CONTRAST, VARIATION, AND CHANGE IN NORWEGIAN VOWEL SYSTEMS

by

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For Jan, Millie, and David.

I wish you were here.

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ABSTRACT

How languages organize sounds in the speech signal into meaningful categories — and if salient differences in that signal constitute different categories — is a fundamental issue in linguistics. Because of its wide-ranging dialectal diversity, along with changing social patterns brought on by relatively recent economic prosperity, Norwegian provides an appealing test case to investigate the relationship of and interactions between phonetics and phonology and the ways in which phonetic patterns are influenced socially. Previous work in general Norwegian phonology and phonetics has focused largely on the Oslo dialect. Little attention has been paid to fine-grained variation in other Norwegian dialects, although there has been considerable investigation into dialectal patterns in segmental inventories from both synchronic and diachronic perspectives. This dissertation addresses these issues by examining regional and social variation in Norwegian vowel categories and productions.

This research draws on phonological theory and sociophonetic methods to investigate the extent to which Norwegian vowels' phonological representations can capture social variation of acoustic features. Using data gathered from sociolinguistic interviews, the dissertation examines vowel productions from twenty-eight Norwegian participants who provide a cross-section of the dialectal variation in Norway. I adopt a framework in which the phonological component of the grammar consists of features that only mark language-specific contrasts. Additional articulatory and acoustic information is then filled in, often as salient social markers, in subsequent components, or levels of representation.

The analysis focuses on broad dialectal differences in vowel productions and a sociophonetic investigation of three vowels in the Long Back-Vowel Chain Shift (LBCS), a diachronic change that distinguishes Norwegian — and Swedish — from other Germanic varieties. The results are consistent with a uniform phonological structure of Norwegian vowels and provide insight into how social categories influence the phonetic properties of that structure. This dissertation offers a step forward in unifying phonological theory with sociophonetic considerations by specifying the ways in which various socially differentiated variations and changes-in-progress affect representational systems in phonology.

Chapter 1: Introduction

In this dissertation, I investigate phonetic and phonological patterns in Norwegian vowel systems by interpreting North Germanic sound changes and contemporary dialectal and sociophonetic variation. Drawing on qualitative and quantitative analyses of Norwegian vowel data, I explore how these outcomes and processes inform our understanding of the relationship between representational systems in phonology and socially indexed phonetic variation.

How languages organize sounds into meaningful units is a fundamental issue in linguistic theory and the cornerstone of my investigation of contemporary Norwegian vowel systems (Modern Norwegian). Languages differ not only in the size and compositions of their sound inventories, but also in the ways in which they categorize distinctions between sounds, i.e., how the members of their sound inventories CONTRAST with each other in a given language. John Goldsmith explains:

> Phonologists find it crucial to be able to represent differences of sound that can be used in a language to distinguish distinct lexical items or distinct grammatical items and categories. It is necessary to say that the differences of sound are used to refer to either distinct lexical *or* distinct grammatical items because not *all* differences need be distinguished in the formalism. (Goldsmith 1995:9–10, original emphasis)

Linguistic systems do not need to represent all the ways in which sounds differ, but only the ways that impart the information necessary for speakers' grammatical and lexical purposes. Some characteristics of sounds often occur as groups, where the presence of one feature is a predictable result of the presence of another. For example, in many languages back vowels are round whereas front vowels are not. In these cases, the presence and absence of rounding may be predictable based on the vowels' horizontal place features, or their place features may be predictable based on the presence and absence of rounding. How languages represent the distribution of features in a formal system requires an analysis of that system as a whole.

Although there appear to be consistent patterns of predictable feature combinations across languages, recent literature has increasingly focused on language-specific arrangements of features into phonological representations (e.g., Dresher 2009). A central insight from this line of research is that separate languages may share the same — or a similar — inventory of sounds yet differ in how those sounds interact in phonological alternations. Southern US English and French, for example, both have fully voiced stops, but only French has voicing assimilation; in Southern US English, the aspirated, not the voiced, obstruents induce assimilation (e.g., Salmons forthcoming). The fact that voicing is phonologically active for French, but aspiration for English, indicates that the two languages differ in their representations of laryngeal contrasts. To account for these types of patterns, Dresher (2009) proposes that contrastive features are assigned to phonemes in an ordered hierarchy, i.e., a contrastive hierarchy, and that a language's phonological activity is the primary metric for evaluating its representational system (see §3).

Because not all distinctions between sounds are phonological (i.e., contrastive), a considerable amount of research has concentrated on describing the interfaces between distinctive sound categories and their surface forms (e.g., Keating 1996; Keyser & Stevens 2006; Hall 2011; Purnell & Raimy 2015). This and similar work posits that non-distinctive features are introduced at sub-phonological levels of representation. Key to this position is the observation each level of representation has its own properties: Phonology, on the one hand, is symbolic and categorical and phonetics, on the other hand, is gradient and continuous (Keating 1996:263). A sound system that is composed of multiple domains — or modules — formalizes the different roles that features have: Whether they distinguish lexical and grammatical items, participate in alternation patterns, or are predictable and dependent on the presence of other features (see §3). Therefore, a strength of a modular sound system is that it models the ways in which languages may differ phonologically, but with similar surface forms. In the French and Southern US English example, the feature for voicing is distinctive and present in the French phonological representations (phonologically SPECIFIED), however it enters Southern US English at a different module (phonologically UNSPECIFIED).

The marking of phonological contrasts as specified or unspecified supposes privative features. That is, either a feature is present for a given set of phonemes or there is no feature at all. This position is in contrast to theories that operationalize binary features, in which phonemes are marked by positive and negative feature values, e.g., [+voice] or [–voice]. A binary model would require Southern US English obstruents to be specified as [+voice]; Northern US English obstruents, which are not fully voiced, would be [–voice]. However, a framework that adopts binary features cannot, in this case, model the fact neither regional variety of US English has active voicing assimilations and that the aspirated series induces assimilations in both. Based on these and other considerations (§3.1), I adopt model of privative features proposed in Iverson & Salmons (1995) and developed in Avery & Idsardi (2001) as the basis for marking phonological contrasts in a hierarchical system.

Another upshot of this model is that it allows both flexibility and specificity for analyses of dialectal and sociophonetic variation. That is, a uniform phonological system can describe multiple varieties of a single language if surface-level differences occur at a sub-phonological level of representation. Through a phonological analysis of a language and a comparison of variation with respect to various social categories, one can evaluate whether differences amount to competing sets of distinctive sound categories (i.e., separate phonological representations), or to variations in how features enter a single system and are indexed socially. In this dissertation, I undertake that type of investigation for Norwegian vowels, drawing on historical and contemporary phonological patterns and acoustic analysis of vowel productions from interviews conducted with Norwegian consultants.

There is a long tradition of research in dialects across Norway, which has produced rich and detailed descriptions of regional and local varieties. Furthermore, there has been considerable sociolinguistic study on the distribution and spread of phonological, morphological, and syntactic variables (see Sandøy 1996). Gjert Kristoffersen's *The Phonology of Norwegian* (2000) provides the most thorough phonological analysis of Norwegian, but it focuses on the Urban Eastern Norwegian (UEN) variety spoken around Oslo, the country's capital and largest city. Whether or not other Norwegian varieties diverge from UEN vowel patterns — and if there are differences, whether they owe to disparities in the sound categories themselves or in how those categories are pronounced — has, to my knowledge, not been investigated. To explore this question, I test the following hypothesis:

Hypothesis 1: There is a single set of phonological representations for Norwegian vowels, i.e., dialectal differences are phonetic and not phonological differences.

Although the evaluation of this hypothesis rests on an analysis and comparison of vowel acoustics across dialects, similar acoustics alone do not support the same phonological system. Rather, it is the analysis of the relationships between those patterns and the representational system that will support or reject *Hypothesis 1*. A principal trait of phonological features is that they are assumed to be categorical (e.g., Keyser & Stevens 2006; Hall 2011); the absence of a feature from surface forms suggests its absence from the phonological representations (see §3). Therefore, *Hypothesis 1* is supported if all attested acoustic patterns comport with predictable surface-level outcomes of phonological representations (see §3) and rejected if they do not.

The second hypothesis I test considers how the framework of a modular sound system captures sociophonetic variation: Does the sociophonetic evidence support separate levels of representation that operate on distinct types of units? Based on the assumption that phonological specifications are categorical and unspecified features are gradient (Keating 1996; Keyser & Stevens 2006; Hall 2011), the strong hypothesis is that phonological 'categoricity' results in phonetic invariance and that only unspecified features will show social and stylistic variations (*Hypothesis 2a*). Support for this hypothesis calls into question the position that levels of representation are distinct, (semi)autonomous domains, and instead provides evidence in favor of a linear relationship between phonological representations and their surface forms.

Hypothesis 2a: Phonologically specified features will not vary significantly.

An alternative, however, is that the phonological representations specify broad instructions for the phonetic implementation of a sound category or, with respect to vowels, a region in the vowel space that is influenced by each phoneme's relationship to other members of the system as a whole (see §3). Therefore, significant phonetic differences may occur for a specified feature yet still fall within the phonetic space that is delineated by that phonological category. In other words, phonological categoricity does not produce phonetic invariance. In this regard, qualitative assessments of vowel systems provide context for the acoustic data I use to evaluate whether statistically significant variations preserve or obscure contrasts within the system. Differences in speaking style, for example, may be due to an intensification of the phonetic outputs of phonological categories in acoustic space while a speaker is engaged in the formal exercise of reading. If comparisons of vowels in wordlists and vowels in conversations (see §4) support this, then such significant differences should be understood as variations in the space of a single category defined across two dimensions (vowel height and vowel advancement). Similar types of variation may, then, occur with respect to region, gender, or other social categories. A sub-hypothesis can be expressed as follows:

Hypothesis 2b: Statistically significant phonetic variations are not incompatible with phonological categoricity.

In other words, statistically significant variations do not necessarily suggest unspecified phonological representations. Rather, such variations reveal fine-grained detail about how those abstract mental categories, represented by underspecified phonological contrasts, are realized for social and contextual purposes. Results that support *Hypothesis 2b* suggest truly distinct phonological and phonetic systems and variables, and that phonetic variables yield insight into (socio)phonetic processes, but do not provide evidence for phonological representations. Although there is certainly a relationship between the two systems and their processes, confirmation of *Hypothesis 2b* would indicate that a complete understanding of the sound system of a language requires analyses of both, and that an account of one system does not necessarily hold for the other. Therefore, substantiation of *Hypothesis 2b* is consistent with the model that the sound system operates over a set of interconnected modules with their own representations.

The remainder of this dissertation is structured as follows. I situate contemporary Norwegian dialects within historical patterns of North Germanic vowels to compare and contrast regional and local Norwegian varieties, broadly construed, based on inherited sets of sound changes in §2. This chapter provides context for evaluating variations in the spoken Norwegian data, specifically whether they reflect the use of competing lexical forms that owe to previous developments in the language or show evidence of differences regarding their sound systems, be they phonological or phonetic in nature.

In §3, I consider the theoretical framework with which I analyze sound patterns in the data. I draw heavily on the model of Modified Contrastive Specification (MCS; Glyne, Piggot & Rice 1994) and a modular sound system with distinct levels of representation (Purnell & Raimy 2015) to propose phonological representations that describe the Modern Norwegian vowel system. My arguments make use of a structural analysis of sound changes in North Germanic and Norwegian, particularly splits, mergers, and chain shifts, building on analyses in Oxford (2015). I assume throughout a generally stable contrastive hierarchy of phonological features (e.g., Purnell, Raimy & Salmons forthcoming) and that structural changes tend to occur with respect to features at the bottom of the hierarchy. Developments from Old Scandinavian to Norwegian, however, show evidence of feature reordering. I, therefore, propose two hypotheses for evaluating structural changes in contrasts in §3.3.2. Finally, I explain Modern Norwegian levels of representation in §3.3.3 and offer an initial attempt at refining the theory to capture how features that serve different functions enter the sound system.

In §4, I discuss the methodological procedures for collecting, processing, and analyzing vowels in Norwegian speech. Data were collected via semi-structured sociolinguistic interviews and a wordlist production task and selectively transcribed to focus on stressed monophthongs. I also outline the quantitative procedures, along with the social factors and acoustic variables, I use to evaluate vowel patterns. Because the data are not uniformly distributed across social categories or vowel tokens, I use nonparametric statistical tests throughout.

I present the results in the next two chapters. In §5, I evaluate the extent to which the phonological representations I propose in §3 describe dialectal patterns in the data, which addresses *Hypothesis 1*. I begin with an analysis of deviations from target vowels in the wordlist task, followed by a qualitative assessment of the relative positions of vowels in acoustic space based on dialect. I continue with a discussion of the evidence for Modern Norwegian phonological representations, with particular emphasis on vowels whose phonological status is in question (/æ, ɵ/) and on vowels that show the clearest regional variations (/e, ɑ/).

In §6, I focus on the sociophonetic variations of three long vowels, /o, u, ʉ/, because of their participation in a Long Back-Vowel Chain Shift (LBCS) that is one of the major characteristics of Modern Norwegian. I examine the regional patterns of these vowels and the ways that their acoustic parameters vary with respect to speaking style and gender. The analysis in this chapter speaks to the second set of hypotheses (*Hypothesis 2a* and *Hypothesis 2b*) regarding the relationship between phonological features and acoustic patterns.

Finally, I conclude in §7 with a full evaluation of the hypotheses above. I proceed with a discussion of the impacts that these results have on phonological theory and language variation and change. I offer suggestions for further research to enhance the insights that studies on phonetic changes-in-progress have for our understanding of phonological representations and how those representations change over time.

This dissertation contributes to the breadth of literature on Norwegian dialectology by adding fine-grained phonetic detail to descriptions of regional varieties. I explore the impact that sociophonetic variation has on phonological representations and the benefits of interpreting that variation in the framework of an underspecified phonological system of contrasts. Accordingly, this study offers a way forward for strengthening and unifying phonological and (socio)phonetic approaches to language and speech.

Chapter 2: Norwegian Vowel Systems

Norwegian dialects fall broadly into one of two categories: Western Norwegian (*vestnorsk*) and Eastern Norwegian (*østnorsk*) (Skjekkeland 2005:157; Hanssen 2010:118), which descend from a west/east split in Common Scandinavian dating as far back as the Middle Ages (see §2.1.1). Although Common Scandinavian should "betraktes som en abstraksjon og forenkling av den språkelige virkeligheten" (Schulte 2008:169; see also Barnes 2007) [be regarded as an abstraction and simplification of the linguistic reality],[1] modern Norwegian is a legacy of these early Scandinavian variations that tend toward one end of the east-west spectrum. These abstractions are therefore useful for situating contemporary Norwegian dialect patterns in historical context.

Subsequent linguistic changes within West and East Norwegian further categorize regional dialect areas: The Eastern group consists of Eastern Norwegian and Trøndsk (alternatively *Trøndersk*) and the Western group of Western Norwegian and Northern Norwegian (Skjekkeland 2005:157; see Figures 2.1, 2.2 for a map with the Norwegian counties referenced throughout). Because southern varieties undergo different consonantal processes (e.g., lenition), they are sometimes considered their own subgroup, Southwestern Norwegian, although usually classified with Western Norwegian. I discuss Southwestern Norwegian as a part of Western Norwegian in this chapter.

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[1] Translations are my own unless otherwise indicated.

Figure 2.1. Norwegian dialect areas (source: https://www.ntnu.edu/now/intro/background-norwegian).

Figure 2.2. Norwegian counties (source: http://www.foreningenfredet.no/norgeskart-klikkbare-fylker.5326191.html).

Norwegian does not have an officially recognized standard pronunciation, and for many the canonical variety is represented in the pronunciation of the upper-class in the capital of Oslo, what Gjert Kristoffersen calls Urban East Norwegian (UEN). Although I do not see UEN as being representative for Norwegian generally, it is useful as a reference variety. I therefore use Endresen's (1991) and Kristoffersen's (2000) descriptions of UEN vowels as a point of comparison to discuss general patterns and regional and dialectal variations. In the following section, I consider pertinent aspects of vowel diachrony to present some general characteristics of Norwegian vowel systems (§2.1). I follow with an assessment of the broad regional vocalic characteristics in Eastern Norwegian and Western Norwegian with additional comments on

Trøndsk, as well as Southwestern and Northern varieties (§2.2). In each of these sections, I expand on the features that are prominent in the urban centers of Oslo and Trondheim, Bergen, and Stavanger. I close with a summary of Norwegian vowel properties (§2.3).

2.1 Inherited vowel patterns

In this section I consider historical North Germanic vowel patterns that contribute to variability in modern Norwegian. I discuss phonemic correspondences with respect to two socio-historical factors. First, Norway forms the geographic and isogloss boundary where East Scandinavian innovations meet with the more conservative West Scandinavian forms. Second, structural changes that spread throughout Norway — including a regulation of syllable weight, vowel harmony effects (*jamning*), and a back-vowel chain shift — differ in their outcomes. I elaborate on these processes and their impacts on modern Norwegian vowel systems in §2.1.1 and §2.1.2, respectively. I first outline the relevant phonological facts for the Common Scandinavian proto-language to prepare the following discussion of their changes — both regular and irregular — that contribute to the linguistic diversity of modern Norwegian.

The vowel system of Common Scandinavian consisted of phonemically short and long vowels and diphthongs. It doubled the five Proto-Scandinavian monophthong phonemes /i, e, u, o, a/ (both long and short) through i-umlaut, in which back vowels were fronted before /i, j/, and u-umlaut, where unrounded vowels were labialized before /u, w/ (Haugen 1976:152; 1982:31; Barðdal et al. 1997:31–33). The breaking of short /e/ before the back vowels /a/ and /u/ introduced the new diphthongs /ia/ and /iǫ/, respectively (Haugen 1982:33). Furthermore, the diphthong /ø̨y/ emerged from the u-umlaut of /ęi/ (</ai/) and the i-umlaut of /ǫu/ (</au/; Haugen

1982:32–3). The Common Scandinavian vowel system is represented in Figure 2.3; it should be noted that some scholars (i.e., Barðdal et al. 1997) exclude the low-round front vowel /ø̨/.

a. <u>Short</u>

i	y		u
e	ø		o
ę	ø̨		ǫ
		a	

b. <u>Long</u>

ī	ȳ		ū
ē	ø̄		ō
ę̄	ø̨̄		ǭ
		ā	

c. <u>Diphthongs</u>

	iu	
ia		iǫ
ęi	ø̨y	ǫu

Figure 2.3. The vowels of Common Scandinavian.[2]

Not all of these vowels were equally stable. Long and short /ø̨/ merged with long and short /ø/ and /ǫ/, contingent on several contextual and dialectal factors, and the /ę/ vowels diverge depending on length and region (Haugen 1982:39). Additionally, the high (falling) diphthongs (/iu, ia, iǫ/) underwent a stress shift from the first to the second member of the diphthong, resulting in a monophthong followed by the semivowel /j/, leaving the language again with the three rising diphthongs /ęi, ø̨y, ǫu/ (Haugen 1982:36, 39). Although tracking these vowel patterns comprehensively through time and space is outside the scope of this dissertation, it is important to underscore that the language had doubled its vowel inventory, and that this system has been in various states of flux up to — and including — the present day.

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[2] Common Scandinavian had nasal long vowel phonemes that merged with their non-nasal counterparts (Hreinn Benediktsson 1959:293). Because the earlier nasal set does not inform later vowel changes I exclude them from the present discussion.

2.1.1 Where East meets West: Early differences that survive today

The first split in the North Germanic languages dates approximately to the Viking Age (ca. 750–1050), when Old West Scandinavian and Old East Scandinavian began to show separate phonological and morphological patterns (Haugen 1982:9–10). The West Scandinavian area comprised most of Norway and extended to Iceland, the Faroe Islands and other Atlantic Norwegian settlements; the East Scandinavian region covered Denmark, Sweden, and neighboring sections of Norway (Haugen 1976:92). Old Norse was the written language of Norway from 1150 to 1370 and of Iceland from 1150 to 1540 (*ONP Prøvehæfte* 1989:xi), and is therefore a normalized version of Old West Scandinavian (Barnes 2008:1–2) that I use for comparative purposes in this chapter.

These two North Germanic divisions, with their accompanying isoglosses, meet in present-day Norway, and many modern Norwegian varieties present an amalgamation of both Western and Eastern forms depending on geographical, social, and historical factors. The fact that Norway is the boundary for Old West and Old East Scandinavian is further represented through their two officially recognized Norwegian writing standards.[3] Bokmål 'book language' is a Norwegianized version of Danish and is most closely based on the upper-class speech of Oslo and the surrounding area of Southwestern Norway (Vikør 2001:57). Danish was the official written language in Norway from the 16th to the 19th centuries because Norway had been united with Denmark from 1536 to 1814 after Sweden left the Kalmar Union (est. 1397) in 1523. Nynorsk 'New Norwegian,' on the other hand, is a written norm that linguist Ivar Aasen developed in the 1840s through the comparative analysis of a number of Norwegian dialects, and is most closely related to Western Norwegian varieties (Vikør 2001:55, 57). These dialects

[3] I specify "Norwegian" writing standard because Sámi is also an officially recognized language in Norway.

tended to be the most isolated from Danish influence and therefore thought by many to be more 'Norwegian' than Bokmål. While Nynorsk is West Scandinavian in form and vocabulary, Bokmål is not monolithically East Scandinavian. It contains typical Norwegian characteristics that distinguish it from Danish and allows some degree of optionality regarding West and East Scandinavian forms to accommodate the speech of its writers. Finally, Nynorsk is strongest among the rural communities in Western Norway, and Bokmål is used most consistently in Eastern Norway and urban centers, including cities in the west. Because of this distribution, Bokmål is the more widespread of the two written norms.

One of the earliest differences between East and West Scandinavian is the East Scandinavian lowering of long /u/ to /o/ (Haugen 1982:35), as in the respective Nynorsk and Bokmål pairs: *tru~tro* 'believe' and *bu~bo* 'live, dwell.' Despite this variation, Norwegian did not regularly extend this pattern to the extent that Swedish and Danish did: Norwegian *ku* 'cow' and *bru* 'bridge' show the retention of old long /u/, where Swedish and Danish *ko* and *bro* reflect the lowered vowels. Furthermore, many of the variants with /u/ are optional in Bokmål. This optionality, however, does not mean that /u/ and /o/ are in free variation; both vowels are contrastive in all Norwegian varieties, as illustrated with the minimal pair *du* 'you sg.' and *do* 'toilet.' The alternations between old long /u/ and /o/ are neither regular nor systematic in Norwegian, and there is a great deal of individual variation in the selection of one of these pairs (I examine this point further in §5.1.1).

An additional early change that crept into Norwegian, also with inconsistent results, is the East Scandinavian breaking of /y/ > /ju, jo/ (Haugen 1982:35–6). Like the lowering of old long /u/ to /o/, the breaking of /y/ did not affect Norwegian as extensively as Swedish and Danish and appears only to have variably targeted the more restricted liquid environment. The vowel in Old

Norse *skyrta* 'shirt' breaks into Norwegian *skjorte* (<*skjurta*; cf. Swedish *skjorta*) — however not in *dyr* 'animal' (cf. Swedish *djur*) nor before the velars in *synke* 'sink' and *synge* 'sing' (cf. Swedish *sjunka* and *sjunga*). Both Bokmål and Nynorsk have /y/ breaking before some liquids, indicating at least the partial adoption of a prototypical East Scandinavian innovation throughout Norway.

The /ju (jo)/ and /y/ pairs show further synchronic variation of lexical items due to the presence or absence of the later progressive j-umlaut (/ju/ > /y/), where vowels are fronted after /j/, and /ju/ merges with /y/ (Haugen 1982:37). Both *syk* and *sjuk*, for example, are attested forms for 'sick' in Norwegian. This change affected the modern Scandinavian languages to varying degrees: Swedish appears to be the least affected; many /ju/ sequences are preserved (cf. *sjunga* 'sing' and *tjugo* 'twenty'), although fronting occurs with other vowels, as in *mjölk* 'milk' (<*mjolk*) and *hjärta* 'heart' (<*hjarta*). On the other hand, Danish shows the most regularity regarding progressive j-umlaut; almost every non-initial /ju, jo/ sequence became /y/ (Haugen 1982:50–1; Barðdal et al. 1997:233–4). Like other diachronic changes, these patterns emerge variably in Norwegian. The previous example *sjuk* 'sick' is a non-umlauted form, whereas *syk* shows the assimilation of old /ju/ to /y/. Additional examples include *ljos~lys* 'light,' *tjukk~tykk* 'thick,' *tjuv~tyv* 'thief,' and *mjuk~myk* 'soft.' The variants with /ju/ or /jo/ are codified in Nynorsk, and the variants with /y/ typify the Danish influence on Bokmål.[4] *Lys*, however, is the only mandatory umlauted form in Bokmål and the only umlauted alternative listed here that is accepted in Nynorsk (Språkrådet 2017). Variation between forms with and without progressive j-umlaut further reflect the competition and negotiation between West Scandinavian and East Scandinavian patterns in modern Norwegian.

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[4] Early versions of Nynorsk had more conservative forms such as *bjoda* 'offer (v.),' *krjupa* 'creep (v.),' and *fljuga* 'fly/flyge (v.)' that have given way to umlauted *by*, *krype*, and *flyge/fly*, respectively (Haugen 1982:47).

Possibly one of the sharpest differences between East and West Scandinavian is the treatment of the diphthongs /ęi/, /ǫu/, and /ø̨y/ (modern /ei/, /au/, and /øy/, respectively). Again, West Scandinavian tends to be the more conservative of the two, and preserves these diphthongs, where East Scandinavian monophthongizes them: /ęi/ > /e/, /ǫu/ > /ø/, and /ø̨y/ > /ø/ (Haugen 1976:200; 1982:37). The East Scandinavian monophthongization area covers all of Denmark, most of Sweden — excluding the far north and some districts that border the northern portion of Norway's Trøndelag region — and parts of Eastern Norway and southern Trøndelag (Haugen 1976:200–1, Map 9). Like the other alterations between West and East Scandinavian patterns in Norway, monophthongization is incredibly variable with respect to its spread and adoption. Some lexical items retain the diphthongs: *øy* 'island' and *hauk* 'hawk' (cf. Iceland *ey*, *haukur*, Swedish *ö*, *hök*, and Danish *ø, høg*); some represent dialect differences with diphthongal variants adopted in standard Nynorsk and monophthongal equivalents in Bokmål: *løype~løpe* 'run (v.)' and *audmjuk~ydmyk*[5] 'humble' (cf. Icelandic *hleypa, auðmjúkur*, Swedish *löpa, ödmjuk*, and Danish *løbe, ydmyg*); and finally some monophthongs enter into (Eastern) Norwegian as optional variants: *veit~vet* 'know (PRES)' and *stein~sten* 'stone' (cf. Icelandic *veit, steinn*, Swedish *vet, sten*, and Danish *ved, sten*). West Scandinavian and East Scandinavian historical patterns meet in Norway and are adopted and diffused across the country in various ways. Some speakers may tend toward one direction or another in the selection of monophthongal or diphthongal variants, and even the most conservative speakers in Western Norway recognize the correspondences between the two types of forms through their exposure to Eastern Norwegian on national television and radio, and the unavoidable presence of Bokmål in the print media.

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[5] The /y/ in *ydmyk* is raised from /ø/; both forms derive from Old Norse *auðmjúkr*. These forms also differ in the application of progressive j-umlaut.

The three vowel-related differences between East and West Scandinavian covered here characterize contemporary Norwegian varieties, but they are not the only examples of Norway's negotiation between its West Scandinavian linguistic roots and its historical and cultural affiliation with its Danish and Swedish neighbors to the east and south. This contact produced, of course, additional phonological, morphological, and lexical variations in Norwegian (see Haugen 1976; 1982; Sandøy 1996; Barðdal et al. 1997; Skjekkeland 2005; Dahl 2008; and Hanssen 2010), and these structural changes resulted in further dialectal differences.

2.1.2 Norwegian today: Quantity regulation, metaphony, and chain shifting

In this subsection, I analyze the changes in syllable weight and back vowel quality that ushered in a host of structural changes in the vowel systems of modern Norwegian varieties. I first present the process by which the types of Common Scandinavian syllables were reduced in Norwegian, and the effect this had on vowel length and a process similar to vowel harmony known as 'metaphony' (*jamning*). I follow with a discussion of a chain shift that targeted the long back vowels and investigate the results of these two processes.

Common Scandinavian allowed three different syllable weights: short, long, and overlong (Haugen 1982:24–5; Küspert 1988:148; Barnes 2008:13; Skjekkeland 2005:38–9). Short syllables are comprised of a short vowel and a single consonant: V̆C; long syllables may be a long vowel in an open syllable or followed by a single consonant: V̄(C), or a short vowel preceding two consonants or a geminate (double consonant): V̆CC/C̄; and an overlong syllable consists of a long vowel with two consonants or a geminate: V̄CC/C̄. The Old Norse words *skip* 'ship' and *skyn* 'understanding' both have short syllables. *Fá* 'get (INF)' and *hús* 'house' both have a long syllable, the former with a with a long open vowel, and the latter with a long vowel and a consonant. An example of a long syllable consisting of a short vowel followed by two consonants is *ǫnd* ‘breath,’ and one of a short vowel followed by a geminate is *þakk* ‘thanks.’ Finally, the words *nótt* ‘night’ and *lítt* ‘little’ represent overlong syllables.

Between ca. 1250 and 1550, most Scandinavian dialects underwent a quantity regulation, in which all stressed syllables became long (Haugen 1976:258–9). This restructuring incurred varying consequences. Although the vowels in overlong syllables were typically shortened, either the vowel or the consonant was lengthened in the short syllables. In sum, these changes “affected all the Sc[andinavian] languages and radically altered the syllable structure as well as the function of vowel quantity” (Haugen 1976:206). Words like the Old Norse examples presented above have been restructured to conform to modern Norwegian’s requirement for a long syllable, as in Figure 2.4. Except for *v* and final *m*, Norwegian orthography reflects the long/short vowel distinction with a single consonant after long vowels, and multiple after short.

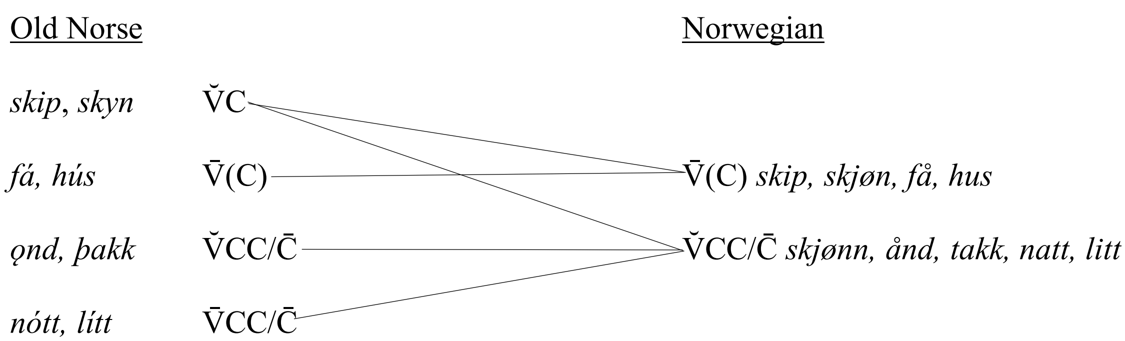

Figure 2.4. Quantity regulation in Norwegian (adapted from Küspert 1988:148).

The results of quantity regulation in short syllables present variably both across languages and dialects. Norwegian and Swedish each have reflexes of former short syllables with lengthened vowels and consonants, but they sometimes differ in strategy. Old Norse *skip* ‘ship’ occurs with a long vowel as *skip* in Norwegian, but with a short vowel and geminate as *skepp* in

Swedish. However, the languages take the opposite strategy with Old Norse *kyn* 'kin; modern sex, gender.' Norwegian retains the short vowel in *kjønn*, where Swedish lengthens it in *kön*. Norwegian *kjøn* 'wise, bold' with a long vowel derives from Old Norse *kǿnn*. Finally, for Old Norse *skyn* 'understanding,' Bokmål requires *skjønn* with a short vowel, but Nynorsk permits the form *skjøn* with a long vowel. Other doublets include *tall~tal* (<*tal*) 'number,' *kjøtt~kjøt* (<*kjǫt*) 'meat,' and *komme~kome* (<*koma*) 'come.'

Further variation in the Norwegian treatment of old short syllables appears in East Norwegian dialects that have a *jamvektregel*, or vowel balance rule (lit. "equal weight rule"), that "har blitt rekna som eit hovudkriterium på om dialekten skal reknast til det austnorske eller vestnorske målområdet" (Skjekkeland 2005:51) [has been regarded as a primary criterion for whether a dialect is included in the East Norwegian or West Norwegian dialect area]. Helge Sandøy explains *jamvekt*:

> Det gamle germanske trykkmønsteret var å legge hovudtrykket på rotstavinga i ordet: *bíta* /ˈbiːta/ og *vera* /ˈvera/. Men i norrøn tid fikk dialektene austafjells, i Trøndelag og Nord-Sverige ei særutvikling ved at ord med to korte stavingar etter kvarandre fikk jamt trykk på begge desse stavingane – altså *jamvekt*: *vera* /ˈveˈra/, mens derimot f.eks. *bíta* heitte /ˈbiːta/ som før. (Sandøy 1996:155)
>
> The old Germanic stress pattern was to place the main stress on the root syllable in the word: *bíta* /ˈbiːta/ ['bite'] and *vera* /ˈvera/ ['be']. But in the Old Norse period there was an innovation in the dialects east of the mountains, in Trøndelag and Northern Sweden in that words with two consecutive short syllables received equal stress on both of these syllables – thus *equal weight*: *vera* /ˈveˈra/, while on the other hand *bíta*, for example, was /ˈbiːta/ as before.

This equal weight stress pattern protected final vowels of Old Norse disyllabic words with short syllables — primarily infinitives and weak nouns — from reduction or apocope (Haugen 1976:261; Skjekkeland 2005:50ff.). The vowel balance rule lengthened and stressed these final vowels (i.e., giving them equal weight as the stem vowel) and made them candidates to participate in vowel changes that targeted the long, stressed vowels, like the rounding of old long /a/ to /o̧/ (see §3.3.2) and the chain shift described below (Sandøy 1996:159). The final vowels in dialects outside this area, on the other hand, did not receive equal weight as the root syllable and, as a result, were either left unstressed or were reduced.

While the status of unstressed vowels in and of themselves is outside the scope of this dissertation, many vowel balance dialects have *jamning* (metaphony or leveling), where the stem vowel in disyllabic words assimilates some (*tiljamning*) or all (*utjamning*), features of the following unstressed vowel. These dialects further vary with respect to the word classes that total or partial metaphony targets (Sandøy 1996:158), as displayed in Table 2.1, below. Here, forms with total metaphony are shaded.

Table 2.1. Total and partial metaphony in East Norwegian, adapted from Sandøy (1996:158).[6]

Old Norse	*sofa* ‘sleep’	*baka* ‘bake’	*vita* ‘know’	*viku* ‘week (OBL)’
Namdalen	[sɑʋ.ʋɑ]	[b̥ɑʰk.kʰɑ]	[ʋɑʰt.tʰɑ]	[ʋʊʰk.kʰʊ]
Inntrøndelag	[sɔʋ.ʋɔ]	[b̥ɔʰk.kʰɔ]	[ʋɔʰt.tʰɔ]	[ʋʉʰk.kʰʉ]
Nord-Gudrandsdalen	[sɔʋ.ʋɔ]	[b̥ɔʰk.kʰɔ]	[ʋæʰt.tʰɑ]	[ʋɪʰk.kʰʉ]
Mjøsa-area	[soː.ʋɔ]	[b̥ɑː.kʰɑ]	[ʋɛː.tʰæ]	[ʋiː.kʰʉ]
Holla	[soː.ʋæ]	[b̥ɑː.kʰæ]	[ʋɛʰt.tʰæ]	——

Final -/ɑ/ in the Namdalen dialect did not undergo rounding, yet the stem vowels in *sofa* and *vita* fully assimilate to /ɑ/; the same is true with the /u/ in *viku.* The dialect of Inntrøndelag also undergoes total metaphony, but the final /ɑ/ had been rounded to [ɔ], so the stem vowels in *sofa*, *baka*, and *vita* is [ɔ]. The /u/ in *viku* shifted forward (see below), which now appears as the

[6] Sandøy groups forms like [sɔʋ.ʋɔ] with other totally metaphonous forms. Additionally, the *viku* column for the Holla row may be empty because of the lexeme *uke* instead of *viku*.

stressed stem vowel in [ʋʉʰk.kʰʉ]. Nord-Gudbrandsdalen has total assimilation in *sofa* and *baka*, but not in *vita*; here the old /i/ becomes low /æ/, assimilating the height, but not the backness, of the final /ɑ/. The dialects around Lake Mjøsa have total metaphony in *sofa* and partial in *vita*. They also lengthen the short vowels throughout, where the previous examples lengthen the consonants. Finally, Holla has only partial metaphony in [ʋæʰt.tʰæ], and varies in whether it lengthens the consonant ([ʋæʰt.tʰæ]) or the vowel ([soː.ʋæ] and [b̥ɑː.kʰæ]).

