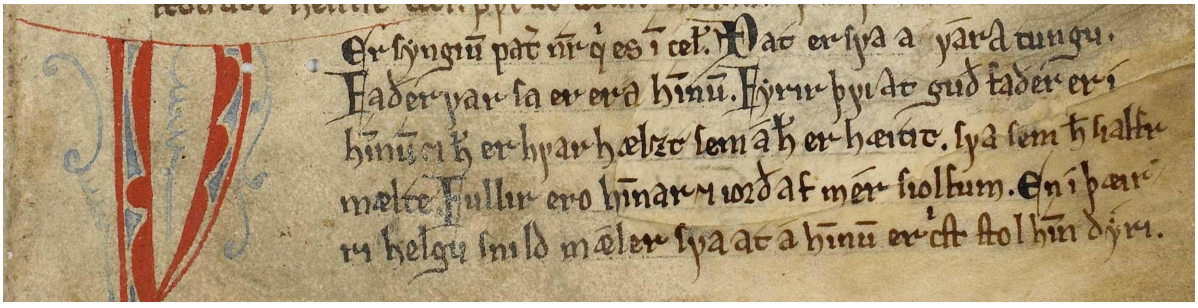


Figure 2: The Old Norwegian homily book. AM 619 4to, *c* 1200–25, the Arnamagnæan Institute, University of Copenhagen. Image by Suzanne Reitz. Fol. 76r, lines 26–30.

VEr ſyngium pater noſter qui es in celis. Þat er ſva a vára tungu. / Faðer var ſa er er a himnum. Fyrir þvi at guð faðer er í / himnum. *ok* hann er hvar hælzt ſem á hann er hæitit. ſva ſem hann ſialfr / mælte. Fullir ero himnar *ok* iorð af mér ſiolfum. En í þæir· / ri helgu ſnild mæler ſva at á himnum er Criſt ſtol hinn dýri. ['We sing *pater noster qui es in cælis*. It is so in our language: / Our father that which is in heaven. For God, father, is in heaven, and he is everywhere where he is called, as he himself said: "Full are heaven and earth of me myself." And in the holy text it is thus said that in heaven is Christ's precious footstool.']

Old Norwegian (*c* 1200–1350) displays a form of vowel height harmony (3)

- resulting in [-i]/[-e] and [-u]/[-o] suffixal alternations

(3) **Height harmony in Old Norwegian** (Sandstedt 2017; 2018)

High	hú̲s-i	<huſı>	hú̲s-um	<huſū>	'house'-DAT.SG./PL.
	ski̲p-i	<ſkıpı>	ski̲p-um	<ſkıpum>	'ship'-DAT.SG./PL.
Non-high	ljó̲s-e	<lıoſe>	ljó̲s-om	<lıoſom>	'light'-DAT.SG./PL.
	se̲gl-e	<ſegle>	se̲gl-om	<ſeglō>	'sail'-DAT.SG./PL.

- cf. non-harmonic Old Icelandic *ljós-i* and *segl-i*

Old Norwegian vowel harmony typology

Old Norwegian vowel harmony is structurally very similar to Bantu height harmony

- e.g. Mbunda (K.15; aka Chimbunda, Kimbunda, or Mbuunda), spoken in Angola and Zambia (Gowlett 1970).

(4) **Early Old Norse height harmony lost in Icelandic**

High	hú̲s-um		'house'-DAT.PL.		hú̲s-um		'house'-DAT.PL.
	ski̲p-um		'ship'-DAT.PL.		ski̲p-um		'ship'-DAT.PL.
Non-/ High	ljó̲s-om	*ljó̲s-um	'light'-DAT.PL.		ljó̲s-um	*ljó̲s-om	'light'-DAT.PL.
	se̲gl-om	*se̲gl-um	'sail'-DAT.PL.		se̲gl-um	*se̲gl-om	'sail'-DAT.PL.

(a) Old Norwegian – [-um] / [-om]

(b) (Old) Icelandic – [-um]

It is currently conjectural that Old Icelandic had vowel harmony, but the possibility is supported by orthogonal evidence from insular runic inscriptions and certain manuscript material

- statistical tendencies towards height harmonic distributions in certain Icelandic manuscripts have been interpreted as post-harmony decay remnants in Old Icelandic (Flom 1934a), and even as far west as Greenland there are indications of height harmony; such as in the first of the Garðar stones (GR 1, ca. 13th–14th century) or the Kingittorsuaq stone (GR 1, ca. 1200/1250 or later) which contrast high **hu**i**l**i**r** *hvílir* 'rests' or **f**y**r**i**r** *fyrir* 'before' with non-high **gl**e**ð**e *gleðe* 'gladness' or the name **b**aa**nn**e *Bjarne*

Attested harmony decay: Harmony decay has occurred in Nordic languages, documented in the Old Norse manuscript corpus

Philological descriptions

Harmony is found in the earliest writing on parchment (*c* mid-12th century)

- decaying gradually over the course of the late 13th and 14th centuries (Flom 1934b, Seip 1955, Hødnebø 1977, Hagland 1978)

> *Dette [vokalharmoni]systemet kan følges fra eldste skriftid og et godt stykke inn i 1300-tallet som en slags norm. Henimot slutten av hundreåret inntrer en jevn tilbakegang med stadig flere unntak fra regelen.*
>
> This [vowel harmony] system can be seen from the oldest writings and up to a good ways into the 1300s as a kind of norm. Towards the end of the century, there is a steady decline with ever-increasing exceptions to the rule. (Hødnebø 1977: 379)

