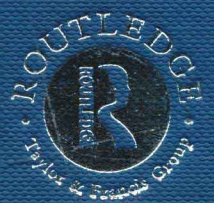
PHONOLOGY

CRITICAL CONCEPTS

Edited by
CHARLES W. KREIDLER



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Volume II
From Features to Underspecification

London and New York

First published 2001
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
270 Madison Ave, New York, NY 10016

Transferred to Digital Printing 2005

Routledge is an imprint of the Taylor & Francis Group

Typeset in Times by RefineCatch Limited, Bungay, Suffolk
Printed and bound in Great Britain by
TJI Digital, Padstow, Cornwall

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
A catalogue record for this book has been requested

ISBN 0–415–20344–9 (Set)
ISBN 0-415-20346-5 (Volume 2)

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VOLUME II FROM FEATURES TO UNDERSPECIFICATION

GENERAL INTRODUCTION

From features to underspecification

Different languages can have quite different systems of vowels and consonants, and comparing systems has been a favorite theme of several linguists. Ladefoged and Maddieson (**20**) have the most thorough account to date of the articulatory features found in the vowel systems of the world's languages. Many vowels can be described by three traditional dimensions: tongue height (as many as five degrees), tongue advancement (up to three degrees), and lip rounding (two kinds of rounding plus non-rounding). Minor vowel features include nasalization, other tongue body features, different phonation types, and dynamic properties.

Phoneticians have always realized that speech is not composed of discrete sounds in sequence but rather consists of articulatory gestures which overlap with one another. If speech must be viewed as a sequence of individual segments and represented by a string of symbols, as has almost universally been the case, each segment can be more accurately defined as a matrix of features. Phonemes are abstract units which have only distinctive features, to which phonological rules add the non-distinctive features that characterize phonetic segments. Phonemes which have one or more features in common constitute a natural class and typically are affected in the same way by the same rules. Just what is the total number of features? Are features defined articulatorily or acoustically? Are features better seen as simplex or as binary, with plus and minus values? Are they co-equal or are they related in some sort of hierarchy? These are among the more important considerations of modern phonology.

Deshpande (**21**) shows that the Indian phonetician Pāṇini recognized that speech sounds are composed of smaller elements or particles and he classified the vowels and consonants of Sanskrit according to the elements they shared.

The Prague School (Trubetzkoy and Jakobson) introduced the notion of distinctive features, an idea embraced by other theorists. Robins (**22**) points out that the distinctive feature has been the most influential theoretical concept in linguistics, in two ways. It has been carried over into other areas of linguistic analysis, with attempts to break down morphological, syntactic

and semantic units into smaller components. And it has led to various refinements in phonology itself, with developments of binarity, sometimes on a basis of articulation, sometimes with an attempt at acoustic correlations, which in turn have brought about the notion of markedness.

Trubetzkoy's notion of features was further developed by Jakobson, Fant, and Halle 1951, succeeded by Jakobson and Halle 1954 – a binary system with acoustic definitions. Chomsky and Halle 1968 continued the binarity but established a system with an articulatory rather than an acoustic basis. Following the publication of *The Sound Pattern of English* various criticisms and attempted improvements of the SPE system of features were made. One example is Campbell (**23**), in which the author points out inadequacies. Rather than introduce new features he suggests sequential clusters of features, thus making a new use of the SPE feature system, a suggestion that has not been widely accepted.

A more radical proposal is that of Sanders (**24**), who notes that phonological units and other units of a language can be represented in two ways, either a complex-feature representation with features indicated as plus, minus, or simply marked (e.g. + voice, – voice, or simple m voice, where voicedness would not be expected) or a simplex feature representation with invariant values for features (e.g. simply voice). What Sanders proposes is thus somewhat akin to the Dependency Phonology of Anderson and Durand (**18**, **19**) or the Particle Phonology which Schane uses in the next article.

Schane (**25**) traces two vowel changes in the history of English and proposes an account in terms of internal components. These components are three 'particles', palatality, labiality, and openness. A high front vowel is palatal, a high back vowel labial, and a low vowel is openness. Intermediate vowels consist of different combinations of these particles. Vowel shifts result from the addition or subtraction of a particle.

