Nordic umlaut, contrastive features and stratal phonology

Johan Schalin

University of Helsinki

Abstract

The data puzzle of Proto-Nordic rounding and front umlauts is addressed by positing an undominated markedness constraint that bans [±round] moraic stem-final segments. A related constraint restricts the assignment of [±round] in affixes. These constraints impact on how stem-final triggers spread features to target vowels, which proves a good predictor of the so far poorly understood distribution of umlaut in the lexicon. Since these constraints refer both to syllabification and to specification of contrastive features, the paper applies a tentative reconciliation of constraint-based Stratal Phonology with Contrastive Hierarchy Theory, which postulates universal organisation of emergent features in binary feature hierarchies. Stem-level segments are accordingly assumed to be stripped of redundant overspecification by stem-level constraints, while umlaut was enacted in word-level phonology.

Keywords: Proto-Nordic, Old Norse, umlaut, stratal phonology, contrastive feature hierarchies

1. Introduction

A set of regressive metaphonic sound changes called 'umlauts' transformed a sparse Proto-Nordic fifth-century vowel system into a far more diversified Old Nordic inventory of root-initial vowels four centuries later. After prior stages of raising and lowering, this metaphony caused fronting, rounding and backing of its targets. Unlike many typical instances of vowel harmony, the umlauts became inventory-enhancing, which deserves consideration. This may be most visibly illustrated by the rounding and front umlauts targeting some non-low vowels, which resulted in an entirely new class of front-rounded vowels, namely /y/, /y:/, /ø/ and /ø:/, as exemplified in Figure 1 by *fœtr* [fø:tr] 'feet' and *smyrva* 'to smear'. When all umlaut processes were concluded, the number of vowels in root-initial main-stressed target syllables had more or less doubled compared to Proto-Germanic (Haugen 1982:28–34).
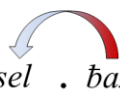

Figure 1. Front umlaut and rounding umlaut; back umlaut evidenced by breaking (illustrated).

Explaining the Nordic umlauts has proved a surprisingly bewildering task. From the first descriptions some two centuries ago by Rasmus Rask and Jacob Grimm (Rischel 2002:127) it has been recognised that the

new umlaut vowels emerged from an interaction between metaphony and trigger reduction. Despite the apparent rigour of the metaphonic logic involved, the uncontested facts concerning this interaction remain deplorably few. Approaches that may serve to explain the less complex West Germanic umlaut data have not yet met the mark in tests on North Germanic data. The interaction of umlaut with trigger loss in North Germanic has by Paul Kiparsky (2009:37) been described as "probably the biggest remaining conundrum of Germanic historical phonology". Attempts to explain the data have been manifold and theoretically innovative but have not yielded progress towards scholarly consensus (Benediktsson 1982 *passim*, Schalin 2018:74–80 with references).

1.1   The characteristics of the problem, initial assumptions and the need for adequate theory

A main problem is that the pre-umlaut and post-umlaut datasets in essence show mutual correlations that appear to be phonologically regular, which requires phonological analysis. Yet essential subsets of data contradict these correlations consistently in well-defined phonological contexts (Liberman 2001:85). Provided that all regularities that flow from these multifaceted data are factored in, there is not much room for cherry picking among one's favoured theoretical assumptions, because a large variety of solutions that are proposed recurrently fail when tested against certain notorious touchstones in the recalcitrant data (Rasmussen 2000:143, Schalin 2018:116–117). This observation applies even to proposals where no attempt was made to unify the explanation of the front umlaut with that of the rounding umlaut, which ultimately will be a reasonable necessity. To make things worse, many exceptions to the main rules are not exceptionless themselves: as soon as a phonological condition that governs an exception seems to emerge, it turns out that it fails to explain the data unless further exceptions to the exception are posited. One of several such examples (see Table 1) is the distribution of front umlaut in the lexicon in cases where a short palatal trigger (here marked 'I') had followed a light syllable: (C)CV.CI(C).

Table 1. Exceptions to exceptions to the front umlaut rule (ON = Old Norse, * = Proto-Nordic).

When a short trigger occurred after a heavy syllable i-umlaut generally applied	When a short trigger occurred after a light syllable i-umlaut did not by default apply
*gas.ti̧ > ON gȩst 'guest' (acc. sg.)	*sta.ði̧ > ON stað 'place' (acc. sg.)
*ful.li.ðō̃ > ON fyllda 'I filled'	*du.li.ðō̃ > ON dulda 'I concealed'
*bar.nis.kaz > ON bȩrnskr 'childish'	*da.nis.kaz > ON danskr 'Danish'

Still, i-umlaut applied in light syllables if the trigger was followed by 'palatal R' (iʀ-umlaut)	
Examples:	*fra.m+iz > ON frȩmr 'further'
	*far+iz > ON fȩrr 'go, travel' (2nd pers. sg.)
	*du.r+iz > ON dyrr 'door(s)'

YET, as an exception to the exception: no iʀ-umlaut applied in nom. sg. of light i-stems	
Example:	*sta.ði+z > ON staðr 'place'

Attempts have been made to compensate for the failures to account for exceptions by assuming generalisations that would have regularised inflectional paradigms. However, since these explanations entail complexes of unrelated developments of 'analogy' and 'levelling' that randomly would have had to conspire to create the phonological appearance that is discernible in the data, such reasoning would seem to defeat the purpose of the exercise (Schalin 2017a:58–66). Instead, it seems more promising to look for more powerful phonological theory. The 'iʀ-umlaut' of Table 1, which is a notorious stumbling block for

explaining the front umlaut, is a good example of a regular exception to a main rule that requires more sophisticated phonological analysis.

The starting point here is that the data, if configured prudently and comprehensively enough, provide the elements of a phonological puzzle that may be solved by means of historical reconstruction. The solution does not come easy, however, because the traditionalist methodologies of historical phonology may prove insufficient unless supplemented by hypothesising about how, in umlaut-era Proto-Nordic, cyclic morpho-phonemic computation may have operated synchronically on segmental representations, which rather than being 'innate' purportedly were language-specific and 'emergent'. This entails that Proto-Nordic vocalic features cannot be uncritically presupposed based on some pre-determined understanding of phonemic representations, whether influenced by trivial graphemic correspondences to runic or Gothic spelling or/and based on theories of supposedly innate characteristics of vowel inventories. Instead, the features of the vowel phonemes need to be reverse-engineered from their participation in phonological activity, similarly to the manner in which a real language learner would have inferred the features during language acquisition. In a historical approach to umlaut, it would have to be assumed that the synchronic metaphony was regular and that after conclusion of the umlaut process, it was sufficiently well fossilised in the Old Nordic daughter languages for its traces to be a proper source to infer the features of Proto-Nordic vowels.

For the purpose of this study, the reverse-engineered feature architecture is assumed to conform with the tenets of Contrastive Hierarchy Theory (CHT; Dresher 2009; 2014; 2019). In this respect it builds on the approach in Schalin (2017b:§1.3; 2018:117–118). By the further use of Stratal Phonology (Bermúdez-Otero 2018), it is possible to dispense of Schalin's (2017b:§6.1; 2018:128–131) problematic assumption that features depended on prominence assignment, and instead to explain differences in the features of trigger vocoids from those of the target vowels by assuming a constraint that restricted the available vowel inventory in stem finality and affixes.

A problem with this approach is that the initial assumptions about theory, which are innovative, and the potential solution to the North Germanic data puzzle that they enable, are simultaneously at stake. Attempts to solve the puzzle have a long research history, while Stratal OT (OT = Optimality Theory) by Kiparsky (2009) and/or representation-based theory of emergent features by Schalin (2017b; 2018:§3.5) have been much less used for this purpose. One reviewer of this paper made an appealing argument for focusing on describing the theories of choice and presenting their method more rigidly but on a small subset of data only, all with a view to scrutinise the usefulness of this choice of theory for historical reconstruction in general. Major adjustments have been made to the paper to accommodate this recommendation. Still, in order to make such an approach meaningful, it is deemed necessary to demonstrate how these theoretical tools may provide the means to solve the bicentenary data puzzle. Therefore, it is also necessary to scrutinise a certain minimum of representative data, even if it requires a lot from readers.

1.2   *Aim of the paper, main findings and progress of presentation*

The primary aim of this paper is to probe the potential of applying CHT along with Stratal OT (Kiparsky 2000a; 2009:29–40; 2018, Bermúdez-Otero 2018) for the pursuit of an acceptable solution to the bicentenary data puzzle of mainland Nordic (hereafter "Nordic")[1] rounding and front umlauts. Special attention is paid to stratal phonological computation of segmental features. Concurrent application of CHT and a stratal constraint-based understanding of phonology is deemed possible, since a theory like OT, which focuses on constraint interaction, does not pay much specific attention to what phonological objects the input and the candidates are composed of, while representation-based phonology focuses precisely on the makeup of segments and the impact this has on their interaction (Bérces and Honeybone 2020:8).

A secondary aim of this paper is to develop Schalin's (2017b; 2018) discussion of how representation-based phonological theory that posits emergent segmental features can be used in historical phonology, an

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[1] Mainland Nordic is a subset of the Nordic languages that excludes only the Gutnish language of Gotland, where umlaut outcomes came to differ a lot. During the umlaut period, Norse was not yet spoken in Iceland or the other Atlantic isles.

endeavour which requires reference to phonological activity in order to reconstruct historical phoneme inventories.

A main finding on the general level is that combining CHT and Stratal OT enables analysis of more umlaut data than before by diachronic phonological means and minimises the need for invoking ad hoc auxiliary explanations for a reduced residual of data with unexpected presence or absence of umlaut. Main findings on the data level are presented in Sections 2 and 4.

The paper is organised as follows. Section 2 presents the two theories employed and introduces (in a computationally rigid fashion by means of key examples) how the method of reverse-engineering the contrastive feature hierarchies of Proto-Nordic vowels can be applied in adherence to CHT while adhering to the constraints inferred in adherence to Stratal OT. The section ends with a brief discussion on the terms under which the two theories may ultimately be deemed compatible. Section 3 introduces the basic diachronic assumptions concerning feature spreading and phonemicisation of allophones, necessary for the analysis in Section 4, which explains the chronological progression of restructurings during the subsequent phases of the umlaut era. It is shown that the progression of umlaut and 'syncope'[2] was driven by a chain reaction where the result of one restructuring triggered the next. The chain reaction could not stop at the intermediate stages because they incurred violations of the above-mentioned markedness constraint that bans moraic segments specified for [±round] in stem-finality and in reduced positions of affixes. This explains why the era of umlaut and syncope advanced swiftly during a couple of centuries at most.

2. The theories and their application to a synchronic stage of umlaut-era Proto-Nordic

2.1   Contrastive Hierarchy Theory

According to the Contrastive Hierarchy Theory (Dresher 2009; 2014; 2019), segmental representations are universally specified by the ranking of 'contrastive features' taking scope over each other by subordination to hierarchically organised binary nodes. While the features and their rankings are both considered variable between languages, their hierarchical manner of organisation reflects an assumably innate imperative for the language learner to classify segments by means of binary contrast. For any specific language, the features are assigned by applying the Successive Division Algorithm until every phoneme has been distinguished (Dresher 2009:14–17). The substantive phonetic correlates of contrastive features are considered language-specific and thus the algorithm is foremost informed by inferring from phonological activity.
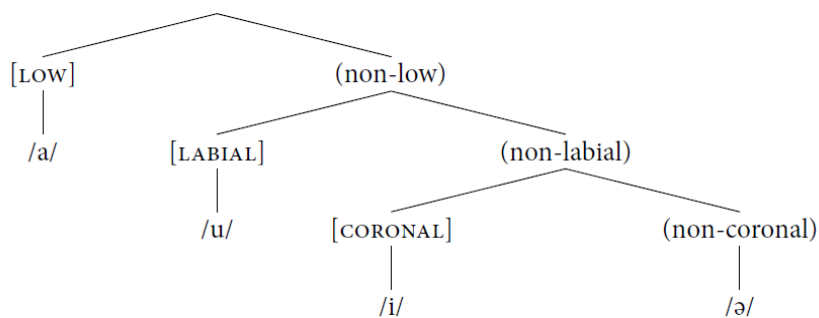
Figure 2. Proto-Eskimo contrastive feature hierarchy (Compton and Dresher 2011:221).

A well-formed Contrastive Feature Hierarchy, or CFH, need not be symmetrical and the number of nodes that takes scope over any given phoneme in the branching tree may thus vary, as seen in the Proto-Eskimo hierarchy in Figure 2 (from Compton and Dresher 2011:221), where /i/ is dominated by three nodes and /a/

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[2] The term 'syncope' may conventionally be used in Nordic studies in a broad sense, encompassing apocope, when the two occurred at the same time under similar conditions.

by one. Such feature architecture accommodates 'underspecification', while it is in obvious conflict with any form of Radical Underspecification because, in the course of the Successive Division Algorithm, phonemes are assigned high ranking class features, which would be discarded as redundant by such theory. The feature (non-low) in the hierarchy of Figure 2 is an example: it is not necessary for uniquely distinguishing any of the phonemes that are specified for it (i.e., /u/, /i/ or /ə/), yet it is contrastive for them by means of class membership as specified by the CFH.

In line with CHT and abiding by its Contrastivist Hypothesis, only features that are truly contrastive are assumed to generate phonological activity.[3] As a corollary, phonological activity is assumed to confirm a contrast in the segment from which it originates. Accordingly, contrastive features can only be reverse-engineered reliably by analysing the phonological activity in which they participate – and the most important cues to the contrastive features of a particular phoneme are generally not its surface representation(s) or its phonetic realisation(s). Variations in phonemes within the range of its activity are more important cues since these reflect the activity targeting them, which in turn reveals the contrastive features of the source. This holds true, whether for a language learner who is acquiring the language or a scholar in pursuit of a valid analysis. There may be situations where the observed phonological activity seems insufficient for the analyst to perform the Successive Division Algorithm and determine unambiguously a resulting CFH. If the same applied to language learners, it could result in different individuals inferring somewhat different CFHs.