The examples with the [ʉ] phones above describe a portion of a chain shift in long back vowels, a shift in which Norwegian has also shown dialectal variation. Despite their differing treatments of diphthongs and some short vowels, both East and West Scandinavian lost long /ø̨/ and /a/; the former merged with long /ø/ in both dialect groups; and the latter merged with long /ǫ/ in West Scandinavian, and with both long /æ/ (< /ę/) and long /ǫ/ in East Scandinavian, resulting in eight long monophthong phonemes (Haugen 1982:39). During the centuries that followed, the back vowels in most varieties of Norwegian and Swedish underwent a chain shift, where long /u/ centralized to [ʉː], long /o/ raised to [uː], and long /ǫ/ raised to [oː] (Haugen 1976:257; 1982:40–1; Küspert 1988:215; Skjekkeland 2005:42–3). Figure 2.5 shows the eight long vowel phonemes in East and West Scandinavian, and the output of the Long Back-Vowel Chain Shift (LBCS; see §§3.3.2, 6); the long [ɑː] is introduced through quantity regulation (see above).

a. <u>East/West Scandinavian</u> b. <u>Post-Chain Shift</u>

Figure 2.5. Long Back-Vowel Chain Shift.

This chain shift is present in most contemporary Norwegian — and Swedish — dialects; the vowel system represented by the outcome of the shift is consistent with the varieties from around Oslo, Steinkjer in Trøndelag, further north in Gildeskål (Sandøy 1996:212, 215, 220), and Bergen in the west (Slethei 1997:72). However, at least up until the 1970s, there was evidence that the shift was not uniformly completed across the whole of Norway. Kjell Venås indicates that older speakers of the Halling dialect, from the mountainous region in eastern Norway, have vowels that are more consistent with a continental (pre-shift) quality (1977:22–3). His position is supported in Helge Sandøy's description of the vowels in the Hol dialect, a town in the Halling region (1996:31), as well as my own analysis of Halling heritage speakers in northwestern Minnesota (Natvig 2016). Furthermore, Sandøy indicates that speakers of the southern town of Lyngdal have centralized [ʉː], without subsequent raising of old long /o/ and /o̹/ (1996:50). It is unclear if the speakers of these more conservative dialects behave more consistently with the typical Norwegian vowel system today, but evidence of various stages in this shift suggests either phonetic or phonological differences across dialects (§§3.3.2, 6) and demonstrates further complexity in the realization of contemporary Norwegian vowel patterns.

Even though the chain shift targeted long vowels, both quantity regulation and metaphony introduced the short equivalents to nine long vowels in Figure 2.5(b). Morphological alternations that add consonants to a stem with a long vowel (e.g., the simple past and perfect suffixes for a subset of Norwegian weak verbs that end in a stressed vowel, and the neuter singular adjectival suffix) and result in long~short vowel pairs, introduce additional short post-shift vowels. For example, the East Scandinavian verbs *bo* [b̥uː] 'live, dwell' and *tro* [tʰɾ̥uː] 'think, believe' have long vowels in the infinitive, but the vowels shorten in the preterite and perfect: *bodde* [b̥ʊd.də], *bodd* [b̥ʊdː] and *trodde* [tʰɾ̥ʊd.də] and *trodd* [tʰɾ̥ʊdː]. This parallel alternation between long and short vowels is also present in the West Scandinavian forms *bu* [b̥ʉː], *budde* [b̥ʉd.də], *budd* [b̥ʉdː], and *tru* [tʰɾ̥ʉː], *trodde* [tʰɾ̥ʉd.də], *trudd* [tʰɾ̥ʉdː]. Similar long~short alternations occur with the adjectives that end in stressed monophthongs, such as *blå* 'blue' and *ny* 'new.' The neuter form of adjectives ending in long, stressed vowels is formed with a geminate -/tʰː/ suffix, resulting in the alternations [b̥loː]~[b̥lɔʰtʰː] (*blått*) and [nyː]~[nʏʰtʰː] (*nytt*), respectively. However, not all short vowels in derived environments shifted to match the quality of their long counterparts. For example, the adjective *god* [ɡ̊uː] 'good (m./f.)' has an asymmetric alternation with short [ɔ] in *godt* [ɡ̊ɔʰtʰː] 'good (n.).'

Short and long alternations have resulted in post-chain phonemes among the set of short vowels. The long vowels are presented in Figure 2.5(b), above, and the short vowels are illustrated by the (near) minimal pairs in Table 2.2, below. The only vowel that is missing is /æ/, which has a limited and possibly problematic distribution (see §§2.2, 3.3.3, 5.2.2). The relative chronology of the changes discussed in this subsection is difficult to determine. However, it is clear that they unfolded over different lengths of time with complex interactions and contribute to present-day variation across Norwegian dialects, where lexemes vary in both phoneme and vowel length. Changes in both long and short vowels, from Common Scandinavian splitting into Eastern and Western varieties as well as later variations across the country, produce the vowel system — or systems — of modern Norwegian and its dialects.

Table 2.2. Minimal and near minimal pairs among the short vowels.

Norwegian	IPA	Gloss
sikker	[sɪʰk.kʰəɾ]	sure
sykkel	[sʏʰk.kʰəl]	bicycle
sukker	[sʉʰk.kʰəɾ]	sigh (PRES)
sukker	[sʊʰk.kʰəɾ]	sugar
sekker	[sɛʰk.kʰəɾ]	sacks, bags
søkker	[sœʰk.kʰəɾ]	sink (PRES)
sokker	[sɔʰk.kʰəɾ]	socks
sakker	[sɑʰk.kʰəɾ]	slow down (PRES)

2.2 The Norwegian vowel system(s)

Broadly considered, Norwegian has nine vowel monophthong phonemes (each long and short) and five diphthongs. Dialects vary with respect to the distributions and functional loads of each phoneme (see below), but the general inventory of vowels, with typical phonetic characteristics, is represented as follows in in Table 2.3. Because vowel length is contrastive in Norwegian surface forms (Kristoffersen 2000:13), many analyses treat long and short vowels as separate phonemes. I therefore present both long and short vowels here for the sake of exposition, but I argue that the long and short sets are allophonic because vowel length is derived from stress assignment and syllable structure (Kristoffersen 2000:147–62; §3.2.3).

Table 2.3. General Norwegian vowel phones

a. Monophthongs (short, long)

	Front		*Central*	*Back*	
	Non-round	Round	Round	Non-round	Round
High	ɪ, iː	ʏ, yː	ʉ, ʉː		ʊ, uː
Mid	ɛ, eː	œ, øː			ɔ, oː
Low	æ, æː			ɑ, ɑː	

b. Diphthongs

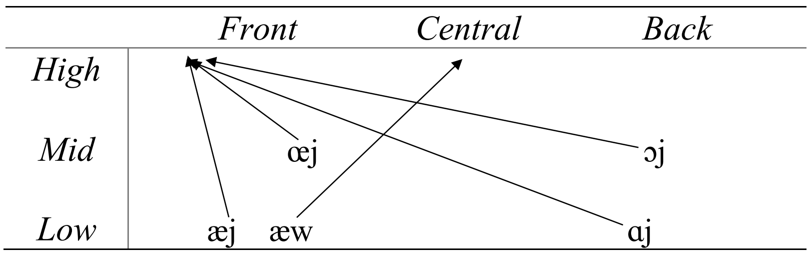

Table 2.3.a shows the monophthongal phonemes with respect to three height (high, mid, low) and three backness (front, central, back) parameters, which are based on the tongue's approximate position in the oral cavity. Front and back are then divided into non-round and round columns. (Non-round central vowels are excluded because they exist in a limited set of dialects, and it is likely that they are not contrastive; establishing whether their phonemic or non-phonemic status requires additional research.) Finally, the short vowels are transcribed with an IPA symbol for a lax vowel, where available, because there are some differences in vowel quality between the long and short sets.

The diphthongs are placed in Table 2.3.b with respect to the vowel position of the onset, with an arrow ending at the approximate position of the offglide. Except for /æw/, all diphthongs' offglides match the roundness of the onset (Kristoffersen 2000:19), so that /œj/ and /ɔj/ are pronounced [œʏ] and [ɔʏ], respectively. The front, high semi-vowel /j/ is used in the phonemic representation for diphthongs because rounding in offglides is predictable. Kristoffersen further provides /ʉj/ as a marginal diphthong and suggests that /ɑj/ and /ɔj/ are marginal, at least in UEN (2000:19), but because it is often left out of descriptions of general Norwegian vowel phonemes, I do not discuss it further.

Finally, a number of disparate dialects underwent a chain shift that lowers the short, front vowels: /ɪ/ > /ɛ/; /ʏ/ > /œ/; and /ɛ/ > /æ/ (Hanssen 2010:64–5). Typical examples are *fisk* ‘fish’ [fɛskʰ], *bryst* ‘chest’ [b̥rœstʰ], and *hest* ‘horse’ [hæstʰ] (Hanssen 2010:64), as well as *finger* ‘finger’ [fɛŋər] in Trøndsk (Hanssen 2010:157). The extent to which this lowering affects the phonological system is unclear. Some examples may represent further phoneme variation due to a wider spread of earlier changes within the short system that fall outside the standardized languages and the dialects that are closer to those norms, or they may signify contemporary phonological or allophonic alternations. The data gathered in this dissertation can move this debate forward, but I will not comment further on these changes except to mention that they appear in varieties across the whole of Norway (Hanssen 2010:130, 157, 165, 181, 189).

In the following subsections, I present regional patterns — how they conform to and divert from the general system — in more detail. In §2.2.1, I discuss Eastern Norwegian and focus on Urban Eastern Norwegian (UEN), the urban dialect in and around Oslo. I continue by elaborating on Trøndsk in §2.2.2 and discuss Trondheim speech. In §2.2.3, I then contrast Eastern Norwegian with the vowel characteristics of modern Western Norwegian and survey the dialects in Bergen and Stavanger. Finally, in §2.2.4 I sketch Northern Norwegian varieties.

2.2.1 Eastern Norwegian and Oslo

Eastern Norwegian is spoken in the eastern portion of the southern half of Norway. The region stretches north to south from the northern border of Hedmark to the southern portion of Telemark counties, and from the Swedish border in the east to the Western counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in the west (cf. Figures 2.1, 2.2). Principally, the segmental phonology of Eastern Norwegian is characterized by vowel balance and metaphony (see §2.1.2, Table 2.1) and 'thick l' (*tjukk l*), a retroflex flap [ɽ] that developed either from Old Norse /l/ or both Old Norse /l/ and /rð/ (Hanssen 2010:125). Many Eastern Norwegian varieties — primarily in Southern Østfold county, although also typical of the upper-class variety spoken in Oslo — are classified as *e-mål* (e-dialects), where final Old Norse unstressed /a, i~e, u~o/ in, for example, infinitives and weak nouns and adjectives, merged to unstressed /e/ (Hanssen 2010:83).[7] Throughout the remaining parts of Eastern Norway, vowel balance preserved -/a/ endings in short syllables, resulting in split endings (either -/e/ or -/ɑ/) in infinities, weak nouns, or both, although "kløyvinga av endringsvokalar etter jamvektssystemet slår ikkje likt ut alle stader" (Skjekkeland 2005:160) [the splitting of final vowels according to the vowel balance system does not spread equally in all places]. Whether a dialect is simply an 'e-dialect,' or has various types of split systems, has consequences for the preceding stressed vowels in varieties with full or partial metaphony (see §2.1.2, Table 2.1). These types of effects are largely absent from the upper-class speech of Oslo.

[7] Other varieties are either *a-mål* (a-dialects) — where unstressed vowels either merged to /ɑ/ — or mixed *e/a-mål* (e/a-dialects) that retain unstressed /ɑ/ in weak feminine nouns, but infinitives reduced final /a/ to /e/ (Sandøy 1996:152).

Particularly prevalent in Eastern Norwegian is its series of retroflex consonants, including the ‘thick l’ /ɽ/.[8] Historically, short /a/ and /o/ fronted to /æ/ and /ø/ before /ɽ/.[9] These vowels were then lengthened in short syllables: compare *kælv* [kʰæɽʋ] ‘calf’ (<*kalfr*) with *høl* [høːɽ] ‘hole’ (<*hol*). Fronting before /ɽ/ has possibly resulted in modern doublets, such as *gærn* [g̊æːɳ] and *gal* [g̊ɑːl] from Old Norse *galinn*, both meaning ‘crazy.’ However, *gal* is broader and can also mean ‘false;’ *gærn* is restricted to ‘crazy.’ In some cases, this pre-retroflex fronting produced central vowels, rather than front vowels, that may appear as <ä> and <ʌ̈> or <ö> in non-standard writing or transcriptions (Skjekkeland 2005:160). Whether this partial fronting resulted in mid vowels that contrast with both their front and back counterparts requires further investigation (see §3.3.2, Tables 3.3, 3.4).

Eastern Norwegian dialects also take part in various degrees of monophthongization of Old Norse diphthongs. This trend is strongest in the Eastern portion of Hedmark county and stretches northward into Sør-Trøndelag and westward into Møre og Romsdal counties (Hanssen 2010:129, Map 22). Furthermore, upper-class sociolects in Oslo tend toward monophthongal variants as a historic artifact of influence from Danish as the language of government, administrations public and private, and literature. Whether monophthongization as a systematic change in the northern portion of the Eastern Norwegian area is different from the monophthongization represented in Dano-Norwegian speech is yet to be investigated. There is evidence in some varieties that the monophthongs that have been simplified from diphthongs maintain a different quality than the phonemes that descend from old monophthongs (Skjekkeland 2005:48). This difference in vowel quality suggests that monophthongization is

[8] See Kristoffersen (2000:88) for a discussion of the phonemic status of retroflexes in UEN.

[9] Although this change does occur in other environments (Skjekkeland 2005:160), it does not appear that it has the same regularity as it does with a following /ɽ/.

either a phonetic or phonological effect (see §3), and not the choice of a monophthong phoneme at the expense of a diphthong phoneme, which is likely for urban Oslo varieties that have monophthongal forms through the incorporation of Danish-influenced variants.

This tension between traditional Eastern Norwegian and Danish (or Dano-Norwegian) patterns produce "a mixed system, where elements from two formerly different varieties live happily together as variants and where either member of a given variable can be called on to different degrees depending on speech style, social and geographical background, etc." and this mixed system is characteristic of Urban Eastern Norwegian (Kristoffersen 2000:9–10). The UEN vowel system is consistent with the phonemes shown in Table 2.3 (Endresen 1991:183), at least from an historical perspective. Kristoffersen's (2000:16–7) measurements in Herz (Hz) of the first and second formants (F1 and F2, respectively) for long and short UEN vowel phones are reprinted in Figure 2.6; F1 approximates vowel height and F2 approximates vowel advancement.

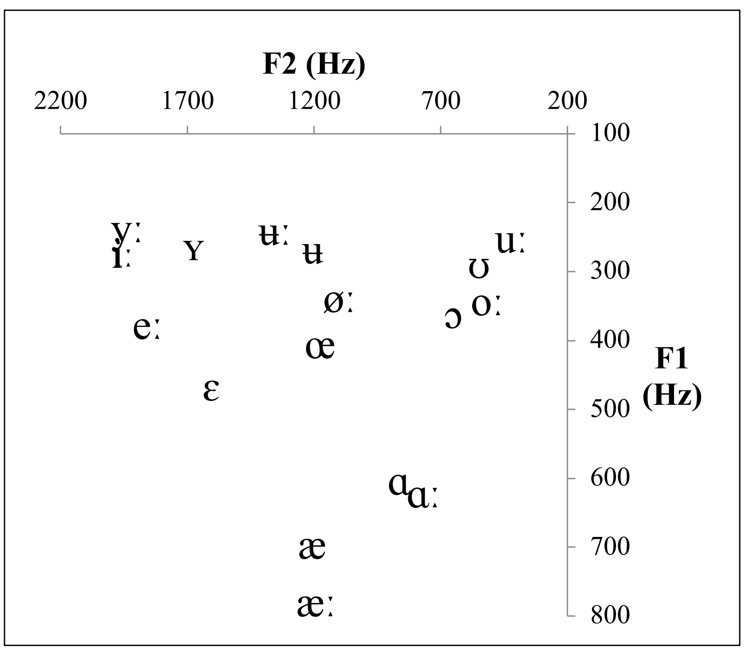

Figure 2.6. UEN vowel measurements (from Kristoffersen 2000:17).

Key differences are among the /æ/ and /ø/ phonemes. Phonetically, both appear to have centralized productions (Kristoffersen 2000:17). The central position of /æ/ in absolute Hz is due to the triangular shape of the vowel space, where the front and back acoustic positions occur along diagonals (Labov 1994:159; §5.3) The /ø/ results are consistent with Endresen's description of Oslo pronunciation, that the vowel "er uttalt litt lenger bak i munnen enn [ø] (omtrent like langt bak som vokalen i *bu*)" (1991:100) [is pronounced a little further back in the mouth than [ø] (almost as far back as the vowel in *bu*)]. He continues, "og sånn er det med ø-lydar i dei fleste verkelege språk" (Endresen 1991:100) [and so it is with ø-sounds are in most real languages]. The latter statement suggests that Endresen positions /ø/ slightly further forward than does Kristoffersen; this is confirmed in his vowel charts that have both /ø/ and /ʉ/ as front vowels phonetically (Endresen 1991:113). I take the differences in descriptions of these phones as an indication of vowel variation and that UEN /ø/ is phonologically unspecified for advancement (Natvig 2017) because a central vowel that may have fronted variants (see §3.3.1). I present an analysis of the motivations for /ø/ centralization in §3.3.2. The consensus is that UEN does not have a three-way contrast in round mid-vowels, like it does among the high vowels.

An additional difference in UEN is in the phonemic status of /æ/ itself, because "it patterns as an allophone of /e/, occurring before /r/ and /ɽ/, where [e, ɛ] in general are blocked" (Kristoffersen 2000:14). There are, however, examples of [eː] preceding /r/, as in the derived present tense *ser* [seːɾ] 'sees' (a minimal pair on the surface with *sær* [sæːɾ] 'weird') and in the verbal suffix *–ere*, as in *studere* [stʉ.ˈdeː.ɾə] 'study.' The lowering of /e/ to [æ] before retroflex consonants (/r/ induces the retroflexion of following coronals; Simonsen, Moen & Cowan 2008:388; Johannessen & Vaux 2012; Stausland Johnsen 2012) can be regarded as a trend in

Eastern Norwegian for retroflex consonants to pull non-high vowels (including /e/, as in *elg* [æɽj] 'moose;' Hanssen 2010:132) toward the low-front portion of the vowel space. What is more, many Old Norse /æ/ vowels raised to /e/ in UEN: *ævintýr(i)* > *eventyr* 'adventure, fairytale,' *hræddr* > *redd* 'afraid,' and *hæll* > *hæl* [heːl] 'heel;' but were preserved before /r/ and /ɽ/: *æra* > *ære* 'honor,' *nær* > *nær* 'near,' and *hæll* > *hæl* [hæːɽ] 'heel.' The reciprocal movements of /æ/ and /e/ obscure their contrast in a wide set of environments and produce a near-complementary distribution among the two phonemes, which leads Kristoffersen to propose that /æ/ is a marginal phoneme in UEN (2000:14). I examine what a 'marginal phoneme' means for its relationship to other phonemes a phonological system in §§3.2, 5.2.2.

The monophthongal phones for UEN are like those for general Norwegian (Table 2.3), with the following exceptions: /ø/ does not pattern with the front vowels (shaded in Table 2.4) and appears to be a phonologically central vowel (henceforth /ɵ/ when decidedly central); and /æ/ is marginally phonemic likely because /æ/ raising and /e/ lowering has left a limited set of contrastive surface forms. Finally, Endresen indicates that the long mid-vowels (/e, ɵ, o/) can be produced with falling offglides (1991:112), like the monophthongal productions of English /o/ in northwestern Minnesota and eastern North Dakota (see Natvig 2016). This diphthongization, however, should not be considered phonemic because they occur in free variation with the monophthongal pronunciations of the mid-vowels (i.e., there is no contrast). Furthermore, the diphthongal productions of mid-vowels are a predictable phonetic outcome from these vowels' phonological structure (see §5.2.3).

Table 2.4. UEN vowel phones (monophthongs)

	Front		*Central*	*Back*	
	Non-round	Round	Round	Non-round	Round
High	ɪ, iː	ʏ, yː	ʉ, ʉː		ʊ, uː
Mid	ɛ, eː		ɵ, ɵː		ɔ, oː
Low	(æ, æː)			ɑ, ɑː	

2.2.2 Trøndsk and Trondheim

The Trøndsk dialect area is centered in Sør-Trøndelag and Nord-Trøndelag counties, and stretches into Nordmøre (the northern portion of Møre og Romsdal county) and even into northern Hedmark, the southern part of Nordland, and over the Swedish border (Dalen 2008a:18; Hanssen 2010:155; see Figures 2.1, 2.2). Because of vowel balance effects, it is often classified as Eastern Norwegian, but with a general pattern of apocope instead of vowel reduction as in the infinitives *å kast* 'to throw' (<*kasta*) and *å dømm* 'to judge' (<*dǿma*) in old heavy syllables, but *å kåmmå* 'to come' (<*koma*) and *å såvvå* (<*sofa*) with full metaphony in the latter group (Skjekkeland 2005:167). Apocope, like most of the vowel characteristics discussed here, is regionally variable. However, apocope is not "så omfattende overalt i Trøndelag og på Nordmøre som ein kan få inntrykk av når trøndersken blir imitert av «utlendingar»" (Dalen 2008b:36) [as extensive everywhere in Trøndelag and Nordmøre as the impression one would get when Trøndsk is imitated by "outsiders"], which suggests that it is a salient characteristic of the dialect region. In general, Trøndsk has the nine-monophthong system (see Figure 2.3.a) in both long and short (Dalen 2008b:41), but — like other groups of Norwegian varieties — with a great deal of variation with respect to which phonemes occur in which lexical items. I now turn to those broad aspects of Trøndsk, and then highlight the urban dialect in Trondheim, the historical and cultural center of Trøndelag (see Dalen 2008a:18).

While the distribution of apocopated and non-apocopated forms does not bear directly on this dissertation, the related vowel balance and metaphony effects are worthy of discussion. Trøndsk has areas with both types of metaphony, and Dalen (2008b) divides Trøndsk into two subgroups with regard to metaphony: "dei ytre måla, eller vesttrøndersken, som har mest av tiljamning og dei indre måla, eller austtrøndersken, som kan ha så godt som gjennomført utjamning" (Dalen 2008b:27) [the outer dialects, or West-Trøndsk, which mostly have partial metaphony, and the inner dialects, or East-Trøndsk, which may best be described by completed full metaphony].

Like other areas encompassed within Eastern Norwegian, as well as East Scandinavian in general, there is a tendency in Trøndsk to monophthongize the old dipththongs /ęi, ø̨y, ǫu/ (contemporary Norwegian /ei, øy, au/) > /e, ø, ø/ (Hanssen 2010:157; Skjekkeland 2005:169). If monophthongization resulted in the collapse of the phonological distinctions between diphthongs and monophthongs, then the Trøndsk vowel system diverged from the general Norwegian system presented in Table 2.3 and is, therefore, only comprised of the phonemes in Table 2.3.a. What is more, Dalen (2008b:43–4) explains that Trøndsk monophthongization primarily affects the southern portion of the dialect area, and that it occurred under two distinct processes. The first, and older, process is the East Scandinavian pattern that extends to the Eastern portion of Sør-Trøndelag county up though Hedmark (cf. Figure 2.2), although here the diphthong /au/ was either unaffected or maintained a quality further back than /ø/ (Dalen 2008b:43–4).[10] But a newer monophthongization process has taken place in Nordmøre and Innherad (in southEastern Nord-Trøndelag; see Figure 2.2), resulting in low monophthong vowels and a core group that merges old /øy, au/ and one that maintains old /au/, likely starting in the middle of the 1800's (Dalen

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[10] While it is difficult to compare this vowel to other descriptions because of inconsistent transcription (<ò> in Dalen 2008b), it is likely that this vowel is the same as the <ö> vowel from Eastern Norwegian back vowel fronting.

2008b:44). These two Trøndsk monophthongization processes, however, may be a phonetic effect along the lines of Southern American English, where the diphthongs /aɪ/ and /ɔɪ/ are monphthongized, yet occupy different positions in the vowels space than /a/ and /o/ and, therefore, maintain the contrast between monophthongs and diphthongs (see Labov, Ash & Boberg 2006:239).

Trondheim (also Trondhjem) is located inland from Norway's west coast on a fjord in Sør-Trøndelag, near the border of Nord-Trøndelag (see Figures 2.1, 2.2). It has been an important cultural and historical center since the Middle Ages, was the capital for the first Norwegian Christian kings (then called Niðaróss), and the see of the medieval diocese. The Nidaros Cathedral was an important pilgrimage site, and it retains its status as the location of Norway's coronation ceremonies. In other words, Trondheim "var og er *Byen* i det nordafjelske Norge" (Dalen 2008b:74; emphasis in original) [was and is *The City* in Norway north of the mountains].

While Trondheim lies geographically within the inner, or East-Trøndsk, area, "Trondheim bymål har om lag same formene som ein finn i ytre trøndske mål" (Skjekkeland 2005:167) [the Trondheim urban dialect has approximately all the forms that one finds in outer Trøndske dialects]. These forms include partial, rather than full, metaphony, and the retention of old diphthongs, which are "svært tronge, men tydelege" (Dalen 2008b:43) [very closed, but clear]. That the diphthongs in the Trondheim dialect appear to be narrower — at least in description — than other varieties, suggests the possibility of *phonetic* monophthongization in progress: that some contrast is maintained between the monophthongs and diphthongs, but with less distance between the onset and offglide, which lend themselves more readily to monophthongal perception. Finally, the urban Trondheim dialect appears to influence the surrounding areas, especially ones undergoing more recent urbanization (Hanssen 2010:163). This influence, both locally and regionally, may also impact the speech of Trøndsk speakers attending university in Trondheim more readily than other urban centers, such as Bergen, that show a great deal of linguistic dissimilarity from neighboring rural varieties (cf. Hanssen 2010:162).

In this subsection, I presented a set of broad Trøndsk vowel characteristics situated with respect to general Eastern Norwegian patterns. These forms have, of course, a variety of consequences for the remaining linguistic systems that fall outside the scope of this study (see Dalen 2008b; Hanssen 2010:155–63; Skjekkeland 2005:167–71 for more detail). The Trøndsk and Eastern Norwegian, including UEN, dialect areas comprise the modern East Scandinavian descendants in Norway. I now turn to a discussion of the contemporary dialects that make up the other side of that division.

2.2.3 Western Norwegian, Bergen, and Stavanger

Figure 2.1 shows the general geographical location of Western Norwegian, starting from Sunnmøre (in the middle of Møre og Romsdal county) and moving south through Sogn og Fjordane, Hordaland, Rogaland, through Vest- and Aust-Agder and up into Telemark (cf. Figure 2.2). Northern Norwegian, stretching from Nordland to Finnmark (cf. Figures 2.1, 2.2), is also categorized as a subgroup of Western Norwegian. All these dialects originate historically from Western Scandinavian and differ from their Eastern Norwegian counterparts today based on several of those early features (see §2.1), as well as a lack of any vowel balance effects or metaphony. Here, I survey general Western Norwegian vowel patterns, and discuss relevant variations across the regions starting with the west and discussing Bergen in detail.

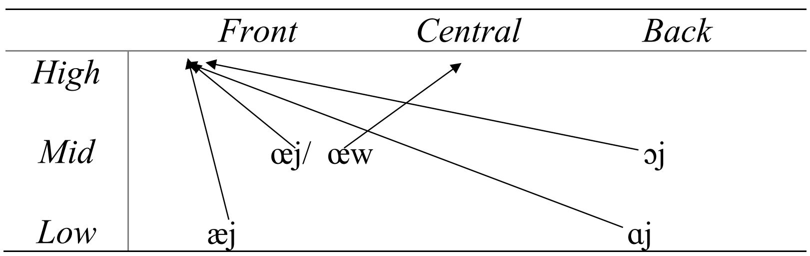
Klaus-Christian Küspert treats Western Norwegian vowel systems in great detail in his book *Vokalsysteme im Westnordischen* (1988; Max Niemeyer), which is extremely valuable in making localized dialectal comparisons and investigating changes in those dialects over time. While the purpose of this section is to provide a broad, not extensive, account of vowel variations, I refer to Küspert's (1988) overview of Western Norwegian (along with others') here and leave his insights on individual Western Norwegian varieties for comparisons with contemporary speakers of those varieties. The Western Norwegian vowel system that Küspert (1988:215) puts forth is essentially the General Norwegian system presented in Table 2.3, but with slightly lowered /u/, /o/, and /ø/ vowels and central /a/. (Whether /a/ in Western Norwegian and /ɑ/ in Eastern Norwegian show markedly different phonetic patterns will be evaluated in §5.) Furthermore, Küspert (1988:215) transcribes the /au/ diphthong as <ŏů>, while Hanssen (2010:164) uses [øu]. In combination, these transcriptions indicate a mid-central rounded onset that rises toward [w]; I therefore use /œw/ for this phoneme. There is no mention of the "marginal" diphthongs /ɔj/ and /ɑj/ in the Western Norwegian descriptions I have found, but I include them in Table 2.5 because they are present in, for example, the interjection *oi!* and the word *hai* 'shark,' respectively. Finally, /æ/ phonemes seem to be stronger in Western Norwegian than in Eastern Norwegian: "innafor mykje av området skil ein mellom fonema lang /eː/ og lang /æː/" (Skjekkeland 2005:174) [within much of the area one distinguishes between the phonemes long /eː/ and long /æː/]; a distinction that appears to be marginal in other varieties, especially in UEN (Kristoffersen 2000:14).

Table 2.5. Western Norwegian vowel phones

a. Monophthongs (short, long)

	Front		*Central*		*Back*	
	Non-round	Round	Non-round	Round	Non-round	Round
High	ɪ, /iː/	ʏ, yː		ʉ, ʉː		
						ʊ, uː
Mid	ɛ, /eː/					
		œ, øː				ɔ, oː
Low	æ, æː		a, aː			

b. Diphthongs



With the exception of quantity regulation and the back-vowel chain shift (§2.1.2; Figures 2.4, 2.5), the vowels in Western Norwegian “har gjennomgått få historiske endringer” (Hanssen 2010:164) [have undergone few historical changes] and appears to largely be consistent with the General Norwegian vowel system. However, if monophthongization is an emblematic feature of Eastern Norwegian, then Western Norwegian’s correlate is diphthongization. Not only are the West Scandinavian diphthongs preserved, but there is a tendency to diphthongize long vowels, as in *beita* (<*bita*) ‘bite,’ *suyna* (<*syna*) ‘seem, appear,’ and *soul* (<*sol*) ‘sun,’ and inland varieties in the Vest- and Aust-Agder, Hordaland, and Sogn show a tendency to diphthongize long /a/ to [aʊ] (Skjekkeland 2005:172–5; see also Hanssen 2010:172). These latter diphthongization patterns appear consistent with a phonetic effect that targets long vowel similar to the diphthongized mid vowels in Oslo speech (see §2.2.1), but in broader set of contexts. I expand upon this point in §5.2.3.

The largest city in Western Norway — and second-largest in the country — is Bergen. It is situated on the coast in central Hordaland county (see Figures 2.1, 2.2), and home to an urban variety that, unlike that of Trondheim, “skiller seg mye fra bygdemåla omkring. Bergen har med rette blitt karaktarisert som ei dialektøy” (Hanssen 2010:176) [differentiates itself greatly from the surrounding rural dialects. Bergen has rightly been characterized as a dialect island]. Its historical and economic position as a Hanseatic trading hub that facilitated the export of dried cod from the Lofoten Islands to Continental Europe and the resulting contact between speakers of Norwegian, Low German, Dutch, and English is often assumed as the cause of Bergen’s unique dialect (cf. Hanssen 2010:176). While it is surely the case that language contact affected the local variety, similar influences impact the Norwegian language — and the other mainland Scandinavian languages for that matter — more generally. But whatever the causes and processes involved in forming *bergensk*, the city’s “særlige posisjon på Vestlandet har ført til at bymålet skiller seg tydelig fra alle andre vestlandske varieteter på mange områder” (Hanssen 2010:176) [exceptional position in West-Norway has led to the urban dialect clearly differentiating itself from all the other Western Norwegian varieties in many areas].

Despite all the ‘clear differences’ in Bergen Norwegian — of which there are many — it does not appear that its vowel system is particularly affected by its ‘exceptional position.’ In *Grunnbok i fonetikk for språkstudenter* (1997; Cappelen Akademisk Forlag), Kolbjørn Slethei presents the following vowel chart for the Bergen dialect in Figure 2.7.[11]

[11] It should be noted that vowel positions and arrows are an approximation based on Slethei (1997:72, Figure 34); notations were also changed for the sake of consistency.

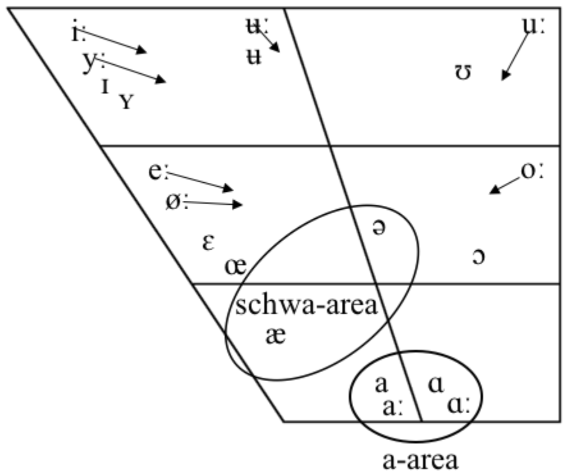


Figure 2.7. Bergensk vowel chart (adapted from Slethei 1997:72, Figure 34).

There are two issues worth noting: One is that the [æ] phone in Figure 2.6 is represented as [ɛ] in Slethei (1997:72) and given as a variant of the unstressed [ə] vowel, which is likely not a phoneme (see Kristoffersen 2000:21); the second is that both low vowels pairs — /a, ɑ/ are given as variants of the same phoneme, so that "på mange norske dialekter kan både lang og kort a-lyd, som i ordpar «hat» og «hatt» variere både i åpningsgrad og fremskutthet. Dette er vist i figuren ved et 'a-område' hvor vi kan finne både 'kort' og 'lang' a-lyd" (Slethei 1997:72) [in many Norwegian dialects, both long and short a-sounds — as in the word pairs *hat* 'hate' and *hatt* 'hat' — can vary both in degree of openness and frontness. This is shown in the figure with an "a-area" where we can find both "short" and "long" a-sounds]. Both 'a-sounds' are given as centralized variants, suggesting that they conform to regional Western Norwegian patterns. It is, however, unclear from this figure whether /æ/ has the strong phonemic status that is purported in other Western Norwegian varieties, or one of the many peculiarities of the Bergen dialect is that it moves beyond Urban Eastern Norwegian in collapsing the /æ/~/e/ contrast into /e/. The data gathered for this dissertation address this issue and will be presented and analyzed in §5.2.2.