As McCarthy notes in an article below, a distinctive feature system must meet four criteria. The first three have been universally recognized since the time of Trubetzkoy: it must adequately represent the phonetic properties of speech; it must be enough to characterize any phonological contrast in any of the world's languages; and it must be able to characterize any natural class in any language. The fourth criterion is more recent in development: the system should characterize the subgrouping of features.

Clements (**26**) demonstrates that the features of a segment are not just random bundles of features that can be represented for any segment as a two-dimensional matrix. Rather, a multi-tiered hierarchical structure is required. (Cf. his Figure 3 or the figure in the Appendix with Dogil's Figure 1 in **31**, below, or the figure which Szpyra-Kosłowska (**29**) has taken from Halle.

The physical facts that justify Clement's hierarchical organization of features are elucidated by Kayser and Stevens (**27**). A speaker controls some

articulators independently while other combinations of articulators are linked. Of the four regions in the vocal tract, one, the vocal folds, operate alone; the pharyngeal, velic, and oral regions are interlinked. Thus the hierarchical organization is a model of speech production: the geometric tree is a model of the instructions to the vocal tract to move some body of muscles and deactivate others.

Smith (**28**) provides something of a critique of the newer feature geometry. He reviews earlier systems of features, including that of Chomsky and Halle 1968, and compares this binary system with the simplex features of Dependency Phonology. Smith borrows from both – from DP the term 'gestures' and the notions of Dominance and Dependency.

Assimilation, or the spreading of features, is one of the main arguments for feature geometry. Some features often assimilate together: adjacent consonants often agree in voicing and share the same place of articulation, vowels are nasalized before nasal consonants, consonants may become palatalized before front vowels, and so forth. Szpyra-Kosłowska (**29**) argues that palatalization processes can be adequately formulated if front vowels and glides are represented as complex segments with two place nodes, coronal and dorsal. Palatalization is seen as spreading the place features of front vowels and glides to the preceding consonants (corono-dorsalization).

McCarthy (**30**) proposes a newly recognized natural class, 'gutturals' – actually uvulars, pharyngeals, and laryngeals, although there is some question about laryngeals belonging to such a class.

Dogil (**31**) argues for an explicit hierarchical structure of distinctive features. Some features are defined in terms of other features, or more precisely in terms of their place in the F-structure configuration. He presents subsumption paths (trees) for a large number of segments in a large number of languages, taking them up by natural classes. He recognizes the role of relative in syllable structure but suggests that sonority hierarchy may be different for different languages.

Archangeli (**32**) asks if underspecification is theoretically possible and empirically desirable and, assuming a positive answer, goes on to compare two approaches to underspecification, Contrastive underspecification and Radical underspecification.

According to Mohanan (**33**), theories of underspecification are based on the formal device of omitting certain kinds of information in underlying representations and supplying it by rule in the derivation. He compares Radical and Contrastive underspecification in their assumptions about markedness and their use of both positive and negative values of features in underlying representations, in all environments or in certain contexts only.

Lexical minimality and Full specification, says Steriade (**34**), are the basic assumptions of underspecification: underlying representations must contain the necessary minimum of phonological information and surface forms must be fully specified. She divides the circumstances in which a feature value

might be predictable into three classes: features predictable from co-occurrence conditions (segment-internal); feature values identified as unmarked by a context-free statement; and features subject to positional neutralization.

Disclaimer

References within each chapter are as they appeared in the original complete work.

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VOWELS OF THE WORLD'S LANGUAGES

Peter Ladefoged and Ian Maddieson

Source: *Journal of Phonetics* 18 (1990): 93–122.

Many of the vowels of the world's languages can be described simply by reference to the three traditional dimensions high–low, back–front, and rounded–unrounded, with the first two of these being considered as names for auditory dimensions. There may be up to five contrasting vowel heights. Some languages contrast otherwise similar front, central and back vowels. There are also two kinds of rounding: protrusion and labial compression. Minor vowel features include: nasalization, other tongue body features (advanced tongue root, pharyngealization, stridency, rhotacization, fricative), different phonation types (voiceless, breathy, laryngealized, creaky) and dynamic properties (long, diphthongal).