Phonetic proximity tells little about how vowels are placed in a CFH, because quite different contrastive specifications may result in phonetic proximities after a post-contrastive phonological process of adding 'feature enhancements'. As the IPA symbols in Figure 2 implicitly reveal, /a/ is thus post-contrastively enhanced by {non-labial} and /ə/ by a sonority feature like {non-high} or {non-close}.[4] The feature enhancements make the two vowels /a/ and /ə/ phonetically adjacent although they differ on account on the highest-ranking feature node, which is [low]. The process of adding feature enhancements seems largely accountable for a universal tendency of phoneme inventories to pattern in terms of relative symmetry and dispersion (Hall 2011, Dresher 2019). As a corollary of the feature enhancements, the substantial phonetic correlates of contrastive features are of little importance for determining contrast in comparison to the hierarchy in which contrast is organised. In Figure 2 it would be of no consequence for the theory, or for the analysis of Proto-Eskimo, if [labial] was replaced by [round] or if [coronal] was replaced by [palatal] or [front]. Feature labels are not understood primarily in articulatory phonetic terms in CHT: they are merely cognitive symbols serving as references for phonological computation.

There are different interpretations of markedness of features within the framework of the CHT and therefore whether the opposite of a positive specification should be understood as unmarked, as in Figure 2, as an empty node (Sandstedt 2018 with references) or as possessing a negative value, as is the approach in this paper (see the Proto-Nordic hierarchy in Figure 4). In the last case, in the Proto-Eskimo inventory [+coronal] would be perfectly equivalent also to [–back]. Note, however, that such a replacement could be of significance in some other language, where ±values of features labelled [back] and [coronal] are understood to co-occur and take scope over each other in the same hierarchy, as claimed for Kalmuk/Oirat Mongolian languages (Ko 2012:119ff, 122ff). Such counterintuitive co-occurrences of specifications are again not primarily statements on articulatory properties but on the phonological behaviour of segments belonging to the corresponding classes of phonemes.

As stated above, it may be difficult enough to infer synchronically an unambiguous CFH for a living language with observable phonological activity. This is even more the case for the process of reconstructing extinct languages, insofar as the evidence for synchronic phonological activity is indirect and may be incomplete or even obscured. In cases where such activity merely affected surface representations it may

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[3] Daniel Currie Halls's (2007:20f) original formulation of the hypothesis is: "The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another." Good arguments (see Nevins 2015, Hall and Hall 2016) have been given as to why this hypothesis may be too strong.

[4] Hereafter, feature enhancements are in curly brackets.

have been omitted in attested orthography and/or may have reverted in later stages of development. This may have been the case for umlaut in Gothic, where no evidence of it remains. In other cases, the results of an activity that originally was phonological may have been reanalysed as morphological generalisations and their scope may have been extended beyond the part of the lexicon, where the phonological activity originally had applied. This is clearly the case for umlaut in High German, where, for example, the use of umlaut to mark plural forms has been extended morphologically. Whenever Old Nordic data is used as evidence for phonological activity in Proto-Nordic, it is a real challenge to sift out forms where an umlaut may have been added or removed by some morphological generalisation. Luckily, there is a solid research history to rely on in this respect, even if it has not quite reached consensus (see e.g., Bibire 1975:183–199, Schalin 2017a:13–24 with references; 2018:127–128).
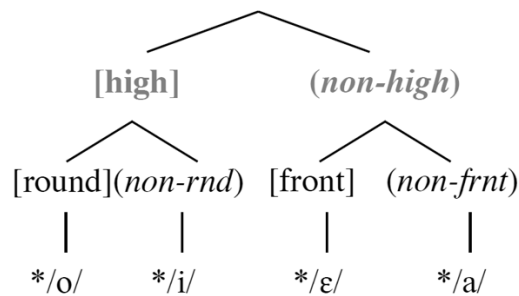

Figure 3. Western and Eastern Algonquian contrastive feature hierarchy (Oxford 2015:336–350).

In many competing representation-based theories the extreme corners of the IPA trapezoid, where [i] and [u] are situated, are accepted as a basis for hypothesising innate phonological features. Some problems have been described, however, with characteristics that are not easily compatible with such theories. CHT is a strong theory for analysing such problems. For instance, in reconstructed Western and Eastern (i.e., non-central) Algonquian the activity of *ɛ differs from the inertia of *i regarding palatalisation of the immediately preceding consonant. Figure 3 displays a CFH reconstructed for these proto-dialects by Will Oxford (2015:336–350). Here *ɛ is analysed to be contrastively specified for fronting tongue thrust by means of [front] even if the inventory also contains a [high, non-round] *i, which does not carry this specification. The inertia of *i as a trigger for palatalisation, which is manifest despite the vowel's palatal phonetic properties, is explained by its subordination to another subhierarchy where colouring is specified only by means of [round]. This solution is only possible if there is a node of higher scope that sets the two subhierarchies apart. In this case it would be a sonority feature, here labelled [high]. Note also how the non-front vowel /a/ is enhanced by further lowering rather than backing and fills the otherwise void gap concerning low vowels, and further how this enables a mid-high realisation of the [high] vowel /o/, which is saliently and uniquely distinguished by lip rounding already. Such conditions of feature enhancing are language-specific and sometimes hard to predict based on their class membership under the CFH only.

2.1.1   Using Contrastive Hierarchy Theory to infer a Proto-Nordic contrastive feature hierarchy

As suggested by the limited data in Table 1, a critical problem of Proto-Nordic umlaut concerns the 'iʀ-umlaut' and the distribution of front umlaut in the Old Nordic lexicon in cases where a short palatal trigger had followed a light syllable: (C)CV.CI(C). A recent study has shown that the distribution could be explained quite well by reference to a contrast between triggers that descended from Pre-Germanic (PreGm) *e (provisionally denoted *i_2), which virtually always caused umlaut, and many triggers that descended from vocalised PreGm *i (provisionally denoted *i_1), which often did not (Schalin 2018:104–105, 128). Accordingly, umlaut is absent in light-stem words that contain suffixes with PreGm *i, including consistently adjectival *-$i_1$ska- and randomly instrumental (locative) *-$i_1$la-. Conversely umlaut applies in front of deadjectival *-$i_2$þu- (< *-eþā-) and diminutive *-$i_2$la- (presumably < *-elo-).

(1) *Juxtaposing front umlaut and its absence in light stems by means of a subminimal pair*
      a. Old Swedish m. nom. sg. *matęr* 'food' (cognate with ON *matr*)
         matęr ← Proto-Nordic *$*mati_1z$ (inert $*i_1$ < Early PGm *matiz*)
      b. Old Swedish fem. nom. pl. *nytęr* 'nuts' (cognate with ON *hnøtr*)
         nytęr ← Proto-Nordic *$*hnuti_2z$ (active $*i_2$ < Early PGm *χnutez*)

Example (1) illustrates this by means of a subminimal pair: umlaut was not enacted in the nominative singulars of light i-stems (1a), while conversely it was completed and fossilised in a plural form of a light monosyllabic stem (1b).[5] Following Schalin (2017a:16–19, 51–65), it makes sense to assume that this corresponds to a synchronic condition that antedated the restructuring of umlaut into the underlying representations. Accordingly, the contrastive features of the triggers must, in adherence to the tenets of CHT, have conformed to the activity that they generated, and hence we arrive at different feature specifications for pre-umlaut $*i_1$ and $*i_2$ respectively. The latter, being an active trigger for front umlaut, must have carried a specification for fronting tongue thrust, which we may label (at will) as [+coronal]. Conversely, from its inertia for umlaut, it is certain that $*i_1$ was not a vowel so specified. Given its Indo-European history and considering observed typological parallels, it is unlikely to have been backed into [ɯ] or [ɨ].[6] Moreover, a contrastively [–coronal] vowel cannot have carried a {+coronal} feature enhancement. Such an enhancement could, however, have increased the salience of a sonority feature like [+high] or [+close] or, even more likely, a delabialising lip thrust feature like [–round] or [–labial]. The latter analysis is far superior because an early rounding umlaut existed in Proto-Nordic (Schalin 2017b:§4; 2020 *passim*), which unambiguously requires the transmission of a lip thrust feature, here (at will) denoted [+round]. This feature was spread from a contrast inherent in /u/, and its non-syllabic allophone [u̯]. Again, the binary nature of the CFH demands that at least one vowel in the inventory be specified for its opposite [–round], a class membership for which $*i_1$ imposes itself as the most obvious candidate.

    A further argument for assuming that $*i_1$ was specified for [–round] is its inalterability by an early rounding umlaut in Old East Nordic, notwithstanding that it tended to be alterable in Old West Nordic. It is much less economical to find another explanation for its inalterability in the east than to find an auxiliary explanation for its alterability in the west: for example, a divergent western constraint ranking at some point in history could have allowed for feature switching in the west. The eastern inalterability of $*i_1$ to feature switching stands in contrast to the alterability of $*i_2$, which indicates that in Proto-Nordic rounding arose by feature filling only, on condition that triggers were contrastive for rounding this early. In example (2) these conditions are illustrated by Old Swedish descendants of words where $*i_1$ and $*i_2$ had been positioned as potential targets of w-umlaut.

(2) *The effect of potential w-umlaut on target vowels of different origin*
      a. target vowel /i_1/ inalterable to rounding umlaut
         PN *$*ku̯i_1ku̯a$- > OSw *kvik(k)ęr* (ON *kvikkr,kvikr, kykr*) 'alive, lively'
      b. target vowel /i_1/ inalterable to rounding umlaut
         PN *$*ni_1ku̯az$-/*$*ni_1ku̯i_2z$- > OSw *nekęr* (ON *nykr*) 'water-monster'
      c. target vowel /i_1/ inalterable to rounding umlaut
         PN *$*i_1zwi_2z$ > OSw *i_1þęr* (ON *yðr*) 'you (pl. acc./dat.)'
      d. target vowel /i_2/ alterable to rounding umlaut
         PN *$*mi_2rku̯az$-/*$*mi_2rku̯i_2z$- > OSw *myrkęr* 'darkness'
      e. target vowel /i_2/ alterable to rounding umlaut
         PN *$*smi_2ru̯i_1jan$ > OSw *smyria* 'to smear'

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[5] While no counterexamples from the latter inflection are available, another example is Old Swedish fem./neut. nom. pl. *dyr* 'doors', cognate with ON *dyrr*.
[6] This constitutes a clear departure from Schalin (2017a:10, 21, 36; 2017b:§2; 2018:103–104), where such phonetic backing is posited to justify that the vowel in phonology continued to interact differently from new /i/ < raised /e/.

A CFH that employs both tongue thrust and lip thrust features for contrast is necessary to account for the concurrent spread of rounding and front umlauts, as well as for the different status of */i₁/ and */i₂/, both as concerns their respective alterability by rounding and their respective triggering capacity for fronting. In order to denote the two required colouring features, the labels [coronal] and [round] are chosen. We may easily exclude that either colouring feature took scope over the other, because in that case the two features would co-occur for some segments and generate a phoneme inventory with back-unrounded vowels (such as [–coronal, –round] /ɯ/ or /ɤ/) and/or front-rounded vowels (such as [+coronal, +round] /y/ or /ø/). Yet no runic attestations, loanword evidence or reconstructions warrant postulation of such vowel classes in Proto-Nordic. Therefore, we may infer that in the Proto-Nordic CFH for short oral vowels [coronal] and [round] took scope over parallel subhierarchies and were separated by a feature node of higher rank that did not affect vowel colouring. In Proto-Nordic this feature, here proposed to be labelled [open], separated nuclear-syllabic vowels from vowels sensitive to glide formation. In a constraint-based Successive Division Algorithm, the asymmetric branching of the tree would be enacted simply by a co-occurrence constraint banning the assignment of [±round] to [+open] vowels.[7] Thus, we arrive at an architecture showing striking similarities (in this respect) with that of Western and Eastern Algonquian in Figure 3.
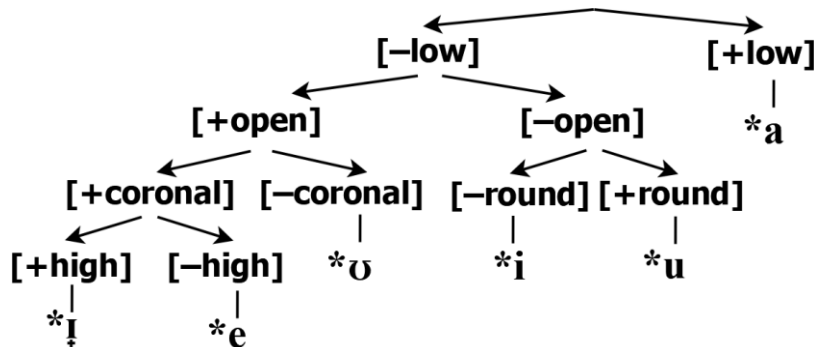

Figure 4. A Proto-Nordic contrastive feature hierarchy for short oral vowels.

In Figure 4 and from this point on, the vowel *i₁ is denoted by plain *i while *i₂ is denoted *i̩ with a subscript '+'-sign. The vowels *i and *u, which are the two vowels that could appear as non-syllabic, are proposed to belong under a branch for [–open], while the nuclear-syllabic vowels *i̩, *e and *ʊ are proposed to belong under a branch of [+open]. Again, recall that in CHT the label of the sonority feature is of minor importance: it could just as well be coined for example [±minimally sonorous] or [±constricted].[8] This would be possible since the theory assumes that features are emergent categories, which are inferred from phonological activity rather than from a predetermined innate or universal set. The same applies to the labelling of the sonority feature coined [high] in Figure 4. This label is chosen here for readability, as this is the property used by convention in phonetics to denote a distinction between [ɪ] and [e].[9] The mutual

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[7] Clearly [round] was the colouring feature more accessible by default since it was used for both nasalised and long vowels.

[8] The better-known labels [±tense] or [±RTR] could come into question but are avoided here owing to their well-known phonetic correlates. These would constitute unsolicited baggage since the methodology applied here and the theory on which it is based do not support precise surface-phonetic statements of this sort, particularly insofar as historical reconstruction is concerned.