Old Norwegian philological material provides thus a sizeable corpus of manuscripts, charters, and runic inscriptions

- covering pre-, transitional, and post-decay stages of vowel harmony

☞ providing rare insights into the full progression of this rare sound change

2.2 Methods and corpus

Methodological challenges

Hødnebø's generalisation is statistical

- using digital corpora, we can begin to quantify variation in Old Norwegian vowel harmony patterns

Digital corpora

Medieval Nordic Text Archive (MENOTA): https://menota.org/forside.xhtml

- an increasing, digitised sample of Old Norwegian manuscript material
  - many of which are lexically and morphologically tagged

Structure of MENOTA transcriptions

(5) **MENOTA transcription of** <hofðíngıanom> **'chieftain'-DAT.M.SG.-DEF. (Holm perg 6 fol.)**

```
<w xml:id='w034581' lemma='hǫfðingi' me:msa='xNC gM nS cD sD'>
<me:dipl>hofðingianom</me:dipl>
</w>
```

Abbr.	Signature	MS or work title		Date	Provenance	Words
AM619	AM 619 4to	*The Norwegian Homily Book*	*c*	1200–25	Bergen	60729
Pamph	De la Gardie 4–7, fols. 3r–5v	*Pamphilus saga*	*c*	1270	Bergen	4470
Streng_h1	De la Gardie 4–7, fols. 17va6–29v	*Strengleikar*–hand 1	*c*	1270	Bergen	18341
Streng_h2	De la Gardie 4–7, fols. 30r–43v	*Strengleikar*–hand 2	*c*	1270	Bergen	20111
AM243	AM 243 bα fol	*King's Mirror*	*c*	1275	Bergen	63910
H34	Holm perg 34 4to	*Bǫjarlǫg ok Farmannalǫg Magnúss Hákonarsónar*	*c*	1275–1300	Bergen	56509
H6	Holm perg 6 fol	*Saga of Barlaam and Josaphat*	*c*	1275	Eastern	76411
DG8	De la Gardie 8 fol, fols. 70v–110v	*Legendary saga of St. Olaf*	*c*	1225–50	Trøndsk	41142
H4_h1	Holm perg 4 fol, fols. 1r–14v	*Þiðriks saga af Bern*–hand1	*c*	1275–1300	Trøndsk	8281
NRA58c	NRA 58 C	*A fragment of Konungs skuggsjá*	*c*	1260–70	Uncertain	2992
H17	Holm perg 17 4to	*Saga of Archbishop Thómas*	*c*	1300	Uncertain	59756
NRA7	NRA 7	*A fragment of Landslǫg Magnúss Hákonarsonar*	*c*	1300–50	Uncertain	5720

Table 1: The elicited manuscripts' size and estimated date / provenance

A vowel harmony database

With the help of Pavel Iosad (University of Edinburgh), we have designed scripts collecting relevant vowel patterns and lexical and morphological annotations

- vowel harmony is an iterative process applying syllable by syllable
- vowel patterns are therefore

  organised into pairwise vowel sequences which are evaluated for height harmonic correspondence (Table 2)

Harmonic span	V1	V2	V1_high	V2_high	VH
{hofðíng}$_1$ ianom	<o>	<í>	0	1	0
hof {ðíngia}$_2$ nom	<í>	<a>	1	0	0
hofðíng {ianom}$_3$	<a>	<o>	0	0	1

Table 2: Division into pairwise harmonic spans – *hǫfðingjanom* 'chieftain'-DEF.DAT.M.SG.

Controlling for variation

An orthographic database like Tab. 2 is useful, but it needs to controll for orthographic variation

* e.g. spelling varation for [o, ǫ, a] – <o, a>
  - more vowel phonemes than graphemes
  - [ǫ] generally has no unique letter in Norwegian writing
    * e.g. both <hofðingia> and <hafðingia> are attested spellings for normalised *hǫfðingja*

Grapho-phonology

Each segment is annotated with corresponding etymological/phonological representations to triangulate between non-/distinct phonological and orthographic values

- e.g. <h**o**fðingia> = <**o**–i> = [o̜–i]
- e.g. <h**a**fðingia> = <**a**–i> = [o̜–i]

Etymological/phonological values are based on Holthausen (1948)

- encoded for the 600 most common lexemes in the corpus (275,554 words)
- allows for the study of harmony variation both with respect to linguistic and orthographic factors

Sample annotated data

An abbreviated example of vocalic data with phonological annotations included in this database are provided in Table 3

This table illustrates how graphophonological annotations capture:

- spelling variation (e.g. <støðe> vs. <stœþe> = [øː-e]
- avoids consonantal vocalic spellings (e.g. <hofðíng**i**anom> for *hǫfðing**j**anom*)
- avoids abbreviated material (e.g. <kkunar> for *k**ir**k**j**un**n**ar*)
- captures linguistically motivated variants (e.g. representation of *j*-umlaut in <gi**æ**va> for [gjæva] vs. non-umlauted <giava> for [gjava])