Unlike Bergen, Stavanger (the capital of the Norwegian oil industry and south of Bergen on Norway's west coast; cf. figures 2.1, 2.2) has a stronger relationship to its surrounding rural communities, and there are fewer differences between the urban variety and neighboring dialects (Hanssen 2010:178). Hanssen continues by stating that "her mangler dessuten mange av de «fremmede» trekka som Bergen har en god del av" (2010:178) [furthermore, many of the "foreign" elements that Bergen has a good deal of are missing here], which suggests that these dialects behave more consistently with general Western Norwegian patterns.[12] However, Hanssen mentions a merger of short /ʉ, ø/ > /y/ among older speakers in Stavanger (2010:179), and older descriptions of the vowels in the Stavanger dialect suggest an obscuring of /e/ and /æ/ similar to UEN: /e/ seems "å nærme sig meget lang ę. Foran r er en tilnærmelse til ę mer gjennomgående" (Berntsen & Larsen 1925:11) [to approach long ę. Before r an approximation to ę is more consistent]. Finally, short /ɑ/ has a more advanced pronunciation than other Norwegian dialects, approaching the cardinal [a] vowel in the central portion of the vowel space (Vanvik 1979:17) These factors will be taken into consideration for a discussion of Norwegian phonological representations in §3, and data on whether younger speakers continue these trends will be presented in §5.1.2.

2.2.4 Northern Norwegian

Finding a home in the three northernmost counties of Nordland, Troms, and Finnmark (cf. figures 2.1, 2.2), Northern Norwegian is often considered as a separate dialect group. A long tradition of Norwegian dialectology categorizes it as a variety somewhere between Western Norwegian and Trøndsk (see Skjekkeland 2005:154–7, quot. Papazian & Helland 2005). Like

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[12] See Hanssen (2010:178–80) for a discussion of dialectal features that fall outside the scope of this dissertation, including consonantal variations, unstressed vowels, and pronouns.

Western Norwegian, the Northern dialects do not have vowel balance rules — a primary feature in distinguishing the East from the West (cf. Sandøy 1996:183; Skjekkeland 2005:51; §2.1.2). Like Trøndsk, however, apocope is a prevalent Northern Norwegian characteristic, but it targets specific word classes or prosodic positions, not syllable types as in Trøndsk:

> Me har tidlegare sett at prinsippet for apokopen i nordnorsk er eit anna enn innafor trøndsk: Om rotstavinga var lang eller kort i norrønt, har som nemnt ikkje hatt noko å seie for utviklinga av trykklette endestavingar i nordnorsk, og såleis ikkje noko for apokopen. . . . Bortfallet er her anten bunde til éin eller fleire formkategoriar, t[il] d[ømes] alle infinitvar. . . eller heng saman med setningstrykket. (Skjekkeland 2005:181)
>
> [We have previously seen that the principle for apocope in Northern Norwegian is different than in Trøndsk: whether the root syllable was long or short in Old Norse has, as mentioned, nothing to say about the development of unstressed final syllables in Northern Norwegian, and therefore nothing about apocope. . . . The [vowel] loss here is either connected to one or more formal categories, for example all infinitives. . . or related to sentence stress]

Apocope as a distinguishing characteristic of the Northern dialects, as Skjekkeland explains, is independent of their 'relatedness' to broad Norwegian dialect groupings. The Northern Norwegian vowel inventory is, according to Hanssen, consistent with conservative Western Norwegian patterns, but with consistent monophthongal long vowels: "det er lite endring av vokalene. Diftongering forekommer ikke, og monoftongering. . . skjer bare foran konsonantgrupper" (2010:189) [there is little change in the vowels. Diphthongization does not occur, and monophthongization. . . only happens before consonant clusters], which seems consistent with quantity regulation that requires short vowels before two — or geminate — consonants. Helge Sandøy (1996:53) provides a Northern Norwegian sample in the speech of Gildeskål in Nordland county with the nine monophthongal and three (primary) diphthongal phonemes characterized by General Norwegian system (cf. figure 2.3), that broadly encompasses both Eastern and Western Norwegian inventories, albeit with the phonetic variations discussed throughout these subsections.

2.3 Summary

Despite centuries of divergent historical developments, the basic Western and Eastern Norwegian vowel inventories appear to be fairly uniform. The phonemic status of /æ/ seems less stable in Eastern than in Western Norwegian, and there is some variety in the phonetic implementation of some phonemes (i.e., the extent and distribution of long vowel diphthongization, monophthongization patterns, and the phonetic targets within the vowel space; see §3.2 for a discussion of the phonological and phonetic aspects of these differences). It is reasonable, then, to proceed with the assumption that Norwegian dialects have the same basic vowel phonemes (monophthongs) at their most abstract level of representation. It follows then that regional and social variations consist primarily of differential phoneme selections resultant from historical patterns (e.g., Eastern *bo* 'live/dwell' vs. Western *bu*, vowel balance, metaphony and quantity regulation, and the East Scandinavian tendency toward progressive j-umlaut and monophthongization), and of variation in the phonetics of abstract phonological categories (e.g., fronted /a/ vowels in the West and centralized /ɵ/ vowels in the East). It is the principal goal of this dissertation to evaluate the evidence that bears on this assumption and to put forth — to the extent that it is empirically justified — a cohesive set of phonological representations of Norwegian vowels, and to analyze the range of phonological and phonetic processes that produce vowel differences throughout the Norwegian dialect landscape.

Chapter 3: Theoretical Framework: Phonetics, Phonology, and North Germanic Vowel Diachrony

The nine (short and long) Norwegian vowel phonemes discussed in §2 (see especially Table 2.5) seem uniform for different Norwegian dialects, although there ARE differences. To compare these regional and social patterns, it is necessary to define the domains in which these differences occur. They may stem from lexical variation (as in, for example, East Norwegian /u/ ~ West Norwegian /ʉ/, see §2.1.1) or as differences within the dialects' phonetic and phonological representations — what I refer to as the SOUND SYSTEM. Throughout this chapter, I present the phonological theory that forms the theoretical foundation for this dissertation. This research builds on the Modified Contrastive Specification (MCS) approach to phonology and the use of the contrastive hierarchy for distributing phonological features across a phonemic inventory (Dresher, Piggott & Rice 1994; Dresher 2009) with clearly delineated levels of representation within the sound system (Purnell & Raimy 2015). Before I discuss the MCS and the architecture of the sound system (in §3.2), I comment on the nature of the relevant phonological features in §3.1. In §3.3, I examine diachronic changes in vowel contrasts to propose the phonological representations for Modern Norwegian that form the basis for qualitative and quantitative dialect comparison (see §§4, 5). To capture the developments from Old Scandinavian to Modern Norwegian, I contribute two hypotheses for understanding contrastive phonological change in MCS: the MINIMAL CONTRAST SHIFT HYPOTHESIS (§3.3.1), developed from proposals in Oxford (2015), and the CONTRASTIVE NEUTRALIZATION HYPOTHESIS (§3.3.2). While my focus throughout is on the monophthong phonemes, the diphthong phonemes are assumed to be derived from the feature specifications of each member of the diphthong (see §3.2.3). I then summarize this chapter in §3.4.

3.1 Features: Form and function

Distinctive features are generally understood to be the primitives of phonological representations (Jakobson, Fant & Halle 1963; Chomsky & Halle 1968). Their main function is to distinguish — or contrast — sounds from each other. The nature of the substance that features carry influences how theoretical models of phonemic representations and phonological alternations operationalize that information. Binary features mark a phoneme's content as either [+feature] or [–feature]: /y/ is [+round] and /i/ is [–round], for example. Unary, or privative, features, on the other hand, encode contrasts as the presence vs. the absence of substance. Here, /y/ is [round], and /i/ lacks any feature that references lip rounding (indicated with the null set symbol '∅'). Whether a distinctive feature exists in a phoneme's phonological representation or not affects the information that the phonological component of the grammar has access to and the generalizations that speakers can make for phonological processes. The phonology would have access to both the positive and negative feature specifications in a binary system (i.e., [±round]), but only the specified feature in a privative one (i.e., [round]). Iverson and Salmons (1995) argue that English 'voiceless' (or *fortis*) obstruents are specified with [spread glottis], and that their 'voiced' (or *lenis*) counterparts are unspecified for laryngeal features. This privative contrast captures the generalization that in English — as well as most Germanic languages — fortis obstruents spread their aspiration to other segments, but no segments assimilate to the laryngeal features of the lenis obstruents because only the fortis obstruents carry a laryngeal feature in their phonological representations (see Salmons forthcoming for a detailed analysis of Germanic laryngeal features). These data indicate that natural classes of segments contrast phonologically by the presence or absence of a single feature (see §3.2).

Peter Avery and William Idsardi (2001) propose a model of underspecified, privative features (e.g., Mester & Itô 1989; Iverson & Salmons 1995; Lombardi 1996) with the fundamental insight that phonological representations operate on abstract DIMENSIONS composed of mutually exclusive pairs of articulatory gestures (Avery & Idsardi 2001:44–5; see also Keating 1996). Because "only a single muscle within a dimension can be activated in a given speech sound . . . [dimensions] cannot be binary, as the muscle is either activated or inhibited by the activation of its antagonist partner" (Avery & Idsardi 2001:44). Figure 3.1 shows the organization of the dimensions and their opposing gestures that are grouped under the laryngeal articulator.

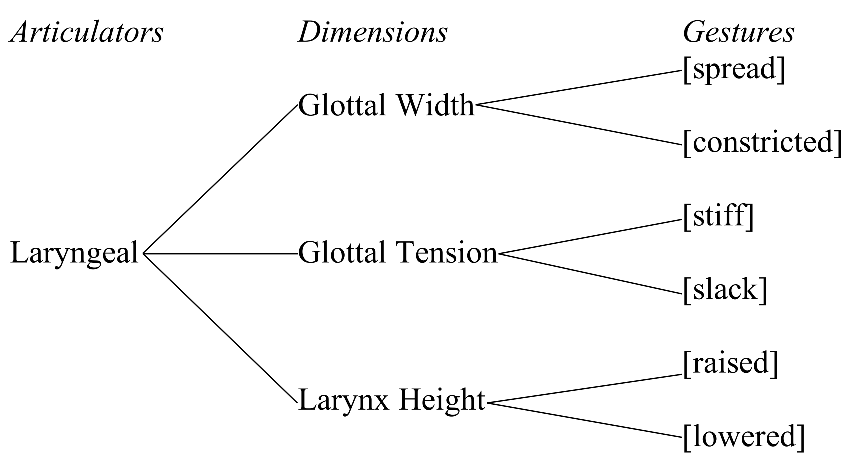

Figure 3.1. Laryngeal dimensions and gestures (adapted from Avery & Idsardi 2001:42)

In this model, the "phonological representations are not by themselves pronounceable. In order to become pronounceable, the mapping from the phonology to phonetics must add the missing gestural specifications," a process they call 'completion' (Avery & Idsardi 2001:46–7). A dimension is completed with one of the opposing articulatory gestures. For example, Glottal Width can either be completed with [spread] or [constricted], which produce aspiration and glottalized sounds, respectively. Glottal Tension may be completed with a [stiff] (voiceless) or [slack] (voiced) gesture, and the Larynx Height may be [raised] or [lowered], producing ejective and implosive sounds, respectively (see Purnell & Raimy 2015:526). Drawing from Iverson & Salmons (1995), English fortis obstruents are specified with Glottal Width in the Avery & Idsardi (2001) model. Furthermore, because they are aspirated in initial position and glottalized in codas ([pʰĩn] vs. [nɪpˀ]), the alternation of aspirated and glottalized English stops provides evidence for the dimension as the phonological constituent (here Glottal Width), with context-sensitive rules for its completion; i.e., fortis stops are specified for Glottal Width and completed with [spread] initially and (optionally) [constricted] in coda position. The full feature geometry proposed in Avery & Idsardi (2001) is shown in Figure 3.2, as presented in Purnell & Raimy (2015:526):

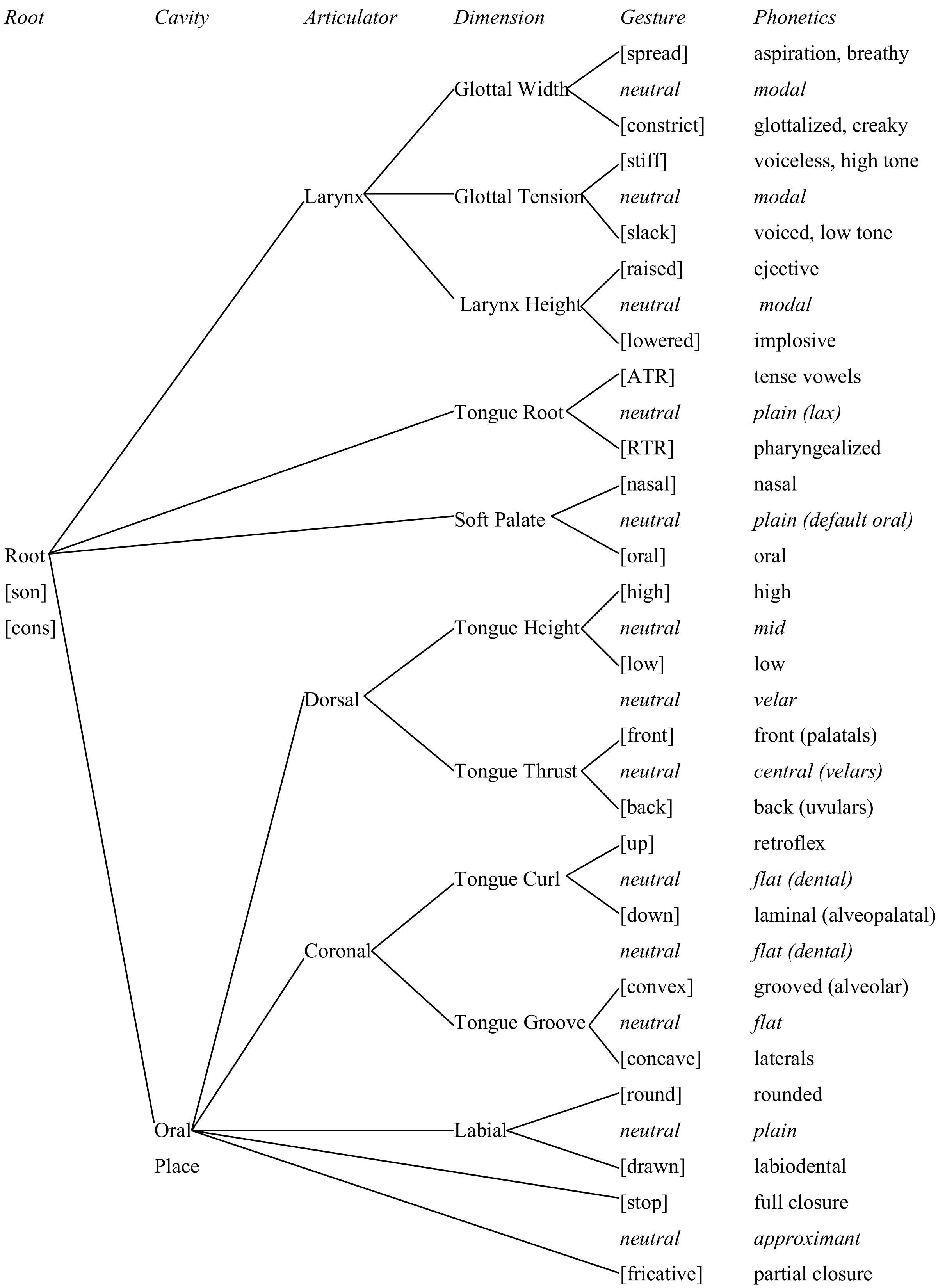

Figure 3.2. Distinctive features: Dimensions, gestures, and phonetics (Purnell & Raimy 2015:526).

The features that specify vowels in most modern frameworks are [high], [front], [back], [low], and [round]. In the present model, however, the dimensions for vowel specifications are Tongue Height, Tongue Thrust, Tongue Root, and Labial. The dimensions under the Dorsal articulator, Tongue Height and Tongue Thrust, respectively, specify height and advancement in vowels. A Tongue Height specification completed with [high] marks high vowels, and Tongue Thrust completed with [front] marks front vowels. Mid vowels are unspecified for height features (Dyck 1996:282). Languages with three phonological heights, such as Norwegian, require two dimensions to specify vowel height. Tongue Height (completed with [high]) marks the high vowels and the low vowels are specified as Tongue Root completed with the Retracted Tongue Root [RTR], a gesture that lowers the tongue body (Purnell & Raimy 2015:533–4). The remaining dimension that can mark vowels is Labial (under the Oral Place node), which — when completed with the gesture [round] — specifies rounded vowels. I use these four dimensions in my proposal for the phonological structure of Norwegian vowels (see §3.3). I first discuss the architecture of the sound system, including the relationship between phonological and phonetic representations within that system.

3.2 The sound system and levels of representation

The Avery & Idsardi (2001) feature geometry adopts an underspecified phonological component of the grammar. Phonological features (i.e., dimensions) are themselves incomplete (Avery & Idsardi 2001:46), and phonological representations are also underspecified in that contrasts are marked through the presence vs. the absence of a dimension, or in the form of ∅/Specified (Iverson & Salmons 1995; Avery 1996; Avery & Idsardi 2001; Purnell & Raimy 2015; Natvig 2017, forthcoming; Purnell, Raimy & Salmons forthcoming). Whether phonologically specified for a feature or not, a phoneme's phonological content requires additional specification to become viable, pronounceable phonetic forms. I therefore concur with Purnell & Raimy's view that the sound system consists of "formal structures resulting from many distinct levels of representation that are required to understand the sound patterns in language" (2015:522). I further adopt their proposal for three broadly distinct representational domains: The Phonological, Phonetic-phonological, and Phonetic (Purnell & Raimy 2015). However, "these three levels present a drastically simplified model of phonological levels between lexical access and motor control programs. . . . There are going to be many more levels of representation than presented [here] and there are necessarily specific processes for mapping from one level to another" (Purnell & Raimy 2015:527–8). In the remainder of this section, I expand on these three broad levels of representation.

3.2.1 Modified Contrastive Specification and The Successive Division Algorithm

The role of phonological representations is to specify contrastive differences among sounds that provide lexical and grammatical distinctions (Goldsmith 1995), yet theories vary with respect to how these representations mark contrast. Substantive theories encode contrasts in the sounds' articulatory surface productions (Dresher, Piggott & Rice 1994:iii). However, the examples from Germanic laryngeal assimilations discussed above illustrate how phonological processes operate on some substantive features, but not others. It is, therefore, the role of the phonological component of the grammar to distinguish differences not just between sounds, but also between active and inactive features. The CONTRASTIVIST HYPOTHESIS (see also §3.3) unifies these functions by proposing that the phonology operates only on the features that contrast the phonemes of a language from each other (Hall 2007:20). Dresher (2009) develops this position within the Modified Contrastive Specification (MCS; Dresher, Piggott & Rice 1994) model with the Successive Division Algorithm (SDA) that apportions features hierarchically to a phonemic inventory:

The Successive Division Algorithm

(a) Begin with no feature specifications: assume all sounds are allophones of a single phoneme.

(b) 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.

(c) Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member (Dresher 2009:16).

The result of the SDA is a contrastive hierarchy of features, which models the acquisition of phonemic contrasts and which may differ cross-linguistically based on learners' generalizations of the phonological activity in the language they are acquiring (Dresher 2009; Hall & Hall 2016). While the SDA is indifferent to the type of feature or contrast (i.e., privative or binary), I adopt a dimension-level, privative contrast for reasons discussed above.

As an example of the SDA and the resulting contrastive hierarchy of phonological active features, Dresher (2009) discusses vowel harmony in Classical Manchu, using feature specifications and vowel harmony analysis from Zhang (1996). Classical Manchu has six vowel phonemes /i, u, ʊ, ə, a, ɔ/, and drawing on patterns of ATR (Advanced Tongue Root) harmony, labial harmony, and consonant palatalization, Zhang (1996) proposes the contrastive hierarchy [low] > [coronal] > [labial] > [ATR] (cited in Dresher 2009:176). Figure 3.3 presents the

Classical Manchu contrastive hierarchy in dimensions, where Tongue Height is completed with the gesture [low], Tongue Thrust with [front], Labial with [round], and Tongue Root with [ATR].

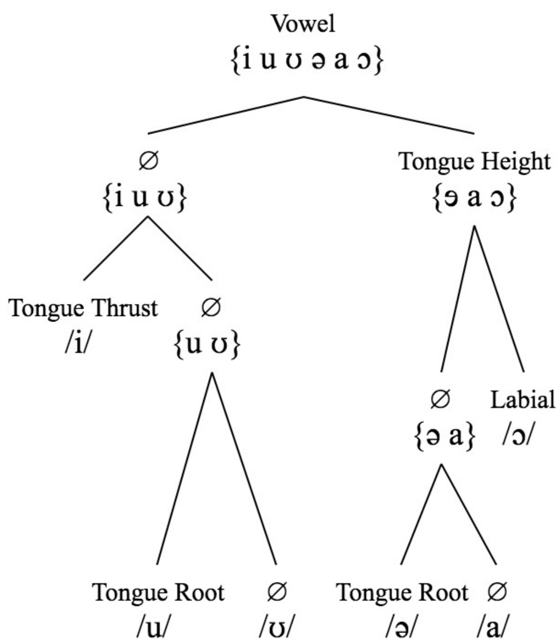

Figure 3.3. Classical Manchu Contrastive Hierarchy (adapted from Zhang 1996 and and Dresher 2009:176).

ATR harmony is only triggered by /u, ə/, with alternations between /u~ʊ/ and /ə~a/. On the other hand, /i/ does not trigger ATR harmony even through it has the [ATR] feature phonetically (Dresher 2009:177). Because Tongue Thrust is higher than Tongue Root in the Classical Manchu contrastive hierarchy, /i/ is completely distinguished from all other members of the vowel inventory without receiving a phonological specification for Tongue Root; it has no feature to trigger ATR harmony. Likewise, the high, (phonetically) round vowels /u, ʊ/ do not have a Labial specification and, therefore, do not induce Labial harmony (Dresher 2009:177). The only contrastively round vowel is /ɔ/, and it is the only vowel that triggers Labial harmony of /a~ɔ/ (Dresher 2009:179–80). Finally, only /i/ triggers palatalization of consonants, "suggesting that it has some relevant contrastive feature" (Dresher 2009:177); in the current framework, that feature is the Tongue Thrust dimension, which only specifies /i/.

The contrastive hierarchy for Classical Manchu in Figure 3.3 shows how a given order of features results in segments that are phonologically unspecified for a feature that presents itself in surface forms — specifically [ATR] for /i/ and [round] for /u, ʊ/. Because these features are not contrastive, they do not participate in the relevant patterns of vowel harmony. A different ordering of the features, however, would produce different outcomes and different contrastive specifications that may better model phonological activity in other languages. Examples include contrastive Tongue Root for /i/, as in Pulaar (see Hall & Hall 2016), and contrastive Labial for /u/ or /ʊ/, as in Spoken Manchu (see Zhang 1996; Dresher 2009:182) and Turkish, for example. The upshots here are that surface characteristics (features) do not define a segment's phonological content, and that languages may differ with respect to the phonological content of similar — or identical — surface forms. The precise content of a language's phonological structure, then, results from the PHONOLOGICAL analysis of that language's phonemic systems and patterns of alternation (e.g., Iverson & Salmons 1995, 2003; Dresher 2009; Oxford 2015).

In the present phonological framework, the features assigned through the SDA result in a contrastive hierarchy of underspecified phonological dimensions. These are the abstract representations that distinguish the segments in an inventory from one another, while providing minimal articulatory instructions (i.e., a muscle group to be activated). These underspecified contrasts comprise Purnell & Raimy's Phonological level of representation (2015:527). Additional features (e.g., [ATR] and [round] for Classical Manchu /i/ and /u, ʊ/, respectively) are added at subsequent levels of representation, to which I turn below.

3.2.2 Completion, enhancement, and phonetic implementation

Both the structure of phonological features (dimensions) and the underspecified contrastive representations apportioned through the SDA — like those discussed for Classical Manchu — require further specification to convert a language's abstract phonemic categories into fully pronounceable phonetic forms. First, dimensions are completed (or filled in) with one of the two opposing gestures. For example, Tongue Height in Classical Manchu (Figure 3.3) is filled in with the gesture [low]. (For Norwegian and its ancestors (see §3.3), Tongue Height is completed with [high].) Second, additional gestures are also added to 'enhance' the perceptual saliency of underlying contrasts (Keyser & Stevens 2006; Hall 2011). For example, Classical Manchu /u, ʊ/ are not phonologically specified as Labial, but receive the gesture [round] to enhance their contrast with /i/; likewise, /i/ is enhanced with the [ATR] gesture. The conversion of dimensions into gestures, as well as the addition of gestures as enhancements or other types of predictable feature combinations, occur at an intermediate level of representation between the Phonology and the Phonetics, what Purnell & Raimy term the Phonetic-phonological level (2015:527, *passim*).[1]

The gesture is the substance of the Phonetic-phonological level of representations, but whether the gesture corresponds to a contrastive dimension or not has consequences for its implementation in the phonetics. Keyser & Stevens (2006), for example, argue that phonological features are categorical, whereas enhancements are gradient and, therefore, prone to both individual and social variation (see also Hall 2011). The conversion of gestures into continuous variables occurs at the Phonetic level of representation (Purnell & Raimy 2015:527; see also Keating 1996 and Keyser & Stevens 2006). With respect to vowels, the implementation of the

[1] See, e.g., Keyser & Stevens (2006) for a more detailed set of representational levels involved in the process of enhancing phonological contrasts, all of which are subsumed under the Phonetic-phonological level here.

gestures that fill in contrastive dimensions are categorical in the sense that these gestures "affect the phonetics by delimiting the space within which the vowel can range" (Dresher 2009:180). Enhancements, then, can vary more freely within the areas of the vowel space that are not carved out by contrastive specifications. However, the degree of variation is constrained by "the number and type of contrasts present in an inventory. . . . Contrasts take up 'space,' leaving less space for underspecified representations" (Dyck 1996:286).

The broad levels of representation — Phonological, Phonetic-phonological, and Phonetic — are presented in Figure 3.4. The gestures at the Phonetic-phonological level are calculated with respect to whether they are contrastive or not; the phonetic features that correspond to contrastive dimensions should present within a more limited range than non-contrastive features. It is this position that forms the basis for evaluating the relationship between the phonetic variables and the phonological structure of Norwegian vowels in this dissertation.

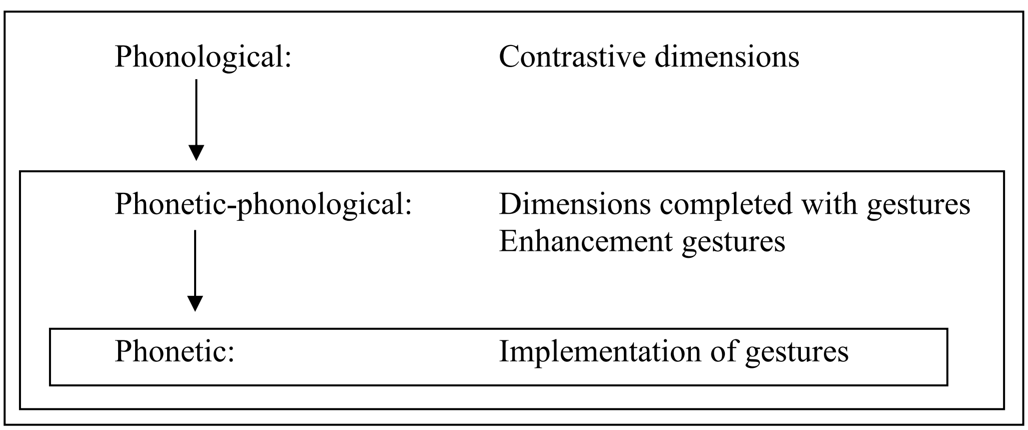

Figure 3.4. Levels of representation in the sound system from Purnell & Raimy (2015).

3.2.3 Phonological representations and quantity

Before I propose contrastive specifications for Norwegian vowels, it is worth discussing the representation of vowel quantity since long and short vowels present surface-level contrasts in Norwegian. Some analyses posit [long], for example, as a distinctive feature within the contrastive hierarchy (e.g., Oxford 2015; see also Dresher 2009:247). Others encode vowel length as projections onto a suprasegmental tier (Clements & Keyser 1983; Hyman 1985; Levin 1985; Ringen & Vago 2010; Purnell & Raimy 2015). Norwegian stressed syllables must be long (see §2.1.2), i.e., short vowels do not occur with single consonants and long vowels do not precede geminates or multiple consonants. Because length in vowels and consonants is reciprocal, deriving vowel length through the mapping of segments onto a long-syllable template captures the "exceptionless surface generalization that a stressed syllable must be heavy" (Kristoffersen 2000:116).[2] Furthermore, in his analysis of Swedish (which underwent the same quantity regulation as Norwegian), Tomas Riad explains that "syllabification controls the lengthening pattern, such that the normal case is for vowels to lengthen in open syllables (and also in final syllables closed by an extrametrical consonant" (2014:170). Kristoffersen (2000) also argues for final consonant extrametricality in Norwegian. An analysis with a phonologically specified length feature, on the other hand, requires an additional explanation for the restricted distribution of half of both the consonant and vowel inventories and must still appeal to suprasegmental structure that governs syllabic weight.

Although a complete analysis of Norwegian syllabification is outside the scope of this dissertation, the evidence suggests that the difference between short and long vowels is captured by whether they are projected onto one or two timing slots, respectively. See Figure 3.5, below,

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[2] Kristoffersen (2000:116–7) analyzes Norwegian stressed syllables as bimoraic and, therefore, refers to them as 'heavy.'

for a suprasegmental representation of the vowels in the minimal pairs *takk* ‘thanks’ and *tak* ‘roof.’ The near-minimal example *teig* ‘parcel, strip (of land)’ with the /æ/ and /ɪ/ of the diphthong phoneme /æɪ/ projected onto its own timing slot. Both members of the diphthong phonemes are specified at the Phonological level of representation; the diphthongal patterns of long mid vowels in Norwegian are derived post-phonologically (§5.2.3). Because vowel length is encoded suprasegmentally, the phonological content of long and short vowels is the same and the long and short surface forms are allophones of the same vowel phoneme. Therefore, the nine vowels /i, y, ʉ, u, e, ɵ, o, æ, ɑ/ (see §2.2) constitute the Modern Norwegian vowel phonemes.

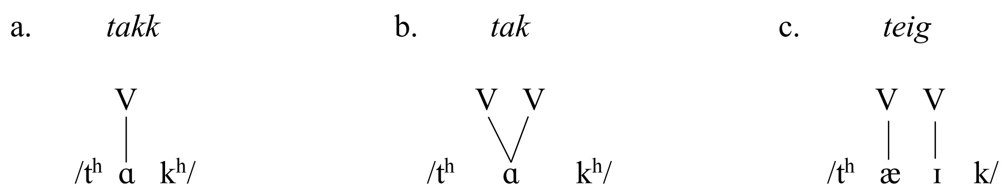

Figure 3.5. Representation of short, long, and diphthong vowel projections.

3.3 Norwegian vowel contrast

The phonological representations proposed in this dissertation consist of the application of the SDA to the Modern Norwegian vowel inventory (see §2.2), resulting in an ordered set of contrastive features. Phonological activity is the primary metric for determining phonological specifications (Dresher 2009) and phonological assimilations, including vowel harmony and vowel context-dependent consonant alternations, for example, provide clear evidence of active phonological features in the vowel system. Vowel assimilations (e.g., umlauts and metaphony, see §2.1) and consonant palatalization occurred in Norwegian as historical sound changes that introduced new vowel and consonant phonemes. However, these processes are no longer active in the modern language. Palatalization, for example, created alternations between /kʰ~ç/ and /k~j/

preceding non-front and front vowels, respectively.[3] At one time, this velar~palatal alternation was predictable based on the backness of the following vowel. Loanwords with velar stops before front vowels, such as *gir* [g̥iːr] 'gear' (cf. *gir* [jiːr] 'give' PRES) and *kø* [kʰɵː] 'line, queue' (cf. *kjøtt* [çɵʰt] 'meat') show that this phonological process is no longer active in the language.[4]

In the absence of clear synchronic phonological activity, additional factors can provide evidence for one contrastive hierarchy over another. These include the historical patterns and processes mentioned above, and mergers and splits (Oxford 2015; Dresher 2015; Purnell & Raimy 2015; Purnell, Raimy & Salmons forthcoming). Historical patterns of phonological activity provide evidence for parent languages' phonological specifications, and how those inventories and patterns change over time support either the maintenance or the change of a given set of ordered features (Dresher 2015; Oxford 2015; Purnell & Raimy 2015; Purnell, Raimy & Salmons forthcoming). In the following discussion of the contrastive hierarchy and diachrony in vowel systems in North Germanic, I adopt the principles of contrast and sound change proposed and supported in Oxford (2015). These consist of four hypotheses: (i) the CONTRASTIVIST HYPOTHESIS (Hall 2007), that only contrastive features are phonologically active; (ii) the SISTERHOOD MERGER HYPOTHESIS, that structural mergers occur among "contrastive sisters" in a contrastive hierarchy (i.e., at the last ordered feature that contrasts two phonemes); (iii) the CONTRAST SHIFT HYPOTHESIS, that contrastive hierarchies are not fixed, but can change over time; and (iv) the SEGMENTAL REANALYSIS HYPOTHESIS, that the contrastive status of segments can be reanalyzed (Oxford 2015:315–7). In addition to these, I propose two additional

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[3] The /ç/ phoneme has dialectal variants, including the palatal stop [cʰ] and affricate [cʰç]. In some areas, this phoneme has merged with apical /ʂ/.

[4] In Trøndsk and Northern Norwegian, long alveolar consonants have also undergone palatalization (Skjekkeland 2005:73–4), a process I assume is related to consonantal structures.

hypotheses in §3.3.2 to account for vowel changes that occurred between the Old Scandinavian and Modern Norwegian periods.

I follow Oxford (2015) and Purnell, Raimy & Salmons (forthcoming) in assuming that contrastive hierarchies are diachronically stable unless independent phonological evidence suggests otherwise. Changes in feature ordering, while admissible under the CONTRAST SHIFT HYPOTHESIS, should be minimal because "an analysis that proposes a dramatic reorganization of contrasts at every diachronic stage would obviously be ad hoc and would provide little in the way of explanation" (Oxford 2015:316). I show that phonological patterns and changes in phonemic inventories (mergers, splits, and chain-shifts) from Proto-Scandinavian to Modern Norwegian support a stable contrastive hierarchy, albeit with a minor adjustment to feature ordering brought on by the Long Back-vowel Chain-shift (LBCS) and the resulting restructuring of phonological representations.

3.3.1 The contrastive hierarchy and phonological change in North Germanic

The five Proto-Scandinavian vowels /i, e, o, u, a/ (long and short) developed from Proto-Germanic /i, e, o~a, u/, where [oː] and [a] constituted a predictable set of surface forms across the long and short series. Purnell & Raimy (2015:536) argue that the contrastive hierarchy for Proto-Germanic is Tongue Thrust > Tongue Height, shown in Figure 3.6. Among the long vowels, [round] is an enhancement for both /u, o/ (see §3.3.3). In the short series, [RTR] is inserted on the unspecified vowel (/o/), resulting in [a] (Purnell & Raimy 2015:535).

