Contrastive feature hierarchies and Germanic phonology:
Jørgen Rischel's analysis of the Scandinavian runic reform

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Abstract: I discuss an analysis of changes in the Scandinavian runic alphabet, or futhark, by Jørgen Rischel (1966). Rischel's article accounts for some puzzling changes in the futhark by employing contrastive feature hierarchies represented as branching trees. Feature hierarchies can be traced back to the work of Roman Jakobson and his colleagues. They enjoyed a brief period of prominence in the 1950s and 1960s, but then disappeared from mainstream phonological theory. However, they were employed in a number of interesting studies of Germanic and other languages whose insights we can still profit from today. The goal of this paper is to bring attention to this largely forgotten approach to phonological analysis, and to spell out the principles that underlie it.

Keywords: Scandinavian, Germanic, runes, contrast, phonological systems, feature hierarchies, branching trees, futhark.

1 Introduction

Contrastive feature hierarchies were once common in phonological analyses. Dresher (2015, 2016, 2018, 2022) has traced their history in phonological theory in general, and in Germanic phonology in particular. This article reviews a particularly interesting example in this genre, an analysis of changes in the Scandinavian runic alphabet, or *futhark*, by Jørgen Rischel (1934–2007).

In section 2, I briefly review the older Scandinavian system of runes representing vowels, and the changes in the Proto-Scandinavian vowel system that led to this system becoming out of step with the phonological inventory. Sections 3 and 4 review Rischel's analyses of the changes in the runes for vowels and obstruents, respectively. In section 5, I consider Rischel's insightful comments on "branching diagrams" (contrastive feature hierarchies), and the criteria he proposes for ordering features. Section 6 is a brief discussion of the origins and history of branching tree diagrams in phonology, and section 7 presents a theory of contrastive specification that is consistent with Rischel's analysis. Section 8 is a brief conclusion.

2 Scandinavian runes: the "older futhark"

Before 700 CE, the Scandinavian runic alphabet, the "older futhark", had symbols for five vowels, which are assumed to correspond to the five vowel phonemes of Northwest Germanic (Diderichsen 1945; Antonsen 1963; Rischel 1966), as shown in Figure 1. Vowel length was phonemic, so there were in fact ten phonemic vowels, each vowel having a long and short form. However, vowel length (along with some other prosodic features) was not represented in the futhark, and I will not consider it further here.
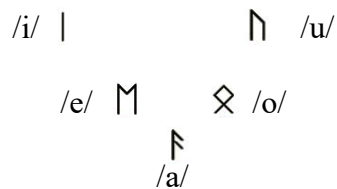
/i/ | ᚾ /u/

/e/ ᛗ   ᛟ /o/

ᚨ

/a/

Figure 1. Northwest Germanic vowel phonemes and runes

Most scholars assume also that, already at an early stage, each vowel phoneme had positional allophones caused by fronting, backing, raising, and lowering. Writers differ as to how many allophones there were; here I mainly follow Antonsen (1963) and Rischel (1966). The significant allophones were as follows:

The phonemes /u/ and /o/ developed front rounded allophones [y] and [ø], respectively, before *j* or *i*; this is the origin of *i*-umlaut.

It is believed that /i/ and /e/ developed back unrounded allophones [ɯ] and [ɤ], respectively, before *u* or *w* (back umlaut). These allophones either did not persist or changed to something else, so I will not consider them further here; but see further Schalin (2017, 2018).

There were morphophonemic alternations between /i/ and /e/ that established a close connection between these vowels. In addition, /i/ developed a lowered allophone before /a/, and /e/ developed a raised allophone when a high vowel followed. As these allophones were mainly transitory, I will not consider them further here.

The phoneme /a/ developed three significant allophones: a fronted allophone before /i/ or /j/ that Rischel represents as [æ] (which may have ranged phonetically as far as [ɛ]); a retracted allophone written [å] before /u/ or /w/, which may have been phonetically [ɑ], [ɒ], or [ɔ]; and central [a] in neutral contexts. There may also have been a raised [ɐ] or [ə], but I will not consider it here.