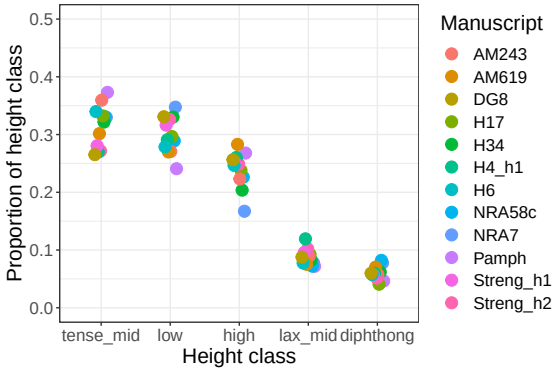
id	dipl	expanded	lemma	seq_no	v1	v2	etym1	etym2	v1_high	v2_high	VH
11857	stendr	stendr	standa	1	e	NA	ɛ	NA	0	NA	NA
30331	støðe	støðe	standa	1	ø	e	ø:	e	0	0	1
48957	stœþe	stœþe	standa	1	œ	e	ø:	e	0	0	1
65048	hofðíngianom	hofðíngianom	hǫfðingi	1	o	í	ɔ	i	0	1	0
65048	hofðíngianom	hofðíngianom	hǫfðingi	2	í	a	i	a	1	0	0
65048	hofðíngianom	hofðíngianom	hǫfðingi	3	a	o	a	o	0	0	1
34024	kkunar	kirkiunnar	kirkia	1	u	a	u	a	1	0	0
18773	giæva	giæva	giof	1	æ	a	æ	a	0	0	1
43804	giava	giava	giof	1	a	a	a	a	0	0	1

Table 3: Examples from the etymologically annotated data-frame (abbreviated)

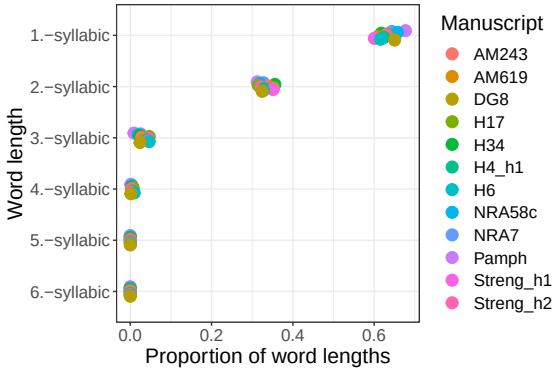
2.3 Sanity check

The manuscripts display good agreement on word length and vowel height class frequencies

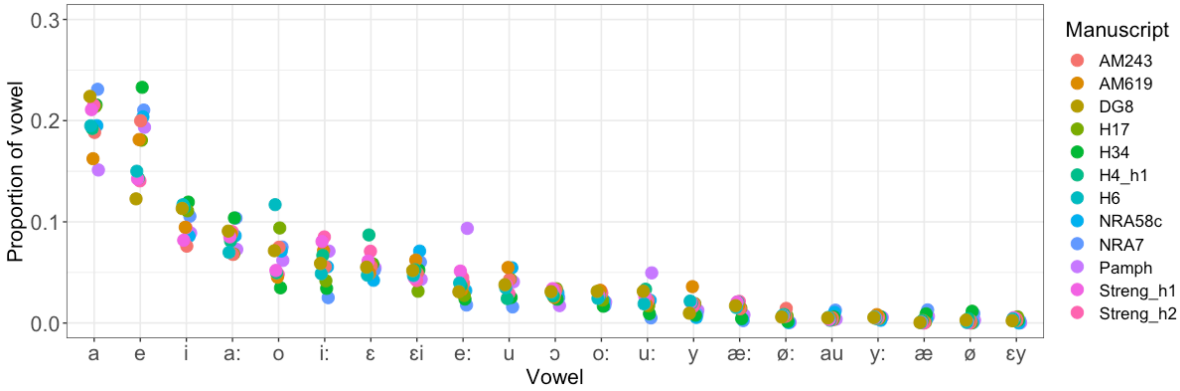
☞ demonstrating coherent and consistent data across the corpus



(a) Vowel height class proportional frequencies



(b) Word length proportional frequencies



(c) Stressed vowel proportional frequencies

Figure 4: Consistent vowel, height class, and word length frequencies across manuscripts

Some basic stats:

- mean syllable length of 1.53
- around 45% of words are polysyllabic
- median word length in writing is 4 letters
- average proportion of vowels to word length in writing is approximately 43% (1.64/3.95)

3 Visualising vowel harmony decay

Using this study's grapho-phonological database, we can begin to measure and visualise harmony variation across the corpus to track the decay of harmony patterns in Old Norwegian

3.1 *PhonMatrix* visualisations

One novel way to examine harmony co-occurrence patterns in written corpora is provided by *PhonMatrix* visualisations, developed by developed by Mayer et al. (2010) and Mayer & Rohrdantz (2013) – accessible at http://phonmatrix.herokuapp.com/

PhonMatrix visualisations provide coloured matrices reflecting vowel co-occurrance frequencies, as in Fig. 5

- easy visual discovery of harmony patterns

Figure 5: *PhonMatrix* visualisations of pre-decay Old Norwegian harmony in H6

PhonMatrix method

PhonMatrix takes as an input a V_1–V_2 vowel matrix

- each vowel pair is assigned some association measure based on their frequency of occurrence
  - e.g. using the phi coefficient

The phi coefficient is a normalised measure of association based on the χ^2 coefficient

- defined as the square root of the ratio of χ^2 to the sample size
  - i.e. $\phi = \sqrt{\frac{\chi^2}{n}}$

A practical illustration of how this is calculated is provided below using the crosstabulation in (6)

- $\phi = \frac{v \cdot z - x \cdot y}{\sqrt{a \cdot b \cdot c \cdot d}}$

(6) **[a…e] contingency table**

	[e]	not-e	Total
[a]	v	x	a
not-a	y	z	b
Total	c	d	

The phi coefficient ranges from -1 to 1

- *PhonMatrix* visualisation maps the phi values to a bipolar colour scale (from red to blue)
- the darkness of the colour provides a visual indicator of the strength of each V_1–V_2 association
  - positive associations are blue
  - negative associations are red

