

Visualising vowel harmony decay in Old Norse manuscripts

Jade J. Sandstedt

jsandstedt@gmail.com

jsandstedt.hcommons.org

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Outline

Topic:

- Tracking vowel harmony changes in written corpora

Methods and solutions:

- rich linguistic annotations
- novel visualisations
- working diagnostics

I Introduction

I.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-yin ‘come’-2.SG.
- d. døjø-yyn ‘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] phik-il ‘cook’-APPL.
- [−high] tsɛk-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 ([Ọ̀lá Orie 2001, 2003](#))

- [+ATR] ògèdè ‘incantations’
- [−ATR] ɔ̀gɛdɛ ‘banana, plantain’

Prevalence and motivations for harmony

Harmony systems are

- 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 & Kapicioğlu 2006)

1.2 Vowel harmony decay

Harmony doesn't last forever

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; Sjöberg 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
 - 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 \(2010\)](#)

Suspected causes of decay:

- changes in vowel inventories (mergers/splits),
- emergence of disharmonic morphemes,
- 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

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	<u>h</u> ús-i	<hufi>	<u>h</u> ús-um	<hufū>	‘house’-DAT.SG./PL.
	sk <u>i</u> p-i	<fkípí>	sk <u>i</u> p-um	<fkípum>	‘ship’-DAT.SG./PL.
NON-HIGH	ljós-e	<líofe>	ljós-om	<líofom>	‘light’-DAT.SG./PL.
	se <u>g</u> l-e	<fegle>	se <u>g</u> l-om	<feglō>	‘sail’-DAT.SG./PL.

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

Old Norwegian vowel harmony typology

Old Norwegian vowel harmony is most similar to Bantu height harmony systems in central and southern Africa

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

(4) Mbunda height harmony on APPL. /-il-/

HIGH	<u>l</u> um-il-	‘cultivate’	t <u>u</u> ng-il-	‘build’
MID	n <u>e</u> n-el-	‘bring’	o <u>c</u> -el-	‘roast’
LOW	kw <u>a</u> t-el-	‘hold’		

Old Norse corpus

There is a diverse Old Norwegian corpus from the harmony period

- including sizeable manuscripts (Fig. 2)
- dated charters (Fig. 3)
- and original runic inscriptions (Fig. 4)



Figure 2: Old Norwegian Homily Book (AM 619 4to; c 1200)



Figure 3: A charter from King Magnus VII – Niðaróss (Trondheim), 29. Jan. 1333



Figure 4: Runestone from Kingittorsuaq (Greenland) with height harmony

(5) Early Old Norse height harmony lost in Icelandic

HIGH	<u>h</u> ús-um	'house'-DAT.PL.	hús-um	skip-um	'house'-DAT.PL.
	skip-um	'ship'-DAT.PL.			'ship'-DAT.PL.
NON-/	ljós-om	*ljós-um	ljós-um	*ljós-om	'light'-DAT.PL.
HIGH	segl-om	*segl-um	segl-um	*segl-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) in Fig. 4 which contrast non-high **gleðe** *gleðe* ‘gladness’ or the name **baanne** *Bjarne* versus **huilir** *hvílir* ‘rests’ or **fyrir** *fyrir* ‘before’.

Attested harmony decay: Harmony decay has occurred in Nordic languages and is potentially captured in the Norse 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 19550, Hødnebo 19770, Hagland 19780)

As summarised by Hødnebo (1977):

Dette [vokalharmoni]systemet kan følges fra eldste skrifttid og et godt stykke inn i 1300-tallet som en slags norm. Henimot slutten av hundreåret inntreer 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. (Hødnebo 1977: 379)

Old Norwegian corpus summary

Old Norwegian philological material:

- provides a sizeable corpus of manuscripts, charters, and runic inscriptions
- covering pre-, transitional, and post-decay stages of vowel harmony in the language