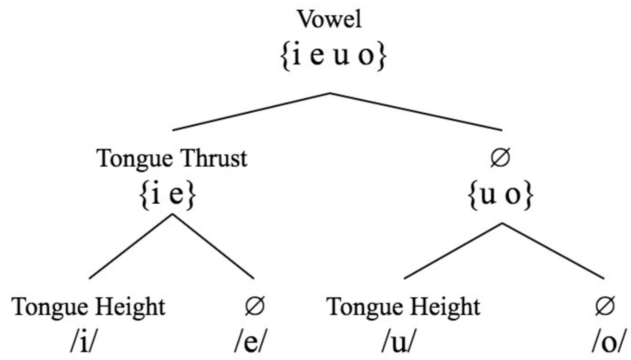

Figure 3.6. Proto-Germanic Contrastive Hierarchy (Purnell & Raimy 2015:536).

The addition of /a/ to the Proto-Scandinavian vowel inventory resulted from the reanalysis of sub-phonological features as contrastive, either the phonologization of /o/ specified with Labial, or /a/ specified with Tongue Root. Because phonological activity demonstrates the contrastive status of a feature, Proto-Scandinavian u-umlaut (compensatory rounding before a rounded unstressed vowel) suggests the presence of Labial in the phonological representation of /o/, contrasting it from /a/. The addition of [RTR] on the unspecified vowel (now represented as /a/) is generalized for both long and short vowels in Proto-Scandinavian. Figure 3.7 shows the contrastive hierarchy for Proto-Scandinavian vowels: Tongue Thrust > Tongue Height > Labial. The split of the Proto-Germanic unspecified vowel into /o, a/ occurs at the lowest level of the contrastive hierarchy, a process that characterizes the inverse of the SISTERHOOD MERGER principle (Oxford 2015; Purnell, Raimy & Salmons forthcoming).

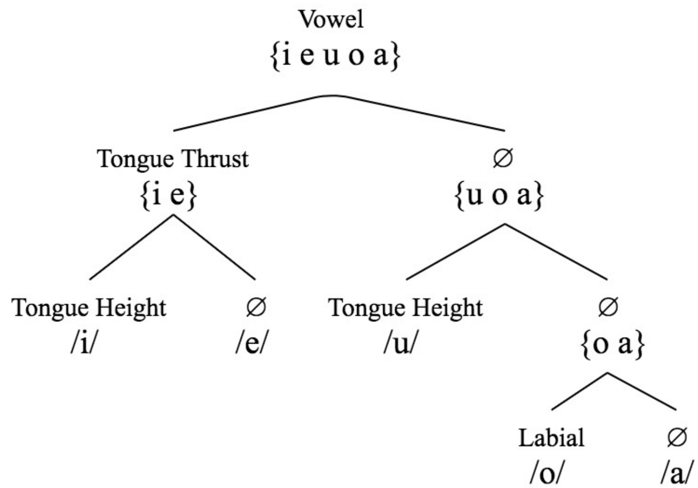

Figure 3.7. Proto-Scandinavian Contrastive Hierarchy.

Phonological conditioning for both Proto-Scandinavian umlaut patterns, i-umlaut and u-umlaut, are present in the contrastive hierarchy in Figure 3.7. Each umlaut is a regressive assimilation of the root vowel to the features of a following unstressed vowel — fronting for i-umlaut and rounding for u-umlaut. Proto-Scandinavian had three unstressed vowels: *a,* variations between *i* and *e*, and variations between *u* and *o* (Hreinn Benediktsson 1959:286–8; Haugen 1982:29). While the /i~e/ variation in unstressed vowels is irrelevant to i-umlaut (both vowels are specified with Tongue Thrust), the hierarchy in Figure 3.7 requires /o/, not /u/, as the unstressed conditioning vowel for u-umlaut because /u/ is not specified for Labial. Since the high and mid vowels never contrast in unstressed syllables, I assume that Proto-Scandinavian only selects the phonemes /e, o, a/ in these positions. Written evidence of unstressed high vowels represents variation in the heights phonemes that are unspecified with respect to height features. For the sake of terminological consistency, then, I refer to i-umlaut as Tongue Thrust assimilation and u-umlaut as Labial assimilation.

Tongue Thrust assimilation produced front allophones of non-front vowels /u, o, a/ before /e/, the unstressed vowel specified with Tongue Thrust. These vowels were phonologized in Common Scandinavian as /y, ø, ę/. Labial assimilation, operating with Tongue Thrust assimilation, rounded the plain vowels /i, e, ę, a/ and created the Common Scandinavian phonemes /y, ø, ǿ, ǫ/. The creation of these new phonemes resulted from the extension of the Labial contrast front vowels and the addition of a Tongue Root contrast to specify the new low vowels /ę, ǿ, ǫ/. The contrastive hierarchy for Common Scandinavian (Figure 3.8) is Tongue Thrust > Tongue Height > Labial > Tongue Root.

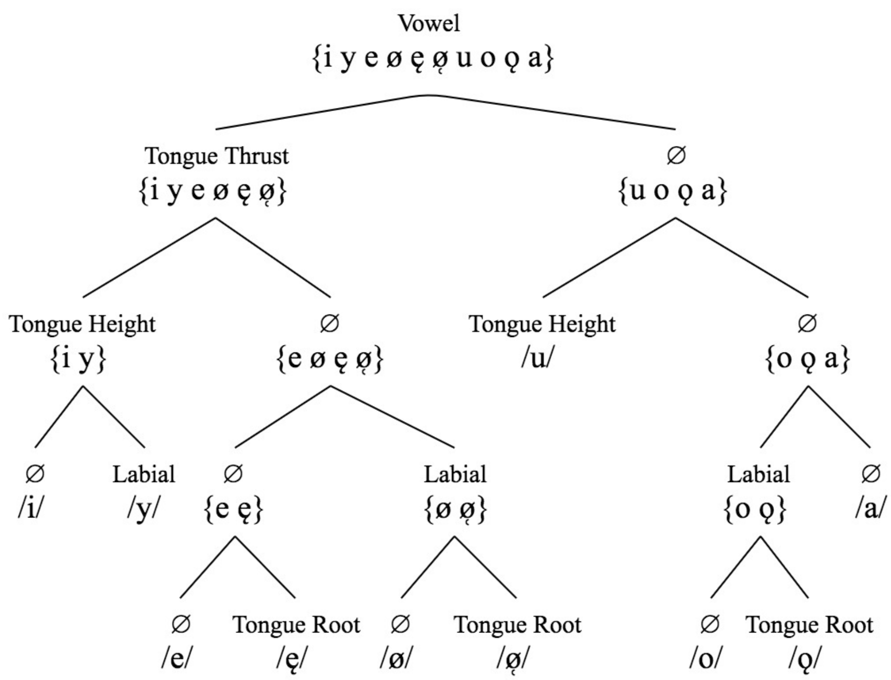

Figure 3.8. Common Scandinavian Contrastive Hierarchy.

Subsequent changes from Common Scandinavian to Old Scandinavian (West Scandinavian and East Scandinavian) support this contrastive hierarchy.[5] In both the long and short sets, /ø̨/ merges with /ø/ (Haugen 1982:39); the loss of the Tongue Root contrast among Tongue Thrust, Labial vowels is consistent with the SISTERHOOD MERGER principle. Other mergers occur asymmetrically among the long and short vowels: only short /ę/ and /e/ merge, and only the long /a/ and /ǫ/ merged (Hreinn Benediktsson 1959:290–1; Haugen 1982:39), although because /ǫ/ merged with /o/ in some cases (Haugen 1982:39), it stands to reason that rounding and low enhancements on long /a/ phonologized and the vowel underwent segmental reanalysis to long /ǫ/; this process, then, did not occur for short /a/. The loss of the Tongue Root contrast between /ę/ and /e/ in the short vowels and the segmental reanalysis of long /a/ as /ǫ/ thus resulted in gaps in surface forms, as in Figure 3.9, which shows the Old Scandinavian vowel inventory for short (a) and long (b) vowels.

a. Short

i	y		u
e	ø		o
			ǫ
		a	

b. Long

ī	ȳ	ū
ē	ø̄	ō
ǣ		ǭ

Figure 3.9. Old Scandinavian vowel inventory (monophthongs).

[5] East Scandinavian and West Scandinavian underwent different historical changes: East Scandinavian breaking of /y/ and progressive j-umlaut (§2.1.1) conditioned changes in backness (viz. Tongue Thrust specification). These changes constitute a SEGMENTAL REANALYSIS, whereby a subset of allophones are subsumed under the phonological specifications of phonemes with identical surface allophones. The unchanged phonemes, however, retain their phonological specifications and there is no loss of a phonological contrast that categorizes structural mergers in East Scandinavian. Therefore, I assume the same contrastive hierarchy for both East and West Scandinavian as an abstraction labeled ‘Old Scandinavian.’

Based on surface forms alone, the long and short series could be represented with one contrastive hierarchy if long /æ/ = short /a/ (cf. Proto-Germanic long /o/ = short /a/), where /a/ is specified for Tongue Root, yet surfaces as a front vowel when long. During this period, however, velar consonants that preceded front vowels, including long /æ/, underwent a palatalization process (Haugen 1982:65), a phonological alternation that suggests a Tongue Thrust specification for /æ/; velars did not palatalize before short /a/. For example, the *k* in Old Norse *kærr* 'dear' is either produced as a palatal fricative [ç], stop [c^h], affricate [c^{h}ç], or has undergone a merger with the retroflex fricative [ʂ] in Norwegian *kjær*. On the other hand, the *k* before short [a] in Norwegian *kalle* 'call' (< *kalla*) retains its velar articulation. The palatalized consonants formed from this Old Scandinavian pattern have since become distinct phonemes (see §3.3).

Considering this pattern, a literal interpretation of the surface forms suggests separate contrastive hierarchies for short and long vowels inherited from Common Scandinavian to capture the sisterhood relationship of short /e, ę/ via Tongue Root, but /a, ǫ/ via Labial (see below). Yet the assumption that feature orderings are diachronically stable unless demonstrated otherwise would seem to require extraordinary evidence for positing parallel contrastive hierarchies for Common and Old Scandinavian. Such a move doubles the phonemic inventory of vowels because length must then be determined lexically, not prosodically. Furthermore, these conflicting representations would then coalesce into a single hierarchy for the modern language. From a diachronic perspective, this appears to limit the explanatory power of that analysis.

An alternative approach addresses the concept of marginal contrast, which characterizes phonological relationships on a continuum between completely predictable (allophonic) and wholly unpredictable (phonemic; Hall & Hall 2016:5–6). Such is the case with /e, æ/ and /ǫ, a/

because a contrast is needed to distinguish each pair, although only in the long vowels for the former and the short vowels in the latter. Vowel length in and of itself does not explain the surface forms of these pairs for the both long and short sets, and "if two phones are unpredictable in at least some contexts, then . . . the system of phonological representations must have some means of distinguishing them" (Hall & Hall 2016:8). I therefore assume the contrastive hierarchy for Old Scandinavian in Figure 3.10, again Tongue Thrust > Tongue Height > Labial > Tongue Root. The asymmetric surface forms in Figure 3.9 (above) result from gaps in the language where /æ/ and /a/ are not projected onto one and two timing slots, respectively. The only change to the contrastive hierarchy from Common Scandinavian, then, is the loss of a Tongue Root contrast among the front, round vowels shown in the merger of /ø/ and /ø̧/.

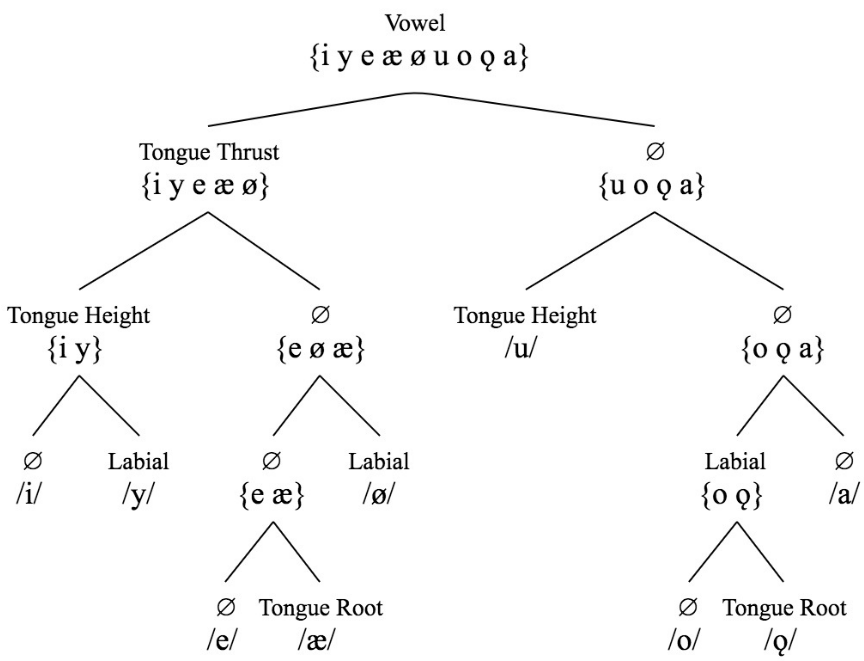

Figure 3.10. Old Scandinavian Contrastive Hierarchy.

The incorporation of Common Scandinavian long /a/ within the same phonemic category as long /ǫ/, or 'the back-rounding of ā' (Haugen 1982:38), warrants discussion. This outcome appears to present a counterexample to the SISTERHOOD MERGER HYPOTHESIS because /ǫ/ and /a/ are not contrastive sisters in Common Scandinavian (Figure 3.9). Although the reordering of Tongue Root over Labial would create a sisterhood relationship (I argue below for such a feature reranking in Modern Norwegian), the unification of the long /a/ and /ǫ/ phonemes is produced not by the loss of contrastive features via sisterhood merger, but the addition of phonological marking through SEGMENTAL REANALYSIS (Oxford 2015:317). Toward the end of the Common Scandinavian period, speakers must have generalized the phonetic roundness of long /a/ as a phonological feature. Accordingly, lexical items with long /a/ consolidated with the lexical items containing long /ǫ/ (cf. Labov's 1994:321 *merger by approximation*). The contrast between /a/ and /ǫ/, however, is preserved in the short vowel series, suggesting that the back-rounding of ā did not produce a structural merger, and that the contrastive hierarchy maintained the Common Scandinavian feature ordering. In distinguishing between these two changes that combine phonological categories, it is critical to evaluate how those combinations impact the contrasts of the entire system, and whether phonological features are lost (sisterhood merger) or added to phonemic representations as in the segmental reanalysis induced by the back-rounding of ā.

3.3.2 The Modern Norwegian Contrastive Hierarchy

The development of Old Scandinavian into Modern Norwegian is marked by the restructuring of non-front vowel contrastive specifications, i.e., my proposal for the CONTRAST SHIFT HYPOTHESES and Oxford's (2015) SEGMENTAL REANALYSIS. These changes resulted from the phonologization of the Long Back-vowel Chain-shift (LBCS), and the quantity regulation that introduced both the shifted vowels into the short series and symmetrized the long and short distributions of Modern Norwegian /o, u, ʉ/ (see §2.1.2). Table 3.1 shows the levels of representation for Old Scandinavian phonemes, where features present in the phonology are in bold, enhancement gestures in plain type, and approximate phonetic descriptions in italics.

Table 3.1 Levels of representation of Old Scandinavian phonemes.

	/i/	/y/	/e/	/æ/	/ø/	/u/	/o/	/ǫ/	/a/
Phonological Level	**TT TH**	**TT TH Labial**	**TT**	**TT TR**	**TT Labial**	**TH**	**Labial**	**Labial TR**	
Phonetic-phonological Level	**[high] [front]**	**[high] [front] [round]**	**[front]**	**[front] [RTR]**	**[front] [round]**	**[high]** [round] [back]	**[round]** [back]	**[round] [RTR]**	[RTR]
Phonetic Level	*front high plain*	*front high rounded*	*front mid plain*	*front low plain*	*front mid round*	*back high round*	*back mid round*	*back low round*	*low plain*

The LBCS that typifies present-day Norwegian (and Swedish) is represented by the introduction of /a/ into the long series through quantity regulation, the raising of long /ǫ/ to [oː] and long /o/ to [uː], and the centralization of long /u/ to [ʉː] (Haugen 1982:40–1; Labov 1994:131). Labov defines the LBCS as a 'Pattern 3' chain-shift, that involves two of his principles of chain-shifting: Principle I, that "in chain shifts, long vowels rise," and Principle III, that "in chain shifts, back vowels move to the front" (1994:116, 129–31).[6] He also considers this a 'push chain,' induced by the introduction of /a/ into the long series and 'pushing' Old Scandinavian /ǫ/ and /o/ upward and Old Scandinavian /u/ forward in the vowel space (Labov 1994:130–1).

In terms of the present theoretical model of the sound system, Old Scandinavian /u/ centralized (lost [back] enhancement) and /o/ shifted upward, both with respect to unspecified phonological features, i.e., /u/ was unspecified for backness, and /o/ unspecified for height; low-

[6] Labov's (1994:116) Principle II deals with short — or 'nonperipheral' — vowels (they tend to lower) and will not be addressed here, although these patterns occur in Norwegian dialects that lower short i > e > æ (§2.2).

back /ǫ/ subsequently raised to [o], evincing Labov's 'Chain-Shifting Principle': "When the phonetic space between two members . . . is increased by the shifting of one member (the leaving element), the other member will shift its phonetic position to fill that space (the entering element)" (1994:184). The phonological implications for the 'entering element' (/ǫ/) are that its raising produces the phonetic conditions for which learners could no longer generalize it as a low vowel specified with Tongue Root. Table 3.2 shows the transitional levels of representation driving the phonologization of the LBCS (with deleted gestures stricken and new gestures and phonetics underlined).

Table 3.2 Levels of representation of transitional back vowel phonemes.

	/u/ = [ʉː]	/o/ = [uː]	/ǫ/ = [oː]	/a/
Phonological Level	**TH**	**Labial**	~~**Labial**~~ ~~**TR**~~	
Phonetic-phonological Level	**[high]** [round] ~~[back]~~	**[round]** [back] [high]	[round] ~~**[RTR]**~~	**[RTR]**
Phonetic Level	*central* *high* *round*	*back* *high* *round*	*back* *mid* *round*	*low* *plain*

The raising of /ǫ/ to [oː] provides evidence for the segmental reanalysis of the back phonemes. At this stage of the shift, the position of /ǫ/ in the vowel space indicates its loss of the Tongue Root specification because it ceased to be categorically [low]. The fact that /ǫ/ loses Tongue Root is compatible with the processes that underlie the SISTERHOOD MERGER HYPOTHESIS: that a phoneme loses the last contrastive feature assigned to it through the SDA. However, the raising of /o/ to [u] allowed speakers to maintain phonetic distance between Old Scandinavian /o/ and /ǫ/ and these two vowels did not merge. Likewise, these vowels also remained distinct from /a/.

Old Scandinavian /o, ǫ, a/ remained a contrastive natural class, but Tongue Root could no longer specify /ǫ/, which motivated the contrast shift from Labial > Tongue Root to Tongue Root > Labial. Tongue Root, then, contrasts /a/:/o, ǫ/, likely supported by the introduction of long [aː] phones from short /a/ via quantity regulation (Hreinn Benediktsson 1970, cited in Labov 1994:130; Haugen 1982:41; §2.1.2). Labial phonologically distinguishes either /o/ or /ǫ/ (see below). This contrast shift also applies to the front series /e, ø, æ/, whereby /æ/ contrasts with {e, ø} followed by the Labial contrast of /ø/ with /e/.

The explanatory power of the contrastive hierarchy as a model of phonological representations is strongest when the ordered set of features captures a language's synchronic phonological activity and its diachronic patterns. A contrast shift is maximally constrained when it involves the "reranking of a single contrast by a single step" (Oxford 2015:316) AND when reranking occurs among the two features with the smallest contrastive scope, i.e., the last two features in a contrastive hierarchy. Feature reranking is motivated by the loss of a contrast between two contrastive sisters, but without a phonological merger. The loss of a phonological feature (Old Scandinavian Tongue Root for /ǫ/), but the maintenance of the contrast (for Old Scandinavian (/o, ǫ, a/) necessitates a new contrastive relationship, whereby a previous enhancement gesture ([RTR] for /a/) is generalized as a contrastive dimension (Tongue Root) for that phoneme. I therefore propose the MINIMAL CONTRAST SHIFT HYPOTHESIS:

Minimal contrast shift hypothesis

(a) A contrastive feature is lost via processes of SISTERHOOD MERGER HYPOTHESIS, i.e., last feature in the contrastive hierarchy is deleted.

(b) A distinction with contrastive sister maintained, i.e., no mergers occur.

(c) The last two features in the contrastive hierarchy are reranked to maintain those contrasts.

The results of the minimal contrast shift reranking of Labial and Tongue Root in Old Scandinavian is presented in Figure 3.11, along with the phonologization of Tongue Height on Old Scandinavian /o/ to produce Modern Norwegian /u/. Old Scandinavian /ǫ/ loses its Tongue Root specification in the phonology following phonetic /u/ fronting and /o/ raising. At the pre-phonologized phase of the chain-shift, /o, ǫ/ raise to phonetically high and mid vowels, respectively, and speakers make the generalization that the contrast between /o, ǫ/ and /a/ is marked not by Labial for /o, ǫ/, but by Tongue Root for /ɑ/ (Figure 3.11). One member of the /o, ǫ/ pair, then, is specified as Labial, signalizing the MINIMAL CONTRAST SHIFT of these two contrastive features. My choice to mark /o/, and not /ǫ/, with Labial in Figure 3.11 is purely for the sake of consistency in that when this vowel is phonologized as the high vowel /u/ with the Tongue Height dimension, it retains the Labial specification, but here to contrast it with high, central /ʉ/. Finally, I use /ɑ/ for Modern Norwegian in keeping with Kristoffersen (2000).

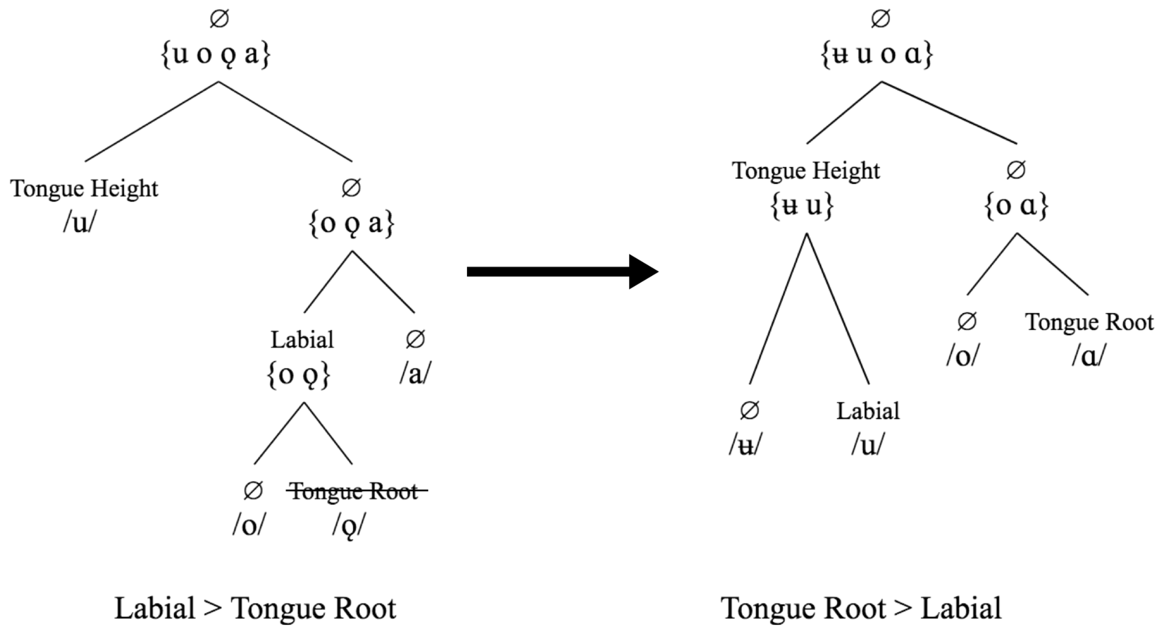

Figure 3.11. Minimal contrast shift and segmental reanalysis of non-front vowels in transition from Old Scandinavian to Modern Norwegian.

The feature reanalysis of Old Scandinavian /o/ to Modern Norwegian /u/ does not constitute a reordering of phonological features, e.g., the addition of Tongue Height to Old Scandinavian /o/ at the bottom of the hierarchy. Rather, it shows a generalization made at some critical stage across different generations of speakers acquiring the Norwegian phonological specifications. The newer generation interpreted the [high] input from old /o/ as a contrastive feature and, therefore, grouped that vowel with Old Scandinavian /u/ when contrasting the high Tongue Height vowels from non-high /ǫ, a/ (in the Old Scandinavian symbols).

Chain-shifts are a process by which mergers are avoided (e.g., Labov 1994:310). Indeed, it is the abstract representations of Old Scandinavian /u/ and /o/ that provided the structural conditions for them to vary with respect to their unspecified phonological content such that the merger between /ǫ/ and /o/ was avoided and the LBCS was possible. Although it has been argued that this chain-shift is a push chain (e.g., Hreinn Benediktsson 1970; Labov 1994), it could not have progressed without the /u/ fronting that cleared the phonetic space for /o/ and /ǫ/ to raise, preserving not only /ǫ/ as a distinct segment, but also the distinction between all four non-front vowel phonemes. Moreover, it appears that /u/-fronting occurred before /o, ǫ/ raising (see Sandøy 1996 for an example of a Norwegian dialect with fronted Old Scandinavian /u/ without raised /o, ǫ/). Ultimately, the push chain-pull chain dichotomy is an unsatisfactory descriptive tool for the LBCS. It is the phonological system that defines the parameters for which the phonetics may vary and produce outputs that either reinforce or inhibit a language learner's ability to uphold the phonological contrasts of the previous generation. In fact, both the push of the back-rounding of ā and the pull of /u/ fronting were necessary for the progression and phonologization of the LBCS in Norwegian and Swedish.

The motivation for positing a {o, ɑ} contrast based on Tongue Root for /ɑ/, and not Labial /o/, rests in the phonological neutralization of Old Scandinavian /ø/, which consists of its segmental reanalysis as the phonologically unspecified vowel in Modern Norwegian. According to Kristoffersen (2000:17; see also §2.2.1), Urban Eastern Norwegian (UEN) <ø> occupies a central position in the vowel space, opposing both front /e/ and back /o/ among mid vowels. For three-way place oppositions in vowels, Keren Rice argues that "the central vowel patterns as unmarked with respect to phonological criteria" (1999:5).

In many Norwegian varieties, /o/ presents with centralized allophones (often written <ö>) primarily preceding retroflex consonants (Skjekkeland 2006:160; §2.2.1). At an intermediate stage between Old Scandinavian and Modern Norwegian, /o/ is the unspecified vowel (Figure 3.11.c); its roundness and conditioned backness occur as enhancements, shown as plain-text gestures in Table 3.3 (contrastive dimensions and their corresponding dimensions are marked in bold type). Because /o/ is unspecified for place features, it may occur within anywhere along F2 space so long it maintains phonetic distance from Tongue Thrust /ø/. This distinction is represented at the Phonetic level of representation in Table 3.3 in that front [ø] is distinct from the central and back /o/ allophones [ɵ ~ o].

Table 3.3 Pre-neutralization, /o/-centralization.

	/ø/	[ɵ]	/o/
Phonological	**Tongue Trust Labial**		
Phonetic- phonological	**[front] [round]**	[round]	[back] [round]
Phonetic	[ø] ≠ [ɵ ~ o]		

Again, at some critical cross-generational juncture, the [ɵ] phones are generalized as members of the same phonological class as Old Scandinavian /ø/ (Table 3.4). For this to occur, the [front] and [round] gestures for [ø] are reanalyzed as enhancements and, therefore, lose their status as completion gestures for the dimensions Tongue Thrust and Labial, respectively. The result is a complete neutralization of phonological structure for the phoneme that presents as both [ø] and [ɵ], resulting in a new phonologically unspecified phoneme /ɵ/. This new contrast is represented in the contrastive hierarchy by the phonemicization of the [round] gesture on /o/ as the Labial. The split of /o/ to /ɵ, o/ supports the hypothesis that Labial is the last contrast in the Modern Norwegian contrastive hierarchy (Figure 3.12; Tongue Thrust > Tongue Height > Tongue Root > Labial) as it is the converse process of SISTERHOOD MERGER, and consistent with the present analysis of previous developments in North Germanic. The contrastive changes for Old Scandinavian /ø/, however, run counter to this principle. It did not just lose the its sisterhood contrast and merge with /e/ but suffered the total loss of phonological specification. Nevertheless, this phoneme's acoustics (§§2.2.1, 5.2.1) demonstrate that it is NOT a front vowel in Modern Norwegian and, therefore, cannot receive Tongue Thrust as a distinctive feature because that specification would require a categorically implemented front vowel.

Table 3.4 Neutralization and segmental reanalysis.

	[ø]	/ɵ/	/o/
Phonological	~~Tongue Trust~~ ~~Labial~~		**Labial**
Phonetic- Phonological	[front] [round]	[round]	**[round]** [back]
Phonetic	[ø ~ ɵ] ≠ [o]		

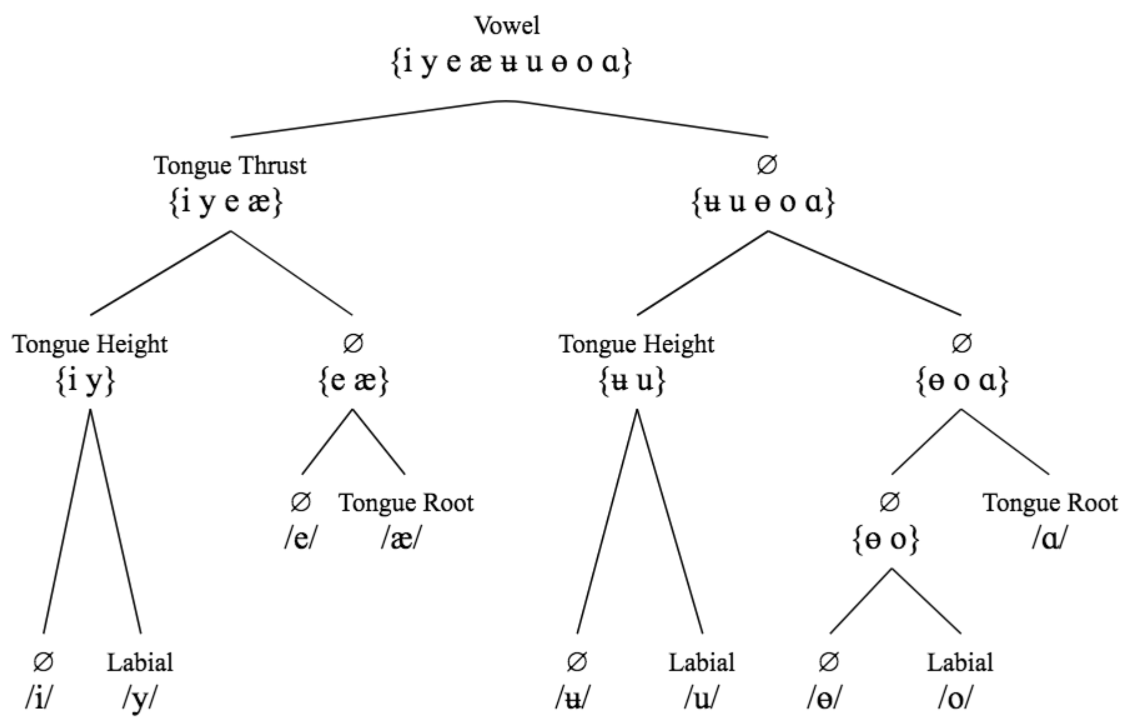

Figure 3.12. Modern Norwegian Contrastive Hierarchy.

The evidence for the segmental reanalysis of Old Scandinavian /ø/ to Modern Norwegian /ɵ/ suggests a second type of merger, one distinct from those described by the SISTERHOOD

MERGER HYPOTHESIS. To model this type of change, I propose the CONTRASTIVE NEUTRALIZATION HYPOTHESIS:

Contrastive Neutralization Hypothesis:

(a) A phoneme loses all of its contrastive dimensions.

(b) That phoneme merges with the phonologically unspecified phoneme.

A promising interpretation of CONTRASTIVE NEUTRALIZATION is that a phoneme loses the FIRST feature in the contrastive hierarchy, thereby prohibiting the assignment of additional features to that phoneme. Recall that it is Tongue Thrust, the first contrast in the Old Scandinavian hierarchy, that proves untenable for specifying /ø/ when learners generalize its category to encompass the [ɵ] phones. When the feature with the greatest contrastive scope is removed from a phoneme, that phoneme is necessarily unspecified phonologically. There is, therefore, no obligation for a deletion process to target any other contrastive feature.

While further analyses of phonological neutralization in a host of languages are required to assess the cross-linguistic validity of the claim that the CONTRASTIVE NEUTRALIZATION HYPOTHESIS targets the first contrastive feature, it has the advantage of operating as an inverse to the SISTERHOOD MERGER HYPOTHESIS. These two hypotheses limit phonological mergers to two types that involve the elimination of the contrast with (1) the smallest contrastive scope, evinced by sisterhood merger, and (2) the greatest contrastive scope, manifested through a merger with the unspecified phoneme. The strong theoretical position is that these are the only two possible types of phonological mergers and that, therefore, hierarchy-internal distinctive features are not subject to contrastive reduction. That Old Scandinavian /ø/ did not merge with what is Modern

Norwegian /o/ suggests the near-simultaneous reanalysis of /o/ as distinctively Labial, possibly supported by the analogous contrast among the high vowels that distinguishes /u/ from /ʉ/.

3.3.3 Modern Norwegian levels of representation

I propose the contrastive hierarchy for Modern Norwegian above based on an analysis of the historical changes in the North Germanic vowels through a set of ordered phonological features. This phonological structure captures much of the vowel differences in dialect descriptions by predicting variation with respect to unspecified features, including possible front variants /ɵ/, lowered /ɵ, o/, and fronted /ɑ/ (§2.2.3), and falling diphthongs among the mid vowels (§2.2.1). Finally, the marginal status of the contrast between UEN /e/ and /æ/ (Kristoffersen 2000:14; see §2.2.1) is encoded through a sisterhood relationship in the hierarchy. While Hall and Hall (2016) do not comment on the position of a marginally contrastive feature within the feature hierarchy, only that it need be present, the limited set of unpredictable environments in which [e] and [æ] occur appear to obscure their contrast and suggest a structural merger in progress. Although comprehensive analysis of the relationships between marginal features and other features within a contrastive hierarchy requires further investigation, I assume that the marginal status of Tongue Root in contrasting /æ/ against /e/ is consistent with the SISTERHOOD MERGER HYPOTHESIS. Table 3.5 presents the derivation these contrastive dimensions to phonetic forms.

Table 3.5. Levels of representation of Modern Norwegian phonemes.[7]

	/i/	/y/	/e/	/æ/	/ʉ/	/u/	/o/	/ɵ/	/ɑ/
Phonological Level	**TT TH**	**TT TH Labial**	**TT**	**TT TR**	**TH**	**TH Labial**	**Labial**		**TR**
Phonetic-phonological Level	**[high] [front]**	**[high] [front] [round]**	**[front]**	**[front] [RTR]**	**[high]** [round]	**[high] [round]** [back]	**[round]** [back]	[round]	**[RTR]**
Phonetic Level	*front high plain*	*front high rounded*	*front mid plain*	*front low plain*	*central high round*	*back high round*	*back mid round*	*central mid round*	*low plain*

The subsequent Phonetic-phonological and Phonetic levels of representations supply additional information that increases the content and structure of each phoneme. At the Phonetic-phonological level of representation, each dimension is completed with its appropriate gesture. Here, Tongue Thrust is completed with [front], Tongue Height with [high], Tongue Root with [RTR], and Labial with [round], and the gestures [round] and [back] are added to /ʉ, ɵ/ and /u, o, ɑ/, respectively. Finally, these gestures are converted to the continuous phonetic representations for the purposes of speech production and perception.