As a result of losses and mergers in the unstressed vowels, some of these allophones eventually became separate phonemes in Proto-Scandinavian, as shown in Figure 2. Thus, the number of vowel phonemes increased from five to nine.
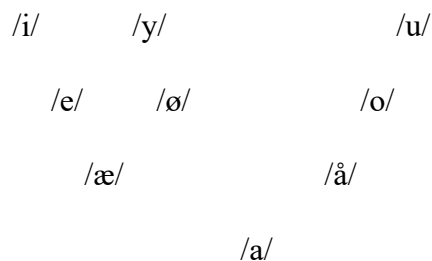
/i/   /y/   /u/

/e/   /ø/   /o/

/æ/   /å/

/a/

Figure 2. Proto-Scandinavian vowel phonemes

3   The Scandinavian runic reform: vowels

Recall that the older futhark had five vowel runes. The futhark could perhaps have added four new vowel runes to keep up with phonological changes, but this did not happen. Instead, somewhat counterintuitively, the number of vowel runes were *reduced* from five

to three! The old runes for /e/ and /o/ were discontinued (and, due to sound changes, the old rune for /a/ was restricted to nasalized *a* and was replaced by the old rune for /j/). Assuming that there were reasons why it would not have been practical to invent four new vowel runes, why were the original five not retained?

Rischel (2009 [1966]: 256) suggests that there may have been an orthographic reason for dropping the runes for /e/ and /o/. He observes that the younger futhark "avoids characters which do not have one full-size vertical line". The characters for /i/, /u/, and /a/ all have one full-size vertical line, but the runes for /e/ and /o/ do not (the /e/ rune has two full-size vertical lines, and the /o/ rune has none).

However, Rischel (2009 [1966]: 262) argues that the more important reasons are phonological: "If the nine vowel phonemes were to be distributed on five runes in such a way that these were still used with roughly the same sound values as before, one would be forced to group the vowel phonemes in a way that would violate the pattern of the language." Rischel imagines what such a system might have looked like, if the existing runes were reassigned based on phonetic closeness. The *i* rune could stand for /i/; the *u* rune could be assigned to /u/ and /y/; the *e* rune could represent /e/ and /æ/; the *o* rune could stand for /o/, /ø/, and /å/; and the *a* rune would continue to designate /a/.

Rischel argues that these groupings "would entail a vehement break with spelling tradition and would be absurd from a morphophonemic point of view." Specifically, the phonemes /a/, /æ/, /å/ are closely related by alternation and etymology, but these would be divided among three different runes; /i/ and /e/ are related by alternations, but these would belong to different runes; and finally, unstressed vowels are reduced to three: /i/ from /i/ and /e/; /u/ from /u/ and /o/; and /a/. We arrive, then, at three logical groupings for both the stressed and unstressed vowels: /i, e/; /u, y, o, ø/; and /a, æ, å/. Each group is represented by a single rune, as shown in Figure 3.
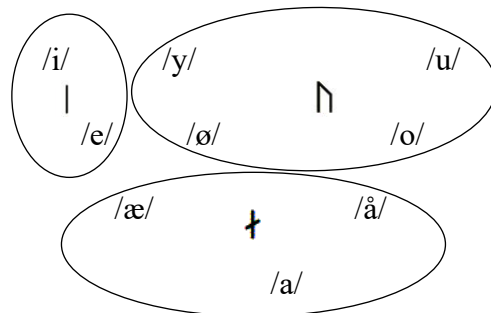

Figure 3. Proto-Scandinavian vowel phonemes and runes

Rischel next considers how these groups can be characterized phonologically. Building on proposals by Diderichsen (1945) and Antonsen (1963), Rischel (1966) employs a feature tree to illustrate how the three younger futhark vowel runes map onto the nine vowel phonemes. The key insight is that, in the newer orthography, some vowel features are underspecified; as Antonsen (1963: 201) put it, "only the crassest oppositions" were represented. The tree in Figure 4 is slightly modified from Rischel (2009 [1966]: 265). The first division of the vowel system is into [–low] and [+low] vowels. The [–low] vowels are divided by [±rounded]. These are the only features

represented in the younger futhark: one rune represents the feature combination [–low, –rounded], another represents [–low, +rounded], and a third is [+low].
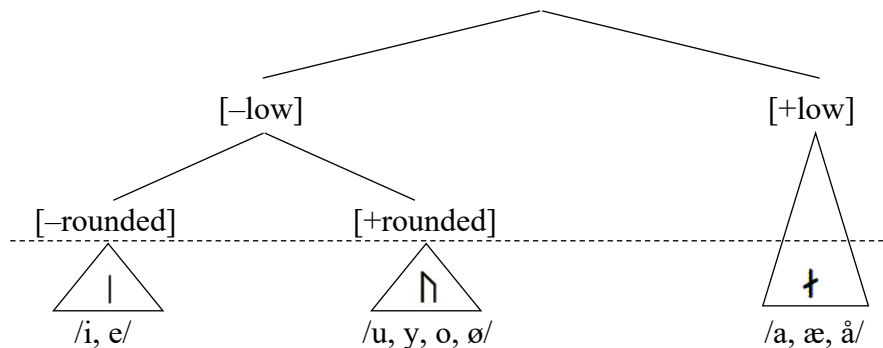