☞ making Old Norwegian a typologically highly significant specimen

2.2 Methods and corpus

Methodological challenges

Hødnebo's generalisation is statistical

- we need to be able to quantify Old Norwegian harmony patterns

Problem: Old Norwegian corpus is largely inaccessible

- and poses significant philological problems

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

Abbr.	Signature	MS or work title	Date	Provenance	Words
AM243	AM 243 b4 fol	<i>King's Mirror</i>	c 1275	Bergen	63910
DG4_7_h1	De la Gardie 4-7, fols. 17va6-29v	<i>Strengleikar</i> —hand 1	c 1270	Bergen	19813
DG4_7_h2	De la Gardie 4-7, fols. 30r-43v	<i>Strengleikar</i> —hand 2	c 1270	Bergen	18640
DG8	De la Gardie 8 fol, fols. 70v-110v	<i>Legendary saga of St. Olaf</i>	c 1225-50	Trøndsk	41142
H4_h1	Holm perg 4 fol, fols. 1r-14v	<i>Þiðriks saga af Bern</i>	c 1275-1300	Uncertain	19802
H4_h2	Holm perg 4 fol, fols. 15r-49v	<i>Þiðriks saga af Bern</i>	c 1275-1300	Uncertain	64582
H6	Holm perg 6 fol	<i>Saga of Barlaam and Josaphat</i>	c 1275	Eastern	76411
H34	Holm perg 34 4to	<i>Bójarlogg ok Farmannalogg Magnúss Hákonarsónar</i>	c 1275-1300	Bergen	11283
H17	Holm perg 17 4to	<i>Saga of Archbishop Thómas</i>	c 1300	Uncertain	59884
NRA61	NRA 61	<i>A fragment of Karlamagnúss saga</i>	c 1250	Uncertain	983

Table 1: The Old Norwegian MENOTA corpus

Structure of MENOTA transcriptions

(6) MENOTA transcription of <hofðingianom> ‘chieftain’-DAT.M.SG.-DEF. (Holm perg 6 fol.)

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

With the help of Pavel Iosad (Edinburgh), we have written scripts, collecting:

- word IDs
- vowel patterns
- morphological annotations
- lemmas
- etc.

A vowel harmony database

Using the data from the MENOTA corpus,

- vowels are organised into pairwise sequences and evaluated for height agreement (2)

Harmonic span	V1	V2	V1_high	V2_high	VH
{hofðing} ₁ ianom	<o>	<i>	False	True	False
hof {ðingia} ₂ nom	<i>	<a>	True	False	False
hofðing {ianom} ₃	<a>	<o>	False	False	True

Table 2: Division into pairwise harmonic spans

Controlling for variation

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

- * e.g. spelling variation for [o, ɔ, a] – <o, a>
 - more vowel phonemes than graphemes
 - [ɔ] generally has no unique letter in Norwegian writing
 - * e.g. <hofðingia> and <hafðingia> for normalised *hofðingja*

Grapho-phonology

We need a way to triangulate between distinct etymological, phonological, and orthographic values for each given segment

- e.g. <hofðingia> = <o-i> = [ɔ-i]
- e.g. <hafðingia> = <a-i> = [ɔ-i]

Phonological/etymological annotations

Etymological annotations based on Holthausen (1948)

- encoded for the 600 most common lexemes in the corpus (220,418 words)

(7) Example annotation of root-initial vowels in *standa* ‘stand’ word forms

```

1 vh_df <- vh_df %>%
2   mutate (etym1 = replace (etym1, which (lemma == "standa"
3     & tense == "preterite"
4     & mood == "indicative"), "o:" )) %>%
5   mutate (etym1 = replace (etym1, which (lemma == "standa"
6     & tense == "preterite"
7     & mood == "subjunctive"), "ø:" )) %>%
8   mutate (etym1 = replace (etym1, which (lemma == "standa"
9     & tense == "present"
10    & number == "plural"
11    & mood == "indicative"
12    & person == "1. person"
13    & v1 %in% c("a", "o")), " " )) %>%
14   mutate (etym1 = replace (etym1, which (lemma == "standa"
15     & tense == "present"
16     & number == "singular"
17     & mood == "indicative"
18     & v1 %in% c("e", "æ", "á")), " " ))

```

(8) Etymological vs. graphic representations of the *standa* ‘stand’ finite verb paradigm

