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CONTRASTIVE FEATURE HIERARCHIES IN OLD ENGLISH DIACHRONIC PHONOLOGY[1]

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Abstract

This article looks at the origins and uses of contrastive hierarchies in Old English diachronic phonology, with a focus on the development of West Germanic vowel systems. I begin with a rather enigmatic remark in Richard Hogg's *A grammar of Old English* (1992), and attempt to trace its provenance. We will find that the trail leads back to analyses by some prominent scholars that make use of contrastive feature hierarchies. However, these analyses often appear without context or supporting framework. I will attempt to provide the missing framework and historical context for these analyses, while showing their value for understanding the development of phonological systems. I will show that behind these apparently isolated analyses there is a substantial theoretical edifice that once held a central role in synchronic as well as diachronic phonological theory, and which is still capable of providing insights into the workings of phonology.

1. Introduction

The study of Germanic phonology has a long and illustrious history. Though much of this history is well documented, there is one analytical approach that has not received the prominence that it deserves, given the role it once played in the scholarly literature. I am referring to the use of contrastive feature hierarchies, the idea that phonemes are specified by their contrastive features, and that contrasts are governed by hierarchical language-specific orderings of phonological features. Unlike some phonological ideas that arrive on the scene with great fanfare and are fiercely debated and then either developed further or found to be inadequate, contrastive hierarchies did not make a big impact in the literature. This is somewhat surprising because, as we shall see, for a brief period they attained the status almost of orthodoxy, as the way one ought to treat phonological representations. And when that period was over, they were not rejected for cause, but simply faded away, their explanatory potential left unexplored.

[1] A version of this article was presented at the 6 June 2015 AGM of the Philological Society at Jesus College, Cambridge. I have benefited from comments by members of the audience, as well as from audiences at the University of Toronto, the University of Oxford, and the special session on Issues in the History of Historical Phonology at the Second Edinburgh Symposium on Historical Phonology. I would like to thank Jack Chambers, Radu Craioveanu, Ross Godfrey, Kathleen Currie Hall, Tom Purnell, Eric Raimy, Johan Schalin, and Christopher Spahr for comments on earlier drafts. Finally, I am very grateful to two anonymous reviewers for many insightful remarks and helpful suggestions.

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The aim of this article is to recover this lost approach by looking at the origins and uses of contrastive feature hierarchies in Germanic diachronic phonology, with a focus on the development of Old English vowel systems from West Germanic. I will begin with a rather enigmatic remark in Richard Hogg's *A grammar of Old English* (1992). In tracing its provenance, we will find that the trail leads back to some prominent scholars who made use of contrastive feature hierarchies. However, their analyses appear without context or supporting framework, and the feature hierarchies are often covert. I will attempt to provide the missing framework and historical context for these analyses, while showing their value for understanding the development of phonological systems. I will show that behind these apparently isolated analyses there is a substantial theoretical edifice that once held a central role in diachronic as well as synchronic phonological theory, and which is still capable of providing insights into the workings of phonology.

Following this introduction, section 2 traces the sources and intellectual influences of Hogg's analysis of the West Germanic vowel system (subsection 2.1) back to the work of the Germanicists Elmer Antonsen (subsection 2.2) and Hreinn Benediktsson (subsection 2.3), and through them to W. F. Twaddell for the analysis of the Germanic vowel system (subsection 2.4), and to Roman Jakobson for the general theory of features (subsection 2.5). Less directly, the trail leads all the way back to the work of Henry Sweet at the dawn of modern phonology (subsection 2.6).

In section 3 we go forward in time to show how Sweet's basic insight was elaborated by the Prague School phonologists N. S. Trubetzkoy and Roman Jakobson (subsection 3.1) and their colleagues and students, notably Morris Halle (subsection 3.2). Some reasons for the decline of this approach in phonological theory are given in subsection 3.3. Subsection 3.4 builds on the preceding sections by articulating an explicit formal theory based on these ideas within the general framework of generative grammar. Subsection 3.5 shows how this theory can be applied to the problem of the phonologization of *i*-umlaut in Old English. Section 4 is a brief conclusion.

2. Tracing the provenance of a comment

*2.1. Hogg (1992): the phonemic status of West Germanic */a:/*

In the first volume of *A Grammar of Old English* (1992), Richard Hogg posits some stages in the development of the vowel system from Primitive Germanic to Old English. As his starting point, he adopts a stage, shown in (1a), that represents 'the period when Germanic had become clearly distinct from the other IE languages but before the time of the Germanic accent shift'. Hogg's term 'Primitive Germanic' is thus roughly equivalent to what other writers designate as 'Proto-Germanic'.

(1) Primitive Germanic vowel system: Initial stage (Hogg 1992: 53)

a. Long vowels	b. Diphthongs	c. Short vowels
*/i:/ */u:/		*/i/ */u/
*/e:/ */o:/	*/ei/ */eu/	*/e/
*/æ:/ */ɑ:/	*/ai/ */au/	*/a/

Let us focus first on the long vowels. Readers familiar with reconstructions of Proto-Germanic may be surprised to see both */e:/ and */æ:/ co-occurring at this early stage. Most scholars (Prokosch 1939: 98; Benediktsson 1967: 175; Antonsen 1972: 136; Voyles 1992: 12; Ringe 2006: 7) believe that the Proto-Indo-European precursor to Germanic had five long vowels, */i:, e:, a:, o:, u:/. The vowel that Hogg writes as */æ:/ descends from Indo-European

/e:/ and is known as '$\bar{e}_1$' in the literature, to distinguish it from '*$\bar{e}_2$' (represented in (1) as */e:/), which is believed to have arisen later.[2]

Early in the history of Germanic, */ɑ:/ merged with */o:/, and the diphthong */ei/ monophthongized to /i:/, yielding the long vowel system that Hogg depicts as in (2).[3]

(2) Primitive Germanic long vowel system: Later stage (Hogg 1992: 53)

*/i:/	*/u:/
*/e:/	*/o:/
*/æ:/	

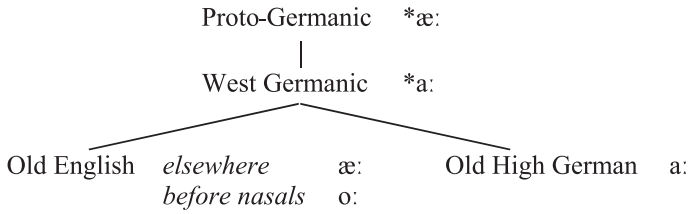
Here is what Hogg (1992: 61) writes about the long vowel system in (2):

> The long vowel system which developed in PrGmc ... was generally well preserved in the Gmc dialects leading to OE. One major exception to this, however, concerns the development of the low long vowel indicated [in (2)] as */æ:/. As will be observed, */æ:/ is the only low long vowel and there is no front/back contrast in operation. From the structural point of view, therefore, the vowel as it develops in WGmc may be considered to be neutral in this last respect, that is, */a:/.

Hogg proposes this analysis as a way of resolving a controversy about the development of the low long vowel into Old English long *æ:* (or *e:* in Anglian dialects). Since the Proto-Germanic vowel corresponding to southern Old English *æ:* is assumed to have also been *æ:, from Indo-European *e: (Prokosch 1939: 99),[4] Wright & Wright (1925) proposed that *æ:* simply persisted into the Old English period. For example, Proto-Germanic *æ: appears in Old English (West Saxon) as *dæ:d* 'deed'; before nasals it retracts to *o:* as in *mo:na* 'moon'.

Against this view is historical and comparative evidence which appears to show that it was a back vowel, *a:, in the West Germanic period that intervened between Proto-Germanic *æ: and Old English *æ:* (Prokosch 1939: 99). For example, the low long vowel in Latin loanwords such as *stra:ta* 'street' was borrowed as Germanic *a:. In other West Germanic languages, this vowel develops as *a:*, as in Old High German *ta:t* 'deed' and *ma:no* 'moon'. The version of events accepted by most other writers (Bülbring 1902; Luick 1914–40; Girvan 1931; Campbell 1947, 1959; see further Hogg 1992: 62) therefore posits, as in (3), that Proto-Germanic *æ: retracted to *a: in West Germanic; this vowel remained in Old High German, but fronted again to *æ:* in Old English when not before a nasal.

(3) Development of Proto-Germanic *æ: (conventional view)



[2] I consider the notations 'ē' and 'e:' to be equivalent ways of denoting long vowels. The former is traditional and still used by many Germanicists, the latter is the current International Phonetic Alphabet (IPA) standard. In this article, I use IPA except when I follow the usage of my sources.

[3] Writers who posit five vowels at the Proto-Germanic stage corresponding to Hogg's initial stage shown in (1) thus posit four vowels following the merger of the low vowel with */o:/: */i:/, */æ:/, */o:/ or */ɔ:/ resulting from the merger, and */u:/. At some later point *$\bar{e}_2$ developed, and we arrive at the stage shown in (2).

[4] The vowel *æ:* appears in the southern West Saxon and Kentish dialects of Old English. In the northern Anglian dialects it is raised to *e:*.

Following in the tradition of structuralist approaches, Hogg (1992: 61–3) proposes to distinguish between the phonetic value and phonemic status of the low vowel at each stage of the language. This approach results in a richer picture of its development. He assumes, as in the traditional account, that */æ:/ was a contrastively front vowel in early Germanic (1a). But at the stage represented by (2), the low vowel was phonemically contrastively neutral with respect to the front/back dimension; therefore, it can be represented as */a:/, whatever its precise phonetic character. Since it is neutral with respect to backness, it could appear to earlier writers as though it were a back vowel in early West Germanic. Hogg suggests that this phoneme may have nevertheless been phonetically front throughout in the dialects that developed into Old English, while being phonetically further back in pre-Old High German.