Figure 4. Younger futhark vowel feature hierarchy

Rischel completes the Proto-Scandinavian vowel feature hierarchy as in Figure 5, extending it to features not represented by the younger futhark. The next contrastive feature after [±rounded] is [±close]. There are no further contrasts in the [–rounded] branch, which terminates with [+close] /i/ and [–close] /e/. In the [+low] branch, there is only one vowel that is [–close], namely /a/. The remaining branches of the tree are divided by [±back]. This completes the feature hierarchy for the Proto-Scandinavian vowels; the features are ordered [low] > [rounded] > [close] > [back].
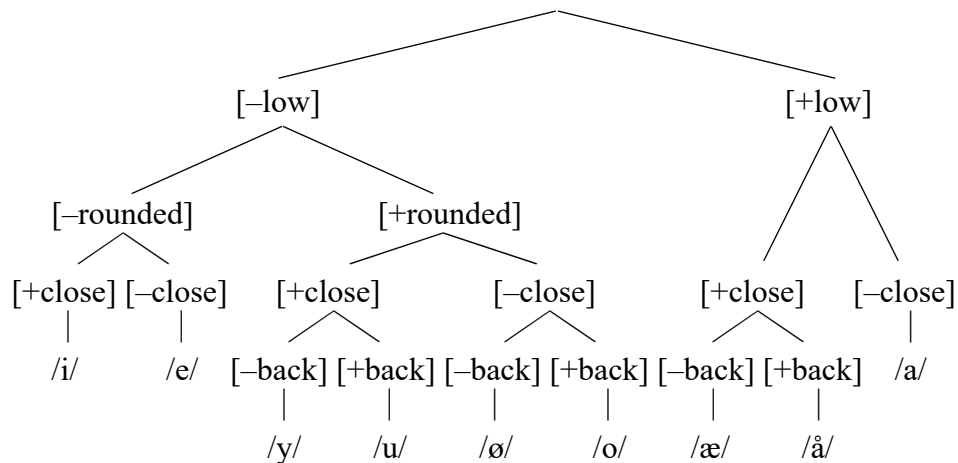

Figure 5. Proto-Scandinavian: all contrastive vowel features

4   The Scandinavian runic reform: obstruents

Rischel (1966) uses another feature hierarchy tree to account for changes in the obstruents of Proto-Scandinavian and their corresponding runes. He writes (2009 [1966]: 266) that in early Proto-Scandinavian there were two important contrasts in the obstruent system: fortis ~ lenis and stop ~ fricative. Fortis consonants, probably voiceless, were in contrast with lenis, probably voiced, consonants; hence fortis [þ] was a member of a

different phoneme from lenis [ð]. Stops, for example [t], were in contrast with fricatives, like [þ]. Rischel proposes that "the fortis-lenis distinction seems to have had the higher rank in early Proto-Scandinavian." The stop-fricative opposition existed only within the fortis obstruents. There was no such contrast in the lenis consonants, which could be realized as stops or fricatives depending on context. Thus, the ordering of the features was major place features > [fortis/lenis] > [stop/fricative], as illustrated in Figure 6. As with the vowels, each obstruent phoneme is represented by a separate rune in the older futhark.
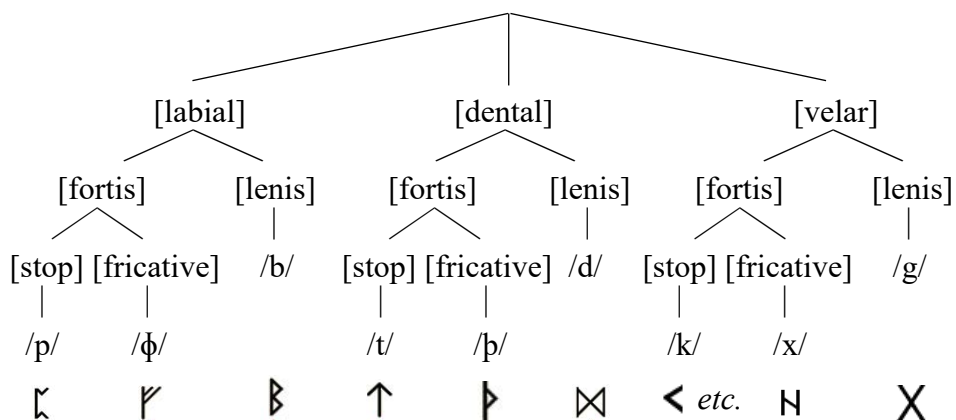