Some caveats:

- the *PhonMatrix* platform currently requires each segment to be monographic
  - i.e. *a:* and *au* are currently not permitted
- some vowels such as short [ø] occur too infrequently to provide reliable results – not included

Comparing harmony frequencies across the corpus

Fig. 6 illustrates the harmony patterns across the corpus in historically harmonising contexts

- including root-initial vowel sequences with potential harmony triggers and potential harmony targets
- excluding compounds, neutral segments, and other non-harmonising contexts

For clarity's sake, I have added reference lines to Fig. 6

- dividing high and non-high vowels

Manuscripts are ordered from highest average harmony levels to least

- illustrating the range of harmony and harmony decay in the corpus

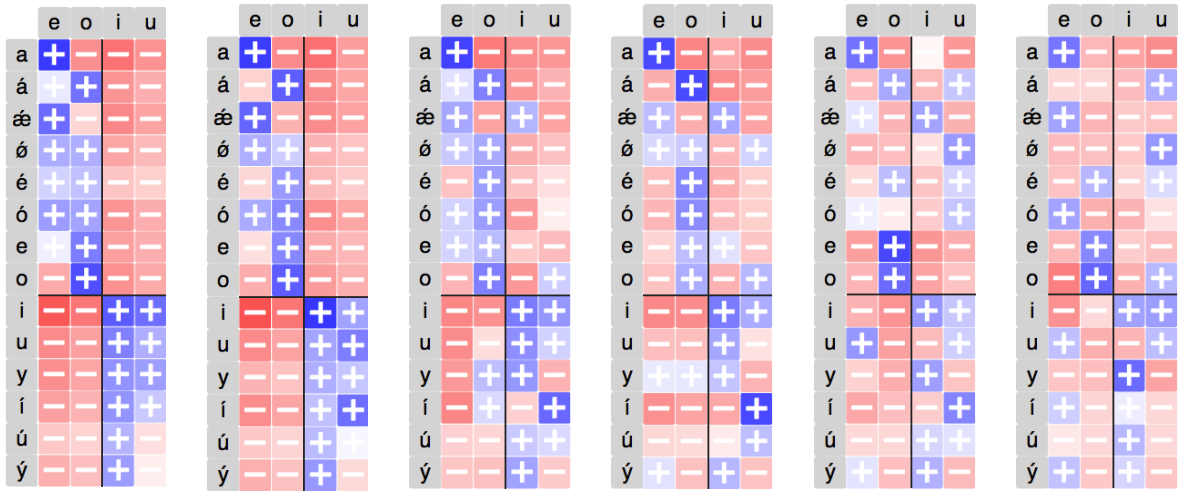


Figure 6: Sample of *PhonMatrix* visualisations of 13th-century Old Norwegian harmony decay

Summary of *PhonMatrix* visuals

In pre-harmony decay manuscripts (H6/DG8)

- V_2-[e, o] vowels (the *e/o* columns) strongly correlate with non-high vowels [a, á, ǽ, ǿ, é, ó, e, o]
- V_2-[i, u] vowels (the *i/u* columns) pattern with high V_1-vowels [i, u, y, í, ú, ý]
  - resulting in the stark asymmetric distribution of blue/red [+]/[−] cells between high/non-high vowels

From left to right, this pattern is less and less discernable as the effect of harmony decay increases to completion in AM243/H17.

3.2 Distinguishing decay stages

Fig. 7 provides a broader look, showing the rate at which different V_1-height classes trigger harmony

- high vowels and diphthongs trigger high harmony
- mid vowels and low vowels trigger non-high harmony

In Fig. 7, the manuscripts are organised by overall mean vowel harmony (the black reference line) – from highest to lowest

- illustrating the gradual progression of vowel harmony decay

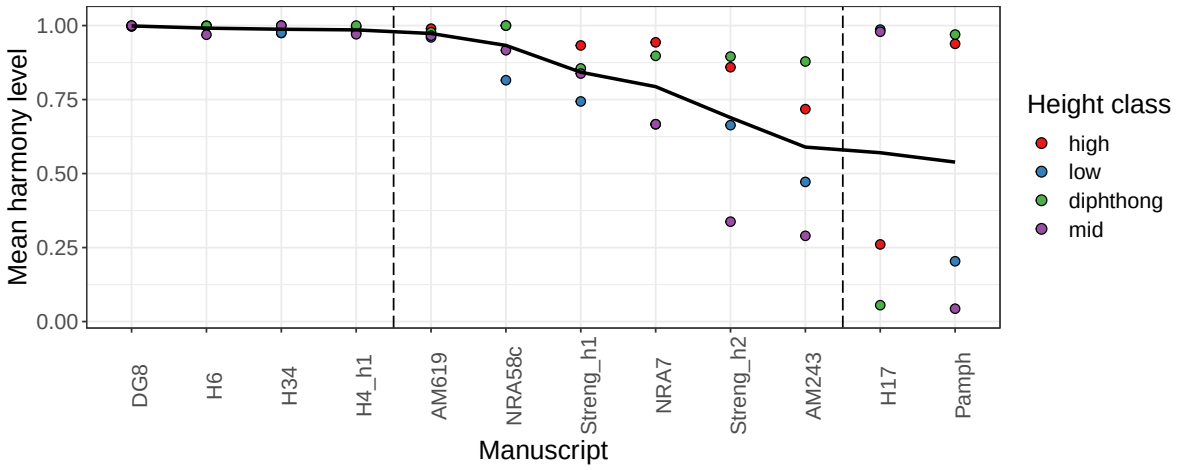


Figure 7: Mean harmony levels in historically harmonising contexts by manuscript height class in pre-decay, intermediary, and post-decay manuscripts