Hence, the alleged shift of Proto-Germanic *æ: to West Germanic *a: and then back to *æ:* in Old English and Old Frisian emerges as 'an artefact of phonemic theory' (Hogg 1992: 62). A phonemic perspective allows for a simpler sequence of development: the phonetic value of */æ:/ may have remained relatively unchanged from Proto-Germanic to Old English, though its contrastive status changed, as shown in (4).

(4) Phonemic and phonetic development of Proto-Germanic *æ: (Hogg 1992: 61–2)

	a. Phonemic	b. Phonetic
Proto-Germanic	*/æ:/	*[æ:]
West Germanic	*/a:/	*[æ:]
Old English	/æ:/	[æ:]

In terms of distinctive features, Hogg's discussion suggests that the West Germanic low long vowel */a:/ (and its short counterpart */a/ in (1c)) should not be specified as being either [+back] or [–back], because there is no front/back contrast in the low vowels. While this analysis appears to give an insightful solution to the development of the low vowel, it raises some questions that his discussion does not address.

First, how do we know to evaluate the backness of */a:/ only in the low domain, and not with respect to all the vowels, or just the non-round vowels? That is, how do we know to represent the backness contrast as in (5a) and not as in (5b)? In (5a), */a:/ clearly appears to be neutral with respect to [front]. But we can also portray the vowel system as in (5b), where the main division is into [−rounded] and [+rounded] sets; in the [–rounded] set, */a:/ is contrastively [−front] as opposed to */i:/ and */e:/.

(5) Evaluation of the backness contrast of the low vowel

a. In the domain of [low]

[+front]	[–front]
*/i:/	*/u:/
*/e:/	*/o:/
[+low] */a:/	

b. In the domain of [rounded]

	[–rounded]		[+rounded]
	[+front]	[–front]	
	*/i:/		*/u:/
	*/e:/		*/o:/
[+low]		*/a:/	

Second, how are contrasts computed in the rest of the vowels? Hogg's comment seems to presuppose that */i:, e:/ are distinguished from */u:, o:/ by [±front], as in (5a); but they could

also be distinguished by [±rounded], or by both [±front] and [±rounded], or even by a combined [±back/rounded].[5] How can we tell which choice is correct?

Third, and more generally, in what theory does this type of analysis find a home? This kind of contrastive underspecification cannot be expressed in a theory that requires full specification of features, such as, for example, the theory of Chomsky & Halle (1968), the 'classical' generative phonology of *The sound pattern of English*.

Finally, what is the source of Hogg's analysis? He does not connect his account of the low long vowel to any specific reference, but writes at the outset (Hogg 1992: 53):

> Fuller discussions of the Germanic material may be found in works such as Prokosch (1939), Krahe and Meid (1969), and the contributions in van Coetsem and Kufner (1972), especially Antonsen (1972) and Bennett (1972).

Of these, Antonsen (1972) turns out to be a key source for Hogg's analysis.[6]

2.2. Antonsen (1972): a contrastive feature analysis of the Proto-Germanic vowel system

Elmer Antonsen was an American linguist and runologist who made a number of contributions to the study of Germanic phonology. His 1972 article cited by Hogg provides a more complete contrastive feature analysis of the vowels of Proto-Germanic.

Antonsen discusses the evolution of the Germanic vowel system in some detail; of the various stages in its evolution from Proto-Indo-European, he provides a distinctive feature analysis for the stage shown in (6). This stage is close to the stage Hogg (1992) posits in (2), but without '*$\bar{e}_2$', which Antonsen attributes to a later stage.

(6) Early Proto-Germanic vocalic system (Antonsen 1972: 139)

a. Long/tense vowels		b. Diphthongs and resonants		c. Short/lax vowels	
*/ ī/	*/ū/	*[r̥, l̥, m̥, n̥, ŋ̊]		*/i/	*/u/
		*/ei/	*/eu/	*/e/	
*/ǣ/	*/ɔ̄/	*/ai/	*/au/	*/a/	

Antonsen (1972) proposes that the four long/tense vowels in (6a) formed a symmetrical two-by-two system, wherein each vowel had a contrastive value for the features [±low] and [±rounded]. Because this system is symmetrical, it is not very informative with respect to our first question above, which arises most sharply in an asymmetrical phoneme system. However, his analysis of the four short/lax vowels is very illuminating. Unlike the long/tense vowels, Antonsen proposes that the short/lax vowel system was asymmetric, with the feature specifications given in (7).

(7) Feature specifications for the Proto-Germanic short/lax vowels (Antonsen 1972: 133)

	*/a/	*/u/	*/i/	*/e/
Low	+	−	−	−
Rounded		+	−	−
High			+	−

Antonsen (1972: 132–3) supports these feature specifications by citing patterns of phonological activity (neutralizations, harmony, and distribution of allophones) and loanword adaptation from Latin. Thus, based on the evidence from the descendant dialects, he assumes

[5] The feature [±back] would also distinguish the non-low vowels in (5a). I assume that the choice of what to call this feature depends on patterns of phonological activity; compare Trubetzkoy's analysis of the Latin, Archi, and Japanese vowel systems discussed in subsection 3.1 below.

[6] It is of course possible that Hogg may have re-invented some or all of the analysis by himself; nevertheless, we will see that there exist ample precedents for it in the literature.

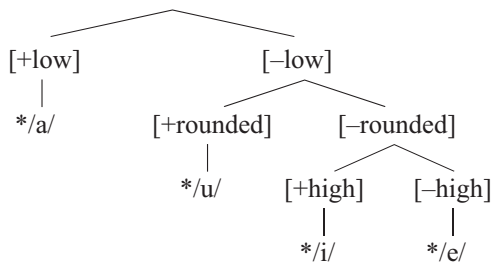
that */a/ had allophones *[a, æ, ə, ɒ], which all have in common that they are [+low]. Moreover, there is evidence that stressed */u, i/ optionally had lowered allophones *[o, e] when followed by a low vowel, which suggests to him that */a/ had a height feature capable of causing lowering. Moreover, there is no evidence that /a/ had any other active features – that is, features that play a role in the phonology by affecting neighbouring segments, or that group */a/ with other segments as a natural class. Therefore, Antonsen assigns */a/ the feature [+low], and no other contrastive feature.

As the feature that distinguishes */u/ from */i/ and */e/ Antonsen chooses [rounded]: */u/ is [+rounded] and */i, e/ are [–rounded]. He could also have chosen [±front] (or [±back]), because */u/ is the only one of these that is [–front]. His reason is that all the allophones of */u/ were rounded, but they were not all [–front].[7]

Antonsen (1972: 133) observes that the contrast between */i/ and */e/ was neutralized in environments that affected tongue height: before high front vowels, low vowels, and before nasal clusters. He argues that this fact supports distinguishing */i/ and */e/ by a single feature, [high]. Further, he notes that the entirely negative (i.e., unmarked) specifications of */e/ are consistent with the fact that 'this is the only vowel which does not cause umlaut assimilations in a preceding root syllable'.[8]

Antonsen does not comment on the theory that underlies these specifications, but their pattern indicates that they can be modeled as a branching tree, with the features in the order indicated in (7) (henceforth, [low] > [rounded] > [high], where '>' means 'is ordered before' or 'takes scope over'). The vowel features can be displayed in a tree as in (8).

(8) Contrastive feature hierarchy: [low] > [rounded] > [high]



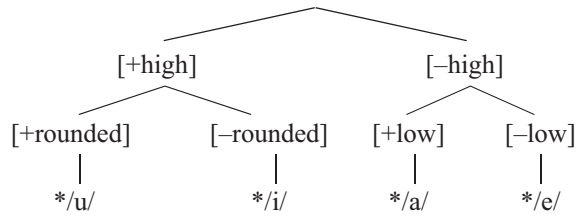
The first division in the tree in (8) divides the vowels on the basis of [low]. Notice that all the vowels receive a value of [±low]: in a hierarchical system of contrasts, there will always be at least one feature that applies to every member of the inventory. There is only one [+low] vowel, therefore */a/ receives no further contrastive specifications. The [–low] vowels are then divided by [rounded]; again, there is only one [+rounded] vowel, */u/, which is not specified further. Finally, the remaining two undifferentiated vowels */i/ and */e/ are split by the feature [high]. All the vowel phonemes are now uniquely specified, and there are no more contrastive features that can be assigned to this inventory.

Notice that the ORDERING [low] > [rounded] > [high] of the features is crucial. A different ordering of the same features, say [high] > [rounded] > [low], as in the tree in (9), results in the very different specifications in (10). In (9) and (10), */i/ is minimally different from */u/, not */e/, and the closest partner of */e/ is */a/, not */i/.

[7] See further subsection 3.5 below, where I give reasons for reconsidering this choice.

[8] The various types of vowel harmony were also affected by consonants (Twaddell 1948; van Coetsem 1968, 1994; Buccini 1992), but this issue will not be discussed here.

(9) A different contrastive feature hierarchy: [high] > [rounded] > [low]



(10) Feature specifications generated by the tree in (9)

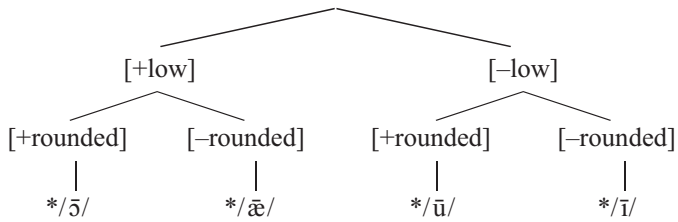
	*/a/	*/u/	*/i/	*/e/
Low	+			–
Rounded		+	–	
High	–	+	+	–

Antonsen (1972) also proposes distinctive features for the four long/tense vowels in (6). He points out that the short/lax and long/tense vowel sub-systems are not isomorphic, despite each having four vowels, and using the same features [low] and [rounded] in the same ordering (the feature tree ends before [high] can be assigned to any long/tense vowel). The tree diagram for the long/tense vowels is shown in (12).