Figure 6. Early Proto-Scandinavian obstruent features

Rischel (1966) shows how a series of changes in the Proto-Scandinavian obstruent system led to a reorganization of the system of contrasts. Fortis and lenis consonants that had been in contrast, such as fortis [þ] and lenis [ð], came to be in complementary distribution and members of a single fricative phoneme, /þ/. At the same time, the stop ~ fricative contrast was extended to the lenis consonants; for example, stop [d] became a separate phoneme from fricative [ð]. The result, according to Rischel, was a contrast shift whereby [fortis/lenis] changed places with [stop/fricative], so that the feature hierarchy was major place features > [stop/fricative] > [fortis/lenis]. Now the stop ~ fricative contrast is the higher one, and the fortis ~ lenis contrast holds only in the [stop] obstruents, as shown in Figure 7.
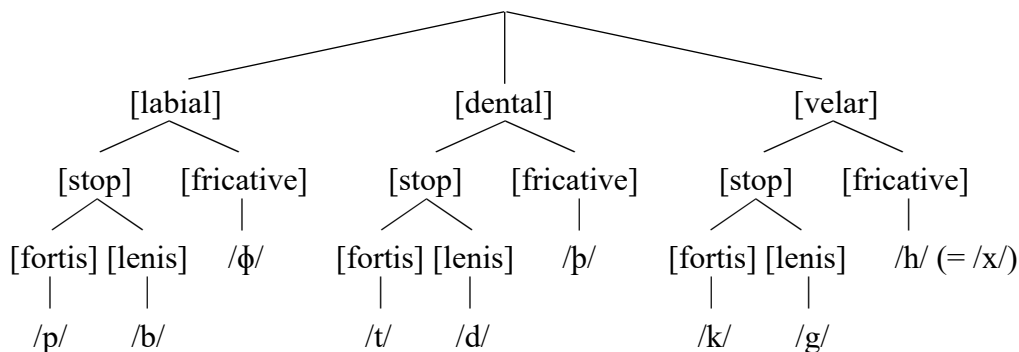

Figure 7. Later Proto-Scandinavian obstruent features

Rischel shows how the younger futhark changed: as with the vowels, the number of runes was *reduced*, in this case from nine to six, although there remain nine phonemic obstruents. Again, Rischel proposes that the younger futhark represents only the higher-ranked place and stop ~ fricative distinctions; it omits the fortis ~ lenis distinctions, as shown in Figure 8.
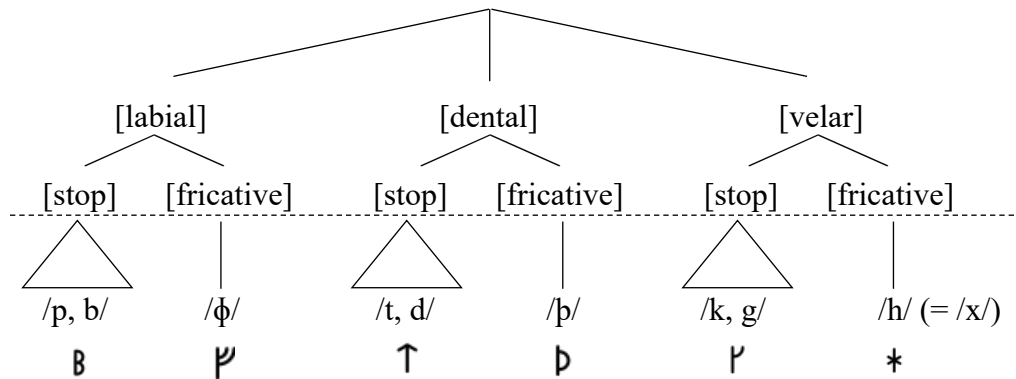

Figure 8. Younger futhark obstruent feature hierarchy

5   Rischel on the "branching diagrams"

Where did Rischel get the idea for representing underspecified features as trees? He writes (2009 [1966]: 263–264),

> Recent analyses of phoneme systems into distinctive features generally appear in the form of branching diagrams, in which the distinctive oppositions among the phonemes … form a hierarchy. The idea of hierarchy implies that some items are considered prior to, or more basic than, others.