The manuscripts are divided up into three groups, separated by dotted vertical reference lines

- pre-decay, robust harmony systems
- probabilistic, transitional decaying systems
- post-decay, non-harmonic systems

Broad generalisations

Lower mean vowel harmony (the reference line) is correlated with increasing dispersion

- demonstrating that harmony decay is present in the corpus

Pre-decay, robust harmony systems

- manuscripts on the left (DG8–H4_h1)
- height correspondence is under tight control

  ☞ high harmony and low variance, i.e. harmony applies categorically

Transitional systems

- DG4_7 manuscripts
- probabilistic harmony

  ☞ lower harmony but still low variance, i.e. rule driven but variable/optional

Post-decay, non-harmonic systems

- manuscripts on the right (AM243–H17)
- no discernable height correspondence
  - low harmony and high variance
  - high or non-high height classes below 50% harmony threshold

    ☞ reflects levelled, non-alternating suffixes

4 The causes and pathways of harmony decay

There are four probable causes and ways in which vowel harmony has decayed in Old Norwegian:

1. Collapse of harmony classes due to vowel mergers
2. Increasing harmony optionality/gradience across domains
3. Lexicalisation of historically harmonising morphemes
4. Narrowing of the harmony domain due to vowel reductions in trisyllabic positions

4.1 Vowel mergers

Exceptions in harmony patterns such as neutral harmony (e.g. transparency, blocking, etc.) are cross-linguistically strongly associated with asymmetric inventory shape (Kiparsky & Pajusalu 2006; Nevins 2010; Sandstedt 2018; van der Hulst 2018)

- e.g. /i e/ are transparent non-participants in Finnish backness harmony (harmonically unpaired for the harmony feature)

	Front		Back	
	Non-Round	Round	Non-Round	Round
High	i	y	*ɯ	u
Mid	e	ö	*ɤ	o
Low	ä		a	

Table 4: Finnish uneven distribution of front–back vowels

It is therefore not surprising that the loss of vowel harmony is commonly associated with changes to the language's sound inventory

- e.g. backness harmony decay between Chaghatai and Modern Uzbek (Turkic) has been attributed to the merger of front/back /i ɯ y u ø o/ contrasts (Harrison, Dras & Kapicioglu 2006)
- e.g. Agoi (Benue-Congo) displays tongue root harmony where the ongoing merger of ATR/RTR distinctions on high vowels /i ɪ u ʊ/ results in /i u/-harmony neutrality (Yul-Ifode 2003)

Old Norwegian provides a cognate case of harmony decay involving vowel mergers

- harmony decay is correlated with the merger of /e ɛ/ (normalised *e*–*æ*, see Hreinn Benediktsson 1964 for an overview)

Merging vowel harmony patterns

In pre-decay manuscripts, /e/ triggers harmony while /ɛ/ does not

- the merger of these vowel qualities results in the gradual merger of their harmony patterns, changing or collapsing these harmony classes and increasing harmony variability

(7) **Distinct vs. merging **e*/**ɛ* vowels and vowel harmony**

DG8 – non-merged /e/–<e> vs. /ɛ/–<æ>

harmonic	**e*	<veg>	'way'-ACC.M.SG.
		<gerðe>	'do'-PRET.3.SG.
neutral	**ɛ*	<kænndi>	'know'-PRET.3.SG.
		<sægir>	'say'-PRES.3.SG.

AM619 – merging /e ɛ/ – <e æ>

dis/harmonic	**e*	<veg, væg>	'way'-ACC.M.SG.
		<gerðe, gærði>	'do'-PRET.3.SG.
dis/harmonic	**ɛ*	<kennde, kennde>	'know'-PRET.3.SG.
		<fægir, fegir>	'say'-PRES.3.SG.

Many-to-few sound–letter correspondences

Studying this merger in Old Norwegian is complicated by the asymmetry between vowel sound and letter inventories

- Old Norwegian has more vowels than letters ([e ɛ æ] – <e æ>)
- the /e ɛ/ contrast is not well represented in all manuscripts, regardless the phonological state of the contrast

Certain manuscripts display contrastive harmony patterns despite non-contrastive spellings (Sandstedt 2018: §5.1.2)

- cf. *æ*-manuscripts like DG8 and *e*-manuscripts like H6 in (8)

[i, iː]	<i>	[y, yː]	<y>	[u, uː]	<u>	HIGH
[e, eː]	<e>	[ø, øː]	<œ, ø>	[o, oː]	<o>	MID TENSE
[ɛ]	<æ, e>			[ɔ]	<o, a>	MID LAX
[æ, æː]	<æ>			[a, aː]	<a>	LOW

Table 5: Old Norwegian sound–letter correspondences

(8) **(Non-)etymological **e*/**ɛ* spellings in Old Norwegian manuscripts**

DG8 – *c* (1225–50) [e ɛ] – <e æ>

**e*	<gev-e>	'give'-3.SG.PRES.SUBJ.	<rek-et>	'drive'-PRET.PART.
**ɛ*	<hæv-i>	'have'-3.SG.PRES.SUBJ.	<tæk-it>	'take'-PRET.PART.

H6 – *c* (1275) [e ɛ] – <e>

**e*	<gev-e>	'give'-3.SG.PRES.SUBJ.	<rek-et>	'drive'-2.PL.IMP.
**ɛ*	<hev-i>	'have'-3.SG.PRES.SUBJ.	<tek-it>	'take'-PRET.PART.