(11) Feature specifications for the Proto-Germanic long/tense vowels (Antonsen 1972: 134)

	*/ī/	*/ū/	*/ǣ/	*/ɔ̄/
Low	–	–	+	+
Rounded	–	+	–	+

(12) Contrastive feature hierarchy: [low] > [rounded] (> [high])



Antonsen (1972: 134) supports the assignment of [+low] to */ǣ/ on the basis of the low outcomes in the daughter languages. In the case of */ɔ̄/ he argues that loanword evidence shows it was [+low]: Latin /o:/ was borrowed as Germanic [–low] /u:/, just as Latin /e:/ was borrowed as Germanic /i:/. Antonsen's (1972) analysis of the long/tense vowels thus does not provide a model for Hogg's (1992) analysis of the low long vowel in (2): */ǣ/ in (11) is part of a four-vowel system, not a five-vowel system as in (2), and Antonsen analyses it as contrastively [–rounded], not neutral with respect to tonality features.

A more direct precursor to Hogg's analysis can be found, however, in an earlier article by Antonsen (1965). In this article Antonsen discusses several stages in the development of the Germanic vowel system. He does not use binary distinctive features, but his analysis of the Proto-Germanic vowel systems in (6) is essentially identical to his 1972 analysis. Thus, he writes (1965: 25) 'On the basis of the reflexes found in the later dialects, we can posit for Proto-Germanic a short-vowel system consisting of four phonemes with the contrast spread-rounded in the high and mid series and with three tongue heights'. And with respect to the long vowels (1965: 26), 'the internal evidence points once again to a four-

phoneme system with the contrast spread-rounded, but in this instance only two tongue heights'.[9]

Antonsen (1965: 28) also discusses a subsequent stage, 'which may be considered the forerunner of all the North and West Germanic languages'. In this stage */$\bar{e}_2$/ was present as a new phoneme, creating a five-vowel system similar to that in (2) above. He writes (1965: 29): 'The displacement of /$\bar{e}^1$/ toward the [ā]-position could have varied in degree within the dialects of this linguistic community … but the position of the phoneme in the structural system of all the dialects was undoubtedly low neutral'. This is exactly the analysis adopted by Hogg (1992).

Returning to Antonsen (1972), his discussion suggests that the length (or tenseness) feature goes at the top of the feature hierarchy, creating two relatively independent vowel subsystems: short/lax and long/tense.[10]

Antonsen (1972) gives us additional context for Hogg's (1992) analysis of the West Germanic low long vowel, and we can now partially answer the questions we had about that analysis.

First, how do we know to evaluate the backness of /a:/ only in the low domain, and not with respect to all the vowels, or just the non-rounded vowels? Antonsen motivates his analysis of short */a/ by referring to the range of variation of its allophones, which all remain [+low], but which may be front or back or rounded or unrounded. Also, he argues that */a/ gives no evidence of having any other contrastive feature apart from [+low]. That is, the neutrality of */a/ with respect to [front/back] and [rounded] is not due solely to its being the only [+low] vowel, but because its phonological patterning supports this feature assignment. We can suppose that similar considerations apply to the low long vowel in (2).

Second, how are contrasts computed in the rest of the vowels? Antonsen answers this question by providing a complete contrastive feature analysis for all the vowels of the stage of Proto-Germanic that he discusses.

Third, in what theory does this type of analysis find a home? Though Antonsen presents a more complete analysis, he does not comment on the theoretical framework in which it is couched. The feature specifications he proposes are consistent with the branching trees in (8) and (12), but there is no mention of trees in his article.

Fourth, what is the source of Hogg's analysis? It appears we have found a source in Antonsen (1972) (and more indirectly, Antonsen 1965); but what is the source of Antonsen's theoretical framework and analysis? Antonsen (1972) cites some of his own previous articles; they present similar phonemic analyses of Proto-Germanic, but lack distinctive features, so cannot be the source of his 1972 feature analysis. He cites another article, Benediktsson (1967). This article will provide a major key to answering our questions, because it serves as a bridge to the origins of branching trees in phonology.

2.3. Benediktsson (1967): a Jakobsonian analysis of the Proto-Germanic vowel system

Hreinn Benediktsson was an Icelandic linguist with many publications on Nordic and Germanic historical phonology. His article, 'The Proto-Germanic vowel system', appears in

[9] The ease with which Antonsen's (1965) analysis could turn into his 1972 distinctive feature analysis shows us how close a standard structuralist analysis of a phoneme system is to a contrastive feature analysis; see further subsection 2.4.

[10] Antonsen (1972) designates the feature as 'long/tense' because the precise phonetic nature of the contrast cannot be determined. Oxford (2012) proposes that whether we call a feature [long] or [tense] may, in many common cases, depend on its ordering in the feature hierarchy: the lower the feature is in the ordering, the more it can be interpreted as pure length, as no other features distinguish between long and short vowels; the higher it is in the ordering, the more distant from each other are the vowels distinguished by it, and thus the tendency is to call it [tense]. On the status of length/tenseness as a feature, see subsection 3.5.

the first volume of *To honor Roman Jakobson* (Jakobson 1967). This fact is significant, because the device of contrastive features organized into branching trees can be traced back to Jakobson and his colleagues.

Benediktsson's feature analysis appears to have inspired Antonsen's. But whereas Antonsen (1972) proposes features for only one stage of the Proto-Germanic vowel system, Benediktsson applies a contrastive feature analysis more pervasively to a number of stages of early Germanic. Indeed, the purpose of his article is to apply the 'new principles' of the 'structural and functional approach in linguistic research' pioneered by Jakobson to the study of linguistic history.

Another difference is that whereas Antonsen (1972) looks for evidence for his feature assignments primarily in the types of phonological patterning and phonetic variation displayed by the various vowel phonemes, Benediktsson considers also the formal relations among features: he wishes to show how an understanding of the feature contrasts active at one period can set the stage for subsequent developments.

A final difference is that Benediktsson uses acoustic features following Jakobson et al. (1952) and Jakobson & Halle (1956): thus, he uses [compact] in place of [low], [diffuse] in place of [high], [grave] in place of [back], [acute] in place of [front], [flat] in place of [rounded], and [natural] in place of [unrounded].

To give something of the flavour of Benediktsson's analysis, let us look briefly at his account of the evolution of the long vowel system beginning with the 'immediate pre-Germanic vowel system' inherited from Indo-European, shown in (13).

(13) Stage I: Pre-Germanic long vowel system (Benediktsson 1967: 175)

a. Schematic diagram

*/ī/ */ū/
*/ē/ */ō/
*/ā/

b. Feature specifications

	ī	*ē*	*ū*	*ō*	*ā*
Long	+	+	+	+	+
Compact	–	–	–	–	+
Diffuse	+	–	+	–	
Grave-flat	–	–	+	+	

Like Antonsen (1972), Benediktsson does not discuss how these specifications are generated, but we can deduce that they follow from a contrastive hierarchy with the features in the order shown: [long] > [compact] > [diffuse] > [grave-flat]. Notice that */ā/, the only [+compact] (= low) vowel, has no contrastive features for [diffuse] (= high) or [grave-flat] (= back-round). The merger of long */ā/ and */ō/ to */ō/ at the close of the Pre-Germanic period theoretically produces Stage II, shown in (14) (Benediktsson writes that it is a matter of conjecture whether this stage ever existed). Benediktsson (1967: 176) selects [diffuse] as the single sonority feature at this stage, rather than [compact], because */a/ and */ō/ may have differed in their compactness, but are both [−diffuse] with respect to the high vowels. 'Similarly, the single tonality feature in stage II must have been acuteness, since the actual degree of gravity in short *a* and long *ō* was probably different'.

(14) Stage II long vowel system (Benediktsson 1967: 175)

a. Schematic diagram

*/ī/ */ū/
*/ē/ */ō/

b. Feature specifications

	ī	*ē*	*ū*	*ō*
Long	+	+	+	+
Diffuse	+	–	+	–
Acute	+	+	–	–

The next step was the addition of the new phoneme */ē$_2$/. This had a major effect on the distinctive feature structure of the vowels (15), and brings us close to the stage in (1c) and (2) posited by Hogg (1992). The return to a three-height system, with */ē$_1$/ lowering to */æ:/ in contrast with */ē$_2$/, brings [compact] back into play, and [acute] is replaced by [grave-flat], which Benediktsson calls 'the optimal feature' in this situation.

(15) Stage III: After addition of */ē$_2$/ (Benediktsson 1967: 175–6)

a. Schematic diagram

*/ī/ */ū/
*/ē$_2$/ */ō/
*/ē$_1$/

b. Feature specifications

	ī	*ē$_2$*	*ū*	*ō*	*ē$_1$*
Long	+	+	+	+	+
Compact	–	–	–	–	+
Diffuse	+	–	+	–	
Grave-flat	–	–	+	+	(–)

The chart in (15b) shows */ē$_1$/ assigned a minus value for [grave-flat] in parentheses. This value is not contrastive in terms of an ordered feature tree, but evidently it is included here to show that it inherits frontness from Stage II. Benediktsson (1967: 177) observes that the loss of this frontness is a possible effect of the introduction of *ē$_2$*: 'Compact *ē$_1$* loses its redundant acuteness (and naturalness) and becomes neutral (with respect to tongue and lip position), viz. *ā*. This happened in North and West Germanic'. This, then, is another precedent for Hogg's analysis of */æ:/ in (2).

Benediktsson also discusses the evolution of the short vowel system of Proto-Germanic and considers how various asymmetries in the long and short vowel systems may have influenced subsequent developments; however, we cannot review the rest of his interesting article here. For our immediate purposes the article is significant in that it gives us a fuller picture of the sort of theory that underpins Antonsen's (1972) analysis. On the other hand, Benediktsson also does not discuss the theoretical framework he uses, or explain how he decides which feature specifications to include and which to omit. However, his article points us directly to the sources of the theoretical framework he employs, to the work of Roman Jakobson and his colleagues.