Present indicative				Present subjunctive			
Singular		Plural		Singular		Plural	
1.	* <i>stēnd</i> <stænd>	* <i>stēndum</i> <standum>		* <i>stānde</i> <stande>		* <i>stāndem</i> <standem>	
2.	* <i>stēndr</i> <stændr>	* <i>standet</i> <standet>		* <i>stander</i> <stander>		* <i>standet</i> <standet>	
3.	* <i>stēndr</i> <stændr>	* <i>standa</i> <standa>		* <i>stānde</i> <stande>		* <i>stānde</i> <stande>	
Preterite indicative				Preterite subjunctive			
Singular		Plural		Singular		Plural	
1.	* <i>sto:ð</i> <stoð>	* <i>sto:ðom</i> <stoðom>		* <i>stø:ðe</i> <stœðe>		* <i>stø:ðem</i> <stœðem>	
2.	* <i>sto:tt</i> <stott>	* <i>sto:ðoð</i> <stoðoð>		* <i>stø:ðer</i> <stœðer>		* <i>stø:ðeð</i> <stœðeð>	
3.	* <i>sto:ð</i> <stoð>	* <i>sto:ðo</i> <stoðo>		* <i>stø:ðe</i> <stœðe>		* <i>stø:ðe</i> <stœðe>	

Sample annotated data

An abbreviated example of the kind of vocalic data included in this database are provided in Table 3

2.3 Sanity check

2.3.1 Vowel and word length frequencies

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

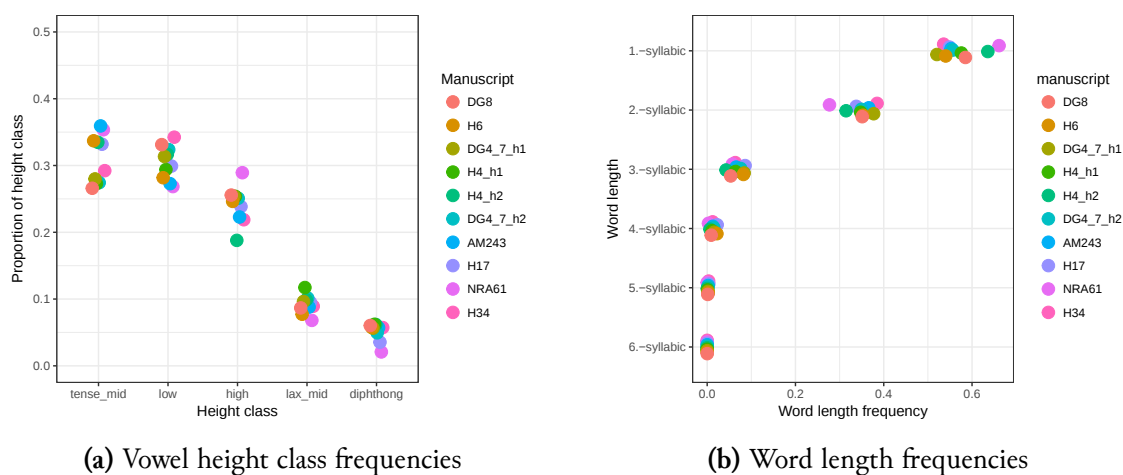


Figure 6: Vowel and word length frequencies by manuscript

Some basic stats:

- mean syllable length of 1.56

id	dipl	expanded	lemma	seq_no	v1	v2	etymi	etym2	v1_high	v2_high	VH
11857	stendr	stendr	standa	1	e	NA	ε	NA	F	NA	NA
30331	støðe	støðe	standa	1	ø	e	ø:	e	F	F	T
48957	stœpe	stœpe	standa	1	œ	e	ø:	e	F	F	T
65048	hofðíngíanom	hofðíngíanom	hofðíngi	1	o	í	ɔ	i	F	T	F
65048	hofðíngíanom	hofðíngíanom	hofðíngi	2	í	a	i	a	T	F	F
65048	hofðíngíanom	hofðíngíanom	hofðíngi	3	a	o	a	o	F	F	T
34024	kkunar	kirkunnar	kirkia	1	u	a	u	a	T	F	F
18773	giæva	giæva	gíof	1	æ	a	æ	a	F	F	T
43804	giava	giava	gíof	1	a	a	a	a	F	F	T

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

- 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% (1.64/4.02)

Sanity check conclusions

- vocalic and word length frequencies are uniform across the corpus
- ☞ coherent and consistent data