[9] To be clear: theoretically stringent separation between phonological contrast and phonetic substance could justify marking the sonority features simply [SonX], [SonY] and [SonZ]. Ultimately, imperfect indirect knowledge of Proto-Nordic surface phonetics, and the need to conform with that knowledge for presentational purposes, justify the use of two conventionally used features [high] and [low] to describe sonority levels of greater amplitude, alongside [open] that has been used for distinctions of lesser amplitude between non-low vowels (see, for example, Sandstedt 2018: *passim*).

ranking of [low] and [open] is a case of great uncertainty. Inverting the order would add a [+open] specification to [+low] /a/ and would remove a [–low] specification from [–open] /i/ and /u/, neither of which might have discernible or falsifiable effects on fossilised phonological activity.[10]

For the choice of IPA symbols (as for feature labels) the CHT grants remarkable freedom, which again is restricted by the presentational need not to depart from conventions (see notes 8 and 9). There are conventions for how to denote phonemes reconstructed for Proto-Nordic and for how to transliterate runes. Moreover, loanword substitutions in Finnic and Sámi constitute indirect evidence of the phonetic properties of these vowels. Representation-based theories other than CHT imply conventions about how abstract phonological features are supposed to correlate with the IPA alphabet, notwithstanding that it is a phonetic alphabet, created to reflect articulatory rather than cognitive properties. The symbols in the Proto-Nordic CFH in Figure 4 are compromises between such divergent considerations, chosen to make the examples recognisable for scholars in Nordic languages and illustrative of the phonological analysis. For example, the choice of the symbol /ʊ/ is a compromise mainly hinting to an ambiguity regarding height, which is evident in its different descendants /o/ versus /u/ in West and East Nordic respectively (on synchronic allophony of this phoneme see note 10). The subscript '+' sign under *i̞ is here not foremost used phonetically, but rather as a visible reminder of its marked [+coronal] phonological specification, useful for the presentation of the topic. At the same time, it is a visual reminder that the use of the IPA symbol "ɪ" is not a statement on centralisation, laxation or tongue root retraction. Rather, the symbol *i̞ is used to visualise the vowel's minimal difference from *i in terms of phonologically evident sonority. The next paragraph presents an additional argument for this difference.

The contrast between the two vowels *i and *i̞ is evident in the fact that while *i could appear as non-syllabic *i̯, the nuclear-syllabic vowel /i̞/, which descended from PreGm *e, could not. This is seen from the dative of light u-stems. To wit, the retained ending exemplified by ON *syni* 'son' testifies to a long pre-syncope era vowel *-ī̞#, which thus must have developed from Proto-Nordic (PN) *sunī̞u̯ (< *sunewe), rather than to a short one, which (considering the ju-stems) would be predicted to have resulted from **sunju[11] after u-syncope. The latter syllabification would be much better-formed and clearly expected if the sequence had consisted of vocoids free to syllabify thus. In Gothic, where PreGm *e and *i had merged, *sunju* is indeed the attested syllabification, which has also been explained as phonologically regular (Riad 1992:77–78). A preserved blocking of glide formation that similarly correlates with the origin of the vowel is evident in the runic inscription on the Tjurkö 1 bracteate reading **Kunimundi̞u** rather than ****Kunimundiju**. The latter (counterfactual) spelling would, considering the parallels, be predicted for a sequence descending from PreGm ****iwe** after early loss of e# and subsequent resyllabification. The same would be expected should *i̞ have merged with *i. Thus, the i/i̞-distinction is evident in syllabification.

Assuming two contrastive vowels with phonetically identical or near-identical realisations but phonologically different behaviour is not a very costly assumption since the phenomenon is attested: a distinction between an active [i] and an inert [i] with respect to vowel harmony exists in Bemba (see references in Smith 2020). Also, the Proto-Eskimo CFH in Figure 2 is reconstructed by Compton and Dresher (2011) in order to explain the difference with respect to palatalisation of adjacent consonants in some Inuit languages between a palatalising 'strong i', descending from Proto-Eskimo */i/ and a non-palatalising 'weak i', descending from Proto-Eskimo */ə/, each of which carried different contrastive specifications. It is uncertain how or whether the phonological difference between *i̞ and *i in Proto-Nordic was matched by an articulatory difference. The vowels could even have been in a relationship of 'near-

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[10] Inverting the order of [coronal] and [high], on the other hand, would not conform to the attested vocalism, because it would remove the [+coronal] specification from /e/, which is the only colouring feature that it had in common with /i̞/. A common colouring feature is the best available explanation for their equal alterability to breaking (Schalin 2017b:§4.3 & 4.4, cf. §4.5). Also /ʊ/ would in that case have to assume a specification for [±high]. This is problematic because of its allophony. As explained in Section 2.2.2, this vowel was under the present analysis realised more like [o] in main stressed syllables before liquids and more like [u] in other syllables, as in the runic attestations n. acc. sg. **horna** 'horn' (Gallehus) and f. nom. sg. **swestar minu liubu** 'my sister, beloved' (Opedal), respectively.

[11] Ill-formed items and counterfactual reconstructions are marked in running text hereafter with a double asterisk: **.

merger', "as when a speaker reliably produces near-merged sounds slightly differently, but cannot distinguish between them, in the speech of other such speakers or in her own speech" (Kiparsky 2009:36 with references). An example of near-merged minimal pairs are *source* and *sauce* in New York. From the fact that near-merged sounds have contrastively different underlying representations, it follows that they may pattern in different ways and participate differently in phonological activity, which may provide sufficient cues for next-generation language learners to acquire their near-merged contrast.

2.2   *Stratal Optimality Theory*

Stratal OT (Kiparsky 2000a; 2009:29–40; 2018, Bermúdez-Otero 2018) is introduced very concisely here, assuming that Optimality Theory (OT), which is well known to phonologists, is familiar to the reader. The 'stratal' elaboration of OT has arisen in order to preserve the original economy of OT in restricting constraints to the two main categories of Markedness constraints and Faithfulness constraints, which has not been possible in other revisions of OT. Instead, Stratal OT modifies the original idea of OT that evaluation of candidates must be strictly parallel insofar as it picks up a concept of cyclicity, akin to the idea developed within Lexical phonology. Accordingly, Stratal OT allows for several stem-level cycles depending on the recurrence of the affixation that triggers them, and subsequently one word-level cycle and one phrase-level cycle. Following this order, the output of each cycle constitutes the input to the next, except the phrase-level cycle, which comes last and generates a Surface Representation. Conversely, within each cycle the evaluation of candidates is strictly parallel. The input to the first stem-level cycle is the Underlying Representation (hereafter "UR"). The concept of UR is familiar from rule-based phonology but differs insofar as Richness of the Base applies, which means that no restrictions may be imposed on the UR.

Constraint rankings for a specific language often differ between the main levels – stem, word and phrase level phonology – but among themselves, the stem-level cycles are subject to the same ranking. As a corollary, what is permitted in any given language in a phonological word may not necessarily be permitted in a stem. Interjections, nicknames and nonsense words enter the word-level cycle without computation in stem-level phonology. This has also originally been the null hypothesis for affixes, but it has been argued that affixes would pass their own 'stem-level' cycle first (Buckler and Bermúdez-Otero 2012, Bermúdez-Otero 2018:§2.3.3). This new claim is not yet an uncontested element of Stratal OT but acceptance of an 'affix-level' cycle appears to be a crucial requirement in order to reconcile the theory with any representation-based theory that treats segmental features as language-specific and emergent. If affixes could enter stem-to-stem cycles or word-level cycles without applying a cycle where features become specified first, their segments would constitute input without any feature specifications whatsoever and it would be difficult to analyse any participation by affixes in phonological activity in the first cycle where they had entered. This of course conflicts with what is known about language.

2.2.1   *Using Stratal OT to infer how a Proto-Nordic stem-level constraint altered triggers*

Stratal constraint-based phonology turns out to be essential for explaining instances where a vowel that descended from PreGm *i, despite its origin, triggered fronting as if it would have descended from PreGm *e. On closer scrutiny the triggering vowel in most of these cases was located either in a monosyllabic affix or at the right edge of a heavy stem.[12] In a mirror image of this, the same but inverse regularity concerns the rounding umlaut: the descendants of PreGm *u failed to trigger an early rounding umlaut in exactly the same environments where the descendants of PreGm *i unexpectedly triggered fronting. These conditions would be exceedingly difficult to explain independently from each other and are shown below to effectively cross-verify the validity of the present analysis.

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[12] The only clear exceptions are the ja-stems, for which the explanation is a feature-switching umlaut that occurred later (see Section 4.2.2).

This breakthrough in the infamous data puzzle is enabled by positing an undominated markedness constraint that banned the specification of [±round] for moraic segments in stem-finality, or in other words for stem-final segments that had to be parsed as moraic in stem-level phonology. A similar constraint prevented the assignment of [±round] to affix-final moraic segments and to any moraic segment in affixes that were parsed as monosyllabic. Since the constraint only concerned moraic segments, it applied where syllabification constraints prevented glide formation in stem-level phonology. In other words, early in the umlaut period, a [–open] vocoid *i or *u could appear as a stem-final segment only if it could be parsed as non-moraic *i̯ or *u̯.

Table 2. The working of the constraint at the stem level and of umlaut at the word level.

Pr-N ancestor of ON:	m. nom. sg. *gestr* 'guest'	m. nom. sg. *staðr* 'place'	m. acc. sg. *stað* 'place'	comparative *fremr* 'further'
stem-level input = UR	'gasti' – 'z'	'stadi' – 'z'	'stadi' – 'N'	'frama' – 'iz' (> 'i̯z')
1. SL output = 2. SL input	VOID	VOID	VOID	[SLfra.ma]+[SLi̯z]
2. SL output = WL input	[SLgas.ti̯]+[SLz]	[SLstaði̯]+[SLz]	[SLstaði̯]+[SLN]	[SLfra.mi̯z]+[∅]
word-level output	[WLgæs.ti̯z]	[WLsta.ðiz]	[WLsta.ði̯]	[WLfræ.mi̯z]

In Table 2 the vowel *i is proposed to appear as non-syllabic in the monosyllabic i-stem [SLstaði̯] in the two centre columns, whereby it evades the discussed constraint. The postulation of this monosyllabic stem type, first of all, requires that the stem vowel was still perceived as belonging to the stem, even if it was deleted or obscured upon the addition of inflectional endings with initial vowels.[13] The monosyllabic analysis also requires that stem-level phonology disfavoured monomoraic main-stressed syllables and/or bisyllabic main stress feet **[SL(C)CV.CV] and that constraints against complex sonority sequencing of rimes should have been ranked low in stem-level phonology. A bimoraic rime with a less well-formed sonority contour [SL(C)CVCi̯] emerged as a winning candidate from such constraints. In such a double-closed monosyllable the weightlessness of the glide, just as for any other consonant, was a corollary of its stem-finality. This syllabification is not mirrored in any case form at the word level – the accusative in the centre-right column is different owing to nasalisation by means of inflection. The light-stem [SLstaði̯] is compared to *gæstiz, a heavy stem that was parsed in stem-level phonology as disyllabic [SLgas.ti̯], since a non-syllabic vocoid, albeit weightless in itself in stem-final position, would have turned the previous consonant moraic. This, in turn, would have created a trimoraic or overheavy rime **[SL(C)CVCCi̯], which was ruled out by a constraint at this historical point of Proto-Nordic phonology.

Therefore, through an interaction of this feature-substituting constraint and the syllabification constraints, a trigger of equal origin as in *staðiz was in the case of heavy stems substituted upon vocalisation by the most similar vowel *i̯. This vowel belonged to another subhierarchy of contrastive features, where tongue thrust features were used to uphold contrast. "Most similar" is here a problematic concept, as one reviewer pointed out, since due to the choice of theory, similarity cannot refer to acoustics or even to a later stratum of phonology but must be evaluated based on the abstract contrastive features that

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[13] The umlaut patterns of at least the a-stems and the i-stems do not contradict the null hypothesis that the descendants of the Pre-Germanic stem vowels were still acquired and memorised as belonging to the stem. The affiliation of the historical stem vowel to the stem has similarly been stipulated for Proto-Germanic on the basis of a floating stem-final melody in Gothic by Kiparsky (2000b:§5). Also, for another Indo-European language, Castilian, Bermúdez-Otero (2007) invokes several arguments for the analysis that stems are memorised with their thematic vowel.

are computed at the stem level. Hence, to arrive at /ɪ/ (see hierarchy in Figure 4 above), a faithfulness constraint must be assumed that incurs a violation for switching [–low] to [+low], and another that penalises [–coronal] in the output when [–round] appears in the input, and yet another that penalises [–high] in the output when [–open] occurs in the input. These faithfulness constraints that make perfect sense from a phonetic perspective must here be assumed to have penetrated the phonology. In Table 3, where the pertinent interaction of constraints is displayed, the ranking of these particular constraints is indicated by lumping them together in one IDENT-(trigger[F]).

Table 3. Constraint hierarchy manipulating the stem vowel of heavy i-stems.

	No trimoraic syllables	*No [±round] stem-final μ:ic segments*	*No deletion*	*No feature substitution*	*No sonorants after obstruents in rimes*
Input: **stadi**	$*\mu\mu\mu$	$*[\mu, [rnd]]\#$	MAX-IO	IDENT-(trigger[F])	SONSEQ (SSG)
sta.ði		!*			
☞ staðɪ̯					*
stað			*	(*)	
sta.ðɪ				*	
Input: **gasti**					
gas.ti		!*			
gastɪ̯	!*				*
gast			*	(*)	
☞ gas.tɪ̯				*	

Accordingly, the vowel /ɪ/ in the stem-level output could have two sources: underlying 'i', a descendant of PreGm *i as manipulated into /ɪ/ by the constraints presented in Table 3, or underlying 'ɪ', a descendant of previously raised PreGm *e. This being the case, a language learner could easily have preferred to restructure the UR of /ɪ/ from 'i' to 'ɪ' in all default cases where the stem-level constraints made it come out as /ɪ/ anyway. Inferring a new underlying 'ɪ' would have had little structural implication in the comparative suffix, as in [WL fræ.mɪz] in Table 2. Yet the language learner may still have refrained from inferring a restructuring where a loss of some morphological generalisation would have ensued. For example, the paradigmatic unity of i-stems may have been reason enough to uphold the original 'i' in UR 'gasti' ~> [SL gastɪ̯], as it could have maintained paradigmatic unity with 'i' in UR 'stadi' ~> [SL staðɪ̯].[14] Either way, the analysis is not undermined or questioned whether these restructurings had occurred or not.[15]

Inferred thus from the data this feature-substituting constraint, which impacted greatly on how triggers thus manipulated (or 'reduced') were spreading features to target vowels, proves to be a good predictor of the so far poorly understood distribution of umlaut in the lexicon. This explains the canonical conundrum concerning masculine i-stems, where heavy stems are umlauted on a regular basis while light stems are not (Benediktsson 1982 *passim*, Schalin 2018:70–80).