2.4. Twaddell (1948): a structuralist analysis of the Proto-Germanic short vowel system

Before turning to Jakobson's theoretical contributions, there is one more publication on the prehistoric Germanic short vowels that deserves to be mentioned here, and that is Twaddell (1948). Twaddell's article is a precursor to all the analyses discussed above. Thus, his analysis of the Prehistoric Germanic short vowels is essentially adopted by Antonsen (1965), and his discussion of how this system might be expected to develop, taking into account structural considerations of symmetry and economy, anticipates Benediktsson (1967). It is not clear, however, whether Twaddell's analysis employs binary features; therefore, it is somewhat ambiguous with respect to our central questions.

The ambiguity can be illustrated by two charts, one near the beginning of Twaddell's article and one towards the end. The first chart, shown in (16), is Twaddell's representation of the short vowel system of West Germanic and North Germanic after the fission of */u/ into two phonemes, */u/ and */o/.

(16) West Germanic and North Germanic short vowels (Twaddell 1948: 141)

	FRONT SPREAD	CENTRAL NEUTRAL	BACK ROUNDED
HIGH	i		u
MID	e		o
LOW		a	

While it is not a big step to convert this chart into a contrastive feature analysis like that of Antonsen (1972), it is not clear that this would accurately reflect Twaddell's analysis. First, it is ambiguous whether the labels FRONT SPREAD and BACK ROUNDED are intended to leave open whether backness or lip rounding is the relevant contrast, or if the two are to be taken as acting together, as in Benediktsson's grave-flat analysis in (13b) above. Second, the label CENTRAL NEUTRAL also admits two different interpretations. Viewed through the prism of contrastive hierarchies made up of binary features, we could interpret it as indicating the lack of a specification for backness or lip rounding, as in Antonsen's specifications in (7). But this may not be what Twaddell intended; we can take his labels more literally as suggesting ternary distinctions FRONT ~ CENTRAL ~ BACK and SPREAD ~ NEUTRAL ~ ROUNDED. While descriptively this interpretation might not seem to be very different from saying that */a/ is underspecified for these properties, formally it is quite different. On one interpretation /a/ is outside the tonality system; on the other, the specifications CENTRAL NEUTRAL have the same status as FRONT SPREAD and BACK ROUNDED. On this interpretation, furthermore, feature specifications are not minimally contrastive: either LOW or CENTRAL NEUTRAL suffices to distinguish /a/ from the other vowels.

Twaddell's (1948: 150) second chart, shown in (17), comes closer to a contrastive feature analysis. The chart represents the significant allophones of 'the final form of the short-syllabic system of Prehistoric Germanic of the Pre-Norse and the Pre-West-Germanic dialects'. In this diagram, the CENTRAL NEUTRAL category is gone, and the main tonality contrast is SPREAD ~ ROUNDED.

(17) West Germanic and North Germanic short vowel allophones (Twaddell 1948: 150)

	SPREAD	ROUNDED
HIGH	[i]	[y, u]
MID	[e]	[ø, o]
LOW	[æ, a]	

The chart in (17) can be seen as a direct antecedent of the contrastive feature analyses discussed above. More generally, Twaddell's article illustrates again how close American structuralist analyses can come to contrastive feature analyses more usually associated with the Prague School and theoretical frameworks that derive from it. In the next section we will resume our search for the origin of branching feature trees.

2.5. Jakobson et al.: origins of branching contrastive feature trees

A branching tree is alluded to in 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 active in the language. By 'oppositions active in the language' they mean that not all phonetic properties of a phoneme are equally important to the phonology: the

properties that are active are the ones that play a role in the phonology of the language, and, in their procedure, these are the contrastive features.

A decision tree of this kind is anticipated a few years before in an article on Standard French by Jakobson & Lotz (1949). The tree itself does not appear. However, their representations, given in (18), are consistent with such a tree, and are difficult to explain otherwise (Dresher 2009: 61–4).

(18) The specifications of Standard French consonants (Jakobson & Lotz 1949: 158)

	p	*b*	*f*	*v*	*t*	*d*	*s*	*z*
Vocality	–	–	–	–	–	–	–	–
Nasality	–	–	–	–	–	–	–	–
Saturation	–	–	–	–	–	–	–	–
Gravity	+	+	+	+	–	–	–	–
Tensity	+	–	+	–	+	–	+	–
Continuousness	–	–	+	+	–	–	+	+

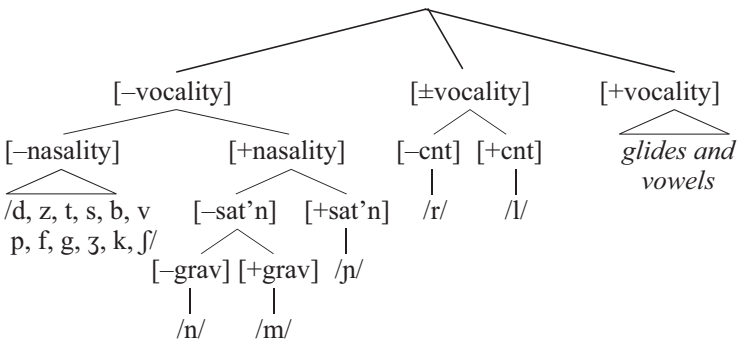
	ʃ	*ʒ*	*k*	*g*	*m*	*n*	*ɲ*	*r*	*l*
Vocality	–	–	–	–	–	–	–	±	±
Nasality	–	–	–	–	+	+	+		
Saturation	+	+	+	+	–	–	+		
Gravity					+	–			
Tensity	+	–	+	–					
Continuousness	+	+	–	–				–	+

Based on these specifications we can deduce that Jakobson and Lotz assume that the features apply in the order they are listed in the table (18). Each feature applies in turn to each branch of the inventory in which it is contrastive.

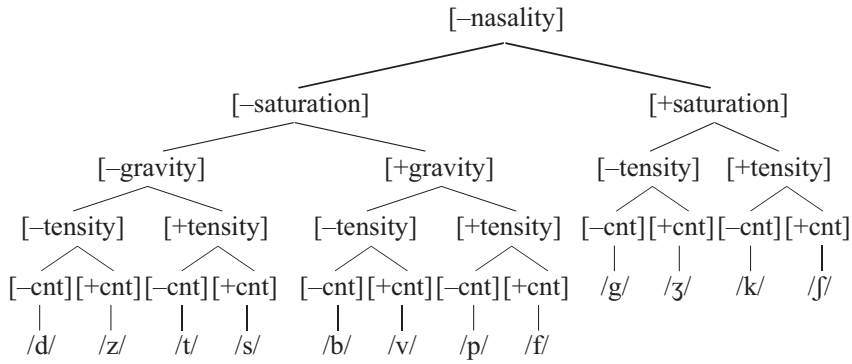
The first division of the inventory in their analysis pertains to [vocality]: consonants are [–vocality], vowels and glides are [+vocality], and liquids have a third, intermediate, value, [±vocality]. The second feature to apply is [nasality]. It is contrastive in the consonants that are [–vocality] and in the vowels, but not among the [±vocality] liquids. If a feature is not contrastive in a branch of the tree, it is not assigned there. In this example, there are only two liquids, /r/ and /l/, and only the last feature, [continuousness], distinguishes between them. The nasal consonants are divided by [saturation] and [gravity], completing the top part of the tree in (19a).

(19) Feature tree for Standard French consonants (based on Jakobson & Lotz 1949)

a. Top of tree: [vocality] > [nasality]



b. Non-nasal consonants [−vocality, −nasality]



We need not go through the whole tree here, but let us briefly look at the expansion of the non-nasal obstruents (19b). The next choice is [saturation]: front coronals and labials are [–saturation], and postalveolars /ʃ, ʒ/ and velars /k, g/ are [+saturation]. The [+saturated] consonants are divided by [tensity] and [continuousness]; this analysis does not distinguish post-alveolars from velars, but mixes the [+saturated] segments together.

In support of this analysis, Jakobson & Lotz observe (1949: 153):

> Thus the difference between velar and palatal is irrelevant in French phonemics ... These contextual variations do not hinder French speakers from rendering the English velar *ŋ* through the French palatal *ɲ* ... or the German 'ich-Laut' through *ʃ*. The advanced articulation of *k g* before *j* or *i*, as well as the existence of *ŋ* instead of *ɲ* before *w*, ... illustrates the unity of the saturated consonants in French.

That is, the idea of representing phonemes only by their contrastive features is *not* motivated here by a desire to economize on lexical representations.[11] Rather, as in the articles by Benediktsson (1967) and Antonsen (1972), the contrastive features are closely tied to activity, that is, to the phonological patterning of the phonemes. The germ of this idea can be traced back to the dawn of modern phonology, in the work of Henry Sweet.

2.6. Sweet (1877): contrastive properties and 'Broad Romic' transcription

According to Daniel Jones (1967: 256), Henry Sweet was the first to distinguish two types of transcription: 'Narrow Romic' (a detailed phonetic transcription), and 'Broad Romic' (suitable to an individual language, what we would now call a phonemic transcription). For example, the vowels in the English words *bait* and *bet* differ in three ways: the vowel in *bait* is tenser and longer than in *bet*, and is a diphthong, whereas the vowel in *bet* is a monophthong.[12] An accurate phonetic transcription would indicate all these distinctions; in the current notation of the IPA, they may be transcribed as shown in (20).

[11] Considerations of economy and minimizing redundancy in representations did become an important criterion guiding underspecification in later work by Jakobson and his colleagues. It is thus noteworthy that this was not the criterion appealed to in the earlier work cited above; see Dresher (2015b) on the shifting criteria governing contrastive hierarchies in the history of phonology.

[12] This is true of many English dialects, but not all. Sweet (1877: 15) writes that the English sounds in his key-words (and presumably when he refers to 'English' without qualifiers) 'are those of the educated southern pronunciation'.