This analysis of the phonological structure of Norwegian vowels stands in slight contrast to what Kristoffersen (2000:33–7) proposes for UEN. The greatest differences between the two proposals is that Kristoffersen argues that /e/ is phonologically unspecified because it shows the most allophonic variation, including reduction to schwa (2000:19–20). The lack of phonological specification for /e/ leaves /i, y, (æ)/ as the only phonologically front vowels (the privative 'Coronal' feature in Kristoffersen's terms); consequently, the central vowels /ʉ, ɵ/ contrast with the back vowels /u, o/ based on the binary feature [±back] (Kristoffersen 2000:33). Because the

[7] The non-low vowels /i, y, e, æ, ʉ, u, o, ø/ are also likely enhanced with [ATR] (Advanced Tongue Root) when long, rendering them tense. Some, including Kristoffersen (2000:13–4), argue that the high vowels /i, y, ʉ, u/ are also tense when short (although see Riad 2014:19–20, who posits lax, short vowels in Swedish, whose vowels — at least impressionistically — do not differ greatly from Norwegian in this respect).

present model uses the dimension as the phonologically relevant level of content, it is not possible to specify both 'front' and 'back' for /i, y/ and /u, o/, respectively. Furthermore, sociophonetic variation of /u, o/ falls out as expressions of these vowels' unspecified content relative to horizontal place (see §§6.2.1, 6.2.2, 6.2.4). Accordingly, /e/ cannot be unspecified without backness features that uniquely specify both /ɵ/ and /o/. I consider, however, patterns of /e/ allophony and its interactions with the stress systems as rich areas for investigations into how prosodic operations interact with — and mold the outputs of — contrastive specifications.

So far, I have described the back /u, o/ and central /ʉ, ɵ/ vowels as [round], with the former receiving the gesture through the completion of the phonological dimension Labial, and the latter as an enhancement supplied at the Phonetic-phonological level of representation. The purpose of an enhancement is to increase the perceptual saliency of a phoneme (Hall 2011), but the addition of [round] to both /ʉ/ and /ɵ/, would in fact, do the opposite, making them more similar to their back, round counterparts /u/ and /o/. The fact that the central vowels are not phonetically plain (i.e., [ɨ, ɘ]) is somewhat strange in a phonological system in which their contrastive sisters are specified with Labial. Furthermore, because the Labial dimension is implemented with the gesture [round], it follows that the phonetic realization of that gesture would signal the Labial specification and would, therefore, not be viable for enhancements. Finally, although accounts disagree in how to categorize the labial gesture of /ʉ/, for example (see Kristoffersen 2000:14–5), there appears to be consensus that these vowels are produced with some type of lip movement.

Even though this model rules out the enhancement of /ʉ, ɵ/ with [round], the Avery & Idsardi (2001) feature geometry provides a second type of gesture for lip movement in opposition to the protrusion associated with [round], namely [drawn] lips (see Figure 3.2).

Accordingly, /ʉ, ɵ/ may receive the labial gesture [drawn] to enhance their contrasts with Labial /u, o/ and the addition of [back] to /u, o/ further enhances the contrast between these sets of vowels.

Although [back] is an enhancement for the Labial vowels, [drawn] enhances the non-Labial, non-Tongue Thrust vowels (i.e., /i/ contrasts with Labial /y/, but does not receive a labial gesture). Because each representational level from the Phonological to the Phonetic increases in structure and specificity, the Phonetic-phonological level may have access to representational labels that are opaque the Phonological level. Therefore, these two enhancements can be expressed through the addition of structure to phonemes at the Phonetic-phonological level of representation that produces more robust differences between the /ʉ, ɵ/ and /u, o/ at the Phonetic level.

Purnell, Raimy & Salmons (forthcoming) adopt 'superordinate null marking' in their analysis of Old English vowel patterns, positing that the unspecified side of a contrast is 'marked' with the node to which the contrastive side is dependent, as defined by the Avery & Idsardi (2001) feature geometry in Figure 3.2. Tongue Root is subordinate to [sonorant], Tongue Height and Tongue Thrust to Dorsal, and Labial to Oral Place. I build on Purnell, Raimy & Salmons' (forthcoming) proposal by submitting that the Phonetic-phonological level of representation has access to superordinate structure to provide the structural motivation for introducing enhancement gestures at the Phonetic-phonological level of representation. This structure is represented in Figure 3.13, where phonologically specified dimensions oppose the unspecified superordinate nodes; because Dorsal has two dependents (Tongue Thrust and Tongue Height), I mark each with a subscript TT and TH, respectively (i.e., Dorsal_{TT} and

$Dorsal_{TH}$), not to suggest that they are separate nodes, but to reflect those nodes' relationships to the dimensions against which they contrast.

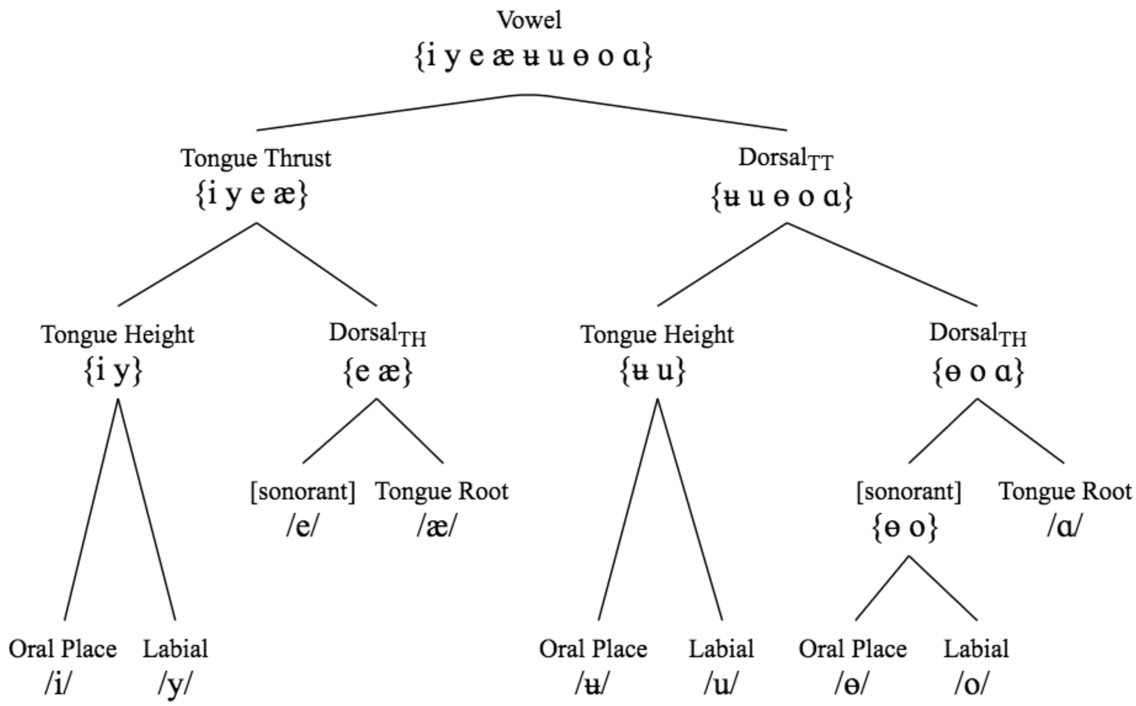

Figure 3.13. Modern Norwegian Contrastive Hierarchy with Superordinate Marking.

With the addition of superordinate null marking, the phoneme classes /ʉ, ɵ/ and /u, o/ can be categorized under unique combinations of articulators and dimensions: /ʉ, ɵ/ are {$Dorsal_{TT}$ + Oral Place}, and /u, o/ are {$Dorsal_{TT}$ + Labial}. The enhancement that produces labial gestures for /ʉ, ɵ/ is essentially a completion rule for an unspecified feature in the context of another unspecified feature. Key to this process being an enhancement is that it does not reference a contrastive dimension and, therefore, occurs outside of the Phonological level of representation, specifically in the Phonetic-phonological module. The enhancement in (1) can be expressed as 'A phoneme that contrasts with Labial (i.e., marked with the Oral Place node in the Phonetic-phonological level of representation) is completed with [drawn] when that phoneme also contrasts with Tongue Thrust.'

Central vowel drawn enhancement

(1) Oral Place → [drawn]//$Dorsal_{TT}$

Likewise, the back enhancement of /u, o/ fills in an unspecified feature, although here in the environment of a phonologically active dimension (Labial). Because this gesture is added at the Phonetic-phonological level of representation to superordinate structure that does not occur in the Phonological level, [back] is an enhancement gesture. Back enhancement is shown in (2) and can be read as 'A phoneme that contrasts with Tongue Thrust (i.e., marked with the Dorsal node at the Phonetic-phonological level of representation) is enhanced with [back] if that phoneme is also specified as Labial.'

Back enhancement

(2) $Dorsal_{TT}$ → [back]//Labial

Table 3.6 captures the conversions of /ʉ/ and /u/ from their phonological dimensions to their phonetic outputs. Based on the contrastive hierarchy in Figure 3.13, /ʉ/ is specified with Tongue Height and /u/ with Tongue Height and Labial, the only structure present at the Phonological level of representation. Additional information is added at the Phonetic-phonological module, including the completion of contrastive dimensions with articulatory gestures (in bold) and the superordinate marking Dorsal, due to both vowels' contrast against the Tongue Thrust vowels. Finally, the drawn and back enhancements for /ʉ/ and /u/, respectively, from the insertion of gestures onto the Oral Place (for /ʉ/) and Dorsal (for /u/) nodes, as in (1) and (2), marked here in plain text. Dorsal is not activated for /ʉ/, resulting in its central position in the vowel space. The combinations of these gestures, then, result in the phonetic productions 'central, high, drawn' for /ʉ/ and 'back, high, round' for /u/.

Table 3.6. Conversions of /ʉ/ and /u/ through the three levels of representation.

	/ʉ/	/u/
Phonological Level	**Tongue Height**	**Tongue Height** **Labial**
Phonetic-phonological Level	Dorsal_{TT} > Ø **Tongue Height** > **[high]** Oral Place > [drawn]	Dorsal_{TT} > [back] **Tongue Height** > **[high]** **Labial** > **[round]**
Phonetic Level	*central* *high* *drawn*	*back* *high* *round*

What is more, the rules in (1) and (2) provide a means by which enhancement gestures are allocated to phonemes based on their positions in the contrastive hierarchy, i.e., how they are specified and against which features they contrast. The addition of superordinate marking to the Phonetic-phonological representations has an additional benefit in that it provides the articulator nodes to which gestures can be affixed ([back] to Dorsal and [drawn] to Oral Place) in a process analogous to the completion of dimensions. This position has the advantage of unifying the process by which gestures are dispensed, but with differences in terms of the types of structure they invoke: only contrastive features (completions), or with reference to superordinate marking (enhancements). Additional research is, of course, necessary to determine if this proposal is adequate for other languages, but it offers a first step toward theoretical specificity in gesture assignments for enhancements. Table 3.7 displays the dimensions, gestures, and phonetics of Modern Norwegian phonemes with [drawn] as the appropriate enhancement for the central vowels.

Table 3.7. Levels of representation of Modern Norwegian phonemes (modified).

	/i/	/y/	/e/	/æ/	/ʉ/	/u/	/o/	/ɵ/	/ɑ/
Phonological Level	**TT TH**	**TT TH Labial**	**TT**	**TT TR**	**TH**	**TH Labial**	**Labial**		**TR**
Phonetic-phonological Level	**[high] [front]**	**[high] [front] [round]**	**[front]**	**[front] [RTR]**	**[high]** [drawn]	**[high] [round]** [back]	**[round]** [back]	[drawn]	**[RTR]**
Phonetic Level	*front high plain*	*front high rounded*	*front mid plain*	*front low plain*	*central high drawn*	*back high round*	*back mid round*	*central mid drawn*	*low plain*

The contrastive hierarchy for Modern Norwegian — Tongue Trust > Tongue Height > Tongue Root > Labial — provides the underspecified features that distinguish phonemes at the Phonological level of representation, and the hierarchy with superordinate structure models the enhancement gestures assigned to Norwegian vowels. This structure, as well as those proposed to explain historical changes, describes the phonological patterns of an abstraction of the language. Throughout the remainder of this dissertation, I seek to test the generalizability of these phonological representations, and how well such an underspecified model captures real regional and social variability in speech sound production.

3.4 Summary

In this chapter, I have presented the theoretical framework within which I analyze the productions of Norwegian vowels. I adopt a modular sound system composed broadly of three levels of representation (Phonological, Phonetic-phonological, and Phonetic) that convert abstract, symbolic phonological representations into continuous phonetic parameters. Phonological representations are underspecified and consist only of contrastive dimensions, which mark phonemes in an inventory through the application of the SDA. The result is an ordered set of contrastive features — or contrastive hierarchy (Dresher 2009). I then propose a contrastive hierarchy for Modern Norwegian vowels based on a diachronic analysis of vowel changes (mergers, splits, and chain-shifts) in North Germanic.

Developments from Old Scandinavian to Modern Norwegian provide evidence for two new hypotheses for contrastive phonological changes over time. The first concerns reranking distinctive features in a contrastive hierarchy, and the second involves phonological neutralization. I propose that reranking occurs among the two features with the smallest contrastive scope (MINIMAL CONTRAST SHIFT HYPOTHESIS) and that any phonologically specified phoneme may merge with the unspecified phoneme through the loss of its phonological features (CONTRASTIVE NEUTRALIZATION HYPOTHESIS). The latter process targets just the feature the widest contrastive scope, in contrast to Oxford's (2015:315) SISTERHOOD MERGER HYPOTHESIS that targets the feature with the smallest scope. In the following chapter, I present the method with which I test the how accurately the contrastive hierarchy for Norwegian vowels in Figure 3.12 models individual and social phonetic variation.

Chapter 4: Methodology

This chapter outlines the methodology with which I test the hypotheses presented in §1. In short, the primary hypotheses address (1) if Eastern and Western Norwegian have different phonological representations for vowels (see §5); and (2) how the effects of social variables on vowel acoustics relate to their phonological representations (see §6). In §4.1, I describe the consultants in this study, including general characteristics, such as age, gender, hometown, dialect group, and any other relevant individual information. I discuss the data collection and processing procedures in §4.2, and review methods for statistical analysis in §4.3.

4.1 Consultant descriptions

The data were collected from self-reported native or near-native Norwegian speakers from February 2016 to April 2016 in the Norwegian cities of Oslo, Stavanger, Trondheim, and Bergen. The consultants were recruited primarily through personal and university contacts. At the Universities of Stavanger, Trondheim, and Bergen I visited medium-sized lectures (either English or Linguistics courses) to request volunteers for participation. In Stavanger, Trondheim, and Oslo, I also solicited consultants from common areas where students gathered, including cafeterias, cafés, and open study rooms. Interviews were conducted in private, quiet rooms, and conversations were recorded as .wav files with the Audacity recording program (version 2.1.2) on an Apple MacBook Pro using a Samson GoMic. The .wav files were then partially transcribed in Praat (Boersma & Weenink 2017) for use in acoustic analysis (see §4.2.2).

The consultants interviewed are presented in Table 4.1 with an alias composed of their hometown followed by a number and either the letter "k" (for *kvinne* 'woman') or "m" (for *mann* 'man') based on the naming conventions of the Nordic Dialect Corpus and Syntax Database

(Lindstad et al. 2009). A total of thirty interviews were conducted (seventeen women and thirteen men), although two interviews (both with men from near Oslo) are excluded from the present analysis because of excessive noise. The remaining 28 consultants' ages at the time of the interviews range from 19 to 36 — born between 1979 and 1996 — with a mean of approximately 23 years old. One consultant (Oslo1k) had completed a bachelor's degree and was working in Oslo, and the remaining twenty-seven were enrolled in bachelor's or integrated master's programs at Norwegian universities;[1] the sample comprises both beginning students (in their first or second year of study) and students nearing completion of their programs. Seven consultants reported having lived at least one year outside of Norway: Bergen1m and Trondheim1m in the United States, Bergen1m and Oslo1k in the UK, Melhus1k in New Zealand, Ås1m in Denmark, and Ringebu1m and Oslo4k in Russia. Three of these consultants were not born in Norway. Bergen1m was born in the UK to Norwegian parents but moved back to Norway as a baby. Ås1m was born in Denmark to Danish parents, and Ringebu1m was born in St. Petersburg to Russian parents. These two emigrated to Norway as children and reported speaking Norwegian more consistently and comfortably than Danish and Russian, respectively. Both had gone to Norwegian schools exclusively from primary school to university. Finally, Tromsø1k is the only Northern Norwegian consultant and may, therefore, diverge from Western Norwegian norms that are impossible from the data to contribute to individual or dialectal factors. Whether Ås1m, Ringuebu1m, or Tromsø1k behave differently than peers will be discussed in §5.1.2.

[1] Integrated master's programs combine bachelor's and Master's programs and usually consist of five years of study.

Table 4.1. Consultants, regions, dialect, gender, and place interviewed.

Consultant	*Region*	*Dialect*	*Gender*	*Age*	*Interview*
Grong1k	East	Trøndsk	Female	19	Trondheim
Trondheim1k	East	Trøndsk	Female	19	Trondheim
Melhus1k	East	Trøndsk	Female	26	Bergen
Trondheim1m	East	Trøndsk	Male	19	Trondheim
Oslo2k	East	UEN	Female	22	Stavanger
Oslo3k	East	UEN	Female	23	Stavanger
Oslo4k	East	UEN	Female	23	Trondheim
Oslo1k	East	UEN	Female	30	Oslo
Oslo2m	East	UEN	Male	22	Trondheim
*Ås1m	East	UEN	Male	28	Bergen
*Ringebu1m	East	Rural	Male	21	Trondheim
Bergen2k	West	Bergensk	Female	19	Bergen
Bergen1k	West	Bergensk	Female	21	Trondheim
Bergen1m	West	Bergensk	Male	26	Oslo
Stavanger1k	West	Southwest	Female	21	Stavanger
Stavanger2k	West	Southwest	Female	22	Stavanger
Stavanger3k	West	Southwest	Female	36	Stavanger
Haugesund1m	West	Southwest	Male	20	Bergen
Stavanger3m	West	Southwest	Male	21	Stavanger
Stavanger1m	West	Southwest	Male	24	Stavanger
Stavanger2m	West	Southwest	Male	25	Stavanger
Flekkefjord1m	West	Southwest	Male	28	Bergen
Svelgen1k	West	West	Female	21	Bergen
Bømlo1k	West	West	Female	22	Bergen
Sogndal1k	West	West	Female	22	Bergen
Volda1k	West	West	Female	25	Bergen
Remøy1m	West	West	Male	22	Bergen
*Tromsø1k	West	North	Female	23	Trondheim

Consultants' linguistic varieties cover the East-West dialect split, as well as the major divisions within each dialect group: East Norwegian, including Urban East Norwegian (UEN) and Trøndsk, and West Norwegian, consisting of dialects from Bergen and Stavanger, as well as Western Norwegian varieties outside these two cities. In all, there are eleven East Norwegian speakers (seven women and four men) and seventeen West Norwegian speakers (ten women and seven men). The map in Figure 4.1 shows the cities in which consultants grew up and, therefore, their approximate dialect region. The colors indicate where the interviews took place (black and gray in Oslo, red in Stavanger, blue in Trondheim, and green in Bergen), with the darker color indicating female consultants, and the lighter color indicating male consultants. Points that represent Eastern Norwegian varieties are located within the circle, with Western Norwegian dialects lying outside. Note that one gray point in Bergen is mostly obscured by an adjacent blue point.

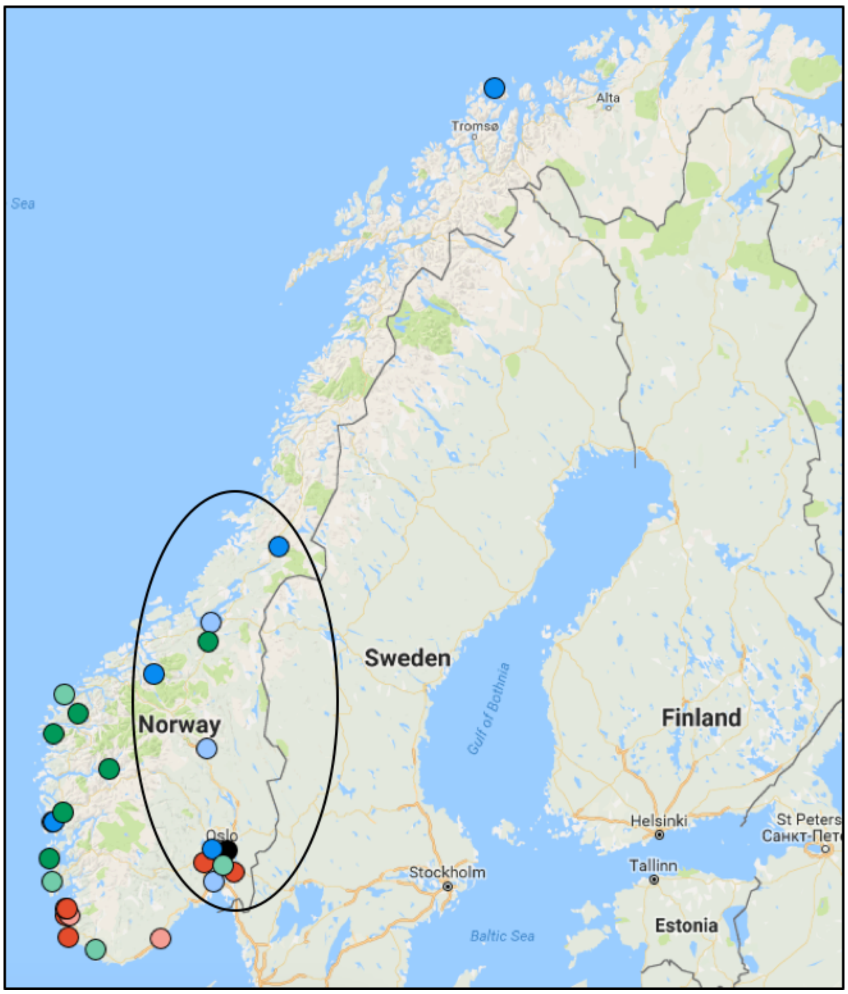

Figure 4.1. Map of consultants' hometowns with interview place shown by color. Retrieved from Google Maps: Norway (Google Maps, n.d.).

4.2 Data collection: materials, processing, and variables

4.2.1 Interview materials

The interviews consisted of two portions: consultants were asked to read a wordlist, and to have a conversation with me about various topics. Following standard sociolinguistic practice, these tasks attempt to elicit more formal and casual speaking styles (see, e.g., Labov 2006:60–3). The consultants likely did not engage with me in their most natural and dialectal speech patterns — I am not a native Norwegian speaker, let alone have native competence in the various dialects under investigation — but differences across these contexts are assumed to fall within a continuum of variation with the most formal and most casual at each extreme. Although I cannot evaluate the extent to which consultants unconsciously altered their vowels in conversations with me, my impression based on more salient linguistic variables, such as pronouns, is that consultants diverged little from expected regional patterns; an analysis of how faithfully they used localized dialectal forms, however, requires more in-depth investigation.

The wordlist was developed from lists previously used in Norwegian dialect research (see Storm 1884; Christiansen 1946–48) and supplemented with additional items to cover all nine phonemes in long and short pairs. With approximately ten tokens for each vowel, the result is a list of 180 items that speakers read word for word, i.e., not in a carrier phrase (see Appendix 1 for complete wordlist). Due to the relatively limited distribution of /æ/, there are at most nine tokens for the short vowel and at least eleven tokens for short /e/. Because /e, æ/ have undergone complimentary patterns of lowering and raising their contrast in both the written and spoken languages is marginal: <æ> is primarily written before <r> and when it occurs in writing before other letters, it is usually pronounced as an [e] (see §2.2.1). Therefore, the instances of <æ> in the wordlist are intended to elicit [æ], although may be produced as [e] in both the long and short sets. I expand upon this in §5.1.1. Finally, one token for short /o/ — *jobbe* 'work' — was removed from the data set because of the difficulties in consistently obtaining measureable short /o/ tokens that did not contain the formants of the preceding sonorant /j/. The 180-word list was divided into three equal (60-word) sections, each followed by a conversation lasting approximately five to fifteen minutes, depending on the consultant's responses.

Conversations were modeled on semi-structured sociolinguistic interviews with three primary sections: demographic information, traditions, and language use and attitudes. In the first section, I asked consultants for general demographic information (see Labov 1984). In this portion of the interview, I also asked consultants to discuss what it was like growing up in their hometowns, what games they played with other children; what their house/apartment looked like; whether they had a garden; if so, what kinds of trees, plants, or flowers it had; etc. In the second section, I asked consultants what traditions they and their families have for Christmas, Easter, and *Syttende Mai* (the seventeenth of May, Norwegian Constitution Day). Finally, in the last section I asked consultants about learning English and their opinions about the increasing prevalence of the English language in Norway and Norwegian society, as well as their experiences and thoughts about learning two written Norwegian norms. These types of questions offered me the opportunity to share some of my experiences growing up in the United States. Many consultants enjoyed comparing cultural differences and similarities, and I found that it often led them to feel more comfortable during their interview and consequently provide longer and more detailed responses; some consultants, however, still preferred single-phrase answers. The range of interviewee speech is between approximately 10 and 40 minutes.

4.2.2 Data processing

I transcribed words and demarcated their stressed vowels in Praat. All words in the wordlists were transcribed and processed (as noted, *jobbe* 'work' was discarded after transcription). Words from interviews were selected in regard their vowels' measurability: priority was given to words with vowels with clear, regular waveforms and vowel boundaries were marked at the beginning and end of these repeating waveform patterns (see Figure 4.2, below). Most often this meant that the vowels selected were between obstruents and after /h/. However, some tokens have preceding liquids (/l, r/) or nasals (/m, n/). Additionally, some vowels that precede the liquids (/l, r/) are used when a clear distinction between the vowel and liquid could be made.

Vowel measurements are taken at heads and tails — 33% and 66% of the vowel duration, respectively — to determine the amount of formant change over the duration of the vowel (see §4.2.3). Figure 4.2 shows the waveform; the first, second, and third formants (F1, F2, F3); and text grids in Praat for the Norwegian word *bog*, a canned meat-like product akin to SPAM™, spoken by Ås1m. The head and tail regions for the [uː] vowel are marked "bogH" (head) and "bogT" (tail), respectively. Each region selects approximately 20 milliseconds of formants measured in Praat; the head and tail values consist of the means of these measurements. The most important formants for this analysis are F1 and F2, which approximate vowel height and advancement, respectively. A low value for F1 (usually around 400 Hz in the present data, depending on individual variation) indicates a high vowel; the greater the (relative) F1 values, the lower the vowel. Back vowels have the lowest F2 (usually between 700–900 Hz) with increasing F2 values corresponding to more advanced vowels; front vowels tend to have F2s greater than 2,000 Hz.

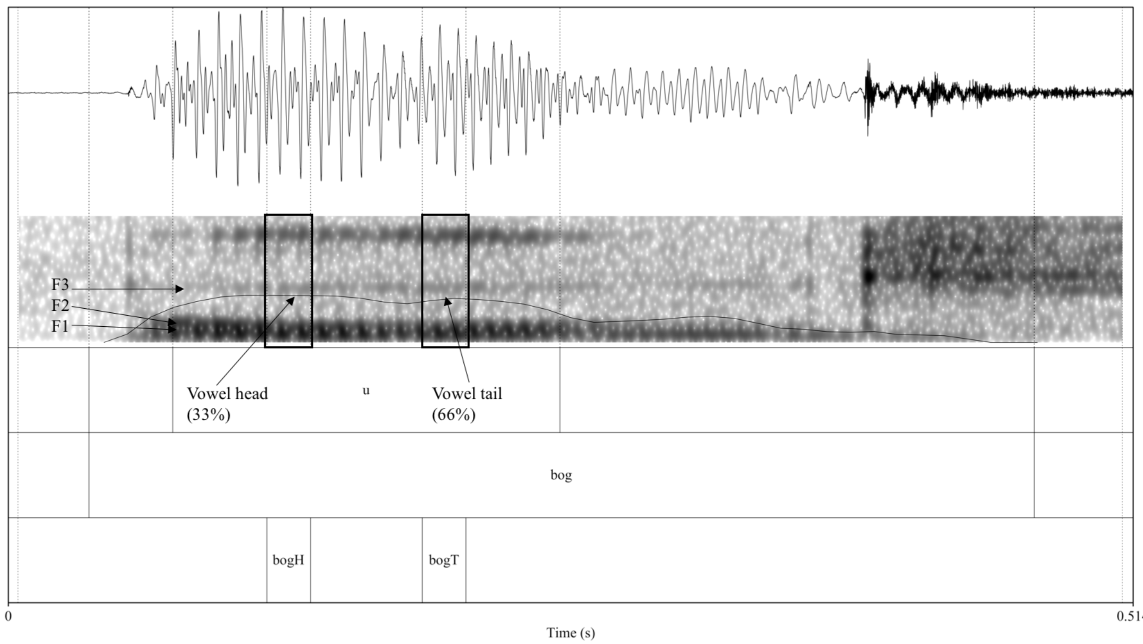

Figure 4.2. Vowel measurement of long /u/ in Norwegian bog.

Because formants vary with respect to speakers' physiological differences (e.g., Thomas 2011:160), raw formant data are normalized with the *TelsurG* method used in the *Atlas of North American English* (Labov, Ash & Boberg 2006:39–40) in the NORM vowel normalization and plotting suite (Thomas & Kendall 2007) to allow for acoustic comparison across the sample. This method is essentially vowel-intrinsic, meaning that each vowel can be normalized without reference to the other vowels in the system because of the stability of the central point (Grand Mean, *G* in *TelsurG*) against which raw formant data is normalized (Thomas 2011:163). Although Adank, Smits & van Hout (2004) find that vowel-extrinsic models (those that require a set of vowels spoken by the same speaker) preserve phonemic and sociolinguistic information better than vowel-intrinsic methods, they "may be impaired when different dialects or languages that show different vowel systems are compared" (Thomas 2011:168). Although the phonological representations of vowel systems are assumed to be the same across dialects, their phonetic realizations may differ in certain circumstances, especially in the conversational style where a vowel's tokens are partially dependent on its frequency in speech. This method, then, avoids skewing of a consultant's vowel system due any accidental gaps in the data.

4.2.3 Factors and variables

I investigate the effects that social and linguistic factors have on normalized vowel measurements. The interview materials provide for a robust set of factors, but at present I limit these to three social and two linguistic factors. The social factors consist of region (East-West) and dialect, gender (female-male), and speaking style (wordlist-conversation), whereas the linguistic factors comprise the preceding and following consonants (phonological environment) and serve to evaluate the extent to which consonantal influences on vowel formant data contribute to social patterns. I treat long and short vowels separately.

I consider seven dependent variables based on vowel production data. For each vowel, I examine the influence that the factors have on normalized F1 and F2 heads and tails, as well as their rates of change (rΔF1 and rΔF2, respectively). The rates of F1 and F2 change are calculated by subtracting the head from the tail values and dividing by one-third of the duration of the vowel (formant change occurs over 33% and 66% of vowel duration). Figure 4.3 demonstrates the formula used to compute rΔF1 and rΔF2 values for statistical comparisons of vowel dynamics.

$$r\Delta F = \frac{F_{tail} - F_{head}}{\left(\frac{1}{3}\right)(Duration)}$$

Figure 4.3. Equation for calculating rates of formant change.

In contrast to changes in F1 and F2, other studies of vowel dynamics (e.g., Hillenbrand et al. 1995; Fox & Jacewicz 2009) operationalize formant changes in the two-dimensional F1 x F2 space (i.e., Euclidean distance or vector length). While vector length provides a measure for a set of vowels' overall movements, it cannot distinguish whether that movement is primarily the result of changes in height, advancement, or both. I have chosen, therefore, to deconstruct vector length into its components (ΔF1 and ΔF2) to compare variation in each of the two vowel-space dimensions. The rate of formant change (rΔF1 and rΔF2) is used in statistical analysis to control for the time in which each vowel's formants can change.

Finally, I examine the (Euclidean) distance within the vowel space between vowel heads across region, gender, and style (i.e., the same vowel in different contexts), as well as the separation between the head of a vowel and the heads of adjacent vowels (i.e., neighboring vowels in the same style), based on the median F1 and F2 heads for each vowel in each context. Figure 4.4 shows the formula for calculating Euclidean distance, where F1 and F2 are the vowel heads and the subscripts 1 and 2 indicate the two vowels in comparison. These measurements are used to quantify the relative distances of vowel heads in acoustic space and to offer a means to compare distances resulting from social factors and those from phonological representations. Because Euclidean distances are computed using central tendencies, they are not evaluated for statistical effects of social and linguistic factors. Finally, I evaluate the relationship that vowel heads have on formant change and rates of formant change when the vowels appear to enter into the phonetic space of a neighboring phoneme. In these instances, F1 and F2 heads are factors tested for their effects on ΔF1 and rΔF1, and ΔF2 and rΔF2, respectively. Table 4.2 summarizes the factors and variables compared in this study.

$$Euclidean\ distance = \sqrt{(F1_2 - F1_1)^2 + (F2_2 - F2_1)^2}$$

Figure 4.4. Equation for calculating Euclidean distance between vowel heads.

Table 4.2. Summary of factors and variables.

Factors	*Variables*
Region	F1 head
Speaker gender	F2 head
Speaking style	F1 tail
Preceding consonant	F2 tail
Following consonant	Rate of F1 change (rΔF1)
	Rate of F2 change (rΔF2)
F1 head	ΔF1, rΔF1
F2 head	ΔF2, rΔF2

4.3 Statistical analysis

Data collection contributes a total of 9,281 vowel tokens, of which 4,902 were from wordlists and 4,379 from conversation. The seventeen female and eleven male consultants produced 5,611 and 3,670 tokens, respectively, and 3,545 of the tokens were from East Norwegian dialects, while the remaining 5,736 tokens were of West Norwegian varieties. From this cursory summary, there are clearly uneven sample sizes across categories. The samples of individual vowels and phonological environments are even more disproportionate. Because all comparisons involve categories with unequal sample sizes, I use nonparametric tests for statistical analysis (see Mann & Whitney 1947). All tests are conducted in the R statistical computing program (R Development Core Team 2008).

The effects of the binary factors, e.g., region, style, and gender (in the present data), on the vowel production variables are assessed with an independent Mann-Whitney *U* test (Mann & Whitney 1947; Wilcoxon 1947). Because preceding and following consonants — as well as the combination of social groups (i.e., women in conversations, women in wordlists, men in conversations, men in wordlists) — comprise multiple factors, a comparison across factors is conducted with a Kruskal-Wallis test by ranks (Kruskal & Wallis 1952) is conducted with a *post-hoc* Dunn's test of multiple comparisons using ranked sums (Dunn 1964; Dinno 2017). These outputs are corrected using the Bonferroni method. Correlations between vowel heads and formant change parameters are tested using the Spearman's rank correlation coefficient (Spearman 1904), also with *p*-values also adjusted with the Bonferroni correction. The significance threshold is set at $p<0.05$.

These tests evaluate the extent to which social and linguistic factors influence formant dynamics and provide a baseline for the degree of regional and social variability for the vowels I investigate in detail. For these types of comparisons, consultants are grouped based on their memberships in the categories of region, dialect, and gender displayed in Table 4.1; individual tokens' normalized formant values — and variables based on their calculations (e.g., $r\Delta F1$, $r\Delta F2$) — for the relevant vowels are investigated for statistically significant effects based on those groups. In the next two chapters, I present the vowel production data and statistical results that (1) support the Modern Norwegian phonological representations for vowels (§5) and (2) demonstrate the sociophonetic variations of past — and contemporary — sound changes (§6).