2.2.2 Extending the demonstration by applying Stratal OT to an early rounding umlaut

Another main finding is that the analysis of front umlaut can be verified by the rounding umlaut, where an original distribution may be discerned that appears inverse to that of front umlaut. Insofar as early rounding was concerned, short triggers after light syllables (C)CV.Cu₁(C) as in ON *fœ* [fø:] 'livestock' (from earlier

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[14] The sign '~>' is hereafter employed to denote synchronic derivation between cyclic levels or strata.
[15] On choosing between two URs with equal outcome, see Kiparsky (2000b:§1 with references).

Pre-Nordic *$fehu_1$*) could trigger an early rounding umlaut, whereas short triggers after heavy syllables (C)CVC.Cu$_2$(C) were not umlaut-triggering, as in ON *réttr* 'right' < *$rehtu_2z$.[16] In example (3) the symbols from Figure 4 are introduced: hereafter, plain 'u' is used for 'u$_1$' while the vowel 'u$_2$' is marked 'ʊ'. This lowered back vowel /ʊ/ must be considered contrastively different from /u/ based on its inertia as a trigger for the earliest rounding umlaut. As illustrated in example (3), an inverse distribution to that of the front umlaut fits perfectly with the hypothesis that feature specifications of triggers were accountable, since the front/back features of the triggers /ʊ/ and /ɪ/ in heavy stems and the [±round] features of the triggers /u/ and /i/ in light stems account for the rounding umlaut active in light stems and for the front umlaut active in heavy stems respectively.

(3) *Stem-to-word-level computation depending on syllable weight and origin of the trigger*
  a. Light u-stems: ON *fǿ* [fø:] 'livestock, creature'

  μμ   μ. μ
  [$_{SL}$fehų̣]+∅ → [$_{WL}$føhu]

  b. Light i-stems: ON *staðr* 'place'

  μμ   μ. μ
  [$_{SL}$staðị̣]+[$_{SL}$z] → [$_{WL}$staðiz]

  c. Heavy i-stems: ON *gestr* 'guest'

  μμ. μ   μμ. μ
  [$_{SL}$gastɪ]+[$_{SL}$z] → [$_{WL}$gæstɪz]

  d. Heavy u-stems: ON *réttr* 'right, entitlement, justice'

  μμ. μ   μμ. μ
  [$_{SL}$rehtʊ]+[$_{SL}$z] → [$_{WL}$rẹəhtʊz] (with incipient breaking, without rounding)

Just like the vowel *ɪ was shown to be, *ʊ was phonemic before it became a replacement for /u/ by means of the feature-substituting constraint. Judging from missing rounding umlauts in Old East Nordic, it was identical with the shortening product of the vowel /ō/ in stem-finality in strong feminine ō-stems, as in f. nom. sg. PGm *$gebō$ > *$geəƀʊ$ > OSw *giæf* 'gift' (not **$gøƀu$- > **$gẹəƀu$- > **$giøf$). It is therefore suggested that this shortening product did not merge with *u but with the opened 'a-umlauted' /ʊ/. This merged vowel appeared more lowered in root-initial syllables before rhotics, as attested in **horna** 'horn' in the Gallehus inscription, and much less lowered in weakly stressed syllables, as in the runic attestation from Opedal f. nom. sg. **swestar minu liubu**, to be read /mīnʊ liʊbʊ/ (cf. note 10). This phoneme also occurred resulting from metaphonic lowering umlaut in second syllables where a low or mid vowel had occurred in the third syllable as in *$mẹəðʊmʊ$ < *$meðumō$ 'hip'. The phonemic status of a-umlauted *u has been subject to a longstanding controversy under the tenets of structuralist phonology, since the trigger for lowering umlaut was still not lost (Stiles 2012). Phonemicisation by allophone merger along the lines just described resolves the problem and explains the contrast to /u/ in triggering positions, which is evidenced by the inertia of this vowel for an early rounding umlaut, as attested in Old Swedish.

In the cases ON *fǿ* and *réttr* in example (3), breaking lapsed due to the particular consonantal contexts in these words, but often rounding occurred in combination with breaking. Again, a different rounding effect is evident after internal reconstruction based on data from Old Swedish. There, the mid vowel /e/ in neutral consonantal contexts and targeted by /ʊ/ came out unrounded as in OSw *giæf* 'gift' and *miæþm* 'hip'. Here the development was *$geəƀʊ$ > (after later rounding umlaut:) *$gjɒf(u)$ > *$gjaf$ > OSw *giæf*, as opposed to (western) ON where the vowel in *$gjɒf(u)$ merged with that of *miɔðʀ* 'meed' to result in *gjɒf* and *miǫðr* as well as *mjǫðm* (Schalin 2017b:§6.6). The OSw examples are probative since here that merger did not occur, which fed rounding reversal for the low vowel *$/ɒ/$. Conversely, the non-lowered trigger /u/ caused an early rounding umlaut that endured breaking, such as in OSw *mioþęr* 'mead' and *miolk* 'milk'.

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[16] For scarcely attested but phonologically probative ON *fǿ* [fø:] versus high-frequent secondary *fé*, see Haugen (1982:33), and for some more data, see Schalin (2018:114–115).

2.3 On the reconciliation of CHT and Stratal OT

Both CHT and Stratal OT dispose of the structuralist notion of contrast, which is based on pairwise comparisons, but from different perspectives. The way in which CHT succeeds in restricting postulates of purely redundant features without resorting to radical underspecification has no real equivalent in Stratal OT since it has not been formulated as a theory of representations. Still, Stratal OT can be applied to explain why both redundancy-free morphophonemes, or M-phonemes (hereafter put between braces {}), and distinctive lexical phonemes, or L-phonemes (hereafter put between slashes //) are different from the structuralist notion of a phoneme (Kiparsky 2018:54–61). The concept of M-phoneme is used here to refer to segments that exit a first phonological cycle parsimoniously specified in conformity with feature hierarchies of CHT. At the word level of Stratal OT predictable segmental specifications typically arise. While these therefore may seem redundant by any strict measure of parsimonious contrast, they are nevertheless distinctive. The umlauted vowels during a synchronic stage antedating trigger loss are a case in point. Within the CHT, such computed features are said to be "within the phonological component".[17]

Outlines of how CHT and Stratal OT might be reconciled exist and one particular synthesis has been applied to empirical data by Sara Mackenzie (e.g., 2013; 2016, cf. Dresher 2009:144–161). A basic corollary of any synthesis of CHT and Stratal OT is that contrastive features must be assigned in conformity with the binary hierarchical organisation as part of constraint interaction during a first cycle at the very deepest stratum of phonology. Accordingly, it is not the features of the underlying representation or the input of the first cycle that is hierarchically organised, but its output (Dresher 2009:144–145). Any other conclusion would conflict with the Richness of the Base principle of OT. As stated above, this requirement must inevitably also apply to affixes.

[nasal] > [voice]
t, d, n

[+nasal]   [-nasal]
   n   t, d

[+vce]   [-vce]
  d   t

	n [+voice] [+nasal]	MAX[nasal]	*[αvoice, +nasal]	MAX[voice]	*[F]
a)	n [+voice] [+nasal]		*!		**
b) ☞	n [+nasal]			*	*
c)	n [+voice]	*!			*
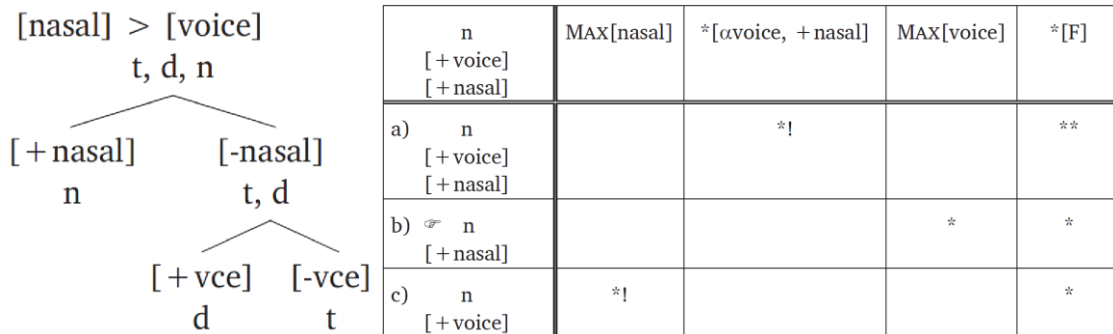
Figure 5. The conversion of contrastive feature hierarchies into constraint rankings.

The two images in Figure 5 show how a feature assignment in strict conformity with a binary CFH (left image) may be generated by constraint interaction (right image). Generating a well-formed hierarchy implies an alternating ranking between faithfulness constraints demanding the preservation of the feature value of relevant features [F] (either + or –) and co-occurrence constraints banning any values of a particular feature αF_1 from occurring with either value of a feature $\pm F_2$ already assigned *[$\alpha F_1, \pm F_2$]. Strict contrastivity is secured by a low-ranked markedness constraint *[F] banning the assignment of any features beyond those already assigned in conformity with the contrastive hierarchy. The images are reproduced from Mackenzie (2016:5–6) where they introduce an analysis for consonant harmony in Nilotic. For more detailed discussion of this, see Dresher (2009:146–160).

An intricate question is whether the strata (as in Figure 6) postulated by the proponents of Stratal OT suffice, or whether constraints that perform a first feature assignment should be segregated from the stem-level phonology. In that case, the output of these constraints would consist of well-formed contrastive

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[17] Dresher (2018:§3.5) in discussing the phonologization of Old English i-umlaut explicitly refers to Kiparsky's notion of salience, which in turn flows from Kiparsky's (2009:31) view on the word-level phonology in Stratal OT.

specifications that serve as the input to phonology proper, a possibility mentioned by Dresher (2009:161) and reiterated by him in a personal communication in August 2020. Such a segregation is a convenient solution for the purpose of condensing the presentation of the other stem-level constraints, as done in this paper. Moreover, since this posits that features are part of the stem-level input already, it makes it much easier to conceive the solution to the problem discussed in 2.2.1 on how the stem-level phonology arrives at which phoneme is the "most similar" candidate as a substitute of an input phoneme that is banned from appearing in stem-final position. This would be a slight modification of the less stratified model assumed by Mackenzie (2016:7–8) and illustrated in Figure 6, whereby the constraint hierarchies performing feature assignment would work in parallel evaluation with other constraints at the stem level.

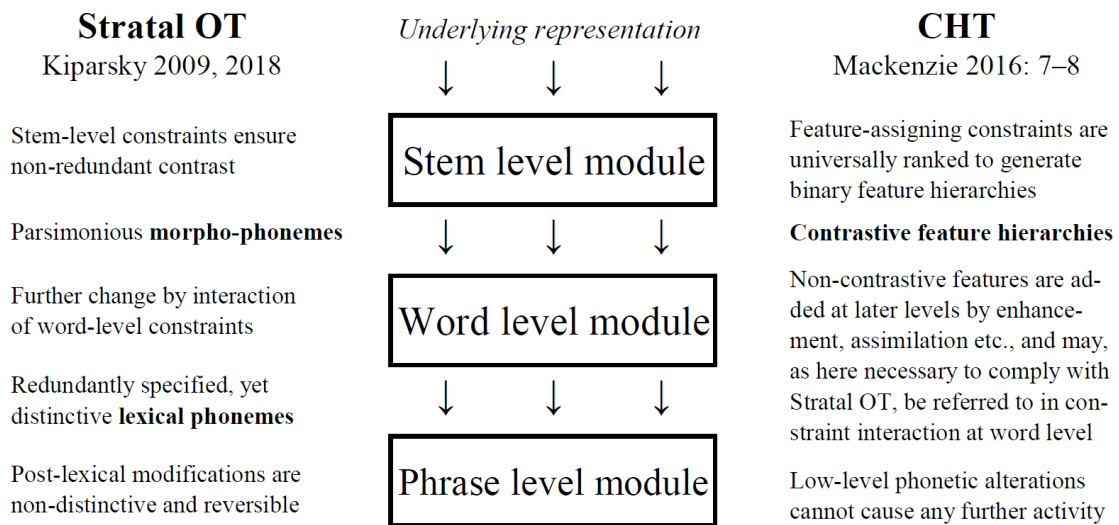| **Stratal OT**	*Underlying representation*	**CHT**
Kiparsky 2009, 2018	↓ ↓ ↓	Mackenzie 2016: 7–8
Stem-level constraints ensure non-redundant contrast	**Stem level module**	Feature-assigning constraints are universally ranked to generate binary feature hierarchies
Parsimonious **morpho-phonemes**	↓ ↓ ↓	**Contrastive feature hierarchies**
Further change by interaction of word-level constraints	**Word level module**	Non-contrastive features are added at later levels by enhancement, assimilation etc., and may, as here necessary to comply with Stratal OT, be referred to in constraint interaction at word level
Redundantly specified, yet distinctive **lexical phonemes**	↓ ↓ ↓	
Post-lexical modifications are non-distinctive and reversible	**Phrase level module**	Low-level phonetic alterations cannot cause any further activity

Figure 6. A possible synthesis of Stratal OT and Contrastive Hierarchy Theory.

In-depth discussion on the ultimate compatibility of the two theories is still needed, and the provisional application of the synthesis to the Nordic umlaut puzzle here may reveal further problems. One could, for example, argue that any adaption of CHT to fit Stratal OT is not well in tune with a basic tenet of OT, which stipulates that the constraints themselves should be universal rather than their ranking, which typically should be variable. This may seem at odds with CHT, which puts a universal restriction on how faithfulness constraints and co-occurrence constraints should alternate in order to generate exclusively the type of binary hierarchies that the theory acknowledges (Dresher 2009:149-153). Moreover, there seems to be a paradox between the Richness of the Base principle, which rejects language-specific restrictions on the UR, and any theory that rejects innate or default features even for basic phonetic entities like [u], [i], [h] or [m], since it may be difficult in that case to formulate any meaningful statement on any make-up of any UR. How, for example, would an UR 'um' in essence differ from an UR 'hi' prior to the assignment of any features at all to the segments? The solution may be to accept a complete overspecification of underlying representations by means of a universal but inconceivably abundant set of features, which can reflect anything that the language learner may perceive and cognise. Thus, it would not after all be the feature set, which is emergent, but the language-specific selection from this overly abundant set of features.