(20) Phonetic differences between *bait* and *bet*

	Differences	IPA
a. *bait*	tense, long, diphthong	[eːj]
b. *bet*	lax, short, monophthong	[ɛ]

These three differences, however, are not independent: recombining the various properties to create new vowels such as [eː], [ej], [e], [ɛː], [ɛj], or [ɛːj] would not result in a new word distinct from both *bait* and *bet*, but would be heard as some, perhaps odd-sounding, variant of one of these words. Sweet (1877: 104) writes:

> Hence we may lay down as a general rule that only those distinctions of sounds require to be symbolized in any one language which are *independently significant:* if two criteria of significance are inseparably associated, such as quantity and narrowness or wideness [i.e., tenseness or laxness/BED], we only need indicate one of them.

Sweet proposes (1877: 109–10) that the broad transcription of the vowel in *bait* ([eːj]) should be 'ei' (or, equivalently, 'ej'), and the broad transcription of the vowel in *bet* ([ɛ]) should be 'e'. Thus, of the three differences in the vowels, he chooses the presence of an off-glide *j* as significant, ignoring both quantity (length) and narrowness or wideness (tenseness or laxness). In this case Sweet gives the rationale for his choice. He observes (1877: 110): 'The narrowness of all E. [English] vowels is uncertain', especially /ij/ and /ej/. That is, these vowels can vary in the degree to which they are tense ([ij], [ej]) or lax ([ɪj], [ɛj]) without essentially changing their identity, as long as other properties do not change.

Similarly, he finds (1877: 18) that 'originally short vowels can be lengthened and yet kept quite distinct from the original longs'. That is, [bɛt] (*bet*) can be lengthened to [bɛːt] without passing into *bait*, and [beːjt] (*bait*) can be shortened to [bejt] without being perceived as *bet*.

While tenseness and length can be altered without changing one vowel phoneme into another one, presumably the same is not the case for the third distinguishing property. Adding a glide to the vowel in *bet*, or removing it from *bait*, could cause the resulting vowel to be perceived as having changed category. We can conclude from his discussion that Sweet's analysis posits that the contrastive features of both the vowels in *bet* and *bait* are mid and front, with no contrastive specification for tenseness or quantity. The difference in the two words resides in the addition of a second segment to the vowel in *bait*.

Sweet did not propose a method for computing contrastive properties, nor did he consistently attempt to identify what the contrastive properties are for every segment (Dresher 2016a: 57). However, we can see in his work the ideas that only contrastive properties need be transcribed, and that these properties can be identified by observing how sounds function in a particular language. The further development of these ideas, and their connection with feature hierarchies, came some years later in the work of the Prague School phonologists.

3. Contrast and hierarchy in phonology

3.1. Trubetzkoy (1939): the connection between contrast and hierarchy

Up to now, I have been tracing the origins of a number of ideas related to feature contrasts, and it would be good to review them before moving on. One idea is that only some properties of a segment are ACTIVE, or RELEVANT, to the phonology, and these are the DISTINCTIVE, or CONTRASTIVE, properties. Another is that contrastive features are computed HIERARCHICALLY BY ORDERED FEATURES that can be expressed as a branching tree.

While these two notions appear together in some of the work we have reviewed, this is not the case, or does not appear to be the case, for all the analyses we have looked at. There is no evidence of a feature hierarchy in Sweet (1877), nor does Hogg (1992) mention a hierarchy in his discussion of Germanic vowel systems. Nevertheless, the notions of contrast and hierarchy are closely linked; that hierarchy goes unmentioned does not mean that it is not there, underpinning the analysis. This connection was made explicit in the 1950s, but its roots can be found in the work of Jakobson and Trubetzkoy in the 1930s.

The phonologist who did the most to establish sub-phonemic contrastive features as an organizing principle of phonology was N. S. Trubetzkoy. His posthumous *Grundzüge der Phonologie* (1939) contains many valuable insights, but no consistent method for computing which features are contrastive (see further Dresher 2007, 2009: 42–59).

There is one place in the *Grundzüge* where Trubetzkoy explicitly alludes to an ordering of features. Given an inventory containing the phonemes /i, ü, u/, one might suppose that the front rounded /ü/ would function as intermediate between /i/ and /u/. However, Trubetzkoy (1939: 93) observes that in the Polabian vowel system, a certain hierarchy existed ('Es bestand eine gewisse Hierarchie') whereby the back ~ front contrast is higher than the rounded ~ unrounded one, the latter being a sub-classification of the front vowels. Evidence is that the oppositions between back and front vowels are constant, but those between rounded and unrounded vowels of the same height can neutralize to the unrounded vowels. Further, palatalization in consonants is neutralized before all front vowels and before 'the maximally open vowel ɑ which stood outside the classes of timbre' (Trubetzkoy 1969: 102). Trubetzkoy (1939) presents the Polabian vowel system as in (21).[13]

(21) Polabian vowel system: [back] > [rounded] (Trubetzkoy 1939: 94)

[–back]		[+back]
[–rounded]	[+rounded]	
/i/	/ü/	/u/
/ê/	/ö/	/o/
[–low] /e/		/ɑ/
[+low]	/ɑ/	

As with West Germanic */a/, the notion that Polabian /ɑ/ 'stood outside the classes of timbre' can be expressed by dividing this vowel from the others by ordering [low] first. Trubetzkoy's analysis suggests that the features are ordered into the (partial) hierarchy: [low] > [back] > [rounded].

Elsewhere, Trubetzkoy (1939) presents analyses that *imply* a contrastive feature hierarchy, though it is not stated explicitly. This can be demonstrated in his review of five-vowel systems. He observes that in many such systems the low vowel does not participate in tonality contrasts, as we saw in the case of Polabian. He cites Latin as an example of this kind of system. In order to exclude /a/ from receiving tonality features, it is necessary to order [low]

[13] In Trubetzkoy's diagram the low vowel is at the top and back vowels are at the left. The feature labels are my own; Trubetzkoy does not employ the notation [±F] for features (indeed, he does not hold that all features are binary). Use of binary features here, however, is consistent with Trubetzkoy's analysis of this example.

Trubetzkoy notes that /ɑ/ is an unrounded back vowel. Polański (1993) presents a somewhat different account of the Polabian non-nasal, non-reduced monophthongs: high vowels /i, ü, u/; closed *é* /ė/; mid vowels /e, ö, o/; and the low vowel /a/ and its rounded counterpart /å/.

highest in the hierarchy, which has the effect of separating /a/ from the other vowels.[14] As for the other vowels, Trubetzkoy (1939: 90) writes that back rounded (maximally dark) vowels are in contrast with front unrounded (maximally clear) vowels. Translating his analysis into binary features, we can designate the distinctive feature as [back/rounded], since backness cannot be disentangled from roundness. The diagram in (22a) thus corresponds to the feature tree in (22b).[15]

(22) Latin vowel system

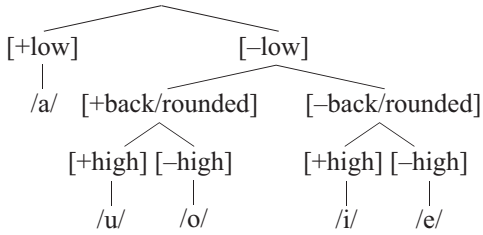
a. Schematic diagram (Trubetzkoy 1939: 90–91)

/i/ /u/

/e/ /o/

/a/

b. Contrastive hierarchy: [low] > [back/rounded], [high]



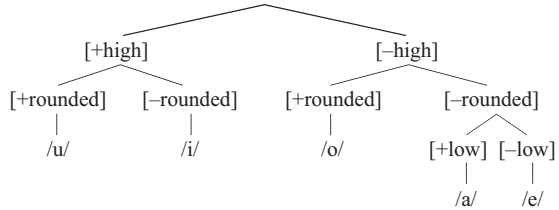
Trubetzkoy observes that other types of five-vowel systems exist. In Archi (East Caucasian), a language of Central Dagestan, a consonantal rounding contrast is neutralized before and after the rounded vowels /u/ and /o/. 'As a result, these vowels are placed in opposition with … unrounded *a*, *e*, and *i*. This means that all vowels are divided into rounded and unrounded vowels, while the back or front position of the tongue proves irrelevant …' (Trubetzkoy 1969: 100–1). As further evidence that backness is irrelevant to the contrastive status of Archi vowels, he observes (1969: 210 n. 17) that *u, o,* and *a* are fronted in specific environments. This analysis, displayed informally in (23a), corresponds to ordering [rounded] first, followed by [high] and [low], as in (23b).[16]

[14] In this and the following examples, the feature notation [±F] is not used by Trubetzkoy.

[15] I have again inverted and flipped Trubetzkoy's diagram so that high vowels are at the top and front vowels are at the left.