3 Visualising vowel harmony decay

With this detailed and richly annotated database, our goal is to:

- visualise and compare harmony frequencies across corpora
- tracking vowel harmony decay in Old Norwegian

3.1 *PhonMatrix* visualisations

PhonMatrix visualisations:

- coloured vowel association matrices
- provide easy visual discovery of harmony patterns
- developed by Mayer et al. (2010) and Mayer & Rohrdantz (2013)
 - accessible at <http://phonmatrix.herokuapp.com/>

PhonMatrix visualisations provide coloured matrices reflecting vowel co-occurrence frequencies, as in Fig. 7

PhonMatrix visualisations

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. $\phi = \sqrt{\frac{\chi^2}{n}}$



Figure 7: *PhonMatrix* visualisations of pre-decay Old Norwegian harmony in H6

A practical illustration of how this is calculated is provided below using the crosstabulation in (9)

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

(9) [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

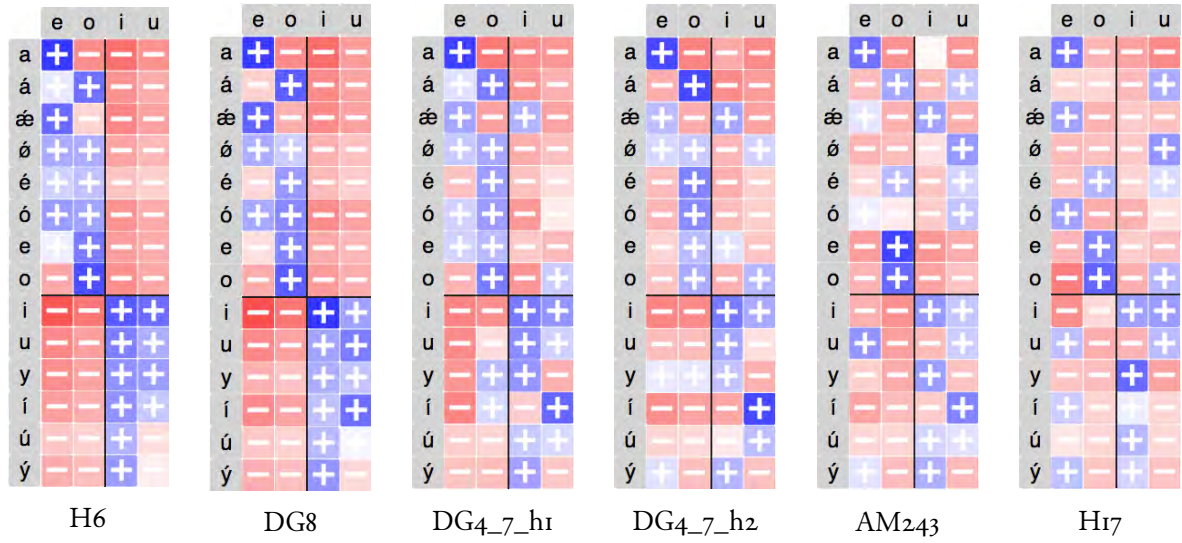


Figure 8: Sample of *PhonMatrix* visualisations of 13th-century Old Norwegian harmony decay

Fig. 8 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. 8, 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

Summary of results:

- in pre-harmony decay manuscripts (H6/DG8)
 - V_2 -[e, o] vowels (the *e/o* columns) strongly correlate with non-high vowels [a, á, æ, ø, 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