　　All in all, the flexibility necessary to enable synthesis has been pursued in this paper without compromising the strict cyclic layering of the strata. The strict adherence to the architecture of contrastivity typical for CHT has been upheld at the M-phonemic stem level but at subsequent levels reference has always been made to the output of the previous stratum, which may imply accepting secondary activity of post-contrastive features, constituting a departure from the contrastivist hypothesis (see note 3). In any event, the synthesis of the two theories is deemed to yield considerable insights that enrich the discussion on the data puzzle of Nordic umlaut.

3. The intersection of diachronic umlaut with representational and computational approaches

3.1 The common denominator of the Germanic languages

The early precursors of Nordic umlaut affected sonority features and comprised raising of *e > *ɪ, which was presumably restructured by the time of Proto-Nordic, as well as opening of *u > *ʊ (o). The effects of these early umlauts were similar to, albeit in part less far-reaching than, those in other Northwest Germanic languages: if there was any lowering of *i > *e, the evidence is far too scarce and sporadic to have it convincingly dated with the early lowering umlaut. Thus was the situation in Proto-Nordic when word-level phonology started to compute the vowel-colouring umlauts, which govern lip rounding and front/back thrust of the tongue.

Table 4. Front umlaut in some Germanic languages.

Proto-Germanic	Northwest Germanic	English	German	ON	OSw
nom. sg. *fõts	[SL fo:t]+[z]~>[WL fo:tz]~>[PL fo:ts]	foot	Fuß	fótr	fõteʀ
nom. pl. *fõtez	[SL fo:t]+[ez]~>[WL fo:tiz]~>[PL fø:tiz]	feet	Füße	<fœtr>=føtr	fõteʀ

The most discussed Nordic umlaut is the front umlaut, conceivably because it conveniently renders itself comparable to similar umlauts in various dialects of West Germanic, which have been well known to many scholars that engaged in North Germanic. Comparisons of its distribution in the respective vocabularies reveal obvious similarities, such as a fronting in the plural of the word for 'foot' in many daughters, as displayed in Table 4. Yet there is no shortage of discrepancies either. The distribution of front umlaut in the vocabulary is quite different, not only when the North and West Germanic branches are compared but likewise between more closely related daughters that both descend from the same main branch (Kiparsky 2009:12–16, 45–48). Hence, insofar as the relative chronology is concerned, the majority view today is that this sound change must have progressed in parallel, after the Northwest Germanic protolanguage broke up (Kiparsky 2009, Dresher 2018:§3.5, note 23, Schalin 2018:54, 58 with references). Against this background, it continues to be justified to pursue reconstruction of the Nordic umlauts internally, as is done in this paper.

Nonetheless, the Germanic umlauts also have common denominators, which are typologically quite marked and therefore also deserve a unified explanation. Such an explanation can be formulated using Stratal Phonology. The most likely scenario is displayed in the column for Northwest Germanic in Table 4, which illustrates how an umlaut could have applied during this ancestral language stage in phrase-level phonology. The differences between the daughters would have emerged when the constraints accountable for umlaut variably started to enter the word-level phonology and to interact with other constraints in that stratum. Germanic languages that later lacked a front umlaut could still have had this property in their past phrase-level phonology, because if it never advanced deeper, it is expected that it would be reversed and lost to later generations altogether. This is a possible hypothesis for Gothic and even for Proto-Germanic. A strong argument against such an early phrase-level umlaut is the general lack of reflexes in relevant loanwords in Finnic (Schalin 2018:63). This argument could be invalidated if the umlaut, while remaining at the phrase level, occurred with a modest fronting amplitude (ibid.:138f).

3.2 On feature filling and feature switching

Prior to their phonemicisation, umlaut allophones are understood here as having been targets of feature spreading, licensed by the features of trigger vocoids that were positioned beyond a sonority minimum in non-initial syllables. This raises the question whether feature spreading was primarily characterised by

feature filling or feature switching. The birth of so many new phonemes strongly suggests that at least some of the umlauts must have been feature filling and the Proto-Nordic vowels must initially have been underspecified. The opposite alternative has little appeal. A postulated Proto-Nordic vowel inventory enabling processes exclusively based on feature switching would inevitably have to be weirdly overspecified, since it should not only have contained all the required features to express the richer end-state inventory, but also have had the phonemes arranged in a hierarchy where they were specified for the opposite value of a feature pertaining to that richer inventory. Just to give one example: the Northwest Germanic */ō/ as in [WL foːtiz] in Table 4 would have to have been overspecified for both a lip-rounding feature and a tongue-backing feature, in order to anticipate the future specification for both the lip rounding and the tongue fronting pertaining to /ǿ/ after the alleged feature switch. Such overspecification cannot be derived from existing binary contrasts in the scarce vowel inventory of Proto-Nordic, where neither rounded front vowels (/yː/ or /øː/) nor spread back vowels (/ɯː/ or /ɤː/) existed.

The requirement to assume feature filling at some stage does not exclude the possibility of feature switching in some umlaut at some language stage. On the contrary, as argued below, feature switching should be assumed for a relatively late exceptionless j-umlaut. Remarkably, it has not been necessary to assume feature switching to explain the main findings concerning the earliest umlauts in Section 2. To assume that feature filling was a predominant mechanism for any umlaut and feature switching a mechanism active in the heyday of front umlaut does not burden the explanatory economy much, because, given the tenets of OT, the mechanism is not a fundamental property of the umlaut phenomenon. All it takes in OT is to assume a reranking of the most pertinent markedness constraint over the pertinent faithfulness constraint for as long as it is necessary to explain a time-limited feature-switching mechanism.

3.3   The pervasiveness of synchronically altered targets and their phonemicisation

The data from attested Old Nordic expose clear enough correlations in Proto-Nordic polysyllabic words between altered target vowels in the root-initial main-stressed syllable and corresponding vocalic triggering contexts in a following syllable. The Germanic umlauts are farthest diversified in the North Germanic languages, where for example in Old Norse a single u-stem paradigm may show a complex of raising, fronting, rounding and (upon back umlaut) breaking, as illustrated in Table 5.

Table 5. Alterations of colouring umlauts in Old Norse by deleted and retained triggers, respectively.

	ON < NWGm i̯-trigger	ON < NWGm u-trigger	ON < NWGm a-trigger
'firth, fjord'	dt. sg. *firði* < **fırþī̜* < **ferþi̯u*	nom. sg. *fjǫrðr* < **ferþuz*	gen. sg. *fjarðar* < **ferþauz*
'staff, stick'	dt. sg. *veli* < **valī̜* < **vali̯u*	nom. sg. *vǫlr* < **valuz*	gen. sg. *valar* < **valauz*
'to fare, go'	2nd pers. sg. *ferr* < **farız*	1st pers. pl. *fǫrum* < **farumz*	3rd pers. pl. *fara* < **faran(ǫ)*

The examples in Table 5 illustrate that the triggering context may be lost, as in the nominative singulars of u-stems *fjǫrðr* and *vǫlr*, as well as in the 2nd pers. sing. *ferr* of strong verbs, all appearing in shaded cells. Yet, triggering vowel qualities may equally be more or less preserved, as in the dative and genitive singular of the u-stems, and in the two plural forms given for the strong verb *fara*. This highlights one of the classic unsolved problems, namely, exactly how the genesis of new contrastive target vowels may have depended on reduction of (some) triggers. Post-Prague-school linguistics came to reject the longstanding theory, postulated by some neogrammarians, that umlaut in its first stage did not affect a potential target unless the trigger was deleted. It is misguided to view trigger reduction alone as the original cause of umlaut, despite the long research tradition that has worked on that premise (Rischel 2008:199f). We are safe to assume that

umlaut first was synchronic and operated uniformly without being contingent on a deletion that was yet to happen (Benediktsson 1982:5).

It has occasionally been suggested that remaining triggers, in the words where they occurred, could have suspended restructuring or phonemicisation, since they provided a neutralising environment where the distinctive properties of the umlauted phoneme could equally well have continued to be derived from the old underlying representation (Dyvik 1973, Iverson and Salmons 2012). Nonetheless, there are no clear data to definitively indicate that this suggestion has much bearing on the explanation of any of the umlauts.[18] Instead, extensive data supports the pattern illustrated in Table 5, all reaffirming that remaining triggers correlate to the new umlaut vowels at least as completely as deleted triggers do. Therefore, in most cases, restructuring into a new UR upon trigger reduction must have attracted other equivalent occurrences of the same distinctive l-phoneme to restructure into the same innovative UR by merits of Lexicon Optimisation, even if these other occurrences of the l-phoneme could have continued to be derived as they were before (cf. note 15 and references in Kiparsky 2000b:§1). To exemplify this by the data in Table 5, when 2nd pers. sg. front umlauted *færɪz* (as derived from *far+ɪz*) lost its trigger and the language learner inferred a new underlying form *fær+z*, when forced to choose, the learner preferred to infer that front umlauted dat. sg. *vælɪ̯* was derived from *vælʷ+ɪ̯* rather than from *valʷ+ɪ̯*.[19] Even if a delay of such sweeping restructuring is imaginable, its role can hardly have been persistent. If there was any such suspension of restructuring in some stem types, it must have been motivated by preventing a loss of paradigmatic uniformity. But even in that case it is unlikely that the two distinctively coinciding outputs of word-level phonology would have dissimilated once again, instead of just becoming restructured later into an output of a unified UR. The received wisdom "once a phoneme, always a phoneme" could be reformulated into a hypothesis "once a single L-phoneme, sooner or later also a single M-phoneme".

In terms of theory, it is intriguing to explain why the synchronic effect on the target did not vanish with the loss of its trigger, considering that the trigger was the continued cause for that effect in the first place. In other words, why would *færɪz*, which was derived from *far+ɪz* by umlaut, become *fær+z* upon the loss of triggering *-ɪ-* rather than expected *far+z*? Logically equivalent target reversion is known to occur commonly in languages (Kiparsky 2009:28). The critical question, which was put in this very context by Robert D. King (1971:4) and echoed by Anatoly Liberman (1991:127) is: why do allophones sometimes remain, and other times revert? The latter answers that distinctive vowel qualities must have emerged prior to cases of trigger loss (Liberman 1991:127). This question of phonologisation has been discussed in the framework of Stratal OT by Paul Kiparsky (2009:29–40). He claims that trigger loss caused restructuring of the new target vowels on condition that their newly altered quality had become categorically and perceptually distinctive, which was contingent on the fact that its computation had advanced from the phrase-level to the word-level phonological stratum. Thus, if the computation of *farɪz* into *færɪz* was delimited by word-boundaries and the result of a word-level affixation [$_{SL}$far]+ɪz ~> [$_{WL}$færɪz], then an i-deleting markedness constraint that had advanced to word level [$_{WL}$færz] would lead the language learner to infer a new stem [$_{SL}$fær]. If the fronting had only affected lower-level phonetics computed at phrase

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[18] The best endeavour to claim anything of the kind may be the proposal by Hreinn Benediktsson (1963) for young rounding umlaut by a remaining trigger in Old East Norwegian manuscripts, but the interpretation of the diverse orthographic data has been meticulously questioned by Jade Sandstedt (2018:§5.1.1). Attempts to apply some similar idea of suspended phonemicisation for the front umlaut have not played out well, as scrutinised by Benediktsson (1982:27–31) himself and by Schalin (2017:§7 with references).

[19] The umlaut patterns generally support the hypothesis that the thematic vowels inherited from Indo-European were synchronic stem vowels (see Section 2.2.1, note 13). As regards the Proto-Norse u-stems, the presence of the stem vowel throughout the paradigm is far from self-evident. Its Pre-Germanic origin was already a stem discontinued by infixation as in *STEM(+e/o+)u̯-* with an *-e-* or *-o-* variably inserted (or three suppletive stems *STEMu̯, STEMeu̯* and *STEMou̯*). Towards late Proto-Nordic, the synchronic manifestations of this were in a process of becoming obscured by sound laws, such in dat. sg. **-mundeu̯i > *-mundɪu̯ > *mundɪ̄*. Similar deletion of the labial also occurred in the nom. pl. **ferþeu̯iz > *fɪrþɪu̯z *fɪrþɪ̄z*. The alternation of umlauts could indicate the emergence of suppletive stems, but it may not be incompatible with an analysis where the stem vowel had been reduced to a floating melody corresponding to the lost stem vowel, which docked on to an empty nucleus in those case endings which still retained an initial vowel that reflected the melody (Kiparsky 2000b:§5).

level, the trigger loss would have caused umlaut reversion. This hypothesis constitutes a basis for the analysis in this paper.

4. Diachronic analysis: Syncope and ensuing contrast shifts

4.1 *Proto-Nordic entering the early umlaut period*

4.1.1 *On a/i-syncope and the effects of word-level trigger loss*

Further findings concern the chronology of umlauts. Every example cited so far illustrates an early umlaut period when a first front umlaut and a first rounding umlaut operated concurrently at the word level at a time when neither had yet been restructured into the underlying representation.[20] The motivation of the restructuring, which in retrospect indeed must have followed, is hard to explain not only under structuralist tenets but also in rules-based generative phonology, where both umlaut and syncope could have continued to coexist indefinitely under a synchronic rule ordering and where restructuring was expected primarily as a consequence of an irregular non-final rule insertion or an equally unmotivated rule reordering (King 1971; 1973). By contrast, under Stratal OT, umlaut and syncope could coexist only if the corresponding constraints were operative in different strata, otherwise syncope must have led to a restructuring of umlaut. This prediction better conforms with what happened, as attested in Old Nordic.

Table 6. The incompatibility of syncope and umlaut in word-level phonology.