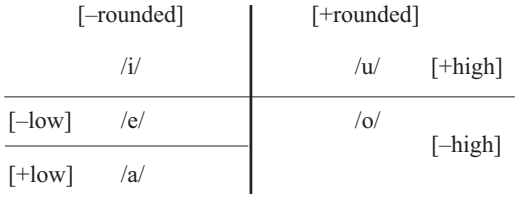
[16] There are other feature orderings that result in all the vowels being assigned contrastive values of [±rounded]; for example, the order [high] > [rounded] > [low], as in (i). However, in this ordering the distinction between high and non-high vowels, which Trubetzkoy does not mention, appears to be more basic than the one based on [±rounded]. Further study of Archi phonology might show which ordering is correct.

i. Contrastive hierarchy: [high] > [rounded] > [low]

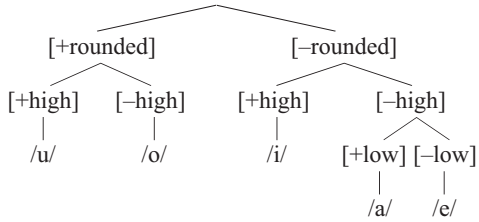


(23) Archi vowel system (Trubetzkoy 1939: 91–92)

a. Schematic diagram



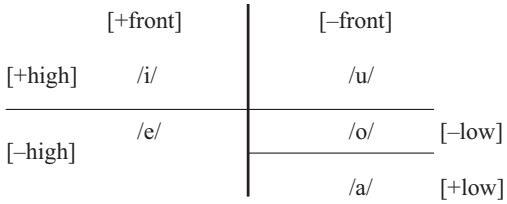
b. Contrastive hierarchy: [rounded] > [high], [low]



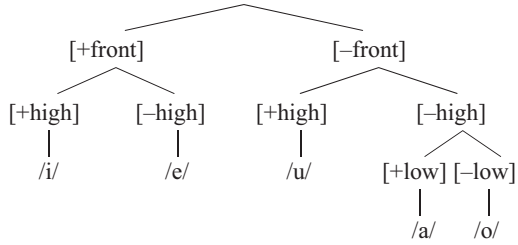
Trubetzkoy (1939: 92) argues that neutralization of the opposition between palatalized and non-palatalized consonants before *i* and *e* in Japanese shows that these vowels are put into opposition with the other vowels /a, o, u/. The governing opposition is that between front and back vowels, lip rounding being irrelevant (24a). As further evidence, he observes (1939: 92 n. 2) that /u/ is usually realized without lip rounding.[17] This analysis corresponds to ordering [front] first, followed by [high] and [low] (the latter only in the back vowels) (24b).

(24) Japanese vowel system (Trubetzkoy 1939: 92)

a. Schematic diagram



b. Contrastive hierarchy: [front] > [high], [low]



Thus we can understand Trubetzkoy's remark in his 1936 article addressed to psychologists and philosophers, that the correct classification of an opposition 'depends on one's point of view'; but 'it is neither subjective nor arbitrary, for the point of view is implied by the system' (Trubetzkoy 2001 [1936]: 20). Feature ordering is a way to incorporate 'point of view' into the procedure for determining contrastive properties. Different orders result in different contrastive features, and hence in different ways of classifying a given contrast. The correct

[17] See Hirayama (2003) for a more recent analysis of Japanese vowel feature contrasts.

ordering is 'implied by the system', meaning, suggested by the patterns of phonological activity in the system.

In light of this review of five-vowel systems, let us consider again Hogg's (1992: 61) statement about the West Germanic low long vowel: '*/æ:/ is the only low long vowel and there is no front/back contrast in operation'. We now understand that this statement reflects a (perhaps tacit) decision to evaluate the low vowel as a separate domain with respect to its contrastive features. And this is equivalent to ordering [low] highest in the feature hierarchy, as was indeed done by Antonsen (1972) and Benediktsson (1967). This ordering reflects an *analytic choice*, and is not dictated by the fact that there is only one low long vowel. Other ways of dividing up the vowel inventory are logically possible, but this is the correct one for West Germanic, 'implied by the system'.

3.2. Halle (1959): a novel argument for branching trees

We have seen above in subsection 2.5 how contrastive hierarchies were utilized by Jakobson & Lotz (1949) and Jakobson et al. (1952). Jakobson and Halle continued to employ them in a series of articles in the 1950s, notably Cherry et al. (1953), Jakobson & Halle (1956), and Halle (1959). Of special interest to our topic is that Halle (1959) advances a novel argument for specifying features by branching trees. He argues that phonological features must be ordered into a hierarchy because this is the only way to ensure that segments are kept properly distinct. Specifically, he proposes (1959: 32) that phonemes must meet the Distinctness Condition (25). This formulation is designed to disallow contrasts involving a zero value of a feature.

(25) 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.

Consider the typical sub-inventory /p, b, m/ shown below, and suppose we characterize it in terms of two binary features, [±voiced] and [±nasal]. In terms of full specifications, the segments are specified as shown in (26).

(26) /p, b, m/: Full specifications

	/p/	/b/	/m/
[voiced]	–	+	+
[nasal]	–	–	+

Which of these features is contrastive? Many people reason as follows: We observe that /p/ and /b/ are distinguished only by [voiced]; so these specifications *must* be contrastive. Similarly, /b/ and /m/ are distinguished only by [nasal]; these specifications must also be contrastive. The remaining specifications are predictable from the others. Since /p/ is the only [–voiced] phoneme in this inventory, its specification for [nasal] is predictable, hence redundant. Similarly, /m/ is the only [+nasal] phoneme, so its specification for [voiced] is redundant. We thus arrive at (27) as the proposed contrastive specifications for this inventory.

(27) /p, b, m/ after removing predictable specifications

	/p/	/b/	/m/
[voiced]	–	+	
[nasal]		–	+

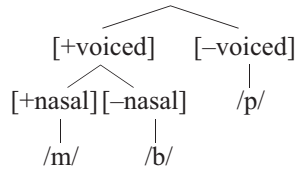
This is a still-popular way of thinking about contrastive specifications, but Halle (1959) argues that it is wrong. According to the Distinctness Condition, /p/ is 'different from' /b/, because /p/ is [–voiced] and /b/ is [+voiced]; and /b/ is 'different from' /m/, because /b/ is [–nasal] and

/m/ is [+nasal]; but /p/ is not 'different from' /m/: where one has a feature, the other has no specification. Therefore, these specifications are not properly contrastive.

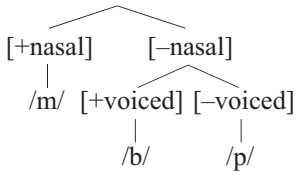
The specifications in (27) violate the Distinctness Condition because no feature hierarchy yields this result. If we order [voiced] > [nasal], we generate an extra specification on /m/, as shown in (28a); if we order [nasal] > [voiced], we generate an extra specification on /p/ (28b).

(28) Feature hierarchies for /p, b, m/

a. [voiced] > [nasal]



b. [nasal] > [voiced]



The Distinctness Condition is thus an argument against arriving at contrastive specifications by means of pairwise comparisons, as in (27). Pairwise comparisons are a popular, if flawed, method of contrastive specification, as demonstrated in Dresher (2009: 19–29). It is shown there that Halle (1959) is correct in arguing that only a hierarchical approach can guarantee that all segments in an inventory are properly contrasted.

3.3. The decline of contrastive hierarchies

The 1950s and early 1960s were prime years for contrastive specification via branching trees. This approach was imported into the early versions of the theory of Generative Phonology; it is featured prominently in Harms (1968), the first textbook in this framework. Underneath the surface, however, the role of contrastive features in phonology was in decline, as the connection between contrastive specification and phonological activity was being eroded for a variety of reasons, as documented in detail by Dresher (2009: 82–102, 2015b).

Thus, Harms (1968) shows that many recent analyses in the literature that presented inventories in the form of underspecified features could not be represented as branching trees, and were therefore illicit. The status of branching feature trees as an insecure and poorly-understood orthodoxy is also exemplified in an interesting 1966 article by Jørgen Rischel (2009 [1966]: 254–71). Rischel uses contrastive feature hierarchies to account for changes in the Scandinavian runic system (Dresher 2016c). He writes (2009 [1966]: 263), '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'. Although such an approach allows for an insightful analysis of the evolution of the Scandinavian runes, Rischel concludes (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'.

The lack of well-established criteria for contrastive hierarchies contributed to their disappearance from mainstream generative phonology when underspecification in general went out of favour, due in part to the arguments of Stanley (1967). Thus, the full explanatory potential of contrastive feature hierarchies remained unexplored for the rest of the twentieth century.

3.4. A theory of contrastive specification

At this point I would like to pull together the various ingredients in the works we have reviewed into an explicit theory of how contrast should be implemented in a phonological

grammar. The above ideas have been incorporated into generative grammar under the names Modified Contrastive Specification (MCS) or 'Toronto School' phonology (Avery & Rice 1989; Dresher et al. 1994; Dresher & Rice 2007; Dresher 2009), or Contrast and Enhancement Theory (Hall 2011), or just Contrastive Hierarchy Theory.

The central principles should by now be familiar. One of the basic ideas is stated in (29a); this idea has been formulated by Hall (2007) as the Contrastivist Hypothesis (29b).

(29) Contrast and activity
  a. Features relevant to the phonology
     Only some properties of a segment are RELEVANT to, or ACTIVE in, the phonology, and these are the DISTINCTIVE, or CONTRASTIVE, properties.
  b. The Contrastivist Hypothesis (Hall 2007)
     The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another.

It follows from the Contrastivist Hypothesis that only contrastive features can be PHONOLOGICALLY ACTIVE, where feature activity is defined as in (30), adapted from Clements (2001: 77).

(30) 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.

If only contrastive features can be active, then (31) follows as a corollary to the Contrastivist Hypothesis. Therefore, activity can serve as a heuristic to help us identify which features are contrastive.

(31) Corollary to the Contrastivist Hypothesis
  If a feature is phonologically active, then it must be contrastive.

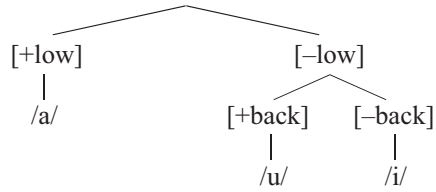
The second major building block is that contrastive features are computed hierarchically by ordered features that can be expressed as a branching tree (32a). This idea can be found in the work of Jakobson and his collaborators (Jakobson et al. 1952; Cherry et al. 1953; Jakobson & Halle 1956). What were called 'branching trees' in the literature of the 1950s and 1960s can be implemented by what Dresher (2009) calls the Successive Division Algorithm (32b) (see Dresher 2009:16–17 for a more detailed version of the algorithm).