If features are put into a hierarchy, we need to have criteria that tell us what the feature hierarchy is for a given inventory. Rischel considers a number of possible criteria, listed in (1).

(1) *Criteria for ordering features (Rischel 2009 [1966]: 264–265)*
    a. Coverage
        A distinction that affects a greater part of the system must be hierarchically superordinate to one that affects a lesser part.
    b. Subsystems
        If a subsystem utilizes only some of the distinctions utilized by the entire system, then, everything else being equal, these distinctions must be the basic ones.

Rischel adds that these criteria may not always be applicable, and may not be the most important ones. He concludes (Rischel 2009 [1966]: 271), "We have as yet no well-

developed theory about rank ordering of distinctive features; all we can do is to consider the problem from various aspects and to weigh the various criteria as best we can."

There is evidence that Rischel had been thinking about this issue for some time. In 2007, Nina Grønnum interviewed him in connection with the collection of his writings that appeared as Rischel (2009). According to the notes on the runic reform article, Rischel stated that he had been interested in feature theory (Danish *trækteori*) since the late 1950s and through the 1960s, and had submitted an article to *Word* about the hierarchization of features in the early 1960s. He goes on (translation slightly rephrased from the Danish):[1]

> When at the time I tried to argue that it was possible to provide a justified hierarchization of the features and not an arbitrary one (as was often done), one not based on which features were major and minor and so on, but based on how they worked in the individual language ... my point of view was that features that function in many different structurally relevant positions – à la Twaddell – are ranked higher than features that only function in a few positions.

In other words, Rischel argued that the ordering of the features in a language should be based on the phonological patterning, or activity, displayed by the language. The article was never published, however, because *Word* wrote back that it was too long, and should either be expanded into a monograph or shortened. Rischel said that he went on to write other things and did not return to this article. As we will see in section 7, Rischel's approach anticipated by some fifty years a central tenet of Contrastive Hierarchy Theory. It is truly unfortunate that his article was never published, because I am not aware of any other attempts in that period to make explicit the principles for ordering features into a hierarchy. It is reasonable to suppose that the lack of discussion of the foundations of the theory contributed to its demise after 1968.

6   Origins and history of the branching trees

Where did the branching feature trees come from? Dresher (2007, 2009, 2015, 2016) has proposed that one can trace their origins to early writings of the Prague School phonologists, Roman Jakobson and N. S. Trubetzkoy, although branching diagrams do not actually appear there. The branching tree is alluded to by Jakobson et al. (1952). They propose that listeners identify phonemes by distinguishing them from every other phoneme in the system. These distinctions are effected by making a series of binary choices that correspond to the oppositions that are linguistically relevant in the language. By "linguistic relevance (expressed in binary terms)" (Jakobson et al. 1952: 11) they

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[1] "Hvor jeg på det tidspunkt forsøgte at argumentere for at man kunne give en begrundet og ikke en vilkårlig — som man tit gjorde — begrundet hierarkisering af trækkene, ikke ud fra hvilke der var major og minor og så videre, men ud fra hvordan de fungerede i det enkelte sprog … da var mit synspunkt det at træk som fungerer i mange forskellige strukturelt relevante positioner — a la Twaddell — er højere rangeret end træk som kun fungerer i få positioner."

mean that not all phonetic properties of a phoneme are equally important to the phonology, but only the contrastive ones. Other notable publications that featured branching trees include Cherry et al. (1953), Jakobson & Halle (1956), and Halle (1959), *The Sound Pattern of Russian*.

The latter has a prominent branching tree diagram that shows the contrastive feature specifications of every Russian phoneme (Halle 1959: 46).[2] This book is also notable in that it contains a novel argument for specifying features by branching trees. Halle proposes that segments are properly distinct only if they meet the Distinctness Condition, given in (2); he argues that phonological features *must* be ordered into a hierarchy, because this is the only way to ensure that segments meet the Distinctness Condition.