Input: **far + ɪz**	*μμμ	AGREE ([+CRNL])	a) MAX-IO	IDENT (trigger[F])	IDENT (target[F])	*i, ɪ, a (weak)	b) MAX-IO
farɪz		*!				*	
a) ☞ færɪz					*	*	
fariz				*!			
b) ☞ farz			*				*
færz			*		*		*
Input: **hald + ɪz**							
haldɪz		*!				*	
☞ hældɪz					*	*	
haldiz				*!			
haldz	*!		*				*
hældz	*!		*		*		*

Table 6 shows that demoting the trigger-preserving faithfulness constraint MAX-IO below the constraint *i, ɪ, a (weak), which demands deletion of the more sonorous vowels in weak positions, makes the umlaut-enforcing constraint AGREE([+CRNL]) irrelevant in light stems, such as [SL far] + [SL ɪz], because the syncopated candidates cannot incur any violation of the latter. No further reranking of constraints can point out the candidate *færz* as optimal without altering the input: the winning candidate, which without syncope is (a) umlauted *færɪz*, would with effective syncope inevitably be (b) un-umlauted *farz*, because that candidate is always more faithful to the target vowel in the input than *færz*. This ranking paradox can only be solved by reverse-engineering a new input, which any next-generation language learner would have

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[20] Not to complicate matters with unnecessary intermediate stages, it is assumed here that restructuring more often occurred upon trigger loss (syncope) than on feature loss (qualitative reduction).

done since /æ/ in umlauted *færɪz* was already a distinctive l-phoneme, which was not prone to be altered. Therefore, a new underlying vowel must have been inferred to enable the selection of the correct output after the demotion of syncope-inhibiting constraints.

To put the consequences in less technical language: to cause restructuring of the underlying form, the syncope need not (as was required when assuming rule ordering) have overtaken umlaut in their "race" deeper into phonological computation; that effect is achieved once syncope catches up with the umlaut at the word level and set off this one critical thrust. After that, syncope may have remained synchronic in word phonology without any chronological *terminus ante quem* since umlaut was already completed.

As regards the corresponding heavy stems of strong verbs, an undominated constraint against tri-moraic syllables *μμμ prevented word-level syncope (Kiparsky 2009:18–27) and would have left the trigger vowel undeleted.[21] Given these circumstances in heavy stems, there would have been no incentive or compulsion to delete the underlying trigger in light stems: only by retaining the inflectional affix [SL ɪz] uniform in both stem types could allomorphs be avoided. Quite conversely, it is highly probable that /æ/ at once restructured into the UR 'æ' also in heavy stems, even if it was not necessary to enable the selection of the correct candidate. In order to simplify the derivation, an alteration of the target vowel in the inflectional paradigms of strong verbs had to be memorised, but this was not an extra burden since it had to be memorised in light stems anyway, and therefore a uniform generalisation could be established.

Table 7. Restructuring of stem vowel without restructuring of trigger loss.

Pr-N ancestor of ON:	2nd pers. sg. *fęrr* 'you go, travel'	2nd pers. sg. *hęldr* 'you hold, keep'	2nd pers. sg. *fęrr* 'you go, travel'	2nd pers. sg. *hęldr* 'you hold, keep'
	Stage 1 synchronic umlaut		**Stage 2: synchronic syncope > restructured umlaut**	
stem-level input = UR	far – ɪz	hald – ɪz	fær – ɪz	hæld – ɪz
SL output = WL input 'M-phonemic'	[SL far]+[SL ɪz]	[SL hald]+[SL ɪz]	[SL fær]+[SL ɪz]	[SL hæld]+[SL ɪz]
word-level output 'L-phonemic'	[WL færɪz]	[WL hældɪz]	[WL færz]	[WL hældɪz]

The same logical pattern would have occurred throughout many paradigms: syncope moved from phrase-level to word-level phonology wherever syllable structure allowed, and deleted the short oral vowels /i/, /ɪ/ and /a/ in weak syllables in contexts where deletion was allowed without violating more highly ranked syllabification constraints. Dorsal /ʊ/ or round /u/ were not yet affected owing to lower sonority.

Important words where syncope first occurred were structured as in example (4). In light-stem mono-syllables syncope occurred before weightless word-final obstruents. Obstruents in general are represented in (4) by 'Z', i.e., the versal for the most common word-final segment -z#. Syncope similarly occurred in final syllables of trisyllables as shown in (4b), as well as in (4c) where any segment is represented by the symbol for a mora ('μ'). Syncope also first occurred medially in light stems which contained a third syllable

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[21] In heavy disyllabic a-stems, such as m. nom. sg. *wolfaz* 'wolf', syncope could only proceed if licensed by epenthetic vowels, which occurred at least in one dialect in Blekinge province (Kiparsky 2009:23–25). The fact that the unsyncopated acc. **-wulafa** occurs in the same inscription DR 359 from Istaby as syncopated nom. **-wulafz** (Nielsen 2009:3–8) should be taken as an indication that the stem vowel in the accusative was more resistant to syncope than in the nominative, which in turn may be explained by preserved nasalisation. It is beyond the scope of this article to examine what effect these epenthetic vowels could have had on later Nordic umlaut, had they appeared in i-stems and/or a larger dialect area.

parsed as heavy (4d). In cases where a word-level umlaut affected the initial syllable, such as in *fyrį̣z, *ænuðį̣z, *mykį̣laz and *bætį̣ző, syncope left the language learner with no other choice than to infer a restructured target vowel in order to maintain the quality of the distinctive l-phonemic umlaut vowel.

(4)   *Examples where deletion of /i/, /į̣/ and /a/ was first allowed (forms with L-phonemic vocalism)*
   a. (C)V.CVZ > (C)VCZ – *fy.rį̣z > *fyrz 'before', *sa.liz > *salz 'hall', *we.gaz > *wegz 'way'
   b. (C)V.CV.CVZ > (C)V.CVCZ – *æ.nu.ðį̣z > *æ.nuðz 'ducks', *my.kį̣.laz > *my.kį̣lz 'abundant'
   c. (C)Vμ.CV.CVZ > (C)Vμ.CVCZ – *an.na.raz > *an.narz 'other', * li:.tį̣.laz > * li:.tį̣.lz 'little'
   d. (C)V.CV.CVV(C) > (C)VC.CVV(C) – *bæ.tį̣.ző > *bæt.ző 'the better' (n.), *lu.ki.lōz > *luk.lōz 'keys'

The restructuring of the new vowel into the UR was contagious and spread by default to most occurrences of the same l-phoneme elsewhere in the vocabulary because this facilitated a more clear-cut economy of derivation (see discussion of Lexicon Optimisation in Section 3.3). Any exceptions to this sweeping restructuring would have pertained to cases where a strong morphological generalisation prevented it. Restructuring happened irrespective of whether the trigger was lost or remained, but only in cases where the trigger actually was /į̣/ rather than /i/. Inert triggers descending from PreGm *i occurred in cases like *katilōz > *katlōz 'kettle' and *talidē > *taldē '(s)he counted', but active ones occurred (as shown above) in nominative plurals (=dative singulars) of consonant stems (example 1, Table 4) and of u-stems (Table 5), in singulars of strong verbs (Table 6, Table 7), in comparatives (Table 2) and in masculine heavy i-stems (Table 2, Table 3). Restructuring also occurred in nouns derived by means of suffixes beginning with /į̣/ < PreGm *e, for example by the diminutive suffix in *myk-į̣laz and the deadjectival feminine suffix -į̣þʋ as in *fræg-į̣þʋ 'repute'. The latter is another example of how heavy stems, despite restructuring, would have resisted syncope so as not to yield a banned trimoraic syllable **fræg.þʋ. In contrast to umlaut, syncope was slower to proceed to the stem level, because there was no motivation for the language learner to infer allomorphy of alternating affixes, where the learner could continue to derive paradigmatic variation of word-level syncope synchronically from one uniform unsyncopated input morph.

4.1.2   Comparing ja-stems to i-stems

The explanations of front umlaut, as they are presented above in terms of a single early development from allophony to phonemicisation, account for quite a number of the most recalcitrant problems. Yet, as is shown next, the well-known problem of explaining why ja-stems and i-stems came out with different umlaut status calls for some further chronological assumptions. The problem is severe, given some poorly motivated initial assumptions upheld in a longstanding Nordic research tradition, which maintains that long before syncope took out the stem vowel *-i in Proto-Nordic i-stems like *sali- 'hall' (> ON unmlauted salr), it should have taken out the stem vowel *-a in ja-stems like *harja- (> ON umlauted herr 'crowd, host'). This chronology would make it difficult to avoid a conclusion that both stem types coalesced in crucial case forms and resulted in equivalent stems, whether *CaCi- or *CæCi-. Nonetheless, the reasoning encounters a paradox between the basic assumptions and the data. The Old Nordic data testifies to differing umlaut outcomes in ja-stems and light i-stems respectively, and of course the attested contrast could not have been restored once it allegedly was lost after such a coalescence of stems. Therefore, an assumption of coalescence must be avoided at all cost (Liberman 2001:86f., Schalin 2017a:56–57).

   The solution is to reject the traditional chronology, which has long since lost its foothold in historical phonology (Kiparsky 2009:41–45). In fact, nothing prevented the -i- in nom. *saliz from being deleted early, no later than the -a- in *harjaz. The traditional sequencing is not supported by any runic attestations (Kiparsky 2009:19–26). Note that **sitiR** (an ancestor of ON sitr 'sits') in the late ninth-century runic carving from Rök, which is often cited as evidence for much later syncope in light i-stems, does not have a word structure equivalent to i-stems. Instead, the structure is the same as that of ON svęrr < PN [SLswarį̣]+[SLį̣z], which may be contrasted with the i-stem [SLstaðį̣]+[SLz]. In [WLswarį̣į̣z] the underlying *į̣/i was common to all forms of the paradigm and would have surfaced (or resurfaced) once the syncopated inflectional ending

restructured into [_SL_z]. Thus, **sitiR** and **swæriR* '(s)he swears' are not "pre-syncope forms" but forms that have passed the first syncope. East Nordic corroborates this analysis because it contrasts unumlauted strong verbs, which contain a trigger only in the inflectional ending, as in OSw *far* '(s)he goes, travels' (<**far̯z*), with verbs that had a trigger also stem-finally as *svær* 'swears' < **swar̯+ız* (cf. infinitive *swæria*). The latter may, just like the ja-stems, have taken a later front umlaut, after the levelling of OSw strong verbs. In all, the form **sitiR** is thus equally syncopated as the runic names in **Hari-** (<*Harja-) and **Kuni-** (<*Kunja-). There are no examples of light i-stems in runic inscriptions from the probative intermediate period.

Equally importantly, in the i-stems the acquisition of the stem vowel relied heavily on the nominative case, so deletion in it may have been enough to motivate a reanalysis of the stem to [_SL_sal], thus making the umlaut dependent on inflectional endings, which in that stem type had palatal triggers only in scarce case forms. Conversely in the ja-stems, the first wave of syncope did not transform a previous stem **har̯a-* into ***har-*, but the result at this stage is a new stem [_SL_har̯] and a new nominative [_WL_har̯z]. The perseverance of *-i-* as a stem formant is supported by all case forms with heavy or nasalised endings, such as the accusative **har̯ą*, the dative **har̯ē* and the plurals: nom. **har̯ōz*, acc. **har̯ąn,* dat. **har̯umz* and gen. **har̯ō̃*. This consistent retention of the stem vocoid would have endured until a later front umlaut was activated by a later contrast shift in the CFH (see Section 4.2).[22] This shift made all unsyncopated triggers derived from inert {i} activated for fronting.

4.1.3 Class 1 weak verbs of light-stems (j-stem verbs)

In the light-stem class 1 weak verbs, it is quite clear where the stem ended and suffixation started. As demonstrated above by both late syncope and by East Norse umlaut in *svær*, the indicative presents of **tal̯an* 'to count, tell' maintained the stem structure [_SL_tal̯]+[_SL_ız] until the ending had shortened into [_SL_tæl̯]+[_SL_z].[23] Therefore all inflexions had the stem [_SL_tal̯] in common and the preterites had a composed suffixed stem [_SL_tal̯]+[_SL_ð] ~> [_SL_talið], to which endings were added. By the time the stem vowel {i} would become umlauting, it was already deleted in the preterites by a word-level constraint. The position was prone to deletion since all preterite endings were bimoraic: [_SL_talið]+[_SL_VV] ~> [_WL_talðVV]. Whether the syncope was further restructured or not makes no difference for this absence of umlaut even if the underlying stem-internal trigger was qualitatively activated by a contrast shift (see Table 6).

A particular set of class 1 weak verbs can serve as an acid test to verify the existence of the constraint against [±round] stem-final moraic segments. Since this constraint is something of a silver bullet for the explanations here of syncope and umlauts, the example deserves a presentation. This set of weak verbs showed the structure of *tau̯an* with the attested form **tau̯ðō** 'I did'. One of those that are attested in Old Norse is *háða* < **hau̯iðō* 'I implemented'. A canonical riddle without a good answer is why medial i-syncope rendered *háða* rather than the expected **hauða (or, alternatively, **haiða if w-deletion had preceded the i-syncope). Not only does the disappearance of the two vowels, one of them syllabic, the other not, seems to be strangely simultaneous, but also it seems to happen despite the cost of having to be compensated by lengthening. The solution may be modelled by an interaction of constraints, on the condition that after stem-level i-syncope the most obvious candidate *[_SL_hau] may be ruled out by the constraint against [±round] stem-final moraic segments. This is shown in Table 8.

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[22] The basic idea that j-umlaut, albeit more consistently reflected across all dialects of Nordic, may be later than early vocalic i-umlaut is not new. In fact, it can be traced back to the 19th-century neogrammarians, whose theoretically obsolete umlaut hypotheses continue to form an implicit frame of reference to this day (Rischel 2008:199f, Schalin 2017a:14f; 2018:74f with references). Note that Voyles (1982), similarly to the present analysis, combined this chronology with differing umlaut effects resulting from outcomes of Sievers's Law. In other respects, the present analysis differs from his.

[23] The necessity to assume a sequence *-i̯- is also evident by comparing [_SL_mau̯]+[_SL_ıla] ~> [_SL_mau̯ıla]+[_SL_ōn] > ON *meyla* versus [_SL_fau̯a]+[_SL_ıþʊ] ~> [_WL_fau̯ıþʊ] > ON *fæð*. Stem level **[_SL_mau̯ıla]+[_SL_ōn] should have rendered **mæla.

Table 8. Stem-level constraint hierarchy manipulating light i-stems upon stem-level syncope.