1 Introduction

This paper describes the parameters of vowel variation and reviews the kinds of vowel sounds that occur in the world's languages. But before we do this we should try to define what we mean by a vowel. In many linguistic descriptions sounds are classified as either vowels or consonants. The phonetic basis of this description is not straightforward. The best early work on this topic is that of Pike (1943) who began by splitting segments in another way. He first of all made a distinction between vocoids and contoids, with a vocoid being defined as a central resonant oral. He then went on to define a vowel as a syllabic vocoid. In practice this is very similar to the definition given by Chomsky & Halle (1968) in the latter part of *The Sound Pattern of English*. Their definition is that a vowel is a segment with the features [+ syllabic, – consonantal], with [– consonantal] sounds being defined as those that do not have a central obstruction of the oral tract. In many ways this is functionally equivalent to the practice of contemporary autosegmental phonologists in defining a vowel as a [– consonantal] segment attached to a V slot.

Whichever definition is used it is equivalent to saying that a vowel is defined by features that ensure that there are no major structures in the vocal tract; and that it is syllabic.

We know what we mean by there being no obstructions in the vocal tract, but what, from a phonetic point of view, do we mean by syllabic? There is no phonetic parameter that can be used to define syllabicity in articulatory, or physiological terms. When Pike proposed his definition, he did so in the light of the research of Stetson (1928), implying that each syllable is associated with the particular kind of respiratory activity that Stetson called a "chest pulse". We now know that syllables are not necessarily associated with a chest pulse (Ladefoged, 1967); but phoneticians have not been able to suggest an alternative definition of the physiological properties of a syllable. The best that we can do is to suggest that syllables are 'necessary units in the organization and production of utterances' (Ladefoged, 1982). This is a neurophysiological, or cognitive view of the syllable, rather than a truly articulatory phonetic one. Perhaps we should not even try to provide a physiological phonetic definition of the syllable. Syllables are identifiable as the primary elements over which the rhythmic patterns of language can be observed, or the primary domain over which sequential constraints apply or coarticulatory adjustments can be made. That is, the syllable is a phonological unit. Accordingly we will be considering in this paper those sounds which have been called vowels because of their phonological function.

Many of the features required for linguistic descriptions of vowels have been established for some time. An excellent summary of their application to the world's languages was given by Lindau (1978). The discussion here will follow a similar framework; we will summarize our differences at the end of the paper.

The basic building blocks of most vowel systems are the three qualities that are traditionally called high–low, front–back and rounded–unrounded. Figure 1 shows the location of a set of reference vowels, the cardinal vowels described by Jones (1956), within the space defined by these dimensions. In our examination of the vowels of the world's languages we will continue to use the traditional terms high–low and back–front, and we will refer to these dimensions as Height and Backness (names of formal vowel parameters are capitalized throughout the paper to distinguish them from other uses of the same words). But although we are continuing to use the familiar articulatory labels, we will regard them as referring to auditory properties. This issue is discussed in more detail in Ladefoged (1990).

2 Vowel height

Variations in vowel quality often involve all three of the primary dimensions, Height, Backness, and Rounding. This sometimes makes it difficult to decide how many levels of Height there may be in a particular language. Consider,

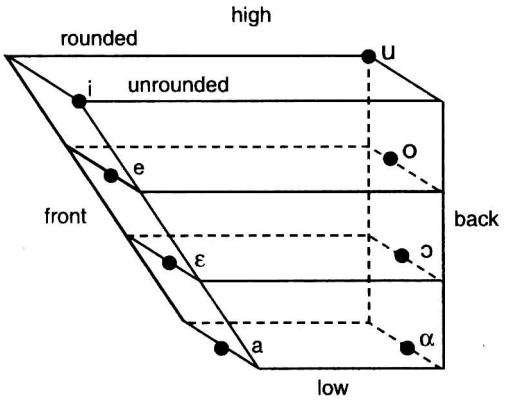

Figure 1 The dimensions of vowel quality.

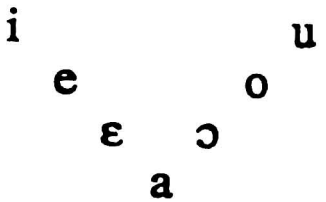

Figure 2 A schematic representation of Italian vowels.

for example, the vowels of Italian, which can be represented schematically as in Fig. 2. There may be four vowel heights; but each vowel also varies along the front-back dimension, and (although it is not apparent from the diagram) in the degree of lip rounding. Furthermore, the low vowel [a] does not contrast in the front-back parameter, and therefore provides little evidence for saying that there are more than three heights possible for front vowels or for back vowels.