(32) Contrastive feature hierarchies (Dresher 2009)
  a. Contrast in features is assigned hierarchically
     Contrastive features are assigned by language-particular feature hierarchies.
  b. The Successive Division Algorithm (Dresher 2009:16)
     i. Begin with *no* feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.
     ii. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.[18]
     iii. Repeat step (ii) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

[18] The algorithm does not determine which features to choose or in what order. This must be determined by the learner on the basis of phonological activity and phonetics; see Dresher (2015b) for a discussion of criteria for ordering features.

On this view, lexical specifications are limited to contrastive features, so are not pronounceable. In the example in (33), the phoneme designated /u/ has only two features: [–low] and [+back]. Unless the vowels are further specified in the phonology by other contrastive features, they are made more specific only in a post-phonological component.

(33) Contrastive feature hierarchy: [low] > [back]



Notice that this type of contrastive specification does not necessarily omit all redundant feature specifications. The vowel /i/ in (33), for example, is specified [–low, –back]; since /i/ is the only phonetically [–back] vowel in this inventory, the specification [–low] is predictable, hence redundant. In some approaches to underspecification, this predictable feature would be omitted. In a hierarchical approach, however, features ordered higher in the inventory are not removed on the basis of features ordered lower down. Thus, this theory does not identify the notions 'contrastive' and 'non-predictable'.[19] This property of hierarchical contrastive specification will be important in the discussion of phonologization in subsection 3.5.

Stevens et al. (1986) propose that feature contrasts can be ENHANCED by other features that have similar acoustic effects (see also Stevens & Keyser 1989; Keyser & Stevens 2001, 2006). Thus, a non-low vowel can enhance its [+back] feature by adding {[+rounded]}, and [–back] is enhanced by {[–rounded]}, because both rounding and backness contribute to lowering the second formant.[20] The feature [–low] can be enhanced by adding {[+high]}. These enhancements take place after the contrastive phonology, in what I will call the enhancement component.[21] The results of adding these enhancements to the vowels in (33) is shown in (34). They are not necessary, however, and other realizations are possible (see Dyck 1995 and Hall 2011 for further discussion).

(34) Typical enhancements of vowels with contrastive features

	/a/	/u/	/i/
Contrastive features			
[low]	+	–	–
[back]		+	–
Enhancement features			
{[high]}	–	+	+
{[rounded]}		+	–

3.5. Application of the theory: the phonologization of i*-umlaut*

Let us return to the Proto-Germanic feature hierarchy of Antonsen (1972). Recall that the feature specifications he assigns the vowels are as in (7) and (11), and that we deduced that

[19] See Dresher (2009: 11–30) for discussion of the logic of contrast.

[20] I follow Purnell & Raimy (2015) in indicating non-contrastive properties contributed by enhancement in curly brackets.

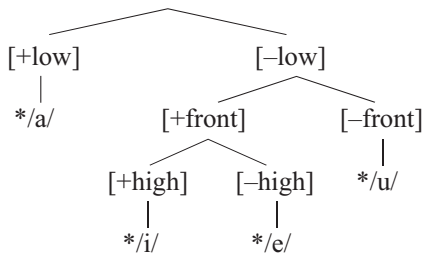
[21] Purnell & Raimy (2015: 527–8) posit at least three distinct levels of phonological representation (they suggest there may be more): the phonological level, which 'only traffics in contrast'; the phonetic-phonological level, where enhancement and other features may be added; and the phonetic level, a more detailed implementation level in the spirit of Browman & Goldstein (1986).

the branching trees that underlie these specifications are as in (8) and (12), respectively. Antonsen, following Twaddell (1948), chose [rounded] as the feature that distinguishes */u/ from */i/ and */e/ in early Germanic rather than [front] or [back], because all the allophones of */u/ were rounded, but not every allophone was [+back]. In particular, */u/ had a front rounded allophone when preceding */i/ or */j/. By the same logic, then, we should attribute to */i/ a feature, such as [±front]), that is capable of causing fronting in a neighbouring vowel. Thus, the evidence points at least as strongly to a frontness feature as it does to [±rounded].

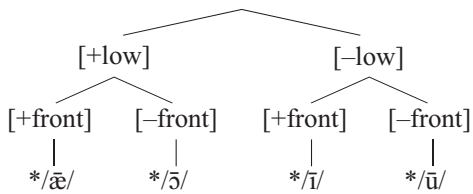
In choosing a front/back feature over [rounded] I follow a number of other commentators, including Lass (1994), Ringe (2006), and Purnell & Raimy (2015). Thus, Ringe (2006: 148) proposes a 'square' long vowel system like that in (11); according to him, however, 'the qualitative differences between the vowels can be minimally described by the oppositions high: nonhigh and front: nonfront'. Therefore, I will amend Antonsen's feature specifications for the Proto-Germanic vowels by replacing [rounded] by [front], as in (35a). The long vowels will now be characterized in a similar fashion (35b).

(35) Revised Proto-Germanic contrastive feature hierarchy: [low] > [front] > [high]

a. Short/lax vowels



b. Long/tense vowels

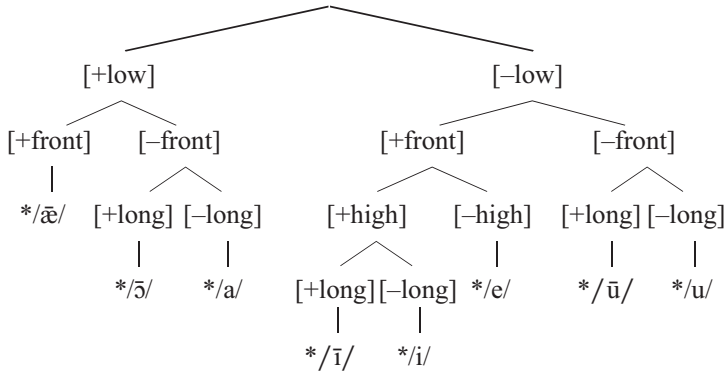


Before going on, a remark is in order about the status of length or tenseness in contrastive hierarchies (cf. note 10). The segregation of short/lax and long/tense vowels into two separate sub-inventories implies that the length/tenseness feature, say [long], is at the top of the hierarchy: [long] > [low] > [front] > [high]. It might be objected that length is not a feature, but rather is represented structurally, as an association of a segment to a skeletal tier: a short segment is associated to one slot, and a long one is associated to two (Kaye & Lowenstamm 1984; Levin 1985; see Spahr 2016 for discussion). Nevertheless, it is still necessary to evaluate the contrastive status of long and short segments, particularly when the long and short inventories are non-isomorphic, as in the hierarchy in (35).

To see this, consider the consequences of evaluating the vowels in (35) as one set, effectively ordering [long] at the bottom of the hierarchy, as in (36). Now, */a/ is [–front], */ī/ is [+high], and */ǣ/ and */e/ have no contrastive length feature. These are not the representations we want. Therefore, it is necessary to order length/tenseness with respect to the other features,

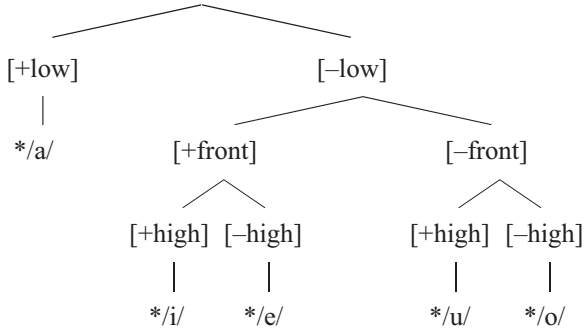
even if we consider that [long] is simply a placeholder for a contrast that is represented structurally.

(36) Proto-Germanic vowels incorrectly ordered [low] > [front] > [high] > [long]

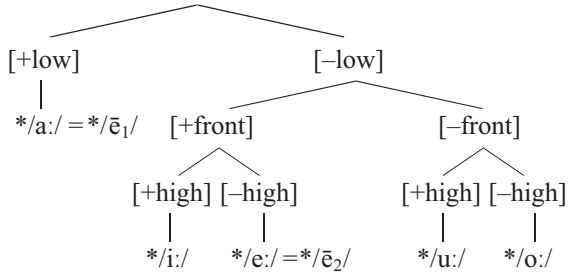


Continuing with the evolution of the Proto-Germanic vowel system, sometime after the stage in (35) a new phoneme */o/ developed from the lowered allophone of */u/ in the short/lax vowels. This expansion of the inventory does not require a change in the hierarchy: we just extend the existing [high] contrast to [–front], as in (37). In the long/tense vowels, the addition of */$\bar{e}_2$/ created a five-vowel system that eventually became isomorphic with the low vowels (Antonsen 1965; Benediktsson 1967), as shown in (38).

(37) Addition of */o/ to the West Germanic short/lax vowels



(38) Addition of */$\bar{e}_2$/ to the West Germanic long/tense vowels



At some point in the history of West (and North) Germanic the back vowels began to develop fronted allophones when preceding *i* or *j* in a following syllable.[22] This process, known as *i*-umlaut, is illustrated in (39), where original *ubil 'evil' changes to *ybil, and *fo:ti 'feet' changes to *fø:ti.

(39) *i*-umlaut of *u(:) and *o(:)

Gloss	a. 'evil NOM.SG'	b. 'foot NOM.PL'
Earlier form	*ubil	*fo:t+i
i-umlaut	*ybil	*fø:ti

i-umlaut crucially preserves the rounded nature of the fronted vowels: in (39), the front feature comes from the /i/, and the rounded feature must come from /u/ and /o:/. We have assumed, however, that [rounded] is not a contrastive feature of the West Germanic vowel system; the result of fronting */u(:), o(:)/ in the contrastive phonology would be to simply make them identical to */i(:), e(:)/.[23] Many commentators, beginning with Kiparsky (1932) and Twaddell (1938), have assumed that *i*-umlaut began as a late phonetic rule. That is, it applies after the features of */u(:), o(:)/ and */i(:), e(:)/ have been enhanced by {[+rounded]} and {[–rounded]}, respectively. Thus, the enhancement feature {[rounded]} must be in play at the point that */u(:), o(:)/ are fronted, as illustrated in (40). Without {[+rounded]}, the features of *[y(:), ø(:)] would be no different from those of *[i(:), e(:)].