Chapter 5: Evidence for the Modern Norwegian Contrastive Hierarchy

In §2, I cited descriptive accounts of Norwegian vowel systems that do not preclude a uniform set of phonological representations for Modern Norwegian encompassing all varieties. It follows that there are two sources for existing dialectal differences: (1) phonemic alternations based on historical patterns and (2) the variable implementation of the phonological categories, for which I argue in §3, shown in the contrastive hierarchy in Figure 5.1 (reproduced from Figure 3.12). Because phonologically specified features are assumed to be categorical (Keyser & Stevens 2006; Hall 2011; §3.2.2), the greatest phonetic differences (regional, dialectal, stylistic, and social) should occur among unspecified phonological features. I survey the broadest dialectal vowel distinctions and evaluate them in the context of the Modern Norwegian contrastive hierarchy.

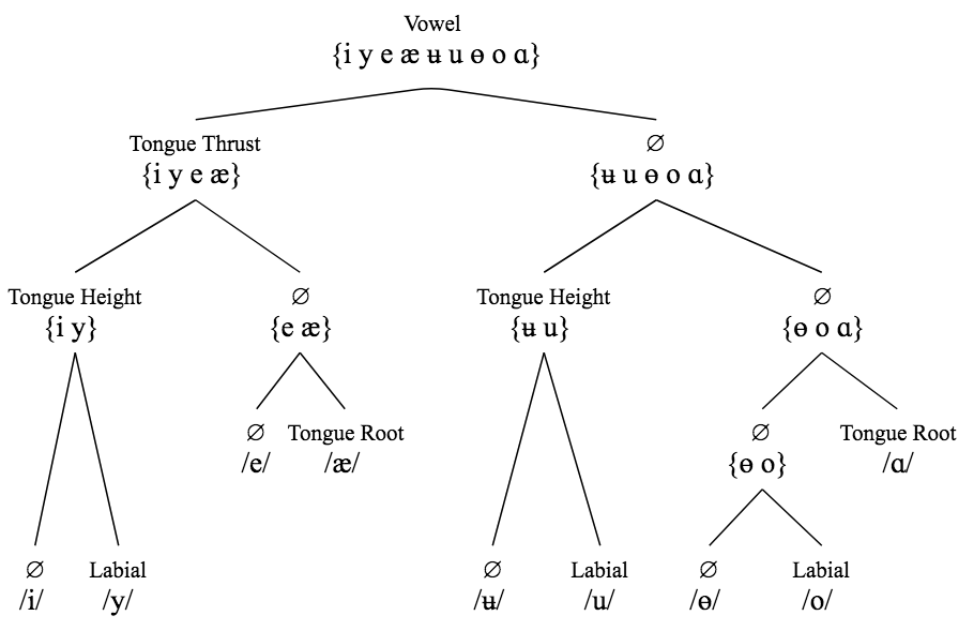

Figure 5.1. Modern Norwegian Contrastive Hierarchy (reproduced from Figure 3.12).

The chapter is structured as follows. I provide an overview of vowel productions in §5.1, including descriptive results from the wordlist task and relevant dialectal and individual acoustic patterns for all vowel phonemes. In §5.2, I discuss acoustic evidence that supports the phonological representations that are derived from the Modern Norwegian contrastive hierarchy. In §5.3, I present my conclusions.

5.1 An overview of vowel patterns

In this section, I evaluate vowel productions for the purpose of cross-dialectal comparison. I begin with a discussion of vowel alternations in the wordlist task (§5.1.1) and follow with a survey of general acoustic patterns by dialect (§5.1.2). I close this section (§5.1.3) with an assessment of two foreign-born consultants (Ringebu1m and Ås1m) that display qualitative differences from the remaining speakers, specifically for the phonemes /o, u, ʉ/. I outline possible sources of these disparities and discuss the limitations that their data have for wider sociophonetic analysis.

5.1.1 Wordlist alternations

The goal of the wordlist was to elicit specific vowels in order to find any consistent patterns, particularly with respect to /ʉ, u/ alternations (West vs. East), the extent to which consultants produced /æ/ preceding non-rhotic environments, and any other noteworthy alternations. No deviations from the intended productions of long and short /i/, /o/, or /a/ were found. For intended /y/, there is one instance of a long~short alternation in Sogndal1k's production of *tytt*. This may be due to a speech error or a misreading of the target word; the form *tytt* 'oozed' is the past participle of the verb *å tyte*, the imperative of which is *tyt* (with a long /y/). Although it is impossible to know how this consultant read the stimulus, the form with a long vowel is a viable word in Norwegian. Finally, four speakers show forms without progressive j-umlaut, where earlier *jo/ju* sequences assimilated to long *y* (§2.1.1). The forms *sjuk* for *syk* 'sick' were produced by Stavanger2k, Svelgen1k, and Remøy1m. Stavanger2k also chose the form *djup* for *dyp* 'deep.' Both variants are common — they are the Nynorsk standards — and likely reflect how the consultants would say those words in their own speech, instead of how it was written on the page. They produced long /ʉ/ in all cases.

Stavanger2k and Remøy1m produce other lexical forms that depart from items in the wordlist. For example, they have back vowel variants in place of central /ɵ/ for the adjective *tørt* 'dry (n.),' as in *turt* with short /u/ for Stavanger2k and *tort* with short /o/ for Remøy1m. The form *turr* is acceptable in Nynorsk, and the variant with the lower vowel *torr* is dialectal; an example can be found in a line from the Knutsen and Ludvigsen ode to Bergen that expresses their longing to return to the city despite being "glad i godt ver og torre kler" [fond of good weather and dry clothes].

Another /ɵ/ variation for these speakers occurred with the words *kjøtt* 'meat' and *kjøkken* 'kitchen,' which intended to elicit the short variant. Both chose the *kjøt* variant with long /ɵ/, reflecting a form with different outcome for quantity regulation, whereby old light syllables were made heavy either through consonant gemination (*kjøtt*) or vowel lengthening (*kjøt*; see §2.1.2). Remøy1m also produced a long vowel in *kjøkken* (i.e., *kjøken*),[1] where Stavanger2k had the variant with the short vowel. Oslo2k substituted short /ɵ/ in *løp* 'run,' which may have been speech error. This word was not a candidate for quantity regulation; the *ø* is the outcome of the monophthongization of the earlier diphthong *au* in *hlaupa* 'run' and was, therefore, already long.

[1] Variants with lengthened vowels were not limited to /ɵ/ for this speaker; he also had long /ʉ/ for target short in *gutt* 'boy,' producing the Nynorsk standard *gut*, as well as a short /æ/ for a target long vowel in *væpne* 'to arm.' While long /e/ is generally considered the appropriate pronunciation for the stressed vowel in *væpne* (Berulfsen 1969:362), all but three Western consultants generated long /æ/.

Stavanger2k and Remøy1m appear to show more solidarity with the lexical variants of their spoken varieties than other speakers. They replace wordlist stimuli with their dialectal equivalents, including the past participle of the 'to be' verb (*vore* for *vært*). There was, however, a slightly wider distribution of departures from wordlist spellings of the preterite and past participles of the verbs *å bo* 'to live' (*bodde, bodd*) and *å tro* 'to think, believe' (*trodde, trodd*). Four speakers, Stavanger2k, Remøy1m, Svelgen1k, and Grong1k, produced some Western forms with old *u* (now shifted to /ʉ/), but all had an Eastern variant for at least one of the four words. Remøy1m had Western /ʉ/ with *budd, trudde, trudd*, but Eastern /u/ in *bodde*; Svelgen2k had Western forms for *tru*, but Eastern for *bo*; Stavanger2k had Western *budde*, but Eastern *bodd*, *trodde*, and *trodd*; and finally, Grong1k (a Trøndsk speaker) had Western *trudde* with Eastern *trodd*, *bodde*, and *bodd*. No Western consultant categorically produced Western variants in wordlist readings, and six Western consultants with Eastern forms for *bo-bodde-bodd* in wordlists categorically produced the Western variants in conversation (instances of *tro/tru* in the past tenses were not common, but most speakers had at least one conversation token for *bodde* or *bodd* when describing their hometowns). While a comprehensive analysis of contextually driven lexical variation is outside the scope of this project, these results show the ease with which many Western Norwegian consultants alternate between Eastern and Western forms in a given speaking or conversational setting.

Wordlist recitations provided evidence for another possible phonemic substitution, specifically the productions of /u/ for expected /ʉ/ and vice versa. In many cases, postvocalic /k^h/ seems to block the fronting of short /u/ to /ʉ/ when the Long Back-Vowel Chain Shift (LBCS; §§2.1.2, 3.3.2) was generalized in short vowel contexts. For example, short /u/ is expected for *bukk* 'goat,' but short /ʉ/ *vugge* 'cradle' (Berulfsen 1969:55, 361). The verb *å sukke* 'to sigh' is one of a few exceptions; short /ʉ/ is expected here despite preceding geminate /k^h/. Eleven consultants (six Eastern and five Western), however, produced *sukke* with a short /u/. On the other hand, seven consultants (three Eastern and four Western) produced short /ʉ/ before geminate /k^h/ in words like *sukker* ‘sugar,’ *bukk* ‘goat,’ and *bukse* ‘pant(s),’ although *sukker* may also be read as the present tense form of the verb *å sukke*. No speaker who produced both substitutions, i.e., short /ʉ/ for intended /u/ and short /u/ for intended /ʉ/.

The final group of phoneme alternations in wordlists concerns /e/ and /æ/. Because there appears to be a certain degree of marginality in the distribution of these two vowels — with /æ/ occurring primarily before /r/ especially in UEN (Kristoffersen 2000:106–9; §2.2.1) — words were selected with both long and short <e> and <æ> before rhotic and non-rhotic environments to investigate whether their respective productions may occur in the same phonological environments, supporting distinct phonemic representations. There were only three instances of a short /e/ production before /r/, in the word *ters* ‘third (musical interval)’ for Trondheim1k, Bømlo1k, and Haugesund1m; the intended vowel was short /æ/. Ås1m’s production of *væske* ‘liquid’ was the only instance of a short /e/ production for orthographic short /æ/ before a non-rhotic among the wordlist items; Berulfsen (1969:362) gives the pronunciation of *væske* with a short /e/.

Alternations between /e/ and /æ/ are limited within the short set, but occur much more frequently among the long vowels. There were no substitutions of long /e/ for /æ/ in wordlist items where intended /æ/ was followed by /r/; these include *lære* ‘learn, teach,’ *mærd* ‘fishing net,’ *nært* ‘near (n.),’ *sær* ‘quirky, weird,’ and *svært* ‘big, great (n.).’ The five words attempting to elicit long /æ/ before non-rhotics were *fælt* ‘awful (n.),’ *sæte* ‘to collect hay into piles,’ *svæv* ‘make fall asleep (imp.),’ *væpne* ‘arm (v.),’ and *væte* ‘wetness.’ Of these, only *fælt* was produced with long /æ/ for all consultants. Three speakers pronounced *sæte* (Oslo4k, Sogndal1k, Svelgen1k) and *væpne* (Sogndal1k, Haugesund1m, Stavanger3m) with long /e/. Six Western Norwegian consultants (Sogndal1k, Stavanger3k, Bergen1m, Flekkefjord1m, Haugesund1m, Remøy1m) had /e/ for *væte*, while nine — two Eastern (Oslo3k, Oslo2m) and seven Western (Bergen1k, Sogndal1k, Svelgen1k, Flekkefjord1m, Haugesund1m, Remøy1m, Stavanger3m) — pronounced *svæv* with long /e/.

These patterns are not strong enough to indicate any consistent phonologically conditioned alternation between [e] and [æ]. Furthermore, all UEN consultants produced long /æ/ before consonants other than /r/. While it is true that many of the words are not particularly common — *sæte* and *svæv* induced most of the perplexed expressions — the speakers' patterns show that they have the ability to produce [æ] in more than just pre-rhotic contexts, consistent with the claim that /æ/ is a Norwegian phoneme, but that a set of vowel changes (§2.2.1) operated in parallel to obscure its contrast with /e/ in most environments and restrict its distribution before /r/ most reliably, although some scattered lexical and morphological exceptions remain.

A summary of the vowel tokens for the wordlist task does not show clear evidence of phonologically conditioned alternations between phonemes. Most of these patterns owe their presence to varied diffusion and social allocation of historical vowel changes, and many of the Western speakers display the ability to alternate between both Western and Eastern variants. Even /æ/, with probably the most limited distribution of the Norwegian vowels, is nevertheless a possible outcome in a variety of consonantal environments. And while these results cannot shed light on the feature hierarchy of Norwegian vowels in Figure 5.1, they do indicate that those phonemes are part of all the consultants' phonological repertoires.

5.1.2 General acoustic patterns by dialect

Turning to the acoustic productions of these vowels, the mean values for each, long and short, are presented in Figure 5.2. Vowel heads, measured at 33% of the length of vowel, are represented at the base of the arrow with the IPA symbol for each vowel; tails, measured at 66% of vowel duration, occur at the tips of each arrow. Eastern Norwegian dialects consist of Urban Eastern Norwegian (UEN; black), Trøndsk (blue) and Rural Eastern Norwegian (red). Western Norwegian dialects are comprised of the varieties from Bergen (blue), Stavanger (red), Northern Norwegian (green), and other parts of Western Norway (black). These plots collapse gender and speaking style and present long and short allophones separately for the sake of exposition (see also Appendix 2 for individual consultants' vowel plots).

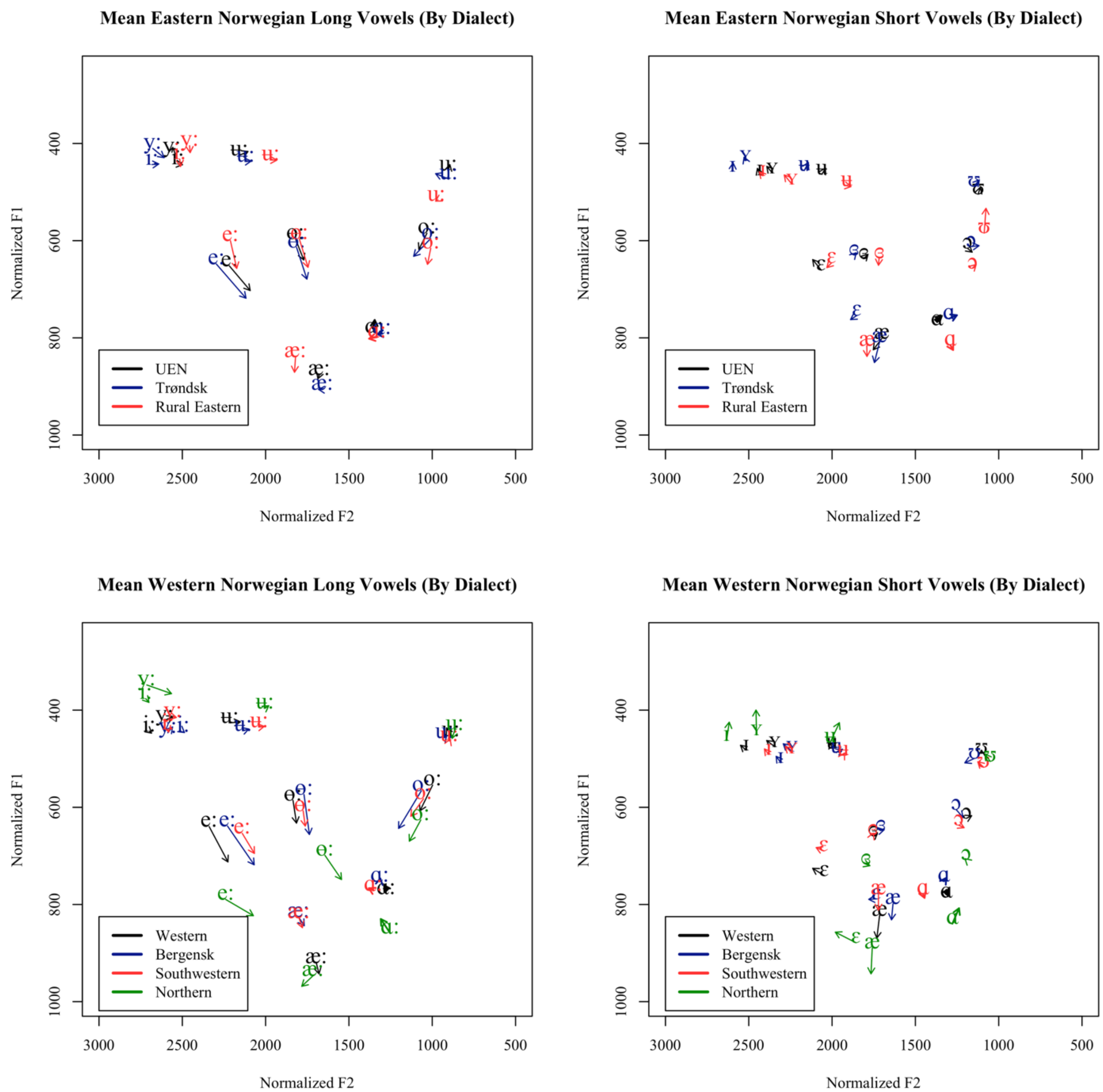

Figure 5.2. Mean Eastern and Western Norwegian vowels by dialect, long and short.

In general, each vowel clusters within the same area of the normalized F1 x F2 space with a few notable exceptions. Firstly, the Rural Eastern and Northern Norwegian tokens show some differentiation when compared to their respective regional dialect varieties. Rural Eastern, for example, has raised long /e/ and long /æ/, backed long /ʉ/, and lower long /u/ and long /o/ productions. The pattern among the latter three are also consistent in the short series, which could suggest some lag in the LBCS among long vowels, as well as the shift's extension into the short set. Finally, short /e/ is lowered, but does not cluster with short /æ/. With respect to Northern Norwegian, high vowels tend to be higher (except for short /u/) and low and mid vowels lower than the other Western Norwegian tokens. In both cases, these results show the vowel productions of individual speakers: Ringebu1m for Rural East and Tromsø1k for Northern. While their results point to areas of further investigation in interregional dialectal variation, the generalizations that can be drawn from them are limited without additional speakers. Therefore, their tokens are removed from data where relevant regional and gender differentiated patterns are investigated (§6). Furthermore, Ringebu1m was born in Russia and moved to Norway as a child, a topic I turn to in §5.1.3, where I discuss the two foreign-born consultants' vowel productions.

Returning to broader dialectal results, Figure 5.2 shows that Trøndsk means cluster tightly with those in UEN, excepting the lowered short phones [ɛ] and advanced [ɪ, ʏ, ʉ]. Short /e/ lowering is also found in Bergen, albeit to a greater degree (see below; §§5.2.2–3), and the fronting of the non-back high short vowels maintains the same contrasts as those in UEN. Finally, Trøndsk is known for monophthongization of Eastern Norwegian [æɪ] to [eː] and [øʏ, æʉ] to [øː] (Hanssen 2010:157; Skjekkeland 2005:169; §2.2.2). There are, unfortunately, no examples of these diphthongs in the data to provide a comparison with the historical monophthongs. Whether the monophthongs and diphthongs have merged phonologically or not remains open to further research.

As mentioned, short /e/ in Bergensk is lowered and clusters with short /æ/, although it is slightly fronted with seemingly less diphthongization than short /æ/. An independent Mann-Whitney *U* test for short /e, æ/ F1 heads shows no statistical significance (U=2303, p=0.379).

Results for F1 tails and F2 heads and tails, however, are statistically significant: U=1729, p=0.001* (F1 tails); U=3238, p=0.004* (F2 heads); U=3286, p=0.002* (F2 tails). Further research may determine if these differences are salient enough to categorically distinguish between the phonemic categories, but Bergensk short /e/ is clearly closer in production to Western Norwegian short /æ/ than the short /e/ produced by Western speakers outside of Bergen. Furthermore, Bergen long /e/ productions are consistent with those in the rest of Western Norway, excluding Tromsø1k. I return to a discussion of Bergensk short /e/ in §§5.2.2–3, but the remaining vowel tokens cluster broadly within similar pockets of the vowel space, supporting a cohesive set of phonological categories within which these vowels vary phonetically with respect to dialect.

Although close to other Western dialects' short /ɑ/, this vowel for Southwestern Norwegian is slightly advanced along F2 space (see §2.2.3). Results for a Kruskal-Wallis test for F2 heads (Table 5.1) and tails (Table 5.2) by dialect (excluding the individual Rural East and Northern Norwegian speakers) shows that Southwestern short /ɑ/ has statistically significant differences in F2 heads ($\tilde{x}$=1457.2) and tails ($\tilde{x}$=1444) compared to all other dialect groups. The combined medians for the other dialects are 1356 for heads and 1330.1 for tails; all measurements that approximate the horizontal position of short /ɑ/ are more advanced in Southwestern Norwegian than in the other groups. Finally, F2 head comparisons between all dialects excluding Stavanger are insignificant, and only between UEN and Trøndsk are F2 tails significant; they are further back in the vowel space in Trøndsk ($\tilde{x}$=1240.9) than UEN ($\tilde{x}$=1321). See §5.2.3 for a discussion of Southwestern short /ɑ/ fronting and Modern Norwegian phonological representations.

Table 5.1. Kruskal-Wallis test and Dunn's *post hoc* test of short /ɑ/ F2 heads by dialect (with Bonferroni correction).

Dialect	Bergensk	Western	UEN	Trøndsk
Western	0.1393 1.0000			
UEN	-1.3198 0.9344	-1.6225 0.5235		
Trøndsk	1.2273 1.0000	1.1855 1.0000	-2.7318 0.0315	
Southwestern	**-4.5993** **0.0000***	**-5.3042** **0.0000***	**3.9073** **0.0005***	**6.1023** **0.0000***

Note. χ^2=53.3304, *df*=4, *p*=0*. For group comparisons, test statistics shown above *p*-values.

Table 5.2. Kruskal-Wallis test and Dunn's *post hoc* test of short /ɑ/ F2 tails by dialect (with Bonferroni correction).

Dialect	Bergensk	Western	UEN	Trøndsk
Western	0.3785 1.0000			
UEN	-0.8415 1.0000	-1.3723 0.8499		
Trøndsk	2.236692 0.1265	2.034905 0.2093	**-3.3997** **0.0034***	
Southwestern	**-4.5546** **0.0000***	**-5.5469** **0.0000***	**4.4549** **0.0000***	**7.2539** **0.0000***

Note. χ^2=66.4428, *df*=4, *p*=0*. For group comparisons, test statistics shown above *p*-values.

An additional claim about the Stavanger dialect is that — at least among 'older speakers' — the short /ʉ/ and short /ɵ/ merge with short /y/ (Hanssen 2010:179; §2.2.3). Although the sample does not contain any 'older' consultants of the Stavanger dialect (the oldest, Stavanger3k, was born in 1979), Figure 5.2 shows clear separation within the vowel space between all three vowels. If short /y, ø, ʉ/ were undergoing a merger, the younger generation of university-aged speakers does not show evidence of it, suggesting that the change is not an actively progressing characteristic of the contemporary dialect.

5.1.3 Foreign-born consultants

As Figure 5.2 demonstrates, Ringebu1m differs from the rest of Eastern Norwegian consultants in the phonetic positions of /e, æ, ʉ, u, o/; he is also the only speaker of Rural Eastern Norwegian. Another source for his slight differences may be that he was not born in Norway, but in St. Petersburg, Russia, and moved to the country as a child. The other foreign-born consultant is Ås1m, who was born in Denmark and likewise grew up in Norway. Both reported Norwegian as their primary language, the language that they speak most often and with which they are most comfortable. However, they also report that their parents speak to them in Russian and Danish, respectively.

Ringebu1m and Ås1m's mean vowel productions (green and red, respectively) together with Norwegian-born men Trondheim1m (blue) and Oslo2m (goldenrod) and female Eastern consultants (black) are provided in Figure 5.3. Because the positions of /e, æ/ for Ringebu1m appear more consistent with other Eastern individuals than they do in Figure 5.2, I focus throughout this subsection on /o, u, ʉ/. Ringebu1m has lowered [oː, ɔ, uː, ʊ,] and the least advanced long and short /ʉ/. He comes from an area of Norway that is considered to be conservative with respect to the LBCS (see Venås 1977 for descriptions of neighboring varieties). Lagging in the completion of this shift would present as backed /ʉ/ and lowered /o, u/, precisely the ways in which Ringebu1m differs from the other Eastern Norwegian speakers. Without other consultants sharing his variety, however, it is impossible to know from the present data if his lowered back vowels are representative of that regional pattern.

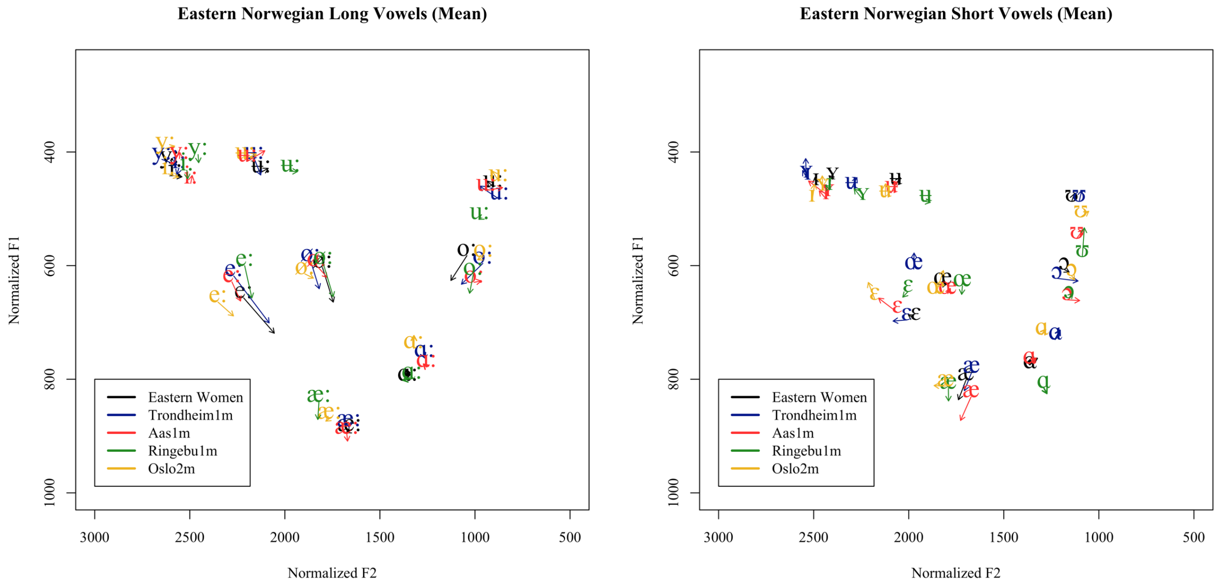

Figure 5.3. Mean Eastern Norwegian vowels: Male individuals and women as a group (long and short).

Ås1m has slightly less lowered [ʊ] than Ringebu1m and his [uː] appears consistent with the rest of the group. He does, however, have lower mid vowels [oː, ɔ]. It is likewise difficult to determine if these differences are the result of a local pattern within Oslofjord region, or if the phonetic targets of his Norwegian phonology have been influenced through contact with Danish, which was not affected by the back-vowel shift. The fact that his /o/ phonemes are not [low] and his /ʉ/ vowels are similar to the other Norwegian speakers suggest that he acquired the Norwegian phonological system.

Ringebu1m and Ås1m comprise half of the Eastern Norwegian male speakers — and Ås1m is himself half of the male UEN consultants — so it is unfortunately impossible to generalize based on variations that appear to be conditioned by gender for Eastern Norwegian. Therefore, an analysis of gender-differentiated effects on vowel dynamics for the present data must either exclude Eastern Norwegian for concern patterns for which region is not a factor.

Individual long and short /o, u, ʉ/ tokens for Ringebu1m (blue) and Ås1m (red) are shown in Figure 5.4 against the combined mean for the remaining Eastern consultants. Ellipses demarcate Eastern vowel heads within two standard deviations of the mean (Kendall & Thomas 2014). With respect to the long and short /o/ vowels, most of the Ringebu1m and Ås1m tokens fall within the same phonetic space as other Eastern speakers, but they are confined to the lower portion of that area. The /u/ vowels show a similar distribution, but with heads for seven Ringebu1m long /u/ tokens that exist outside of the Eastern ellipsis. Ås1m's long /u/ mostly conforms with the spread of the other Eastern consultants. Both Ringebu1m and Ås1m have short /u/ tokens that primarily occupy a lower slice of the F1 x F2 space taken up by the other speakers' short /u/s. Finally, only Ringebu1m has slightly backed long and short /ʉ/ tokens compared to the rest of the group, although most of them pattern within the expected ranges for the long and short series, with three long and five short /ʉ/ heads occurring outside of the Eastern ellipses. With respect to this vowel, Ås1m appears consistent with the rest of the group.

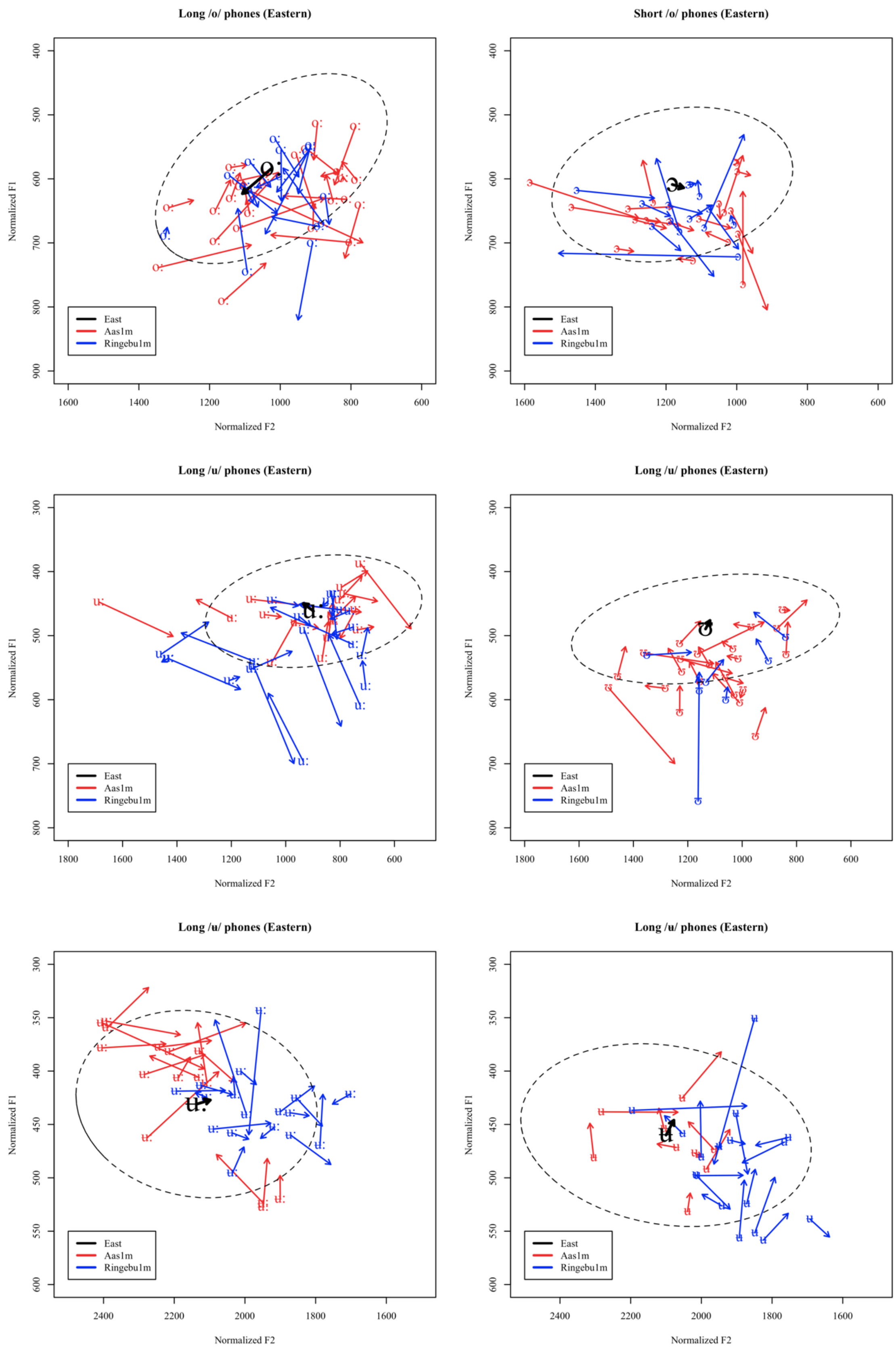

Figure 5.4. Individual long and short /o/, /u/, and /ʉ/ tokens for UEN women, Oslo2m, Ås1m, and Ringebu1m.

The data do not provide a definitive basis for determining the cause of Ringebu1m and Ås1m's vowel patterns in comparison with the other Eastern Norwegian speakers. Though they are the only consultants not born in Norway, their tokens generally do not diverge in ways that conflict with the Norwegian phonological system. First, their samples may be skewed and more advanced /ʉ/ and raised /u, o/ tokens may just be missing from the data set. Second, their phonetic patterns may reveal contact effects, whereby processing for comprehension or production of a less dominant language may influence the implementation of the dominant language's phonemes, regardless of the order of acquisition (e.g., Natvig forthcoming). Third, they may demonstrate the representative vowel productions of localized Norwegian varieties. Without ample means to support one of the three possibilities, I remove Ringebu1m and Ås1m from statistical analyses of /o, u, ʉ/ (§6).

The results examined in this section show that vowel phonemes pattern consistently, but with some minor dialectal and individual discrepancies. Deviations from target vowels in the wordlist task generally owe to historical distinctions between East and West Scandinavian, and Western Norwegian speakers typically show the knowledge and use of some Eastern forms. The clearest dialectally conditioned variations occur among short vowels: short /e/ lowering in Bergen — and to a lesser extent in Trøndsk — and short /ɑ/ fronting in Southwestern Norwegian. In the next section, I discuss the phonetic support for the Modern Norwegian phonological representations put forward in §3. Again, the distinction between specified and unspecified features is determined through an analysis of phonological activity (synchronic and/or diachronic). Because phonological representations are grounded in their realizations as continuous acoustic variables, corroborating phonetic data strengthens the phonological analysis.

5.2 Evidence for phonological specifications

Each regional group taken as a whole displays similar relationships between vowel phones within the vowel space (cf. Figure 5.2). Figure 5.5 shows the mean values for vowel heads and tails for all vowels. I use this plot as a general reference point from which I evaluate the phonological representations in Figure 5.1. I also expand on evidence from the previous section to supplement the analysis.

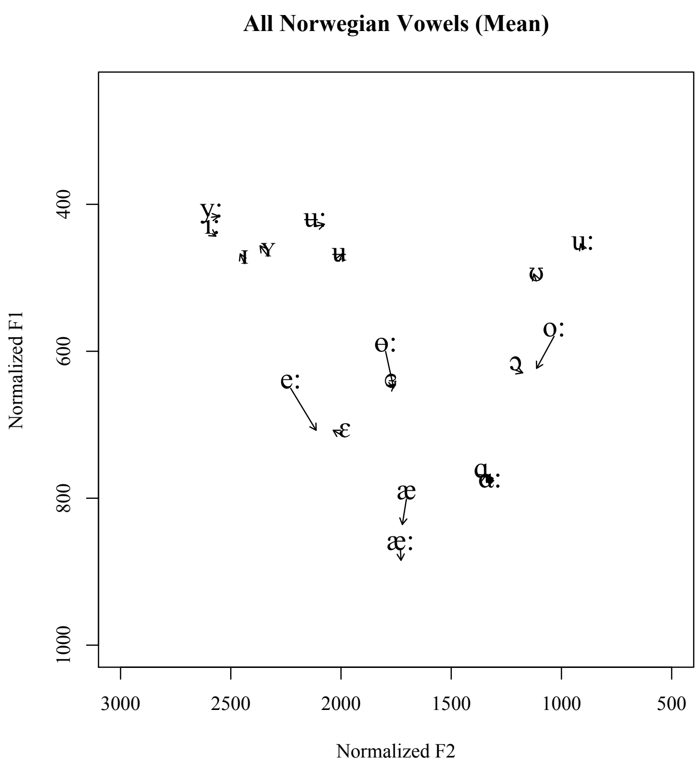

Figure 5.5. Mean Norwegian vowels, all consultants (long and short).