(2) *The Distinctness Condition*
Segment-type {A} will be said to be different from segment type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

This approach was imported into early versions of the theory of generative phonology; it is featured prominently in the first generative phonology textbook by Robert T. Harms (1968).

In addition to Rischel's analysis of early Scandinavian, contrastive feature hierarchies were employed by the Icelandic linguist Hreinn Benediktsson (1967) in an article on the Proto-Germanic vowel system. His article appears in the first volume of *To honor Roman Jakobson*, and employs a Jakobsonian approach to distinctive features. He again employed a contrastive feature hierarchy in his account of *The First Grammatical Treatise* (Benediktsson 1972).

Elmer Antonsen, an American linguist and runologist, also used a contrastive feature hierarchy in his 1972 analysis of the Proto-Germanic vowel system. Antonsen (1972) posits the feature hierarchy [low] > [rounded] > [high] for the Proto-Germanic short vowel system (Figure 9), which has four vowel phonemes.[3] It is very similar to Rischel's hierarchy for North Germanic, which is more complex because it covers nine vowels.
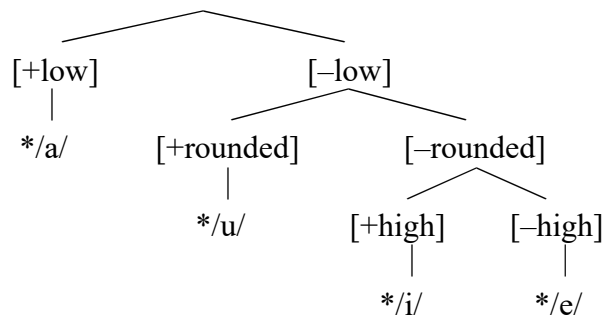
Figure 9. Proto-Germanic feature hierarchy for short vowels (Antonsen 1972)

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[2] For a detailed discussion of Halle's (1959) contrastive hierarchy, see Dresher & Hall (2021).

[3] See Dresher (2018) for discussion of Antonsen's (1972) analysis.

Despite their status as a kind of orthodoxy in the 1960s, after the publication of *The Sound Pattern of English* (Chomsky & Halle 1968) contrastive feature hierarchies virtually disappeared from phonological theory for the rest of the twentieth century, for reasons documented by Dresher (2009, 2015, 2016). Contrastive feature trees made sporadic appearances (Cairns 1988; Boersma 1998) before they were more systematically revived by G. N. Clements (2001, 2009) and, independently, by phonologists at the University of Toronto and colleagues (Dresher et al. 1994; Dyck 1995; Zhang 1996; Dresher 1998, 2009; Hall 2007, 2011; Mackenzie 2011, 2013; Ko 2010, 2011, 2018; Spahr 2014; Oxford 2015; Krekoski 2017; among others).

7   A theory of contrastive specification

The latter have been trying to fill out the theory that underlies analyses such as Rischel's account of the Scandinavian runes. One basic tenet has been formulated by Hall (2007: 20) as the Contrastivist Hypothesis (3).

(3) *The Contrastivist Hypothesis*
The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another.

That is, the Contrastivist Hypothesis posits that only contrastive features can be *phonologically active*, where activity is defined as in (4) (adapted from Clements (2001: 77).

(4) *Phonological activity*
A feature can be said to be active if it plays a role in the phonological computation; that is, if it is required for the expression of phonological regularities in a language, including both static phonotactic patterns and patterns of alternation.

The second major tenet of the theory is that contrastive features are computed *hierarchically by ordered features* that can be expressed as a branching tree. Branching trees are generated by *the Successive Division Algorithm*, given informally in (5) (Dresher 1998, 2003, 2009).

(5) *The Successive Division Algorithm*
Assign contrastive features by successively dividing the inventory until every phoneme has been distinguished.

It follows from the above that the most important criterion for ordering features into a hierarchy is phonological activity: if only contrastive features can be active, then features should be ordered in such a way that the active features are all contrastive.[4] I believe that

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[4]   Thus, minimization of feature specifications is *not* the main motivation for underspecification in this approach, unlike some other underspecification theories discussed by Sullivan (1998); see further Dresher (2015) and Dresher & Hall (2021).

this is the main criterion that Rischel (1966) actually used in determining the feature hierarchies for early and later Scandinavian. Thus, his hierarchies are based on the phonological patterning, that is the activity, exhibited by the language, supplemented by orthographic evidence from the futhark.