	No [±round] *stem-final μ:ic segments*	*No hiatus*	*No epenthesis*	*No deletion*	*No monomoraic stems*	*No feature substitution*
Input: **hau**	*[μ, [rnd]]#	ONSET	DEP	MAX-IO	PwdMin	IDENT-(stem-final [F])
hau	!*					
hau̯					*	
ha.ʊ		*				*
haau̯			*			
hau̯u			*			
ha				*	*	
☞ haa						*

The constraint matrix may in much the same way be tested on the root noun for 'cow' *kū*, which has a vowel specified for [+round] in its syllable nucleus. Differently from the case in Table 8, there are no viable stem-final feature substitutions for an input 'kuu' without further manipulations like *kʊʊ or a CCV-stem *ku̯ʊ. Therefore, a monomoraic [SL kuu̯] or [SL kʊu̯], equivalent to hau̯ in the second row, would be the most probable winning candidate. This prediction conforms with the fact that ON *kú-* in poetry may be parsed as a short syllable.

4.1.4 *Further consequences of the first word-level syncope, including for the vowel inventory*

The developments described in the beginning of this subsection had consequences for the continuation of the umlaut process, in particular through how it enhanced the vowel inventory and the corollaries that the new [±coronal] contrasts had for the contrastive specifications of pre-existing unumlauted vowels. In Figure 7 the focus is again on the short oral vowels. Here a new CFH is shown; in relation to Figure 4 this is enriched with the M-phonemes {æ} and {y}. The hierarchy further demonstrates that the two vowels which were immediately contrasted against these two, namely {ɑ} and {u}, must have acquired a new [–coronal] specification. As a result of that, they joined {ʊ} in a class of trigger vowels for breaking, and this happened in time before a-syncope was extended to heavy disyllabic stems (after the constraint *μμμ is demoted). Again, this chronology conforms with the fact that {ɑ} is attested to have caused breaking only in heavy stems, where deletion had been delayed compared to light stems (Schalin 2017b:210, with references).

At this point, {i} was the only short oral vowel not specified for [±coronal]. Indeed {i} had been subject to the influence of the same deleted fronting triggers as {u} and should have had the same reason to split up in [±coronal] descendant phonemes. In the hypothetically umlauted [+coronal] {i} the change would have been covert, but in the hypothetically unumlauted [–coronal] **{ɯ} or **{ɨ} the change would have been salient. The suggestion here is that these types of counterintuitive changes did not happen. A phoneme split was motivated by an addition (or switch) of a feature that made the allophone saliently different from the unaltered phoneme, as the former was manifested beforehand with its actual feature enhancements. Thus, because [–open, –round] {i} with an addition of [+coronal] by feature spreading was perceived as the same as [–open, –round] with a {+coronal} non-contrastive feature enhancement, no [–coronal] opposite could be inferred from that opposition and therefore no phoneme split could happen.

For the first time, [round] and [coronal] were mutually ranked within the same CFH, as shown in Figure 7. The suggestion is that [round] took scope over [coronal] to reflect the actual dichotomy between the phoneme split of /u/ and the continued underspecification of /i/ regarding [coronal].[24]

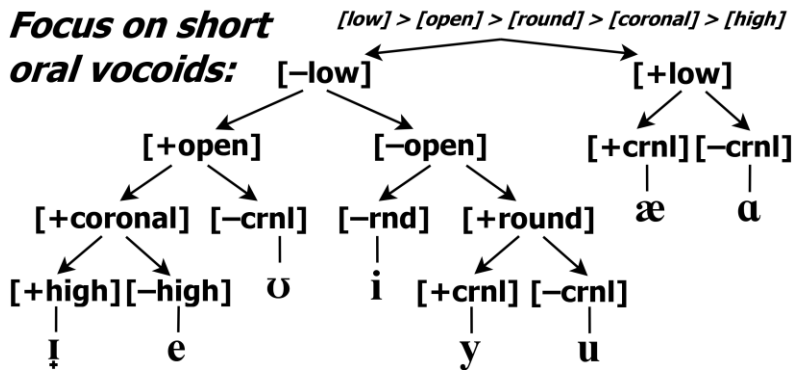**Focus on short oral vocoids:** [low] > [open] > [round] > [coronal] > [high]

Figure 7. Contrastive feature hierarchy for a first intermediate umlaut period.

This was still the only subhierarchy where one colouring feature took scope over the other, but the issue of mutual ranking was emerging: once front umlaut in heavy stems took effect, the same would happen to the subhierarchy for long vowels and once rounding umlaut on {ɪ} and {e} took effect, the two features would have to be able to co-occur in the subhierarchy to which these vowels belong.

4.2   Stem-level a/i-syncope and ensuing phonological chain reactions

The developments that followed the first wave of word-level syncope and ensuing umlaut were driven by a chain reaction advancing like a falling row of dominoes: syncope penetrating from word level to stem level affected the specification of triggers and ensuing umlauts led to a reorganisation and enrichment of vocalic contrast in the inventory, which again respecified triggers and enabled them to spread new features.

4.2.1   The progression of a-syncope to the stem level of affixes

We need to assume that a- and i-syncope next entered the stem level in cases where it was already fully accomplished at the word level, which occurred at least in the trisyllabic structures exemplified in examples (4c) and (5). The stem-level syncope became inevitable once all reflexes of the stem vowel were lost at the word level. The last frontier must have been the accusative singular, where the nasalised stem vowel endured a bit longer than the oral equivalents in the nominative and genitive (see note 21). Unlike in bisyllabic stems, these deletions (in third syllables) were not blocked in heavy stems either, so full deletion was now inferable for the stem itself. In this way a new stem type would have emerged with inflectional endings attached directly to a thematic bisyllabic consonant stem. This happened a little earlier than the thorough reshuffles discussed in 4.2.2, still during a phase while the word-medial triggers originating from PreGm *i were in heavy stems blocked from being deleted at the word level by constraints like *μμμ. This means that, e.g., *gur.þi.laz* 'girdle' became *gyr.þɪlz* (ignoring at this point possible 'r-breaking', rendering *gʲur.þɪlz*) since **gurþ.laz* (or **gurþ.lōz*) would have violated *μμμ, while moving the syllable border to **gur.þlaz* or **gur.þlōz* would have violated constraints against complex onsets.

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[24] This feature ranking may also be inferred from predicting the results that an opposite ranking would have had. As explained in Sections 4.2.2 and 4.2.3, an instant chain reaction would have been set off causing early deletion of inert triggers in heavy stems with bisyllabic suffixes. This in turn would have left these words unumlauted, which is falsified by their actual umlauts, as exemplified by nom. pl. *gur.þi.lōz* > *gyrþ.lōz* > *gyrðlar* 'girdles' and *bar.ni.skõz* > *bœrn.skõz* > *bernskar* 'childish (fem. pl)'.

The stem-level syncope in trisyllabic stems would have taken out the final syllables in the suffixes and enacted the constraint banning the assignment of [±round] to segments in monosyllabic affixes. For example, the suffix [$_{SL}$ila] would have been chopped into [$_{SL}$ɪl], since owing to the loss of its thematic vowel, it would have become a monosyllabic suffix, and on that account have become subject to the aforementioned constraint (cf. discussion on comparative [$_{SL}$ɪz] in Table 2). The resulting enforced change of the vowel would have been instant. Equally instantly, a front umlaut would have been enforced at the word level by the constraint AGREE(+CORONAL), which by its high ranking strongly penalised back target vowels before front-vocalic triggers. Umlaut would have ensued in the heavy-stem plurals because the suffixes changed there too, namely from before a-syncope [$_{SL}$gurþa]+[$_{SL}$ila] ~> [$_{SL}$gurþila]+[$_{SL}$ōz] ~> [$_{WL}$gurþilōz] into > (after a-syncope) [$_{SL}$gurþa]+[$_{SL}$ɪl] ~> [$_{SL}$gurþɪl]+[$_{SL}$ōz] ~> [$_{WL}$gyrþɪlōz]. As expected of a word-level constraint, umlaut was not part of stem-to-stem cycles, which is seen from the light-stem plurals [$_{SL}$luka]+[$_{SL}$ɪl] ~> [$_{SL}$lukɪl]+[$_{SL}$ōz] ~> [$_{WL}$luklōz].

(5) *Trisyllabic masculine a-stems; syncope and trigger substitution in suffixes and ensuing umlaut*
      a. Heavy stems in *-ila- > *- ɪl-
         m. nom. sg. *gur.þi.laz > gyr.þɪlz*, nom. pl. *gur.þi.lōz > gyr.þɪ.lōz*
         'girdle', 'girdles'
      b. Light stems in *-ila- > *- ɪl-
         m. nom. sg. *lu.ki.laz > ly.kɪlz*, gen. *lu.ki.las > ly.kɪls*, nom. pl. *lu.ki.lōz > luk.lōz*
         'key', 'key's', 'keys'
      c. Heavy stems in *-iska- > *- ɪsk-
         m. nom. sg. *bar.nis.kaz > bær.nɪ(skz)*, nom. pl. *bar.ni.skōz > bær.nɪ.skō(z)*
         'childish (sg.)', 'childish (pl.)'
      d. Light stems in *-iska- > *- ɪsk- and *-ista- > *- ɪst-
         m. nom. sg. *da.nis.kaz > dan(skz)*, *ba.tis.taz > bat(stz)*, nom. pl. *da.ni.skēz > dan.skē(z)*
         'Danish (sg.)', 'best (sg.)', 'Danish (pl.)'.

The suffix *-iska-* (as in *dan-iska-z* 'Danish' and *barn-iska-z* 'childish') and superlative *-ista-* were chopped almost in the same way and with similar consequences. The difference was that light-stem nominatives and genitives lost also their medial vowel /i/ at the word level at the latest when they lost their thematic vowel at the stem level, so these forms were not umlauted, as evidenced by *dan(skz)* and *bat(stz)* in example (5d). The early medial syncope requires that the cluster consisting exclusively of obstruents could be extrametrical (marked by parentheses) this early, because the umlauted heavy stems in examples (5a) and (5c) are clear evidence that *μμμ would not have allowed a violation. Accordingly, [$_{WL}$danskz] was after syncope composed of [$_{SL}$[$_{SL}$dan]+[$_{SL}$ɪsk]]+[$_{SL}$z], but the potential fronting trigger {ɪ} was deleted in the output and could not enforce umlaut by means of the relevant markedness constraint.

This second phase of i-umlaut was clearly feature switching in character since all targeted vowels had become specified for a backing tongue thrust feature as a result of the previous feature-filling phase (cf. 4.1) but would still be fronted in this second phase. The new mechanism may be explained by the wide scope of the previous feature-filling front umlaut, which was due to the status of vocalism in Proto-Norse before that, where the only [–coronal] vowel in potential target position was {ʊ} and due to its origins as a lowering product, it had very seldom occurred in the lexicon before a coronal trigger. These distributional conditions had permitted the promotion of a markedness constraint such as AGREE(+CORONAL). The very high rank of this constraint would have initiated a feature-switching mechanism (similar to the feature switching presented for umlaut in Kiparsky 2009:30–39).

4.2.2 *The phonemicisation of early rounding umlaut and the initiation of j-umlaut*

In this subsection the presentation starts by demonstrating the most critical requirement for any feature-based explanation of the next stage of front umlaut: a Contrast Shift. A possible new CFH is presented, which is able to account for the activation of [–open, –round] triggers {i}/{ị} that up till then were inert for

fronting, in other words an i-umlaut by unsyncopated triggers, which encompassed the j-umlaut. This happened during an intermediate period, after the early umlaut era described in Section 2 and 4.1 and before the Old Nordic era, when the productivity of the front umlaut was extinguished. Only after this demonstration is an explanation offered in the discussion of example (6) for the plausible cause of this Contrast Shift. Moreover, this explanation accounts for the phonemicisation of the first rounding umlaut.

Figure 8 demonstrates the two main alternatives for the overall architecture of colouring features in languages that lack back-unrounded vowels like {ɯ} or {ɤ} but have front-rounded vowels like {y} or {ø}: either a tongue thrust feature takes scope over a lip thrust feature or vice versa. The right-hand alternative illustrates the ranking type that emerged from the first front umlaut in Figure 7. Recall that a third alternative, elaborated upon in 2.1.1 and illustrated in Figure 4, entails that none of the features takes scope over the other but the features are both in parallel subordinated to another type of feature, such as a sonority feature. The difference of such organisation, shown in Figure 4, from the alternatives in Figure 8 is that only those in the latter figure may generate M-phonemic front-rounded vowels like {y} or {ø}.
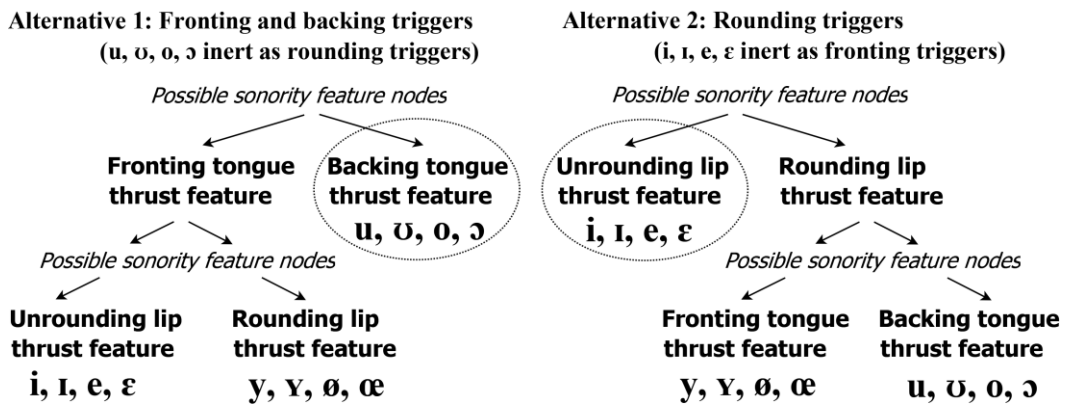

Figure 8. Main alternatives for underspecification of fronting and rounding features with no {ɯ} or {ɤ}.