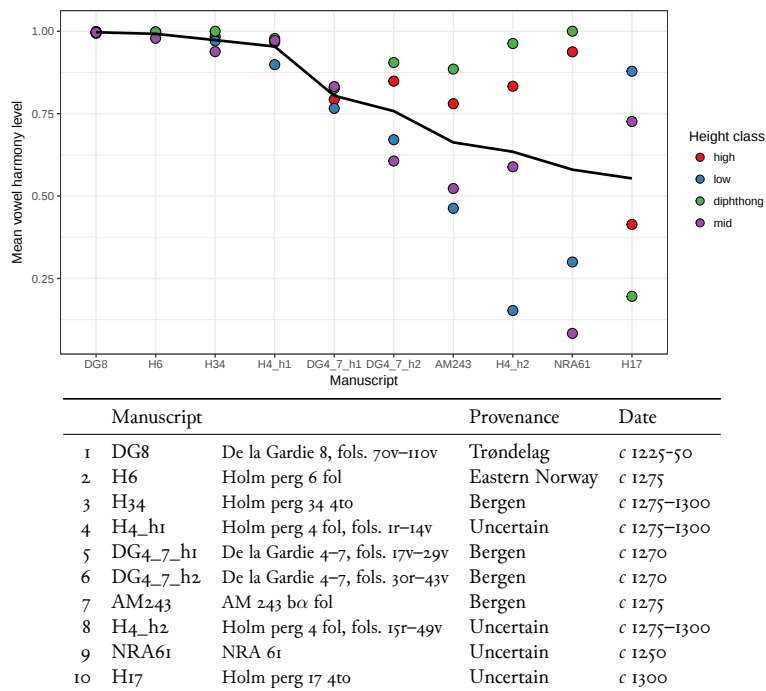


Figure 9: Mean harmony levels by manuscript height class in pairwise sequences

Taking a broader look:

- Fig. 9 illustrates mean height harmony percentages in historically harmonising V_1 – V_2 sequences by V_1 -height class
 - high vowels and diphthongs trigger high harmony
 - mid vowels and low vowels trigger non-high harmony

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

Transitional systems

- DG4_7 manuscripts

- probabilistic harmony
 - lower harmony but still low variance

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

Coherent directions of change

The final stages of harmony decay result in levelled [-e, -o] or [-i, -u] suffixes

- both outcomes are documented in this corpus and found among modern Nordic languages, as illustrated in (10)

(10) Post-harmony inflectional systems

hús-i house-DAT.SG.
hús-um house-DAT.PL.

ljós-i light-DAT.SG.
ljós-um light-DAT.PL.

(a) AM₂₄₃ – [-i] / [-um]

hús-i house-DAT.SG.
hús-um house-DAT.PL.

ljós-i light-DAT.SG.
ljós-um light-DAT.PL.

(c) Mod.Icelandic – [-i] / [-um]

hús-e house-DAT.SG.
hús-om house-DAT.PL.

ljós-e light-DAT.SG.
ljós-om light-DAT.PL.

(b) H₁₇ – [-e] / [-om]

hus-e house-DAT.SG.
hus-om house-DAT.PL.

dal-e valley-DAT.SG.
dal-om valley-DAT.PL.

(d) Mod.Norw. (eastern) – [-e] / [-om]

4 Conclusions

Vowel harmony decay: rarely attested and poorly understood sound change

- Old Norwegian provides us with rare and typologically significant insights
 - but comes with significant philological and historical phonological challenges

Novel corpus linguistic methods:

- automated data collection using MENOTA transcriptions
- automated clean-up and linguistic annotation
- allows for easy stats/analysis

Generalisations:

1. **Reliable phonological data despite philological challenges**
 - consistent patterns and coherent directions of change
2. **Documented vowel harmony change**
 - clear spectrum of decaying harmony patterns
3. **Distinct stages of decay**
 - *pre-decay*: DG8, H6, H34, & H4_h1 – (high harmony ~ low variance)
 - *transitional*: DG4_7_h1/h2 – (medium harmony ~ medium variance)
 - *post-decay*: AM243, H4_h2, & H17 – (low harmony ~ high variance)

Limitations and speculations

Explanatory model:

- proof of concept
 - only 10 scribes
 - far off from the kind of statistical power we'd need to *explain* why harmony decay has occurred
- ☞ but we'll get there :-)

Aims and directions for future research

Decay diagnostics:

- aids for identifying changing harmony systems
 - e.g. Crimean Tatar (Turkic; [Kavitskaya 2013](#)); Kazakh (Turkic; [McCollum 2015](#)); Itelmen (Chukotko-Kamchatkan; [Bobaljik 2018](#))

Historical dialectology:

- Old Norwegian harmony decay provides rich variation
 - can be used to better map geographic and chronological variation

Broader philological applications:

- These corpus methods allow for broader linguistic and philological study
 - e.g. sound mergers/splits, umlaut processes, scribal hand identification, etc.

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