8   Conclusion

I will conclude by reiterating Rischel's 2009 [1966]: 271) comment that "We have as yet no well-developed theory about rank-ordering of distinctive features". Though research into contrastive feature hierarchy theory was abandoned shortly after Rischel wrote those words, almost sixty years later we can again hope to make progress on this question. Recent work on Germanic vowel systems along these lines includes papers by Purnell & Raimy (2015), Dresher (2018), and Purnell, Raimy, & Salmons (2019) on West Germanic and Old English, and by Schalin (2017, 2018) and Sandstedt (2018) on Scandinavian.

References

Antonsen, Elmer H. 1963. The Proto-Norse vowel system and the younger fuþark. *Scandinavian Studies* 35(3). 195–207.

Antonsen, Elmer H. 1972. The Proto-Germanic syllabics (vowels). In *Toward a grammar of Proto-Germanic*, ed. by Frans van Coetsem & Herbert L. Kufner, 117–140. Tübingen: Max Niemeyer.

Benediktsson, Hreinn. 1967. The Proto-Germanic vowel system. In *To honor Roman Jakobson*: *Essays on the occasion of his seventieth birthday, 11 October 1966*, Vol. 1, 174–196. The Hague and Paris: Mouton.

Benediktsson, Hreinn (ed.). 1972. *The First Grammatical Treatise*. Reykjavik: University of Iceland, Institute of Nordic Linguistics.

Boersma, Paul. 1998. *Functional phonology: Formalizing the interactions between articulatory and perceptual drives*. The Hague: Holland Academic Graphics.

Cairns, Charles E. 1988. Phonotactics, markedness and lexical representation. *Phonology* 5(2). 209–236.

Cherry, E. Colin, Morris Halle & Roman Jakobson. 1953. Toward the logical description of languages in their phonemic aspect. *Language* 29(1). 34–46.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.

Clements, G. N. 2001. Representational economy in constraint-based phonology. In *Distinctive feature theory,* ed. by T. Alan Hall, 71–146. Berlin: Mouton de Gruyter.

Clements, G. N. 2009. The role of features in phonological inventories. In *Contemporary views on architecture and representations in phonological theory*, ed. by Eric Raimy & Charles Cairns, 19–68. Cambridge, Mass.: MIT Press.

Diderichsen, Paul. 1945. Runer og runeforskning i nordisk belysning. *Nordisk tidskrift för vetenskap, konst och industri* 21. 319–334.

Dresher, B. Elan. 1998. On contrast and redundancy. Presented at the annual meeting of the Canadian Linguistic Association, May 1998, Ottawa. Ms., University of Toronto.

Dresher, B. Elan. 2003. Contrast and asymmetries in inventories. In *Asymmetry in grammar, volume 2: Morphology, phonology, acquisition*, ed. by Anna-Maria di Sciullo, 239–257. Amsterdam: John Benjamins.

Dresher, B. Elan. 2007. Variability in Trubetzkoy's classification of phonological oppositions. *The LACUS Forum* 33. 133–142.

Dresher, B. Elan. 2009. *The contrastive hierarchy in phonology*. Cambridge: Cambridge University Press.

Dresher, B. Elan. 2015. The motivation for contrastive feature hierarchies in phonology. *Linguistic Variation* 15(1). 1–40.

Dresher, B. Elan. 2016. Contrast in phonology 1867–1967: History and development. *Annual Review of Linguistics* 2. 53–73.

Dresher, B. Elan. 2018. Contrastive feature hierarchies in Old English diachronic phonology. *Transactions of the Philological Society* 116(1). 1–29.

Dresher, B. Elan. 2022. Diachronic phonology with Contrastive Hierarchy Theory. Presented at the Twenty-Fifth International Conference on Historical Linguistics, (ICHL 25), University of Oxford, August, 2022.

Dresher, B. Elan and Daniel Currie Hall. 2021. The road not taken: *The Sound Pattern of Russian* and the history of contrast in phonology. *Journal of Linguistics* 57(2). 405–444. doi:10.1017/S0022226720000377

Dresher, B. Elan, Glyne L. Piggott, & Keren Rice. 1994. Contrast in phonology: Overview. *Toronto Working Papers in Linguistics* 13(1). iii-xvii.