This is because of the asymmetry between sound–letter inventories (Table 6)

- *æ*-manuscripts privilege the contrast between tense [e] – <e> and lax [ɛ] – <æ> mid vowels
  - therewith collapsing the distinction between [ɛ æ] in writing (both written <æ>)
- *e*-manuscripts privilege the contrast between mid [e ɛ] – <e> vs. low [æ] – <æ>
  - therewith collapsing the distinction between tense [e] and lax [ɛ] in writing (both written <e>)

æ-mss.		*e*-mss.
<e >	[e]	<e >
< æ>	[ɛ]	<e >
< æ>	[æ]	< æ>

Table 6: Contrasting *æ*- and *e*-orthographies in Old Norwegian writing

The prediction is that both *æ*- and *e*-manuscripts should represent *j*-umlaut-product vowels (/ja/→[jæ]) as <æ>, which is borne out by the data. *E*-manuscripts have a clear distinction between, e.g., *i*- and *j*-umlaut product vowels, as in the following data. This distinction is lacking in *æ*-manuscripts, as predicted by Table 6

- /ˈgjaf-ir/→[ˈgjæver] <giæver>
- /ˈhaf-ir/→[ˈhɛvir] <hevir>

(9) **Distinct *j*- and historical *i*-umlaut product vowels in *e*-manuscripts (H6)**

a.	/ˈgj̲af-ir/	→	[ˈgj̲æver]	<giæver>	‘gift’-ACC.PL.
b.	/ˈhaf-i̲r/	→	[ˈhɛvi̲r]	<hevir>	‘have’-PRES.3.SG.INDIC.
c.	/ˈtj̲ald-at/	→	[ˈtj̲ældat]	<tiælldat>	‘tent’-PRET.PART.
d.	/ˈtal-d-i̲/	→	[ˈtɛldi̲]	<telldi>	‘count’-PRET.-3.SG.SUBJ.

Vowel mergers and harmony decay

In manuscripts whose orthography distinguishes [e]–<e> vs. [ɛ æ]–<æ>, we see a general relationship between the level of orthographic contrast and the level of /e/-harmony

- this merger has a predictably strong effect on V1-/e/harmony patterns since the merger can lead to the collapse of historically distinct harmonic and disharmonic patterns, motivating harmony decay

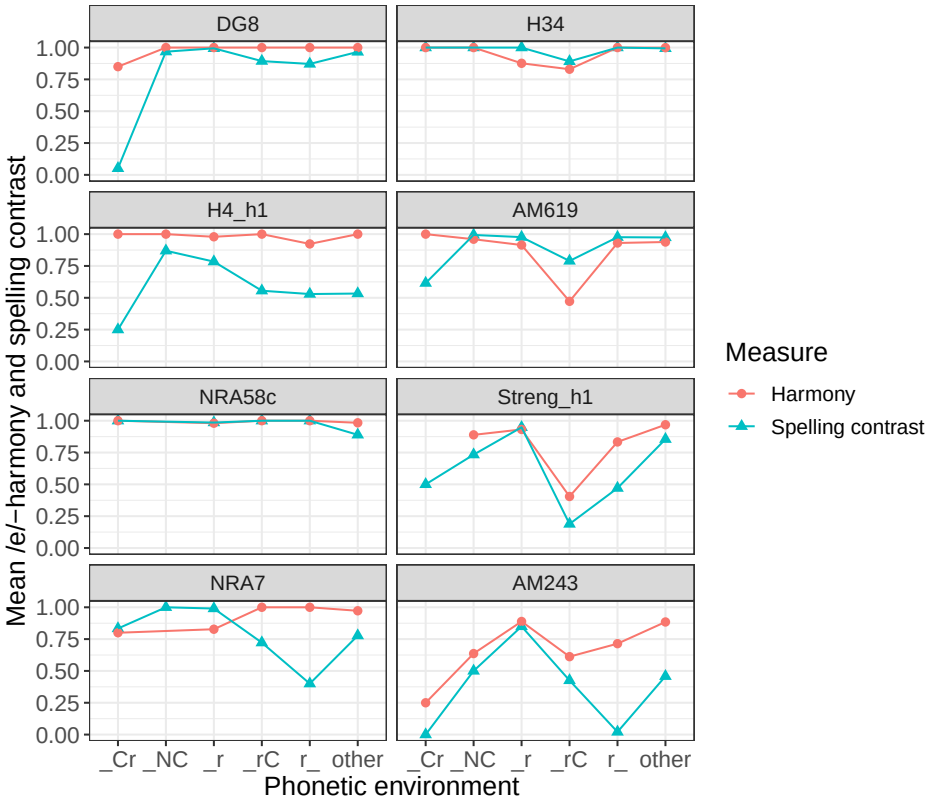


Figure 8: Mean /e/-harmony and spelling contrasts by phonetic environment in /e ɛ/-contrasting manuscripts

4.2 Increasing harmony optionality

Across languages, the most salient characteristic of decaying harmony systems is harmony variability (optionality or gradience)

- **optional harmony**: Southern Veps (Finnic) consistently harmonises second syllables but only optionally third-syllable vowels (Zaiceva 1981)
- **gradient harmony**: harmony targets in Kazakh and Uyghur (Turkic) display partial or incomplete assimilation; harmonisation decreases monotonically the farther the target is from the trigger (McCollum 2019a,b)

Similar to these languages, Old Norwegian harmony decay is associated with general harmony variability

- but whether gradient or optional is unclear due to the philological nature of the data

(10) **Variable harmony in decaying Streng_hɪ**

a.	[vi̲l-di, vi̲l-de]	<villdi^{26} ~ villde^{3}>	'want'-PRET.3.SG.INDIC.
b.	[ha̲f-ðe, ha̲f-ði]	<hafðe^{59} ~ hafði^{21}>	'have'-PRET.3.SG.INDIC.
c.	[si̲ð-um, si̲ð-om]	<siðum^{3} ~ siðom^{2} >	'custom'-DAT.PL.
d.	[go:̲ð-om, go:̲ð-um]	<goðom^{12} ~ goðum^{3}>	'good'-DAT.PL.