Bearing this in mind, we will consider how many levels of height are used in the world's languages. Some linguists (e.g. Chomsky & Halle, 1968) have suggested that there are only three (although, of course, these linguists recognize other dimensions which they use for representing what we regard as simply variations in height). Jones's (1956) Cardinal Vowel scheme makes reference to four particular levels of the Height dimension, but has provision for more possibilities. The full set of vowel symbols recommended by the IPA (1989) implies that there are seven levels. We doubt that any language uses this full range; but there are clearly more than three levels of the auditory property Height.

Table I Contrasts illustrating four degrees of vowel height in Danish

vilə	*wild (pl)*	vi:lə	*rest*	vi:ðə	*know*
menə	*remind*	me:nə	*mean (vb)*	ve:ðə	*wheat*
lɛsə	*load*	lɛ:sə	*read*	vɛ:ðə	*wet (vb)*
masə	*mass*	ma:sə	*mash*	va:ðə	*wade*

Evidence for the possibility of more than three contrasting vowel heights comes from Danish, in which there are four front vowels that contrast simply in vowel height. Examples are shown in Table I. It is noteworthy that in each of these four vowel heights there is also a contrast between a short and a long vowel, which do not differ appreciably in quality. These vowels are even more interesting because it is quite clear that they are not equidistant. Uldall (1933) represents them as shown in Fig. 3. There is a much larger gap between the vowels represented here [ɛ] and [a] than there is between the vowels [i] and [e]. This raises the possibility that there might be a language with five vowel heights.

Traunmüller (1982) has suggested that the Bavarian dialect spoken in Amstetten, Austria, might be such a language. In his analysis this language has four front unrounded, four front rounded, and four back rounded vowels, in addition to the low central vowel [a]. Traunmüller conducted a controlled study in which he recorded a number of speakers of this dialect, and measured the acoustic characteristics of the 13 vowels so as to obtain an indication of the traditional height and backness values. The mean formant frequencies of eight of his speakers (as reported by Disner, 1983) are shown in Fig. 4. In this figure (as in all our vowel formant charts in this paper) the frequency of the first formant F_1, is plotted against the difference between the frequencies of the second and first formants, F_2–F_1. The frequency values are scaled so that equal distances along either axis more nearly correspond to equal perceptual distances (using the Bark scaling techniques proposed by Schroeder, Atal & Hall, 1979). The scale on the ordinate is double that on the abscissa, as, in our view, this gives appropriate prominence to F_1 and makes

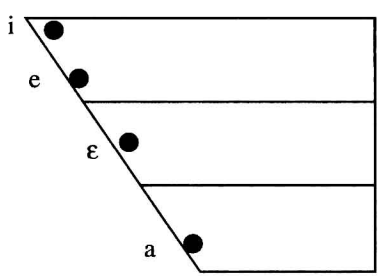

Figure 3 The relative phonetic qualities of the four front unrounded vowels of Danish, based on Uldall (1933).

the plots more in accord with the auditory judgments of professional phoneticians. The origin of the axes is to the top right of the plot. These plotting techniques (which are all incorporated in a computer program) produce vowel charts that are in good accord with traditional representations of vowels. We have not ourselves investigated the vowels of this dialect of Austrian German, and so we cannot say whether there are any other factors involved which might lead to it being possible to describe this language as having fewer than the five vowel heights that are apparent in Fig. 4.

All languages have some variations in vowel quality that indicate contrasts in the vowel height dimension. Even if a language has only two phonologically contrastive vowels, the differences will always be in this dimension rather than the front-back dimension. Thus in native vocabulary, the Chadic language Margi has /ɨ, a/ and the Australian language Arrernte (Aranda) has /ə, a/. Among the Caucasian languages, Ubykh and Abkhaz have only two phonological vowel heights, with the contrasts usually represented as /ə – a/ (Catford, 1977*a*). None of these two-vowel languages makes any phonological use of the front-back, or the rounding, dimensions. The same is true of some of the other Caucasian languages, such as Kabardian, which have three phonologically contrastive vowels (not zero, one, or two as suggested by Kuipers (1960), Anderson (1978), and Halle (1970) respectively).