Notwithstanding the fact that [round] took scope over [coronal] in the stage illustrated in Figure 7, it is suggested that soon after, at the time of a new j-umlaut, the ordering of [round] and [coronal] became inverse. It is necessary to assume such a Contrast Shift in order to explain why every occurrence of an undeleted {i}/{i̧} in triggering position became active for j-umlaut as part of a younger i-umlaut. This is because with no back-unrounded vowels in the inventory, the vowel {i} could not otherwise be assigned a tongue thrust feature without becoming illicitly overspecified (see Figure 8), and without a contrastive tongue thrust feature the trigger vowel may not be assumed to participate in the spreading of such a feature. Figure 8 also reveals that such a Contrast Shift does not necessarily entail phonematically overt restructurings in the vowel inventory, but only a regrouping of the class membership of phonemes.
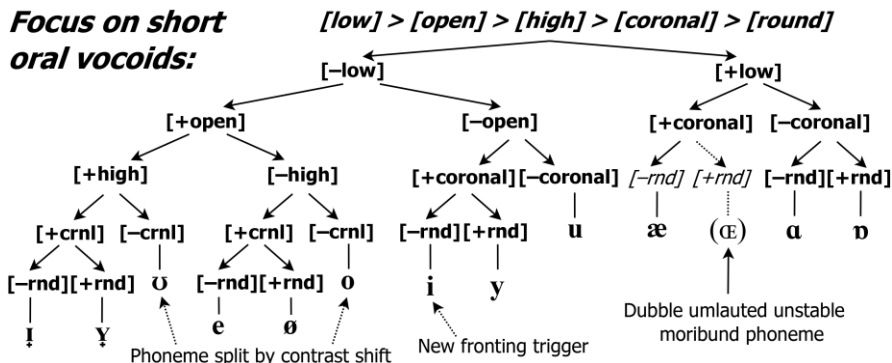

Figure 9. Contrastive feature hierarchy for a second intermediate umlaut period (i/j-umlaut).

In Figure 9, a possible vowel system of short oral vocoids is illustrated for this i/j-umlaut era. The figure shows how {i} in this reranking, as opposed to the one in Figure 7, assumes the [+coronal] specification of an active fronting trigger. At this point, the CFH includes vowels arisen out of a very recent feature-filling rounding umlaut, which split {ɑ} into {ɑ}/{ɒ}, {æ} into {æ}/{œ}, {e} into {e}/{ø}, and {ɪ} into {ɪ}/{ʏ} and was part of the chain reaction which brought about the reranking of [round] and [coronal].

A few more remarks on Figure 9: The double-umlauted vowel *{œ} as in ON *øx* 'axe' < **akwɪsiʊ-* was not stable and all its descendants soon merged either with those of {æ} or with those of {ø}. Except for the new u-umlauted vowels and disregarding the covert reranking, the rest of the inventory appears near-identical to that of Figure 7. An exception is the vowel {o}, which represents a split-off phoneme from a lower allophone of {ʊ}. This latter phoneme split would have been an instance of phonemicisation of distinctive allophones by Contrast Shift. Such phonemicisation is theoretically substantiated by Dresher (2018:§3.5) when arguing for his hypothesis of Old English front umlaut. The idea is that a salient non-contrastive feature, which may be contrastive for some other subhierarchy already, takes contrastive scope over another subhierarchy by promotion to a rank above a pre-existing contrastive feature. Here the promotion of [±high] over the negative value of [coronal] compels {ʊ} and its lower distinctive allophone /o/ to adopt either value of [±high]. East Nordic and West Norse outcomes differed, so that in the east fewer words assumed contrastivity for [–high] and {o} was phonemicised mainly before tautosyllabic -r- only, as in OSw *horn* 'horn' and *borgh* 'fortification'. The rather sporadic nature of where (in terms of geography and vocabulary) the lowering umlaut was fossilised presumably may depend on this particular phonemicisation mechanism.

Just like the secondary front umlaut in Section 4.2.1, the new i/j-umlaut was again feature switching since all targeted vowels had become specified for a backing tongue thrust feature already. The driving force that activated the trigger was again a compulsion caused by the undominated markedness constraint that banned [±round] moraic stem-final segments, this time a compulsion to avoid a [+round] stem final -u#. Since morphology prevented a substitution with {ʊ}, the conflict was resolved by a contrast shift that replaced the illicit specification with [–coronal]. As shown in Figure 9, a corollary was that the specification of {i} was supplemented with [+coronal]. The series of events that triggered this are elaborated upon next.

The existence of a first rounding umlaut this early may be evidenced by the case of East Nordic (Schalin 2020) and the case of Finnic loan words (Schalin 2017b:§4.1.2.2 & 4.2.4). Given the late date of u-syncope, the early date of phonemicisation is remarkable and must have been caused by some other 'trigger reduction' instead. The conducive conditions for trigger reduction of pivotal significance for rounding umlaut were present at least in heavy masculine wa-stems and wi-stems.

(6) *Origin of {ʏ} by rounding umlaut on /ɪ/*
    a. ON *tryggr* 'true, secure': M-phonème {ɪ} ~> L-phoneme /ʏ/ > trigger change > M-phoneme {ʏ}
       [sʟtrɪg.gu̯ɪ]+[sʟz] ~> [wʟtrʏg.guz] > stem-level syncope & SAMPRASĀRAṆA > [sʟtrʏg.gU]

    b. ON *lyngs* 'heather's': M-phoneme {ɪ} ~> L-phoneme /ʏ/ > trigger change > M-phoneme {ʏ}
       [sʟlɪn.gu̯a]+[sʟs] ~> [wʟlʏn.gus] > stem-level syncope & SAMPRASĀRAṆA > [sʟlʏn.gU]

The development presented in example (6) entails deletion of the stem vowels -a and -i, not only in word-level phonology as before, but also in stem-level phonology. Deletion at the word level would not have caused umlaut by qualitative trigger reduction since the [+round] trigger {u}, which was illicit stem-finally, was perfectly allowed in this position in the word. In this respect [wʟlʏn.gus] (n. gen.) is equivalent to [wʟha.ris] <~ [sʟhar.ɪa]+[sʟs] (m. gen.). Events however led to stem-level deletion, which is plausible owing to problems of acquisition: in case forms where the oral stem vowel had manifested itself overtly, it was already lost at the word level and at most the nasalised vowels (i.e., n. nom./acc. [wʟlʏn.gu̯ą]) was left but was also deleted after some delay (see note 21). Also, from the perspective of syllable structure there was no impediment for deletion of the stem vowel, even if the constraint *μμμ was still in place.

Thus, just as well as [sʟhar.ɪa]+[sʟz] was disposed to become [sʟharɪ]+[sʟz] this early, also [sʟtrɪg.gu̯i]+[sʟz] would have become [sʟtrʏg.gU]+[sʟz], except for one complication that justifies the ambiguous

marking of the stem vowel with a capital U in example (6). Owing to syllable structure it would have been vocalised, and of course being [+round] it could not have taken up the position as a stem-final vowel without violating the constraint against [±round] stem-final moraic segments. It definitely could not have been substituted by {ʊ} either, along the mechanism for u-stems exemplified in (3d), because this [+open] vowel could not participate in glide formation, which was necessary to generate well-formed words in all case forms except nominative, genitive and accusative singular.

The proposal made here is that this conflict of constraints was resolved by a contrast shift in the CFH, namely by inverting the order of [round] and [coronal] in a way which turns the ranking in Figure 7 into the one in Figure 9. In the latter hierarchy, the more constricted [–open] vowel {u} lost its specification for [±round] but not its ability to participate in glide formation, which made it apt as an input segment to generate well-formed case forms similar to those above in the descendants of the heavy wa- and wi-stems. The loss of the [+round] feature in the trigger meant that the same L-phonemic rounding feature in the target could no longer rely on feature spreading, which was why trigger reduction was followed by restructuring of [+round] into the UR of the target. As a corollary of the Contrast Shift, the vowel {i}, which hitherto had been inert as a trigger for front umlaut, assumed the specification [+coronal] and initiated the feature-switching i/j-umlaut. Note that while this contrast shift did enact instant umlaut when [$_{SL}$harịa]+ [$_{SL}$z] ~> [$_{WL}$harịz] via a virtual stage [$_{SL}$harị]+[$_{SL}$z] ~> [$_{WL}$harịz] turned into [$_{SL}$harị]+[$_{SL}$z] ~> [$_{WL}$hærịz], it did not incur a violation of the constraint against stem-final [±round] moraic segments in this item, because the trigger continued in these ja-stems to be a glide at the stem level, and glides did not violate the constraint.

4.2.3 The demise of *μμμ and a next round of a/i-syncope

Analysis along these lines entails other instant chain reactions, which compresses the developments during the umlaut period to very few generations of language learners. This is exactly the scenario that descriptive diachronic research has been proposing: the transitional period from Proto-Nordic to Old Norse is congested with sound changes, despite being short, a couple of centuries at most (Schalin 2018:§3.5.5, cf. §1.2 & 2.1). In Section 4.2.1 the argument was that the progression of early a/i-syncope to the stem level caused both the phonemicisation of an early rounding umlaut and a contrast shift, which in turn initiated a feature-switching i/j-umlaut. A further corollary of the early rounding umlaut was the assignment of [–round] features to the unumlauted opposites of the new vowels. A look at Figure 9 shows that by this development, with the exception of {u} and {ʊ}, all the historical stem vowels, namely {ɑ}, {ɪ} and {i}, had become specified for [–round], and therefore could not exist stem-finally unless they were non-syllabic. This was once again due to the undominated constraint banning any [±round] specification for moraic stem-final segments. In face of this fatal conflict, either this constraint had to subside or all syllabification constraints that stood in the way of deleting these illicit stem vowels had to be demoted enough to allow for their deletion. As anyone familiar with the historical phonology of North Germanic would know, events progressed in line with the latter scenario: the syncopation process was taken to a new level at the expense of the ban against trimoraic syllables, and all the stem-final moraic occurrences of {ɑ}, {ɪ} and {i} were eliminated. This explanation also makes sense of the peculiarity that u-syncope seems late by a century at least, while there is no solid evidence to discern a date between a-syncope and i-syncope (Grønvik 1998:19–26).[25] This is at least in part owing to the fact that it had become the only vowel that did not violate the constraint banning any [±round] specification for moraic stem-final segments (see Figure 9).

4.3 Epilogue: Towards the younger rounding umlaut and Old Nordic

It remains outside the scope here to elaborate on the further developments that turned the vowel system generated by the CFH in Figure 9 into the attested vowel systems of the medieval dialects of Old Nordic.

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[25] The pairwise example used for contrasting the dates of a-syncope and i-syncope in Nielsen (2009:7), **-wolAfz** vs. **bAriutiþ**, is not probative for reasons given in note 21. The example cited for later, yet not much later, syncope of -u after heavy syllable **sbA** (< *spahu) stands in an environment of hiatus, which could have brought the date forward (cf. Table 8).

There are more than four further centuries to bridge until the First Grammatical Treatise, which analyses a standardised early 12th century Icelandic vernacular, recorded in an adapted custom-made Latin alphabet. The main phonological issues to cover are the simplification of the use of sonority features, which led to mergers of non-low vowels, and the initiation of the younger rounding umlaut, which requires that a further contrast shift promoting [round] over [coronal] must have happened well before the deletion of the rounding triggers in the eighth and ninth centuries (Schalin 2017b:§6.6; 2020:274–279).

As concerns this younger period, it seems more difficult to state why the contrast shift may have happened. This gives reason to point out that more often than not, research in diachronic change does not want to ask "why" at all and rather stays within the limits of description, which is understandable since language change has proven very unpredictable. Conversely, it is quite natural that endeavours to answer "why" by means of understanding the subsequent synchronic phonologies in full, not to mention the causes for the replacement of one for the other, unsurprisingly leads to an appearance of explanatory complexity. The less profound structures, such as L-phonemes and vowel inventories, would not always have changed that much, so a less theoretical account would have had much less to explain and ostensibly would have appeared more elegant.

5. Concluding remarks

The primary aim of this paper was to probe the potential of applying CHT along with Stratal OT for the pursuit of an acceptable solution to the bicentenary data puzzle of mainland Nordic rounding and front umlauts. This has been accomplished insofar as coherent explanations have been given to the most unsettling canonical data puzzles, such as the difference between heavy i-stems and light i-stems, the difference between light i-stems and other light stems with palatal triggers (iʀ-umlaut) and the difference between light i-stems and ja-stems, along with explanations for a number of suffixes. A remarkably intertwined integration of explanations of rounding and front umlauts has been outlined, even if the comprehensive treatment of rounding data would require a further study. Another area, which is not touched upon here, is the issue of bimoraic or long trigger and target vowels, where a draft section with a possible solution to some difficult problems was omitted to keep the data limited. Likewise, omission of a draft subsection concerns heavy -ija-stems, where the main problem is not really how to explain the umlaut but rather the syncope and the restructured epenthesis of an extra segment. Some minor digressions on umlaut by nasalised trigger vowels were also omitted.

Further exclusions concern breaking, which in North Germanic often, or even most often, is the result of a back-umlauting vocalic trigger. The issues at stake involve for example the distribution of breaking in the vocabulary, the possible effects of tautosyllabic liquids on the target, the chronological interaction with the rounding umlaut and the possibility of an intermediate diphthongisation before full segmentation (Benediktsson 1963:429ff.; 1982:41–55, Schalin 2017b:§4 & §6.5.2). Ultimately an umlaut theory must stand the test of being reconcilable with good explanations in response to all such logically pertinent and chronologically interrelated issues.

In any event, combining CHT and Stratal OT has here made it possible to analyse an unprecedented set of umlaut data by diachronic phonological means and minimised the need for invoking ad hoc auxiliary explanations. The drawback is most obvious. As one referee pointed out, the two theories employed are both considered powerful, and their combined application certainly increases the scope for bending the most recalcitrant data into an analysis, especially as uncertainties of description grant a bit of leeway to try out different sequencing of some developments. The last word has obviously not yet been pronounced on whether these theories could be instrumental for generating more than one clean solution to the problem. While the number of hypothetical CFHs that may be constructed is immense and the restrictions on how to rank and label features are few, it is, however, surprising that the choices that had to be made in reverse-engineering the CFHs were seldom rivalled by alternatives or uninformed by phonological activity.

These considerations must be borne in mind when evaluating the secondary aim of the paper, which was to develop discussion of how representation-based phonological theory that posits emergent segmental

features can be used in historical phonology. Fortuitously, Nordic umlaut provides an abundance of reasonably well fossilised phonological activity, which facilitates the reverse-engineering of historical phoneme inventories. Therefore, it is not clear to what extent the methodology used here may be generalised to other language-specific contexts of diachronic phonology.

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