4.3 Lexicalisation of historically harmonising morphemes

In decaying harmony systems, harmony variability is commonly accompanied by lexical changes (e.g. levelling harmony alternations on specific affixes)

- e.g. significant lexical restrictions in Chaghatai; only half of high suffixes are subject to vowel harmony (Eckmann 1966: 33–36; Bodrogligeti 2002: 14–16)

In Old Norwegian, we observe increasing levelling of harmony alternations in harmonising morphemes

- front and back vowel suffixes lexicalise at different rates

Lexicalisation in decaying harmony systems

Figure 9 plots the degree of harmony on front and back vowel suffixes following high and non-high vowel harmony triggers

- represented by the front/back vowel suffixes /-ði -ðu/ and high/non-high roots /skyl-, mæ:l̥-/ simply for readability

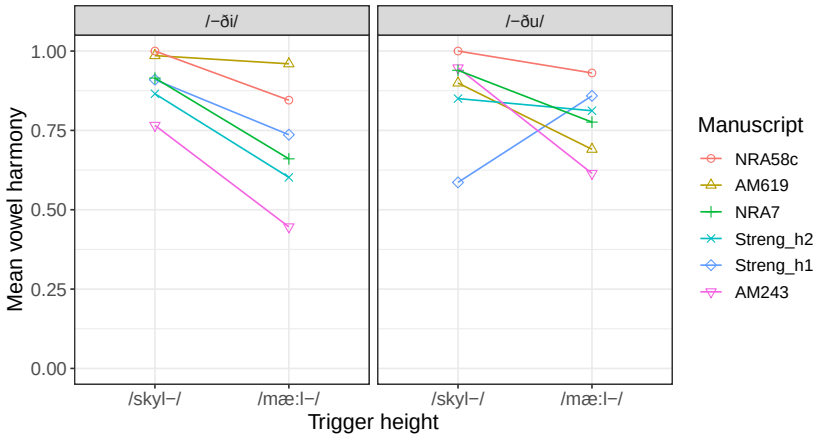


Figure 9: Varying harmony levels on front/back harmony targets following non-/high harmony triggers in intermediary decaying harmony systems

  - the patterns of lexicalisation in this corpus do not appear to depend on part of speech; the data below represent all inflectional suffixes across all word classes

In Figure 9, any asymmetry or positive/negative slope in the level of harmony between high and non-high /skyl-, mæːl̥-/ harmony triggers indicates some lexicalisation of inflectional suffixes

- towards either fixed high /-ði, -ðu/ or non-high /-ðe, -ðo/
- the direction of the asymmetry points to the direction of levelling

In Figure 9, we observe varying degrees of harmonic levelling in all manuscripts

- there is consistently more harmony in the left plot on front vowel suffixes in all manuscripts
  - i.e. there is much more [-i] than [-e] in the corpus than would be expected based on historical harmony generalisations – indicating levelling towards high front vowel suffixes
  - AM619 is an exception which displays categorical harmony in front vowel suffixes

Back vowel targets (the right-hand plot) display much more variation across the manuscripts

- fairly even levels of harmonisation in NRA58c and Streng_h2
- levelling towards /-ðu/ in AM619, NRA7, and AM243
- levelling towards /-ðo/ in Streng_h1

(11) **Different trajectories of harmonic levelling in intermediary harmony manuscripts**

AM243/NRA7: levelling towards [-i -u]

		/-ð**i**/	/-ð**u**/		
a.	/v**i**l-/	v**i**l-d**i**	v**i**l-d**u**	<þilldi, þilldu>	'want'-PRET.3.SG./PL.
b.	/g**æ**:t-/	g**æ**:t-t**i**	g**æ**:t-t**u**	<gætti, gættu>	'watch over'-PRET.3.SG./PL.

Streng_h2/NRA58c: levelling towards [-i] but harmonising [-o -u]

		/-ð**i**/	/-ð**u**/		
c.	/v**i**l-/	v**i**l-d**i**	v**i**l-d**u**	<villdi, villdu>	'want'-PRET.3.SG./PL.
d.	/m**æ**:l̥-/	m**æ**:l̥-t**i**	m**æ**:l̥-t**o**	<mællti, mællto>	'speak'-PRET.3.SG./PL.

AM619: levelling towards [-u] but harmonising [-e -i]

		/-ð**i**/	/-ð**u**/		
e.	/v**i**l-/	v**i**l-d**i**	v**i**l-d**u**	<vildi, vildu>	'want'-PRET.3.SG./PL.
f.	/m**a**:t-/	m**a**:t-t**e**	m**a**:t-t**u**	<mátte, máttu>	'must'-PRET.3.SG./PL.

Streng_h1: levelling towards [-i -o]

		/-ð**i**/	/-ð**o**/		
g.	/sk**y**l-/	sk**y**l-d**i**	sk**y**l-d**o**	<skylldi, skylldo>	'should'-PRET.3.SG./PL.
h.	/m**æ**:l̥-/	m**æ**:l̥-t**i**	m**æ**:l̥-t**o**	<mællti, mællto>	'speak'-PRET.3.SG./PL.