In all these cases of languages that have only height differences, there are also very obvious allophonic differences in the front-back dimension, so that to the casual observer it might appear as if the language used a wider

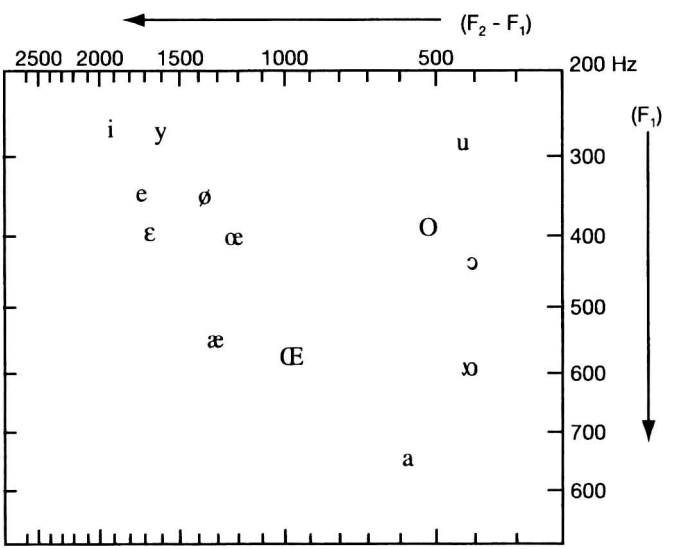

Figure 4 The mean formant frequencies of the vowels of eight speakers of the Amstetten dialect of Bavarian. (Data from Traunmüller, 1982.)

Table II Arrente vowel variations; column (1) is a phonological transcription of the two vowel system, column (2) is a narrow phonetic transcription of a recording, using current IPA symbols and diacritics (International Phonetic Association, 1989), in which an underline indicates retraction, and superscript cross indicates centralization

	(1)	*(2)*
elder brother	kakə	kakɐ
cut	akəkə	akəkɐ
head	kapəɭə	kapəɭʌ
frog	ancəcərə	əncɪcɛ̆rɐ
nasal mucus	təŋkʷəlkŋə	təŋkʷʊlkŋʌ

range of vowel qualities. Table II shows, in the first column, a phonological transcription of some words in Arrente, illustrating the two constrastive vowels. The next column shows a narrow phonetic transcription of these words, giving an indication of the surface phonetic qualities.

As another example, Fig. 5 is a formant plot of the allophones of some Kabardian vowels analyzed by Choi (1990). As is shown by the location of the points on the chart, this language has a wider range of vowel qualities

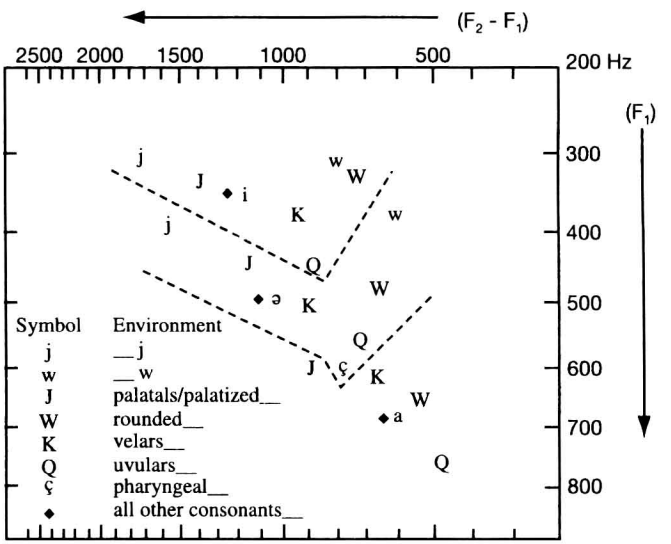

Figure 5 Mean formant frequencies of the three Kabardian vowels in different contexts as produced in connected speech by three speakers (from Choi, 1990). The symbols indicate the formant frequencies of the steady state portion in the contexts shown.

than is indicated by the use of just three symbols that represent only differences in vowel height. In Kabardian all these different qualities are predictable allophones of the three vowels, /ɨ, ə, aː/. It is also clear, as Choi (1990) points out in discussing this analysis, that Catford (MS) (and many Soviet linguists) are correct in recognizing /a/ as a third vowel. In Choi's view /aː/ is a long vowel, but it is a separate phoneme, and cannot be considered to be an allophone of /ə/ as suggested by Kuipers (1960) and Halle (1970).