Modern Norwegian has an inverted triangular-shaped vowel space, providing a baseline by which classes of vowels may be compared. The front and central vowels occur at a diagonal that decreases with respect to normalized F2 from /i/ to /e/ to /æ/ and from /ʉ/ to /ɵ/ to /ɑ/, respectively, with the lower vowels pushed further back in absolute space. Conversely, the diagonal from /u/ to /o/ to /ɑ/ for back vowels increases in normalized F2, and the lower vowels are more advanced in an absolute sense relative to their higher counterparts. Because /ɑ/ occurs at the junction of the central and back diagonals, it is unclear from the acoustic data alone if it is enhanced with [back] based on these measurements alone. Because, as I argue in §3.3.3, [back] enhances the Labial dimension in the context of the superordinate Dorsal$_{TT}$ node, it is only an enhancement for /o, u/. The gesture [drawn] is also predicted to enhance the contrast between /ʉ, ɵ/ and Labial (<[round]) /u, o/. These facts are reflected in Table 5.3 (adapted from Table 3.3), which displays the Norwegian phonemes' phonological representations, completed and enhancing gestures, and phonetic outcomes. Enhancements are shown in plain type; /ɑ/ lacks [back] as an enhancement.

Table 5.3. Levels of representation of Modern Norwegian phonemes (from Table 3.6).

	/i/	/y/	/e/	/æ/	/ʉ/	/u/	/o/	/ɵ/	/ɑ/
Phonological Level	**TT TH**	**TT TH Labial**	**TT**	**TT TR**	**TH**	**TH Labial**	**Labial**		**TR**
Phonetic-phonological Level	**[high] [front]**	**[high] [front] [round]**	**[front]**	**[front] [RTR]**	**[high]** [drawn]	**[high] [round]** [back]	**[round]** [back]	[drawn]	**[RTR]**
Phonetic Level	*front high plain*	*front high rounded*	*front mid plain*	*front low plain*	*central high drawn*	*back high round*	*back mid round*	*central mid drawn*	*low plain*

In the following subsections, I discuss the vowel production data in relation to the Modern Norwegian contrastive hierarchy (Figure 5.1) and the vowel phonemes' levels of representation (Table 5.2). I begin with an analysis of the unspecified phoneme, /ɵ/, followed by arguments for the phonemic status of /æ/ and its sisterhood relationship with /e/, drawing in part on short /e/ lowering. I then present an account of mid vowel diphthongization based on their phonological structure, and I conclude this section with a discussion of the remaining phonemes, including some limitations of the present data for illuminating variable and categorical patterns.

5.2.1 Unspecified /ɵ/

Acoustic measurements are the continuous, physical components of sounds contained in the Phonetic level of representation. In isolation, acoustic analysis cannot providence for a given segment's phonological representations or the order in which the phonemic inventory is assigned these features through the Successive Division Algorithm (SDA; Dresher 2009). Based on the assumption that a language's phonological features are categorical and thus require phonetic representation (Keyser & Stevens 2006; Hall 2011), the vowels' relative positions to each other can provide (counter)evidence for the phonological features allotted to a given vowel, or set of vowels.

For example, it is my position that /ɵ/ is a central vowel without phonological specification, even though it is the descendant of two historical processes involving the dimension Tongue Thrust — rounding of Proto-Scandinavian /e/ and fronting of Proto-Scandinavian /o/ — which coalesced into a Tongue Thrust and Labial specification for /ø/ by the Common Scandinavian period (§3.3.1). Its historical high counterpart /y/, on the other hand, retains the Common Scandinavian Tongue Trust, Labial combination. The plot in Figure 5.6 shows that, for both the long and short series, /i/ and /y/ generally overlap: their mean positions appear to be closer to each other than, for example, the positions of /y, ʉ, e, ɵ/. The Euclidean distances from the median values of vowel heads (§4.2.3) between /y/ and /i/ and between /y/ and /ʉ/, therefore suggest a baseline for how close or distant vowels that do and do not share Tongue Thrust within the same height specification. The distance between /e/ and /ɵ/ indicates how these vowels compare to the corresponding high vowels.

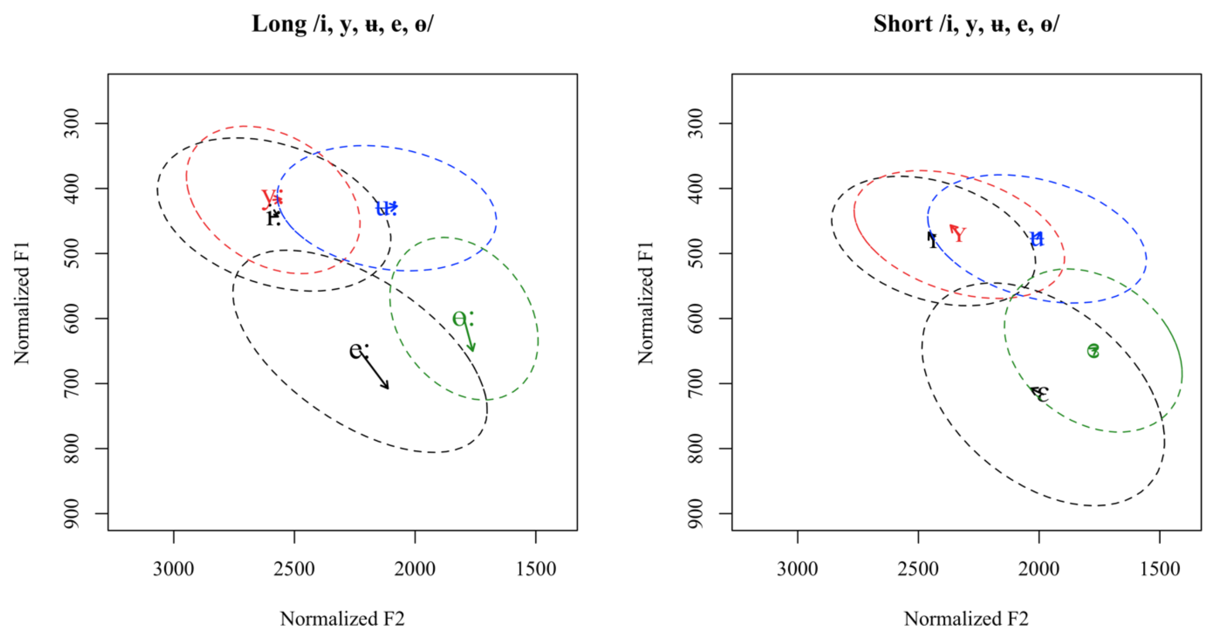

Figure 5.6. Front vowel heads' (long and short) relative positions in acoustic space.

The Euclidean distance between long /i/ and long /y/ is remarkably small at 24.47. Short /i/ and /y/ are slightly further apart, 93.32, but, as the plot in 5.6 shows, they are still fairly close and occupy the same general region of the vowel space with considerable overlap of their ellipses. The Euclidean distances between front /y/ and central /ʉ/, on the other hand, are much larger: 464.91 for the long and 346.02 for the short. For the mid vowels, long /e/ and /ɵ/ have a Euclidean distance of 424.36 and short /e/ and /ɵ/ of 226.16, both of which are larger than the distance between /i/ and /y/. Furthermore, the distances between /e/ and /ɵ/ are more to the distances between /y/ and /ʉ/ than between /i/ and /y/. For purposes of comparison, the Euclidean distances between the low vowels /æ/ and /ɑ/, which like /y, ʉ/ and /e, ɵ/, contrast according to the presence and absence of Tongue Thrust, are 435.67 and 353.63 for long and short, respectively.

Recall that Tongue Thrust is completed with the gesture [front] at the Phonetic-Phonological level of representation and then converted to a continuous variable in the Phonetics that fall within a limited range of acoustic outcomes. Although a vowel that is not specified for Tongue Thrust may present acoustic measurements within that range (e.g., enhancement), the completion of Tongue Thrust with the gesture [front] requires a vowel with that specification to do so. The distances between /e/ and /ɵ/ suggest that they do not fall within the same gesturally defined acoustic pocket, like /i/ and /y/, for example. Furthermore, the closeness of /i/ and /y/ indicate that the distance between /e/ and /ɵ/ does not result from a Labial contrast, but a lack of Tongue Thrust marking on /ɵ/. In this regard, the acoustic evidence is consistent with the phonological representations in Figure 5.1.

5.2.2 Evidence for the phonemic status of /æ/

In the Bergensk, /e/ lowers toward /æ/ when short, concealing the contrast between the two short vowels in acoustic space. There is, of course, no phonological height specification for /e/, and although its lowering undermines the contrastive power of Tongue Root for /æ/, it does not violate its own phonetic implementation of phonological features. The lowering of short /e/ appears to be a consequence of the marginality of the /e, æ/ contrast in Norwegian. In Bergensk, the phonetic differences among the short vowels are all but phonetically neutralized, and the contrast is only acoustically observable for the long vowels. This contrastive obfuscation is consistent with a merger-in-process stage of language change. While it is not my position that Bergensk speakers will ultimately lose the distinction between these two vowels, the contrastive sisterhood relationship I propose for /e/ and /æ/ models that potential outcome.

It is important to note that, at least for UEN, Kristoffersen (2000:105–9) accounts for the near complementary distribution of [eː, ɛ] and [æː, æ] by positing two 'e-lowering' rules, whereby the feature [low] (here Tongue Root) is inserted on /e/ when it occurs (1) as the onset of a diphthong and (2) before underlying /r/. With respect to the diphthongs, there appears to be very few cases of mid [ɛ] as the first member of <ei> [æɪ] and <au> [æʉ] in native Norwegian words, although Kristoffersen (2000:19, fn. 13) notes that [ɛɪ] may be possible in English loanwords like *teip* 'tape.' I do not investigate the phonetic properties of Norwegian diphthongs in this dissertation, but under the current analysis either phoneme is suitable as the underlying onset; /e/ could be lowered as an enhancement to increase its distance from the high offglides and reinforce the diphthongal character of the vowel. Further research is necessary to evaluate the phonetic distributions of these diphthongs and if, as Kristoffersen argues, [æ] is the only possible onset for native Norwegian words, it follows that the underlying onset is /æ/.

The lowering of /e/ before rhotics must mark the exceptional cases where [eː] occurs before /r/, such as the causative suffix *–ere* [eː.ɾə] and words like *mer* [meːɾ] 'more (non-count)' and *flere* [fl̥eː.ɾə] 'more (count).' In forms such as these, according to Kristoffersen, /e/ is marked as [–low] and blocks the lowering rule; /e/ is unspecified elsewhere (see also Weinstock 1972). Notice that this proposition requires an additional, abstract phoneme to account for the occurrences of [eː] and [ɛ] preceding all consonantal environments: one [–low] and one [∅low]. This is functionally equivalent to specifying both /e/ and /æ/, but with the reverse privative relationship (one /e/ phonologically [–low] instead of /æ/ as [+low] or Tongue Root here). The present analysis requires no stipulation for /e/ to lower before /r/, and the exceptional phoneme (/æ/) is the member of the pair that occurs in the most restricted contexts. There are, however, indications that /e, æ/ do alternate, e.g., in variants for *stjele* 'steal,' as in [stjæː.ɽə] before the retroflex, but [stjeː.lə] before the laminal in a more formal pronunciation (Kristoffersen 2000:106). Whether or not this is the result of a stylistic substitution of phonemes, akin to /u~ʉ/ alternations among Western speakers, or dialectal /æ/ raising in Norwegian is open to further investigation. The latter may be addressed by a perceptual study to uncover if there are any asymmetric categorization patterns when replacing [e] and [æ] phones in different consonantal environments. In sum, because two types of height specifications are required to account for an 'e-lowering' rule and that UEN speakers show the ability to produce this vowel in non-rhotic environments, albeit with some uncommon lexical items (§5.1.1), the phonemic status of /æ/ is supported by both phonological and vowel-production evidence.

5.2.3 Diphthongization in mid vowels

The mid vowels /e, ɵ, o/ present phonetically as diphthongs when long. Endresen (1991:112) discusses this as a feature of UEN, but the production data demonstrate that it is a broader pattern in Norwegian speech, at least for the age group sampled here. The mean Euclidean distances for long /e, ɵ, o/ are 129.71, 61.44, and 90.38, respectively, and a visual inspection of Figure 5.5 reveals that they are longer than both their short allophones and the remaining vowels, long or short.[2] Furthermore, long mid vowels on average have falling trajectories, i.e., a change in height (increasing F1values) over the course of their durations (but see §6.2.4). That this change only occurs for the long mid vowels provides acoustic support for their lack of a specified feature for height. The high and low vowels, on the other hand, are all monophthongal when long and specified with Tongue Height and Tongue Root, respectively.

[2] For purposes of comparison, the longest Euclidean distance for a height-specified vowel is 39.01 for short /æ/.

One way of representing the differences between the productions of long and short mid vowels is via the insertion at the Phonetic-phonological level of representation of an [RTR] gesture that is affixed to the second member of the timing tier, as in Figure 5.7. When short, the mid vowels project to the first slot (Figure 5.7.a) and to both slots when long (Figure 5.7.b). Projections are represented as solid lines and insertions as dotted lines; the second member in the short projections never occurs and is, therefore, deleted.

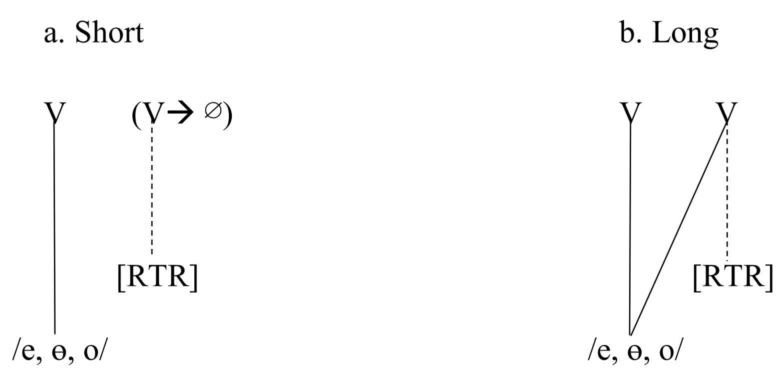

Figure 5.7. Mid vowel projections onto the timing tier.

A benefit to positing [RTR] insertion on the second V slot is that is can portray the process by which short /e/ in Bergen categorically lowers. The [RTR] gesture spreads to the first timing slot for short /e/ (Figure 5.8.a), but not for short /ɵ, o/ (Figure 5.8.b). The lowering occurs for /e/, but not /ɵ, o/, reflecting the general tendency for the contrast between /e/ and /æ/ to be minimized in a variety of phonological contexts (§5.2.2), since it is only /e/ that has a sisterhood relationship with a single Tongue Root phoneme. The contrastive hierarchy in Figure 5.1 posits that Tongue Root > Labial so that neither /ɵ/ nor /o/ are sisters with a Tongue Root-specified vowel, namely /ɑ/. Finally, the fact that short /e/ lowers in Trøndsk, yet not the extent that it does in Bergen, attends to the phonetically gradient nature of the implementation of gestures. Trøndsk, then, undergoes the process of [RTR] spreading in Figure 5.8, but with dialectal variation in the conversion of articulatory gestures to continuous representations at the Phonetic level of representation. When [RTR] is the completed gesture of the Tongue Root dimension, however, these vowels categorically occur within the low region of the vowel space.

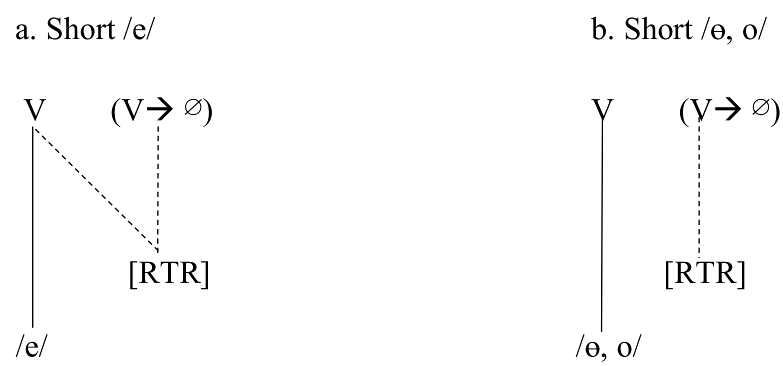

Figure 5.8. Bergensk and Trøndsk short mid vowel projections onto the timing tier.

5.2.4 Southwestern short /ɑ/ fronting

The low vowel /ɑ/ also shows dialectal variations. Kruskal-Wallis pairwise comparisons of short /ɑ/ F2 heads (Table 5.1) and tails (Table 5.2) reveal statistically significant differences in their productions in the Southwestern dialects (§5.1.2). Further investigation shows that this dialectal marker is more advanced among women (F2 head $\tilde{x}$= 1523) than men (F2 head $\tilde{x}$= 1421). An independent Mann-Whitney *U* test of F2 heads confirms that these differences are significant (U=3559, p<0.001*). Because women almost always lead sound changes (e.g., Labov 2001:357); and others), their advanced F2s compared to men suggest a change in progress in which short /ɑ/ is advancing in the vowel space. Because /ɑ/ is only specified for Tongue Root, there is no phonologically related gesture that governs the advancement of this vowel. Variation across this parameter, therefore, does not violate the phonological content of the phoneme.

A glance at Figure 5.2, however, shows that there is still considerable space between short /ɑ/ and short /æ/ (ΔF2 head=266.95), and that this change in progress has not crossed a categorical boundary. That is, the variation that Southwestern speakers exploit for short /ɑ/ appears to occur WITHIN its own phonological category, which is defined along F2 space by its distinction from /æ/. Investigations of future phonetic differences in short /ɑ/ for Southwestern Norwegian will reveal if the vowel will continue along this this trajectory and cross into the vowel space occupied by short /æ/. While the Modern Norwegian contrastive hierarchy cannot predict such a change, this type of phonetic variation is a conceivable outcome of the gradient nature of unspecified phonological features. The extent to which the categoricity of phonological specifications limits (socio)phonetic variation, on the other hand, is an issue I turn to in §6.

5.2.5 The rest of the vowel system

The supporting evidence for Modern Norwegian phonological representations I presented thus far has primarily addressed the mid and low vowels, though also the high /i, y, ʉ/ phonemes to a lesser extent. These vowels and /u/ are phonetically high vowels and must be phonologically specified as such (via Tongue Height), since Norwegian has three phonologically distinct vowel heights; the low vowels /æ, ɑ/ are specified as Tongue Root, and the mid vowels /e, ɵ, o/ are unspecified.

The Euclidean distances I discuss in §5.2.1 confirm that /i/ and /y/ are almost on top of each other in the high, front region of the vowel space. Furthermore, /i/ and /y/ are approximately as far from high central /ʉ/ as /e/ is from /ɵ/. The Euclidean distances from the heads of /y/ to the heads of /ʉ/ are 322.22 and 470.84 for short and long, respectively. For the sake of comparison, the distances from central /ʉ/ to back /u/ are much larger: 894.53 for short and 1215.28 for long.

Even though the /ʉ/ phones are closer to front /y/ than back /u/, it clusters between the other high phonemes along the F2 scale — supporting its lack of specification for place features — and that the other (phonetically) round vowels /y, u/ must have phonological specification in that regard (e.g., Rice 1999). The fact that /ʉ/ is closer to /y/ than to /u/ is an outcome of its lack of a phonological feature that governs its horizontal position in the vowel space.

In the Avery & Idsardi (2001) feature geometry, there are only two vowel dimensions that can distinguish phonemes based on horizontal place: Tongue Thrust and Labial. Because each feature can only distinguish the specified against the unspecified sets, there is a maximum of four possible phonemes that Tongue Thrust and Labial can produce among the Tongue Height vowels; Tongue Root is impossible here since it is a proxy for [low], which is incompatible with [high]. Therefore, the only other possible way to specify the Norwegian high vowels /i, y, ʉ, u/ within the theoretical model adopted in this dissertation is for Tongue Thrust (completed with [back]) to mark /ʉ, u/ as back. Acoustic data for /ʉ/, including its closer proximity to /y/ than /u/, as well as its patterning with the other central vowels, belie the position that /ʉ/ could be phonologically specified as a back vowel. Even though these facts cannot speak to the order in which these phonemes receive their specifications through the SDA, there is no other empirically supported way to distinguish all four high vowels from each other in the present model. Therefore, /ʉ/ must be specified with Tongue Height, /u/ with Tongue Height and Labial, /i/ with Tongue Height and Tongue Thrust, and /y/ with Tongue Height, Tongue Thrust, and Labial.

Finally, it is an assumption that the non-front Labial vowels (/u, o/) are enhanced with [back], which increases their salience from the central rounded vowels (/ʉ, ɵ/). The central vowels, then, are rounded by redundancy as non-front vowels (see §3.3.3). Because Labial is phonological for /u, o/, but not for /ʉ, ɵ/, it is possible that the latter group has unrounded variants. Impressionistically, the central vowels seemed to all be round; labiality — or roundness — is not a feature that I can address based on the present data. Therefore, I leave it to future study to investigate if it is a variable feature for Norwegian central vowels. The phonetic corroboration for the Labial specification for /u, o/ stems from their status as the only vowels that are clearly back vowels; a result from [back] enhancement on the only two non-front Labial vowels in Norwegian.

5.3 Summary

In this chapter, I have outlined general patterns of vowel production among Norwegian-speaking consultants with a variety of dialects, subsumed under two general regional categories: East and West. Results from the wordlist task show that deviations from the intended vowels primarily consist of the realization of historical differences that date back to vowel changes in East and West Scandinavian vowel patterns, with individual variation in the degree to which those differences materialize in speaking tasks. Moreover, a survey of acoustic measurements reveals consistent cross-dialectal — and cross-regional — phonetic implementation of phonemes, which does not reject a single, unified phonological structure for Modern Norwegian vowels for all the dialects studied here. Finally, the broadest dialectal differences, namely short /e/ lowering and short /ɑ/ fronting, and consistent patterns concerning central /ɵ/, /e/ and /æ/ distributions, mid vowel diphthongization, and high vowel saturation, lend support for the distinctive features for Modern Norwegian vowel phonemes posited in §3. A summary of the levels of representation for Modern Norwegian vowels with notes on their variations and relative positions in the vowel space is presented in Table 5.4.

Table 5.4. Norwegian vowel phonemes' levels of representation with summary of patterns.

	Phonological Level	Phonetic-Phonological Level	Phonetic Level	Notes and variations
/i/	**TT** **TH**	**[high]** **[front]**	*front* *high* *plain*	–long higher and more advanced than short –more advanced than mid /e/
/y/	**TT** **TH** **Labial**	**[high]** **[front]** **[round]**	*front* *high* *rounded*	–long higher and more advanced than short –some retraction in the short series
/e/	**TT**	**[front]**	*front* *mid* *plain*	–diphthongal when long with a falling tail –more advanced than /æ/ –long heads higher and more advanced than short; long tails approach short tails –short /e/ lowering in Trøndsk and Bergen
/æ/	**TT** **TR**	**[front]** **[RTR]**	*front* *low* *plain*	–long lower than short –further back than /e/
/ʉ/	**TH**	**[high]** [drawn]	*central* *high* *drawn*	–alternates with /u/ for historical reasons –long higher and more advanced than short –more advanced than /ɵ/
/u/	**TH** **Labial**	**[high]** **[round]** [back]	*back* *high* *round*	–alternates regionally and possibly socially with /ʉ/ for historical reasons –long higher and further back than short
/o/	**Labial**	**[round]** [back]	*back* *mid* *round*	–diphthongal when long with a falling tail –long heads higher and further back than short; long tails approach short
/ɵ/		[drawn]	*central* *mid* *drawn*	–diphthongal when long with a falling tail –long heads higher and more advanced than short; long tails approach short tails –further away from /e/ than /y/ to /i/, patterns like /ʉ/ to /y/, consistent with no TT specification
/ɑ/	**TR**	**[RTR]**	*low* *plain*	–long slightly lower than short –overlap in central and back diagonals, [back] enhancement unclear –slight, but significant, fronting for Southwestern Norwegian

Chapter 6: The Sociophonetics of the Long Back-Vowel Chain Shift

The Long Back-Vowel Chain Shift (LBCS) is one of the defining characteristics of the Norwegian and Swedish vowel systems. The fronting of long /u/ and the raising of long /o, o̜/ in Old Scandinavian is a substantial structural innovation that distinguishes not only Norwegian and Swedish from the other Scandinavian languages but also from the rest of the Germanic family. This shift is present for all the consultants of the study: they all produce the three round vowels /y, ʉ, u/ and all have /o/ in the mid region of the vowel space (see §5.1.2; Appendix 2). Because Modern Norwegian /o/ is not a low vowel (and, in fact, tends to be closer to /u/ than /ɑ/, see §6.2.4, Table 6.10), it is clear that Old Scandinavian and long /o̜/ lost its Tongue Root specification. Accordingly, it appears that the results of the chain shift have been phonologized in the abstract representations of these vowels in both regions; Old Scandinavian long /o/ also acquired Tongue Height to become Modern Norwegian /u/ (see §3.3.2). The shift, however, is sometimes discussed as an Eastern Norwegian phenomenon (cf. Haugen 1982:40–1; Labov 1994:130), and Küspert (1988:239–60) discusses conservative vowel patterns in a host of Western Norwegian dialects, which suggests that the chain shift likely spread from east to west (see also Venås 1979 and Sandøy 1996 for descriptions of dialects with more 'continental' vowels). It is therefore worth investigating the extent to which the chain-shifting patterns vary phonetically by region, and also if the vowels are still moving along that same chain-shifting track with long /ʉ/ and /u/ fronting and long /o/ raising.

If Western Norwegian LBCS vowels show residual phonetic effects from lagging behind Eastern Norwegian early on in the change, Eastern speakers should present acoustic patterns that are more advanced along the track of the chain shift for vowel heads, vowel tails, or both. That is, Eastern Norwegians would have lower F1 values for long /o/ and greater F2 values for long

/ʉ/ than Western Norwegian. Furthermore, Eastern long /u/ may have lower F1 than the Western variants if the vowel continues on the raising track, or it may have a greater F2 if it has reached its maximum height and starts following long /ʉ/ along the horizontal dimension of the vowel space. These same patterns of chain shift progression should be present in wordlist tokens compared to conversations because this task elicits more careful speech, with more emphasis and with more focus on a standard style of pronunciation (Labov 2006:60–3). Finally, any change-in-progress (but not residual regional effects) of LBCS development should be evident in gender comparisons. Advanced shift productions among women compared to men suggest the continuing progression of the shift because women are almost always leaders in sound change (e.g., Labov 2001:291). These predictions are summarized in Table 6.1, below.

Table 6.1. Predictions for LBCS differentiation

Vowel: Outcome	*Null hypotheses*	*Contributing groups*
1. /o/: Lower F1	No difference in F1 heads, tails, or rΔF1	East, wordlist, women
2. /u/: Lower F1	No difference in F1 heads, tails, or rΔF1	East, wordlist, women
3. /u/: Greater F2	No difference in F2 heads, tails, or rΔF2	East, wordlist, women
4. /ʉ/: Greater F2	No difference in F2 heads, tails, or rΔF2	East, wordlist, women

I present results that speak to these predictions throughout the rest of the chapter. In §6.1, I discuss regional outcomes, and in §6.2, I present stylistic and gender differentiated comparisons for each LBCS vowel starting with long /o/, followed by long /u/, and then long /ʉ/. I follow this analysis with a summary of the LBCS and how the vowels' acoustic patterns relate to their phonological contrasts. In §6.3, I investigate consonantal effects that may contribute to gender-style differentiations and that illuminate areas of further investigation. All statistical tests are nonparametric because I do not assume that the data present evenly across categories or with normal distributions (see §4.3). I conclude in §6.4.

6.1 Regional Effects on the Long Back-Vowel Chain Shift

In this section, I analyze the results for the formant dynamics of long /o, u, ʉ/ by region: East and West. Table 6.2 shows descriptive statistics for the vowels' F1 and F2 heads, tails, and rates of change, with median values displayed above means and standard deviations in parentheses. Recall that Tromsø1k, Ås1m, and Ringebu1m are removed from the analysis for reasons discussed in §5.1.3. For each vowel's data points, approximations for differences of the medians and means between East and West (East-West) are also presented, calculated from the rounded values in cells above. These differences provide estimates for how close the central tendencies for Eastern and Western vowel dynamics compare to each other.

Formant values for Eastern and Western Norwegian tend to fall within 30 normalized Hz of each other for each parameter. The F1 data are approximately identical and F2 heads and tails tend to show greater differences than the F1 measures. The largest distinctions occur for the F2 tails of long /u/ ($\tilde{x}_E–\tilde{x}_W$=41.9, $\bar{x}_E–\bar{x}_W$=31.6), followed by the F2 tails of long /ʉ/ ($\tilde{x}_E–\tilde{x}_W$=38, $\bar{x}_E–\bar{x}_W$=20). Furthermore, differences in rates of change for both F1 and F2 between Eastern and Western Norwegian tend to be low; only rΔF2 for long /u/ is greater than 0.5 normalized Hz per millisecond (for both median and mean calculations).

Table 6.2. Descriptive statistics for long /o, u, ʉ/ dynamics by region.

/o/							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East	582.4 584.0 (74.16)	626.4 623.1 (67.57)	1018.6 1025.4 (163.96)	1098.7 1107.1 (161.35)	0.719 0.545 (1.904)	1.476 1.572 (3.278)	201 F=161 M=40
West	571.4 570.8 (69.00)	614.2 619.9 (67.65)	1015.4 1038.6 (164.65)	1114.0 1126.4 (178.41)	0.844 0.909 (1.647)	1.720 1.884 (3.827)	394 F=214 M=180
Difference	11 12.2	12.2 3.2	3.2 -13.2	-15.3 -19.3	-0.125 -0.364	-0.244 -0.312	NA
/u/							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East	456.3 461.8 (43.98)	448.1 449.6 (50.24)	844.5 897.9 (199.45)	899.2 935.4 (182.38)	-0.202 -0.222 (1.340)	0.625 1.145 (5.004)	152 F=123 M=29
West	456.3 459.0 (48.23)	446.4 450.8 (50.25)	872.9 900.3 (187.55)	857.3 903.8 (191.82)	-0.147 -0.221 (1.406)	-0.137 0.428 (4.779)	334 F=197 M=137
Difference	0 2.8	1.7 -1.2	-28.4 -2.4	41.9 31.6	-0.055 -0.001	0.762 0.717	NA
/ʉ/							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East	433.2 430.9 (43.91)	425.3 427.1 (46.23)	2147 2137 (170.68)	2107 2098 (141.08)	-0.116 -0.159 (1.076)	-0.940 -0.922 (3.095)	142 F=114 M=28
West	432.3 433.0 (47.06)	423.7 430.9 (49.76)	2126 2110 (257.79)	2069 2078 (228.53)	-0.067 -0.193 (1.266)	-0.597 -0.659 (3.166)	269 F=150 M=119
Difference	0.9 -2.1	1.6 -3.8	21 27	38 20	-0.049 0.034	-0.343 -0.263	NA

Note. Median values given above mean values, standard deviations in parentheses.

Results for the Mann-Whitney *U* tests (Table 6.3) show that only long /u/ F2 tails and rΔF2 are statistically significant by region. Neither long /o/ nor long /ʉ/ displays any statistically significant regional differences, and long /u/ has insignificant height (F1) differences by region. Therefore, these results fail to reject the null hypothesis that there are no regional differences in long /o, ʉ/ in the progression of the LBCS: long /o/ is not higher, and long /ʉ/ is not more advanced for Eastern speakers than for Western speakers. What is more, long /u/ does not show regional height differentiation; these results also fail to reject the null hypothesis that East and West will not differ by F1 measures. With respect to predictions 1, 2, and 4 in Table 6.1 — lower F1 for long /u, o/ and greater F2 for long /ʉ/ in Eastern Norwegian — these results show remarkable consistency in the phonetic realizations of the LBCS vowels by region.

Table 6.3. Mann-Whitney *U* test for long /o, u, ʉ/ dynamics by region.

/o/						
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
East-West	43472 0.051	41014 0.475	38337 0.525	37026 0.195	36655 0.138	37761 0.355
/u/						
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
East-West	26310 0.519	25141 0.866	24215 0.416	**28538** **0.028***	25606 0.877	**28547** **0.028***
/ʉ/						
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
East-West	18990 0.925	18479 0.589	20038 0.413	20432 0.245	19126 0.982	18303 0.487

Note. *U* statistic given above *p*-value.

These findings, however, suggest that one prediction — advanced F2 in Eastern long /u/ — may be subject to regional sociophonetic variation in the progression of the chain shift. Although there is no significant difference in F2 heads, Eastern F2 tails are on average more advanced than Western ones, which likely also contributes to their greater rΔF2. Figure 6.1 shows mean Eastern (blue) and Western (red) long /u/ heads and tails with ellipses that demarcate each region's F2 tails within two standard deviations of the mean.

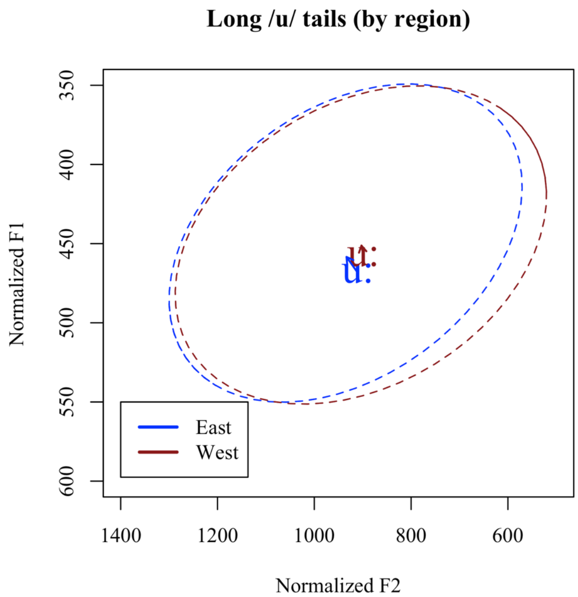

Figure 6.1. Long /u/ tails by region.

The spread of F2 tails suggests that Eastern Norwegian is not more advanced than Western Norwegian, but that there are more Western long /u/ vowels with F2 tails that occur further back in the vowel space. Because men tend to have lower F2 for long /u/ tails than women (see §6.2.2), one reason for the pattern in Figure 6.1 is that the Eastern group has fewer male speakers and, as a result, fewer tokens from men (29 Eastern, 137 Western). Furthermore, the front boundaries for F2 tails are approximately identical for both regions, a result that does not support Eastern Norwegian long /u/ advancement along the horizontal track of the chain shift relative to the Western dialects. There is no evidence of Eastern Norwegian long /u/ fronting that extends beyond the boundaries in which Western Norwegian forms occur. Therefore, it appears that none of the predictions in Table 6.1 holds for regional effects, and that Eastern and Western Norwegian have reached approximately the same stage of the LBCS, at least for the university-aged consultants interviewed for this study.

6.2 Style and gender effects on the LBCS

Because region does not appear to influence the progression of vowel dynamics of long /o, u, ʉ/ along the track of the LBCS, a uniform analysis of the chain shift's stylistic and gender-differentiated variations can proceed by collapsing the regions East and West into a single category. Therefore, there are enough male and female speakers for comparison (recall that only two Eastern male speakers are included in this analysis). In the following subsections, I discuss each vowel individually and compare the results of wordlist and conversational tokens for each gender, as well as gender differentiations within each style. The data are separated into four gender-style groups: women in conversation (W Con), women in wordlists (W WL), men in conversation (M Con), and men in wordlists (M WL). Both style and gender prove to have greater effects on the acoustics of LBCS vowel formants than region (see Appendix 4 for style-gender group effects on all Norwegian phonemes, long and short).

6.2.1 Long /o/

The data for long /o/ consists of 595 tokens (W Con n=216, W WL n=159, M Con n=124, and M WL n=96). Vowel plots for long /o/ are shown in Figure 6.2, in which a comparison of stylistic variation for women is on the top left, stylistic variation for men on the top right, gender-based variation for conversations on the bottom left, and gender-based variation for the wordlist tasks on the bottom right. In each plot, ellipses demarcate vowel heads within two standard deviations of the mean.