(40) *i*-umlaut involving enhancement features

	*u	b	i	l	⟶	*y	b	i	l
Contrastive features									
[long]	–		–			–		–	
[low]	–		–			–		–	
[front]	–		+			+		+	
[high]	+		+			+		+	
Enhancement features									
{[rounded]}	+		–			+		–	

i-umlaut did not remain in the enhancement component forever, for we know that the allophones produced by it eventually became independent phonemes in many West and North Germanic dialects.[24] In early Old English, for example, the /i/ trigger of *i*-umlaut was either lowered after a light syllable, as in (41a), or deleted after a heavy syllable (41b); in many cases, the *i*-umlaut trigger must have become unrecoverable to learners.

(41) Early Old English *i*-umlaut of *u(:) and *o(:)

Gloss	a. 'evil NOM.SG'	b. 'foot NOM.PL'
Pre-Old English	*ubil	*fo:t+i
i-umlaut	*ybil	*fø:t+i
i-lowering/deletion	yfel[25]	fø:t

[22] At what point *i*-umlaut began is a matter of controversy. Scholars following in the tradition of Twaddell (1948), such as Antonsen (1961, 2002), Benediktsson (1967), and Penzl (1972), propose that its origins can be traced back to Proto-Germanic (perhaps not including East Germanic). Others, including van Coetsem (1968), Cercignani (1980), and Voyles (1992), argue that it arose later at different times in different dialects; see Buccini (1992) for a review. This issue is orthogonal to the problem being investigated here, which concerns how *i*-umlaut became a rule of the contrastive phonology in any dialect, whenever it arose.

[23] The same result would ensue if we assumed that the contrastive feature was [rounded] rather than [front] (or [back]).

[24] See Schalin (in press) for a contrastive hierarchy analysis of umlaut in Scandinavian vowel systems.

[25] Proto-Germanic */b/ was a voiced fricative, presumably *[ß], between vowels (Hogg 1992: 69; Ringe 2006: 215). In Old English, /f/ was voiced to [v] between vowels, resulting in a close similarity between [ß] from /b/ and [v] from /f/ which was eventually resolved in favour of [v]; hence, in Old English orthography the letter *f* is used to represent the voiced fricative in 'evil' (Hogg 1992: 283).

According to the well-known account of Kiparsky (1932) and Twaddell (1938), the loss of the *i*-umlaut contexts led to the phonologization of [y(:)] and [ø(:)] as new phonemes; an example is 'evil', whose underlying form is restructured from /ufil/ to /yfel/, as in (42a).[26]

(42) Phonologization of allophones *y(:)* and *ø(:)*

Gloss	a. 'evil NOM.SG'	b. 'foot NOM.PL'
Underlying form	/yfel/	/foːt+i/
i-umlaut	—	føːti
i-lowering/deletion	—	føːt
Surface form	[yfel]	[føːt]

Many scholars have pointed to problems with this account of the phonologization of the front rounded allophones. I will not attempt to go into the details here (see Liberman 1991; Fertig 1996; Janda 2003 for discussion and review of the issue, and Kiparsky 2015 and Dresher 2016b for recent proposals); but I would like to clarify what I mean by 'phonologization'. I assume that phonologization is a process involving several stages, whereby an allophone that starts in the phonetic component is promoted into the contrastive phonology, and then into lexical representations as an underlying phoneme. Thus, before an allophone can become an underlying phoneme, it must first enter the contrastive phonology. This poses a challenging question, stated in (43).

(43) Question about the phonologization of the allophones *y(:)* and *ø(:)*
Why and how do the products of *i*-umlaut enter the contrastive phonology when they involve predictable non-contrastive features that originate in enhancement?

A key to a solution to this question is to look at phonological change in terms of CONTRAST SHIFT, a change in the contrastive structure of the phonology (Jakobson 1972 [1931]). The notion of contrast shift, combined with the insight that 'contrastive' is not the same as 'unpredictable', can provide a new perspective on the phonologization of *i*-umlaut.[27]

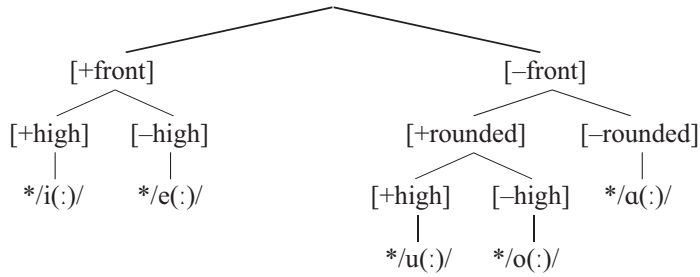
Let us revisit the stage when *i*-umlaut was a post-enhancement rule. Kiparsky (2015), building on an observation by Jakobson et al. (1952), proposes that the front rounded umlaut allophones at some point became more perceptually salient than the unstressed syllables containing the umlaut triggers, which were progressively weakening. Taking up his account, I propose that the increased salience of these allophones reached the point where it caused learners to hypothesize that [rounded] is a contrastive feature. This hypothesis would lead them to construct a new feature hierarchy. It follows from how contrastive hierarchies are constructed that the promotion of one feature in the hierarchy, without an increase in the phonemic inventory, must necessarily involve the demotion of another feature. In this case, it is easiest to demote [low], which allows [rounded] to be contrastive over the back vowels. Thus, the contrasts in the vowel system are redrawn from (37) and (38) to (44).[28]

[26] It is possible, as in (42b), that *i*-umlaut may have persisted for a while as a synchronic rule in forms with alternations like *foːt ~ føːt* 'foot ~ feet', but whether or not this was the case does not affect the current discussion.

[27] The notion that contrast shift is a type of grammar change has proved to be fruitful in the study of a variety of languages (for references, see Dresher et al. 2014; Dresher 2015a: 520 n. 19). The analysis presented here was inspired by Purnell & Raimy (2015), though the details differ.

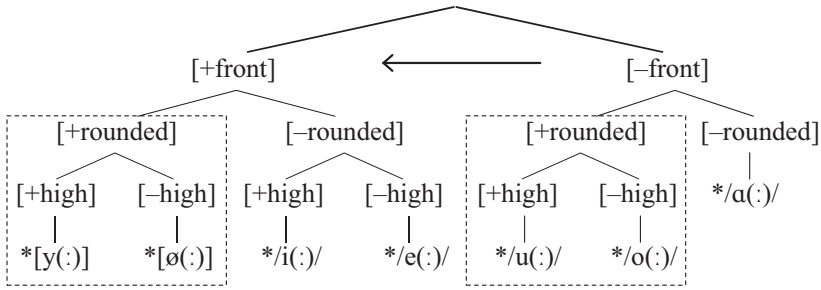
[28] The grouping of the short vowels with their long counterparts in (44) is an expositional shortcut; because the short and long vowel systems are isomorphic, the feature specifications are the same no matter where [long] is ordered. The feature [low] remains contrastive in dialects that also contain */æ/ or */æː/, which must be distinguished from */e/ or */eː/.

(44) West Germanic vowel hierarchy II: [front] > [rounded] > [high] (> [low])



Notice that this contrast shift does not immediately result in an overt change to the inventory, and *i*-umlaut can continue as a post-phonological rule. However, it is now possible for it to be promoted to the contrastive phonology; changing the [–front, +rounded] vowels to [+front] in the contrastive phonology results in front rounded allophones, as shown in (45).

(45) Creation of front rounded allophones using contrastive features



Although they are allophones, the derived umlauted vowels can arise in the contrastive phonology because they consist only of contrastive features. They are thus what Moulton (2003) calls 'deep allophones', referring to the voiced allophones of the Old English fricatives, which also arise in the contrastive phonology. Deep allophones (similar to the 'quasi-phonemes' of Korhonen 1969 and Kiparsky 2015) are possible because contrastive features are not all necessarily unpredictable.

Promotion to the contrastive phonology is the first step in the phonologization of deep allophones. Once there, I assume that deep allophones are eligible to be reinterpreted as underlying phonemes by learners who can no longer recover their triggering contexts. This process may occur sporadically at first, and may proceed differently depending on the data available to individual learners.

Another consequence of the contrast shift is that the vowels /ɑ:/ and /ɑ/ no longer have the feature [+low]; as far as I can tell, however, they do not need it. We thus predict that these vowels do not trigger lowering in Old High German and Old English, in striking contrast to earlier stages of Germanic, in which high vowels lowered before */a/.

4. Conclusion

We began with an observation by Richard Hogg (1992) about the early Germanic vowel system. In searching for the sources of his analysis we discovered a rich history that connects to major currents of phonological theory. Once we fill in the supporting assumptions, Hogg's deceptively simple observation turns out to rest on substantial empirical and theoretical foundations that are still capable of yielding insights into phonological systems.

Building on these foundations, I have proposed that phonology operates on contrastive features assigned by hierarchies that can vary across languages and over time. Evidence for this approach comes from the fact that contrastive specifications can capture observed patterns of phonological activity. Equally significant, like the dog that didn't bark, is the activity that we do *not* find, as predicted from the absence of features that are non-contrastive in the proposed analyses.

Specifically, the evidence of early Germanic vowel systems is that [low] was highest in the hierarchy of vowel features, and only one of the features [front] and [round] was contrastive. Later, however, the rise of front rounded allophones created by *i*-umlaut and the weakening of their triggering contexts brought about a contrast shift, whereby both [front] and [round] were contrastive and [low] was demoted. This approach sheds light on the phonologization of the front rounded allophones by showing how they could be incorporated into the contrastive phonology, and suggests new avenues to explore in understanding diachronic change.

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