4.4 Harmony domain narrowing via vowel reductions

A fourth common pathway of harmony decay across languages is the reduction in harmony domains

- e.g. vowel harmony in Southern Veps is largely limited to the initial disyllable (Zaiceva 1981)
- e.g. Crimean Tatar dialects display variation in harmony domains (Kavitskaya 2013; McCollum & Kavitskaya 2018)
  - Southern Crimean Tatar – harmony on all non-initial high vowels: [tuz-luɣ-u] 'salt'-NMZR-POSS.3.SG.
  - Central Crimean Tatar – harmony only on initial disyllable: [tuz-luɣ-ɯ]
  - Northern Crimean Tatar – no harmony, with optional unrounding: [tuz-lɯɣ-ɯ] or [tɯz-lɯɣ-ɯ]

Harmony iterativity may also be limited via vowel reductions in unstressed positions

- e.g. Khalkha or Kalmyk Oirat (Mongolian) have root-initial stress with reduction of short unstressed vowels which increases the further the unstressed vowel is removed from the stressed syllable

  - masking harmony effects, contributing to harmony decay (Binnick 1991: §3.4)

Non-iterative harmony has been recorded for certain Old Norwegian material

- e.g. Hagland (1978: 144) reports that 14th-century Trøndelag charters in general fail to harmonise third-syllable vowels
  - [stuːk-u-n-ne], not *[stuːk-u-n-ni] 'chapel'-DAT.SG.-DEF.-DAT.F.SG
- Hagland interprets these patterns as the reduction (lowering/centralisation) of high vowels /i u/ → [e o] in trisyllabic positions

We can confirm this with the current corpus

- many decaying or decayed harmony manuscripts display significantly more V_3-[e o] than V_3-[i u]
  - contributing to decreased harmony in high vowel contexts – e.g. [liːtil-le] rather than pre-decay [liːtil-li]

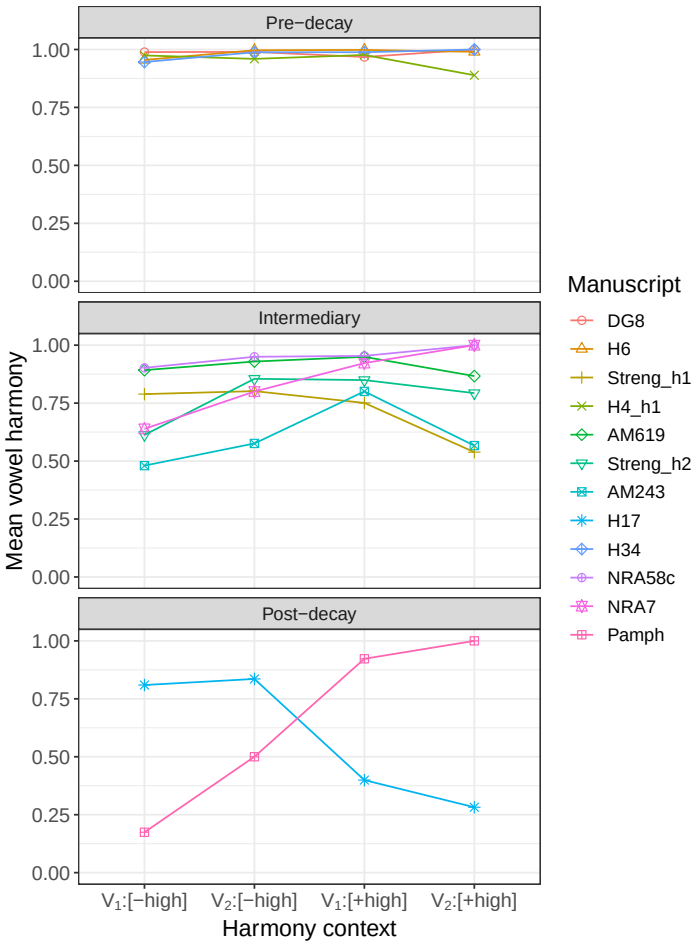


Figure 10: Contribution of sequence number and trigger vowel height to harmonic correspondence in pre-decay, intermediary, and post-decay manuscripts

5 Conclusions

The factors which motivate the loss of vowel harmony and the pathways by which this rare sound change occurs are poorly understood

- Old Norwegian provides us with rare and typologically significant insights

Old Norwegian manuscript material provides the first corpus illustrating a detailed and coherent transition from fully harmonic to non-harmonic stages, distinguishing:

1. robust, productive harmony
2. intermediary, decaying systems
3. fully decayed, non-harmony

Harmony decay motivations and pathways

In this study, we have explored the factors motivating harmony decay in Old Norwegian and the pathways this sound change has taken

- /e ɛ/-merger collapses distinct harmony patterns
- increasing harmony variability across domains
- lexicalisation of harmonising morphemes
- harmony domain narrowing via trisyllabic vowel reductions

Each of these decay mechanisms contributes to decreasing harmony rates, limiting harmony iterativity, and increasing the dispersion between different height classes' harmony behaviours to the point of completed harmony decay

- the composite result of these individual sound changes is a remarkably gradient transition from pre-decay to post-decay stages of the language

Conclusions

The individual mechanisms of Old Norwegian harmony decay are shown to be all typologically consistent with other decaying or decayed harmony languages

- providing good empirical confirmation of suspected causes and pathways of harmony decay
- illustrating valuable diagnostics for identifying and analysing harmony change in other languages

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