3 Front–back variations in vowels

The languages of the world make much more limited use of the front-back and rounded-unrounded dimensions, which usually support no more than binary oppositions. There are not many cases of a language with three vowels that contrast just by being front, central and back, with all other features remaining the same. One possibility is Nimboran, a Papuan language. Anceaux (1965) describes this language as having six vowels which he symbolizes /i,e,a,o,u,y/. He notes that "all vowels are unrounded and voiced. They contrast in tongue height and tongue placement". The vowel /i/ "is a voiced high close front unrounded vocoid". His /y/, for which he says "the symbol . . . has been chosen quite arbitrarily and for practical reasons only", he describes as "a rather tense voiced high close central unrounded vocoid". We would transcribe this vowel as [ɨ]. He describes his [u] as "a voiced high close back unrounded vocoid", which we would transcribe as [ɯ]. It would therefore appear as if there were three high unrounded vowels contrasting only in backness in this language. Examples (from his data, but in our transcription) are shown in Table III.

Another language which can be said to have a three-way contrast in the front-back dimension is Norwegian, which is described by Vanvik (1972) as having three high rounded vowels, as shown in Table IV. Consideration of a number of very different cases, such as Ngwe and Norwegian, leads us to conclude that it is probably appropriate to recognize a front-back dimension containing three major phonetic categories: [front], [central] and [back]. There are also phonological reasons for saying that in languages with five

Table III High vowels in Nimboran (based on Anceaux, 1965)

Front	*Central*	*Back*
di	'und ɨ	dɯ
wood	*banana*	*child*
ki	k ɨ	kɯ
woman	*faeces*	*time, day*
kip	k ɨp	'pak ɨp
fire	*lime*	*lid*

Table IV Contrasting front, central and back rounded vowels in Norwegian

	Front	*Central*	*Back*
High, rounded	by: *town*	bu: *shack*	bu: *live*

vowel systems, and in many of those with seven vowel systems, the lowest vowel is neither front nor back, and should be regarded as central. This is often the position taken in descriptions of the vowels of Italian shown in Fig. 2. It is arguable that a similar situation obtains in English with respect to the starting points of the diphthongs in *high* and *how*. Despite the rules in Chomsky & Halle (1968), for many people these diphthongs have the same, or very similar, starting points. A generalization is lost if the inadequacies of the feature system do not allow one to say that both these diphthongs start with a low central vowel.

A rather unusual acoustic correlate of the front-back parameter occurs in a variety of /i/ in Swedish, which differs from the more usual varieties of [i] in that it is made with the constriction even further forward. This effect can be achieved by slightly *lowering* the body of the tongue while simultaneously raising the blade of the tongue (Ladefoged and Lindau, 1989), and we suggest that this may occur in the usual Stockholm Swedish pronunciation of these vowels. Acoustically they are characterized by having a very high F_3, and an F_2 which is *lower* than that in [e].

4 Rounding

The great majority of the world's languages have a predictable relationship between the phonetic Backness and Rounding dimensions. Front vowels are usually unrounded and back vowels are usually rounded. However, as shown above for Bavarian German, front vowels with a rounded lip position also occur. In addition, back vowels without lip rounding can be found, sometimes simply because a language has relaxed the linkage between Backness and Rounding (as for the high back vowel of Japanese), but also on occasion because rounded and unrounded vowels are independently contrastive within the class of back vowels, as in the Turkic languages Chuvash and Yakut.

Rounding and Height are also related in that higher vowels are usually more rounded than lower vowels. There are exceptions to this relationship. In Assamese there are two low back vowels with very similar formant frequencies, as can be seen in Fig. 6. In this word the second vowel, here designated as [ɔ], is a low back vowel fairly similar to the cardinal vowel [ɔ]. The first vowel, which we have transcribed with the symbol [ɒ̝], appears to have the tongue position of the low back cardinal vowel [ɑ], but a much closer lip