Dyck, Carrie. 1995. *Constraining the phonology–phonetics interface, with exemplification from Spanish and Italian dialects.* Doctoral dissertation, University of Toronto.

Hall, Daniel Currie. 2007. *The role and representation of contrast in phonological theory.* Doctoral dissertation, University of Toronto.

Hall, Daniel Currie. 2011. Phonological contrast and its phonetic enhancement: Dispersedness without dispersion. *Phonology* 28(1). 1–54.

Halle, Morris. 1959. *The sound pattern of Russian: A linguistic and acoustical investigation*. The Hague: Mouton. Second printing, 1971.

Harms, Robert T. 1968. *Introduction to phonological theory*. Englewood Cliffs, NJ: Prentice-Hall.

Jakobson, Roman, C. Gunnar M. Fant, & Morris Halle. 1952. *Preliminaries to Speech Analysis.* MIT Acoustics Laboratory, Technical Report, No. 13. Reissued by MIT Press, Cambridge, Mass., Eleventh Printing, 1976.

Jakobson, Roman & Morris Halle. 1956. *Fundamentals of language*. The Hague: Mouton.

Ko, Seongyeon. 2010. A contrastivist view on the evolution of the Korean vowel system. *Proceedings of the Sixth Workshop on Altaic Formal Linguistics (WAFL 6). MIT Working Papers in Linguistics* 61. 181–196.

Ko, Seongyeon. 2011. Vowel contrast and vowel harmony shift in the Mongolic languages. *Proceedings of the Seventh Workshop on Altaic Formal Linguistics (WAFL 7). MIT Working Papers in Linguistics* 62. 187–202.

Ko, Seongyeon. 2018. *Tongue root harmony and vowel contrast in Northeast Asian languages.* Wiesbaden: Harrassowitz Verlag.

Krekoski, Ross. 2017. *Contrast and complexity in Chinese tonal systems.* Doctoral dissertation, University of Toronto.

Mackenzie, Sara. 2011. Contrast and the evaluation of similarity: Evidence from consonant harmony. *Lingua* 121(8). 1401–1423

Mackenzie, Sara. 2013. Laryngeal co-occurrence restrictions in Aymara: Contrastive representations and constraint interaction. *Phonology* 30(2). 297–345.

Oxford, Will. 2015. Patterns of contrast in phonological change: Evidence from Algonquian vowel systems. *Language* 91(2). 308–357.

Purnell, Thomas & Eric Raimy. 2015. Distinctive features, levels of representation and historical phonology. In *The handbook of historical phonology*, ed. by Patrick Honeybone & Joseph Salmons, 522–544. Oxford: Oxford University Press.

Purnell, Thomas C., Eric Raimy, & Joseph Salmons. 2019. Old English vowels: Diachrony, privativity, and phonological representations. *Language* 95(4). e447–e473. https://doi.org/10.1353/lan.2019.0083.

Rischel, Jørgen. 1966. Phoneme, grapheme, and the "importance" of distinctions: Functional aspects of the Scandinavian runic reform. *Interim Report No. 1*, Research Group for Quantitative Linguistics, Stockholm, 1–21. Reprinted in Rischel 2009: 254–271 (cited as Rischel (2009 [1966]).

Rischel, Jørgen. 2009. *Sound structure in language*, edited and with an introduction by Nina Grønnum, Frans Gregersen, & Hans Basbøll. Oxford: Oxford University Press.

Sandstedt, Jade. 2018. *Feature specifications and contrast in vowel harmony: The orthography and phonology of Old Norwegian height harmony.* Doctoral dissertation, University of Edinburgh.

Schalin, Johan. 2017. Scandinavian umlaut and contrastive feature hierarchies. *NOWELE* 70(2). 171–254.

Schalin, Johan. 2018. *Preliterary Scandinavian sound change viewed from the east: Umlaut remodelled And language contact revisited.* Doctoral dissertation, University of Helsinki.

Sullivan, William J. 1998. Underspecification and feature geometry: Theorems of a reticular theory of language. *LACUS Forum* 24. 53–65.

Spahr, Christopher. 2014. A contrastive hierarchical account of positional neutralization. *The Linguistic Review* 31(3–4). 551–585.

Zhang, Xi. 1996. *Vowel systems of the Manchu-Tungus languages of China*. Doctoral dissertation, University of Toronto.