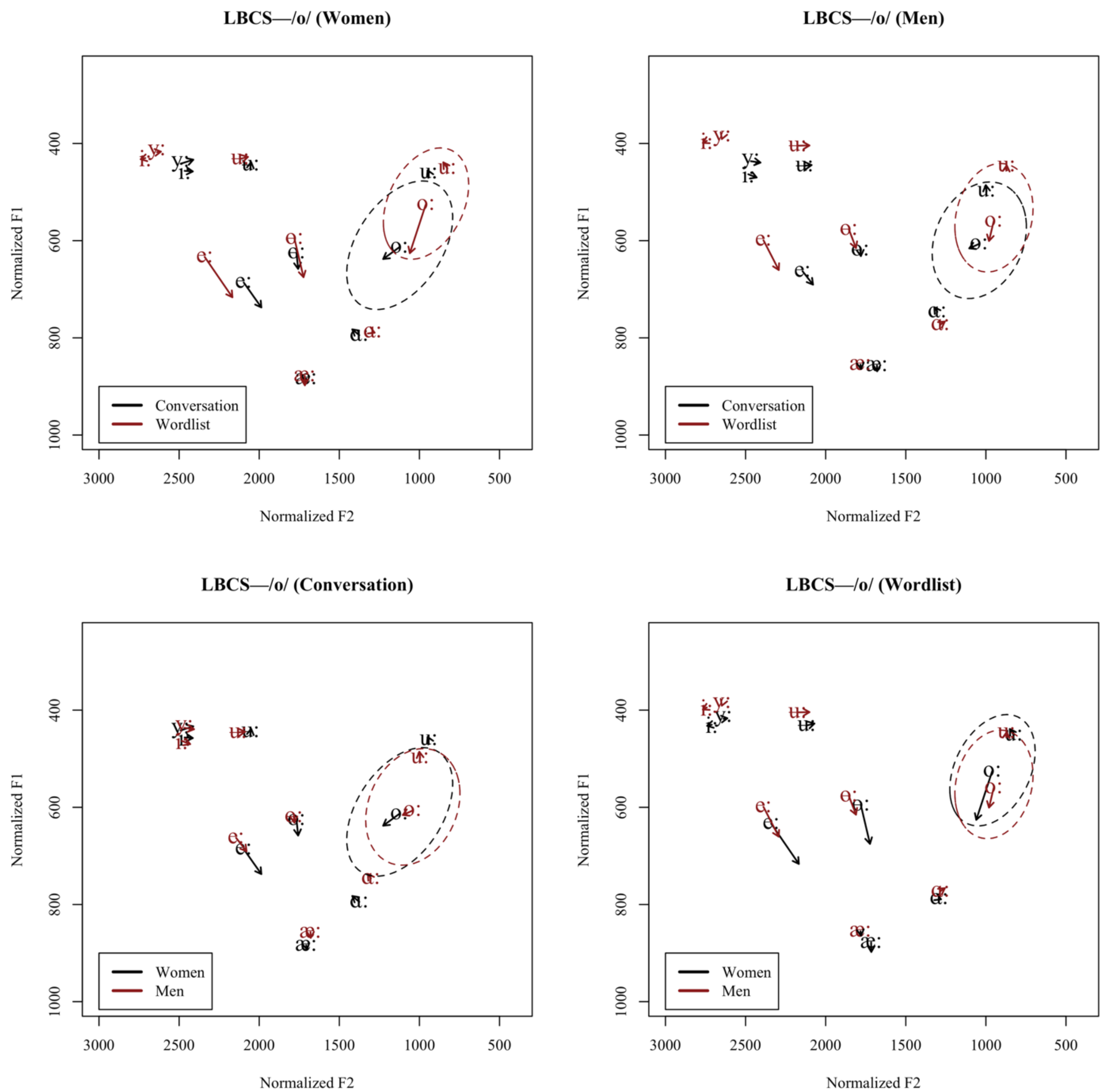

Figure 6.2. Long /o/ plots by style and gender with vowel head variance.

For both men and women, wordlist tokens are raised relative to conversations with lower median F1 head values ($\tilde{x}$=510.9 in W WL, $\tilde{x}$=609.1 in W Con; $\tilde{x}$=546.9 in M WL, $\tilde{x}$=590.5 in M Con). In conversations, women and men have approximately the same upper height boundaries for F1 heads, although they also have more advanced heads among the lower long /o/ tokens. Therefore, the heads of wordlist tokens are further back than in conversations for both men and women, and women's tokens are more advanced than men's in conversations, but not wordlists ($\tilde{x}$=951.6 in W WL, $\tilde{x}$= 1113.6 in W Con; $\tilde{x}$=945.4 in M WL, $\tilde{x}$=1022.8 in M Con).

A similar plot in Figure 6.3 displays the spread of vowel tails within ellipses, indicating that men and women have more advanced F2 tails in conversations than wordlists ($\tilde{x}$=1074.3 in W WL, $\tilde{x}$=1226 in W Con; $\tilde{x}$=969.5 in M WL, $\tilde{x}$=1102.9 in M Con). Furthermore, tails are slightly lower (greater F1) for women than men in both speaking styles ($\tilde{x}$=627.2 in W WL, $\tilde{x}$=593.5 in M WL; $\tilde{x}$=635.1 in W Con, $\tilde{x}$=604.6 in M Con). With respect to horizontal tail position, the most advanced male tokens (those in conversation) are similar to the least advanced female tokens (those in wordlists). These results suggest gender-differentiated fronting that is consistent with a change in progress with women at the fore. Parallel gender-based variation is not found for the height parameter of long /o/. Although women appear to have raised F1 heads relative to men in wordlists (Figure 6.2), this pattern in reversed for F1 tails (Figure 6.3).

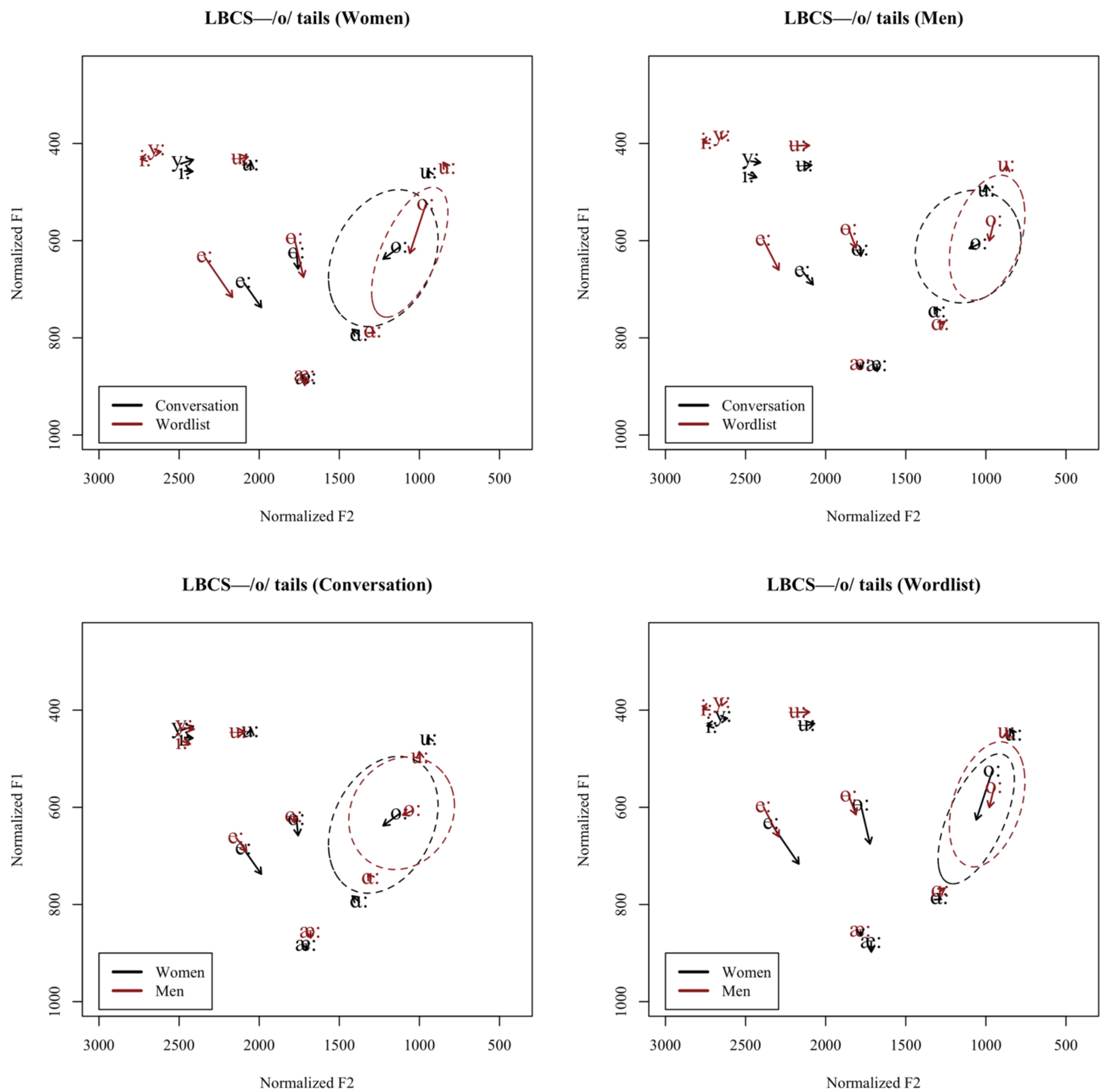

Figure 6.3. Long /o/ plots by style and gender with vowel tail variance.

A Kruskal-Wallis analysis of variance confirms that both gender and style are statistically significant factors for long /o/ vowel dynamics (Table 6.4). A Dunn's *post hoc* test (Table 6.4) indicates that differences in F1 head are statistically significant across styles for the same gender, but that F1 tails are not. These results confirm the stylistic raising of long /o/ of Prediction 1 in Figure 6.1, but only for vowel heads. Furthermore, gender differentiated long /o/ raising is statistically significant for F1 heads and tails in wordlists, but only tails in conversations; rΔF1 is significant for style among women and not men, and for gender in wordlists and not in conversations. A comparison of rΔF1 for W WL ($\tilde{x}$=1.655) and W Con ($\tilde{x}$=0.542) shows a statistically significant result with a greater positive (downward) rate of change in wordlists. There is also a significant outcome in a comparison of W WL and M WL, but with a more downward change for women ($\tilde{x}$=1.655) than men ($\tilde{x}$=0.677). This pattern may be due to the tendency for women to have higher heads than men for the wordlist task, thereby producing vowels that are more diphthongal and with a greater rΔF1 over its duration. In sum, these results cannot confirm the gender differentiated long /o/ raising of Prediction 1. Although women have raised heads relative to men, men have raised tails relative to women in conversation with no difference in wordlists.

Table 6.4. Kruskal-Wallis test and Dunn's *post hoc* test (with Bonferroni correction) for long /o/ by style and gender.

	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
χ^2 *p*-value	**172.108** **0.000***	**30.537** **0.000***	**128.177** **0.000***	**157.989** **0.000***	**76.164** **0.000***	**19.563** **0.000***
W Con- W WL	**12.027** **0.000***	1.784 0.224	**9.720** **0.000***	**9.027** **0.000***	**-7.095** **0.000***	**2.451** **0.0428***
W Con- M Con	1.392 0.492	**3.472** **0.002***	**4.295** **0.0001***	**5.666** **0.000***	1.668 0.286	0.545 1.000
W Con- M WL	**7.015** **0.000***	**5.160** **0.000***	**8.872** **0.000***	**11.410** **0.000***	-0.161 1.000	**4.109** **0.0001***
W WL- M Con	**-9.181** **0.000***	1.710 0.262	**-4.439** **0.000***	**-2.544** **0.0329***	**7.756** **0.000***	-1.623 0.3127
W WL- M WL	**3.066** **0.007***	**3.456** **0.0016***	0.561 1.000	**3.531** **0.001***	**5.583** **0.000***	1.919 0.165
M Con- M WL	**5.176** **0.000***	1.779 0.226	**4.445** **0.000***	**5.599** **0.000***	1.528 0.3799	**3.256** **0.0034***

Note. *df*=3, for group comparisons, *Z* statistics shown above *p*-values.

With respect to long /o/ fronting, the pairwise comparisons of F2 heads and tails show that the only insignificant group comparison is between W WL and M WL. Generally, wordlist tokens are further back than conversational tokens, and women's long /o/s are more advanced than men's. These differences diminish in wordlists, with each gender generally producing back vowels, which likely denotes a more standard pronunciation due to the nature of the speaking style. Although there is stylistic variation that pushes long /o/ along the track of the LBCS (wordlists higher than conversations), both stylistic and gender-differentiated variations appear to target the advancement of the vowel, with women producing variants slightly further to the front than their male peers with a greater difference due to speaking situation, supported by the finding that rΔF2 is significant for the factor style, but not gender. Therefore, conversational tokens for both men and women display more forward movement over the duration of the vowel than each do in wordlists ($\tilde{x}$=1.369 in F WL, $\tilde{x}$=2.242 in F Con; $\tilde{x}$=0.401 in M WL, $\tilde{x}$=2.019 in M Con).

Prediction 1 in Table 6.1 is confirmed for style, but not for gender. For both women and men, long /o/ is higher, for both heads and tails, in wordlists than in conversations. Gender differences in long /o/ height are fairly inconsistent: women have higher heads than men in wordlists but exploit the lower portion of /o/ space in conversations. Women's F1 tails also occupy a lower portion of that space relative to men. The data reveal variation distinct from LBCS, namely /o/ fronting that is more pronounced in comparisons of style than gender, but with significant results for both factors. Each variation — raising and fronting — occur relative to unspecified phonological features for /o/, which is only marked with Labial (§3.3.3), a result that is consistent with the assumption that these features are manipulated for variable, socially relevant purposes. Of course, the extent to which /o/ raising and fronting are socially salient and/or subject to in-progress change requires further research, but these results show that long /o/ variations occur within and outside of the LBCS track (raising and fronting, respectively), and that they comport with theories that adopt phonological underspecification to model phonetic variation (e.g., Hall 2011).

6.2.2 Long /u/

Like long /o/, long /u/ is unspecified relative to horizontal features. However, it is marked with Tongue Height, denoting that it is a categorically high vowel. Both the horizontal and vertical position of the vowel, however, may indicate its relative progression within the LBCS among the social groups investigated here. Prediction 2 (Table 6.1) supposes that wordlist tokens and women will have higher vowels (lower F1) compared to variants in conversations and among men. Furthermore, Prediction 3 (Table 6.1) supposes that productions in the wordlist task will be further forward in the vowel space than in conversations and more advanced for women than for men. Confirmation of this prediction indicates that the long /u/ is progressing in accord with Old Scandinavian /ū/, which centralized to Modern Norwegian /ʉ/ (§3.3.2). The results presented in this chapter confirm Prediction 2 and reject Prediction 3.

In this analysis, there are 486 long /u/ tokens (W Con n=169, W WL n=151, M Con n=79, and M WL n=87). Vowel plots for long /u/ are show in Figure 6.4 with women (conversation and wordlist) on the top left, men (conversation and wordlist) on the top right, conversations (women and men) on the bottom left, and wordlists (women and men) on the bottom right. Again, the spreads of vowel heads within two standard deviations of the mean are marked by ellipses.

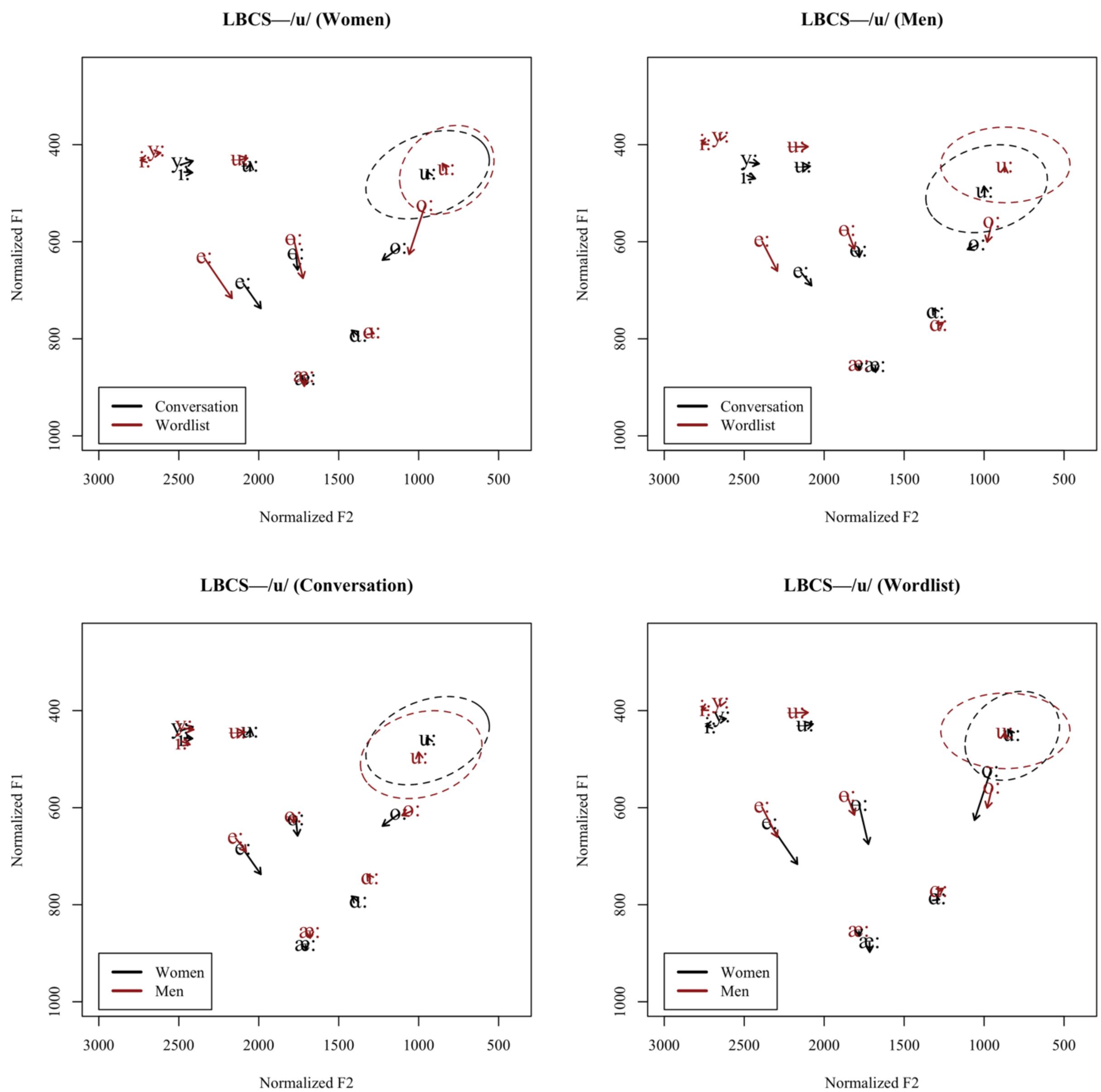

Figure 6.4. Long /u/ plots by style and gender with vowel head variance.

For women, long /u/ F1 heads are slightly higher (lower values) in wordlists ($\tilde{x}$=447.5) than in conversations ($\tilde{x}$=457.9), but vowel heads show more advanced variants (greater F2) in conversations ($\tilde{x}$=892.9) than wordlists ($\tilde{x}$=794.5). Wordlist tokens for men are even higher than in conversations ($\tilde{x}$=440.5 in wordlists, $\tilde{x}$=498.8 in conversations) and, like women, long /u/ in conversation ($\tilde{x}$=939.3) is more advanced than in wordlists ($\tilde{x}$=838.4) for men. Within the same speaking styles, W Con tokens are raised relative to M Con, but in wordlists, men's long /u/s show a wider horizontal spread than women (*sd*=202.07 for men, *sd*=147.71 for women).

Vowel plots that delimit long /u/ tails in ellipses are presented in Figure 6.5. Like vowel heads, women's tails are higher (lower F1) in wordlists ($\tilde{x}$=451.0 in conversations, $\tilde{x}$=437.6 in wordlists) and more advanced (greater F2) in conversation ($\tilde{x}$=901.3 in conversations, $\tilde{x}$=830.6 in wordlists). Head and tail patterns are also similar for men, with higher and less advanced average tails in wordlists (F1 $\tilde{x}$=436.6, F2 $\tilde{x}$=835.7) than in conversations (F1 $\tilde{x}$=467.4, F2 $\tilde{x}$=961.0). Also like long /u/ heads for men, their tails show less vertical and more horizontal variance in wordlists (F1 *sd*=38.95, F2 *sd*=201.57) than in conversations (F1 *sd*=54.31, F2 *sd*=185.90). Finally, like long /u/ heads, women's tails are raised and further back relative to men in conversations (F1 $\tilde{x}$=451.0, F2 $\tilde{x}$=901.3 for women; F1 $\tilde{x}$=467.4, F2 $\tilde{x}$=961.0 for men); women's tails also have more vertical and less horizontal variance compared to men's tokens in wordlists (F1 *sd*= 52.45, F2 *sd*=143.61 for women; F1 *sd*=38.95, F2 *sd*=201.57 for men).

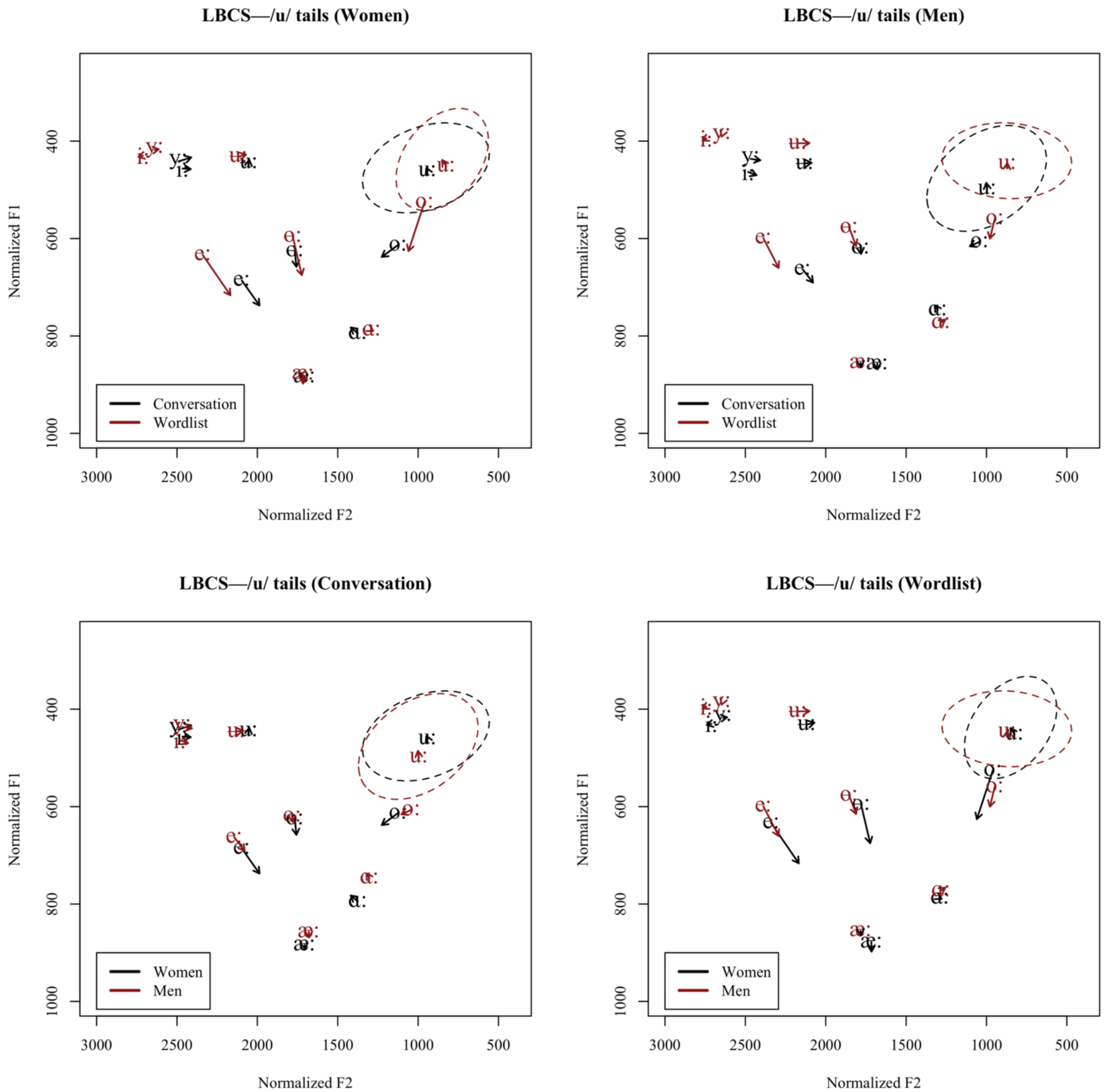

Figure 6.5. Long /u/ plots by style and gender with vowel tail variance.

A Kruskal-Wallis test (Table 6.5) shows statistically significant results for F1 and F2 heads and tails for the style and gender factors; rΔF1 and rΔF2, however, are not significantly affected. The Dunn's *post hoc* test (Table 6.5) shows the results for pairwise group comparisons. With respect to the height of long /u/ heads, stylistic variation is statistically significant for men, but not for women, and gender differences are significant in conversations, but not in wordlists.

The fact that W Con F1 heads are significantly higher than M Con places those vowels closer to their wordlist counterparts for women and likely contributes to their lack of stylistic significance for F1 heads. Women's F1 tails, however, are significantly higher in wordlists than in conversations, which is consistent with Prediction 2: that long /u/ will show higher variants in wordlists. Moreover, the F1 heads and tails are significantly lower (higher in the vowel space) in wordlists compared to conversations for men, which further confirms Prediction 2, at least with respect to style.

Table 6.5. Kruskal-Wallis test and Dunn's *post hoc* test (with Bonferroni correction) for long /u/ by style and gender.

	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
χ^2 *p*-value	**57.876** **0.000***	**33.938** **0.000***	**71.256** **0.000***	**55.403** **0.000***	5.316 0.15	1.186 0.76
W Con- W WL	1.908 0.169	**3.268** **0.003***	**6.475** **0.000***	**4.942** **0.000***	-0.101 1.000	-0.948 1.000
W Con- M Con	**-4.845** **0.000***	**-2.661** **0.023***	-2.016 0.131	**-2.531** **0.034***	0.835 1.000	-0.688 1.000
W Con- M WL	**3.3766** **0.0022***	**2.529** **0.034***	**3.716** **0.001***	**3.559** **0.001***	-1.744 0.243	-0.080 1.000
W WL- M Con	**-6.294** **0.000***	**-5.248** **0.000***	**-7.201** **0.000***	**-6.469** **0.000***	0.901 1.000	0.089 1.000
W WL- M WL	1.723 0.255	-0.240 1.000	-1.744 0.243	-0.622 1.000	-1.626 0.312	0.710 1.000
M Con- M WL	**7.116** **0.000***	**4.481** **0.000***	**4.923** **0.000***	**5.241** **0.000***	-2.213 0.081	0.536 1.000

Note. *df*=3, for group comparisons, *Z* statistics shown above *p*-values.

Gender-based effects on the height of the vowel are present in conversations for both heads and tails. Women produce slightly higher vowels than men in both regards. However, gender is not shown to be statistically significant in wordlist productions. These results suggest that both women and men have a consistent target for the vowel (based on its central tendencies) in the more careful and standard-like speaking style, although women appear to exploit more vertical variation and men more horizontal variation. Here, Prediction 2 is partially confirmed for gender with the caveat that raised variants for women are only present in conversations.

Prediction 3 addresses the horizontal positions of the vowel, expecting that productions in wordlists and among women will be more advanced than in conversations and among men, respectively, if long /u/ has reached its maximum vertical position in the vowel space and continues to shift horizontally following the trajectory of long /ʉ/. This prediction is not confirmed. For women and men, both F2 heads and F2 tails are more advanced in conversations than in wordlists with statistically significant results. Differences between women's and men's F2 heads are not significant in either style. In conversations, women's tails are slightly further back than men's, but the plot of long /u/ tails in Figure 6.5 suggests that these fall within a similar horizontal range in the vowel space.

Although style and gender contribute to height variations in long /u/, all F1-related measures cluster in the high portion of the vowel space, and within each group they generally maintain some acoustic distance from long /o/ (although see §6.2.4). Therefore, sociophonetic height variations for long /u/ seem to occur within the vowel space defined by its Tongue Height specification. Furthermore, fronted long /u/ variants generally do not cross into long /ʉ/ space. In fact, there appears to be a considerable amount of horizontal space for long /u/ to advance and still maintain a phonetic distinction with the central vowel. Future research with real or apparent time data can determine if Norwegian long /u/ progresses forward in the vowel space for men relative to women. However, the fact that men tend to have slightly more fronted long /u/s than women suggests that the horizontal position of long /u/ is relatively sociolinguistically stable, because for these variables women are often more conservative than men (e.g., Labov 2001:266). Labov argues that "women deviate less than men from linguistic norms when the deviations are overtly proscribed, but more than men when the deviations are not proscribed" (2001:367). The fact that men also have more horizontal variation in the wordlist style is consistent with their non-adoption of a more standard-like backed form. Although we still do not understand the social motivations for this type of gender pattern, these patterns are robust in the sociolinguistic literature.

6.2.3 Long /ʉ/

The data for Norwegian long /ʉ/ comprise a total of 411 tokens, divided between W Con (n=104), W WL (n=160), M Con (n=56), and M WL (n=91). Because /ʉ/ is only specified for Tongue Height, it should be prone to variation across horizontal space, i.e., with respect to phonologically unspecified features. Prediction 4 (Table 6.1), therefore, presumes that if the vowel continues to move along its LBCS track, the advancement of the vowel will be more prevalent in wordlists and among women. The data, however, do not support this prediction.

Figure 6.6 displays mean long /ʉ/ vowels for each gender-style group, with ellipses denoting the vowel heads that occur within two standard deviations of the mean. Plots follow the same order as previously with stylistic comparisons for women (left) and men (right) on top and gender comparisons for conversations (left) and wordlists (right) on the bottom. Regarding women, long /ʉ/ is slightly higher and more advanced heads in wordlists (F1 $\tilde{x}$=435.1, F2 $\tilde{x}$=2143) than in conversations (F1 $\tilde{x}$=442.1, F2 $\tilde{x}$=2043). These finding are also present for men (F1 $\tilde{x}$=398.5, F2 $\tilde{x}$=2211 in wordlists; F1 $\tilde{x}$=438.7, F2 $\tilde{x}$=2178 in conversations). Men also appear to have much more horizontal variance in conversations (F2 *sd*=321.58) than in wordlists (F2 *sd*=251.14) similar to their long /u/ productions, suggesting that these two vowels show consistent patterns of variation relative to unspecified phonological features (see §6.2.4). In both styles, men display more horizontal variance than women (F2 *sd*=191.64 in conversation, *sd*=194.63 in wordlists) and cross well into the phonetic space of long /y/, although both women and men present similar central tendencies for F2 heads.

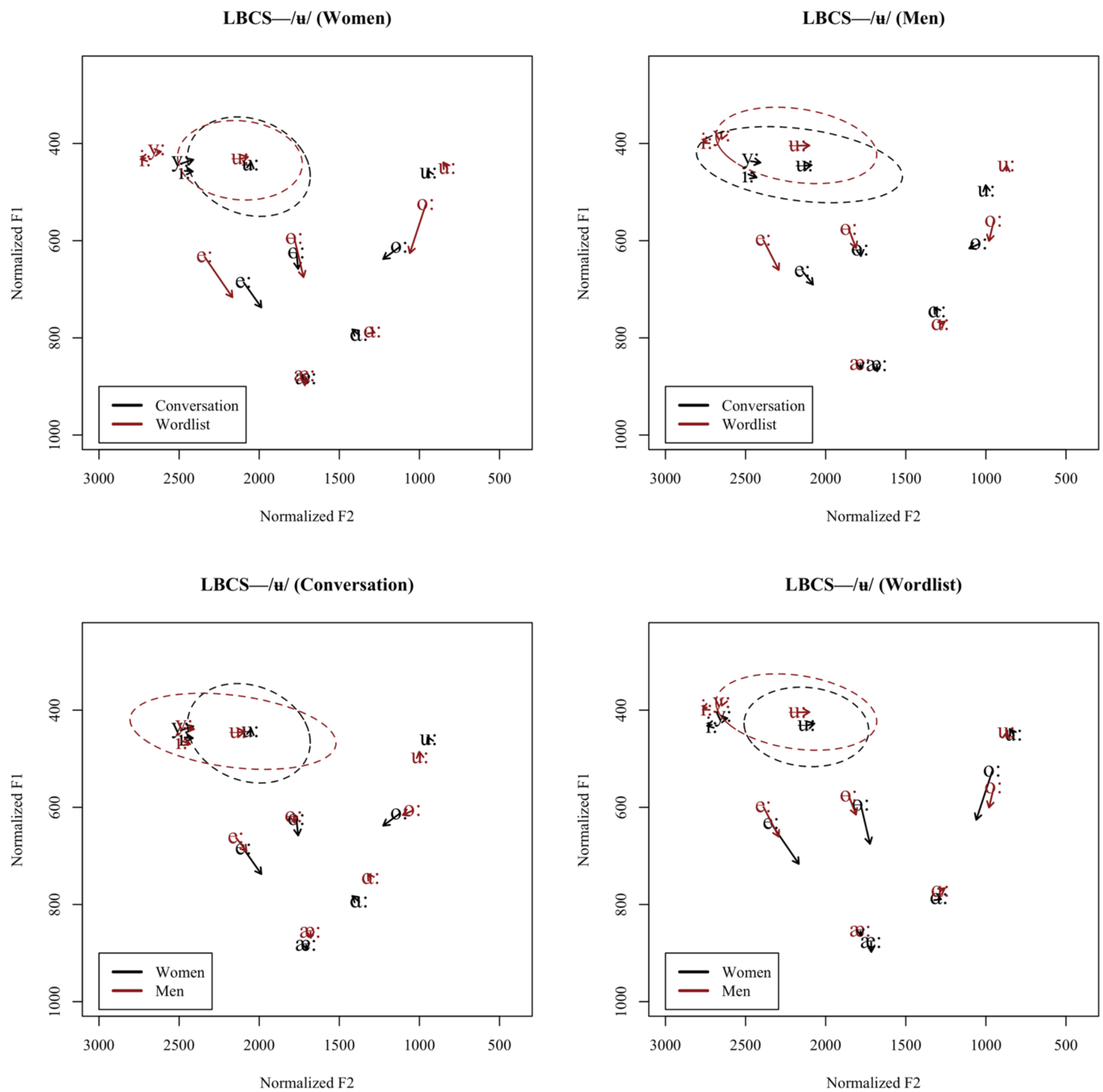

Figure 6.6. Long /ʉ/ plots by style and gender with vowel head variance.

Long /ʉ/ tails show similar group patterns as heads (Figure 6.7). Women's tails are slightly higher and more advanced than in wordlists (F1 $\tilde{x}$=427.6, F2 $\tilde{x}$=2082) than in conversations (F1 $\tilde{x}$=437.1, F2 $\tilde{x}$=2030). The same is true for men (F1 $\tilde{x}$=403.6, F2 $\tilde{x}$=2138 in wordlists; F1 $\tilde{x}$=447.6, F2 $\tilde{x}$=2108 in conversations), who also have more horizontal variance in conversations (F2 *sd*=276.22) than in wordlists (F2 *sd*=213.87). Again, women and men have approximately the same median tail positions, although men are slightly raised relative to women in wordlists. Like long /ʉ/ heads, a striking difference in tails between women and men is that men have a wider range of horizontal variants than women (F2 *sd*=180.25 in conversations, *sd*=176.68 in wordlists).

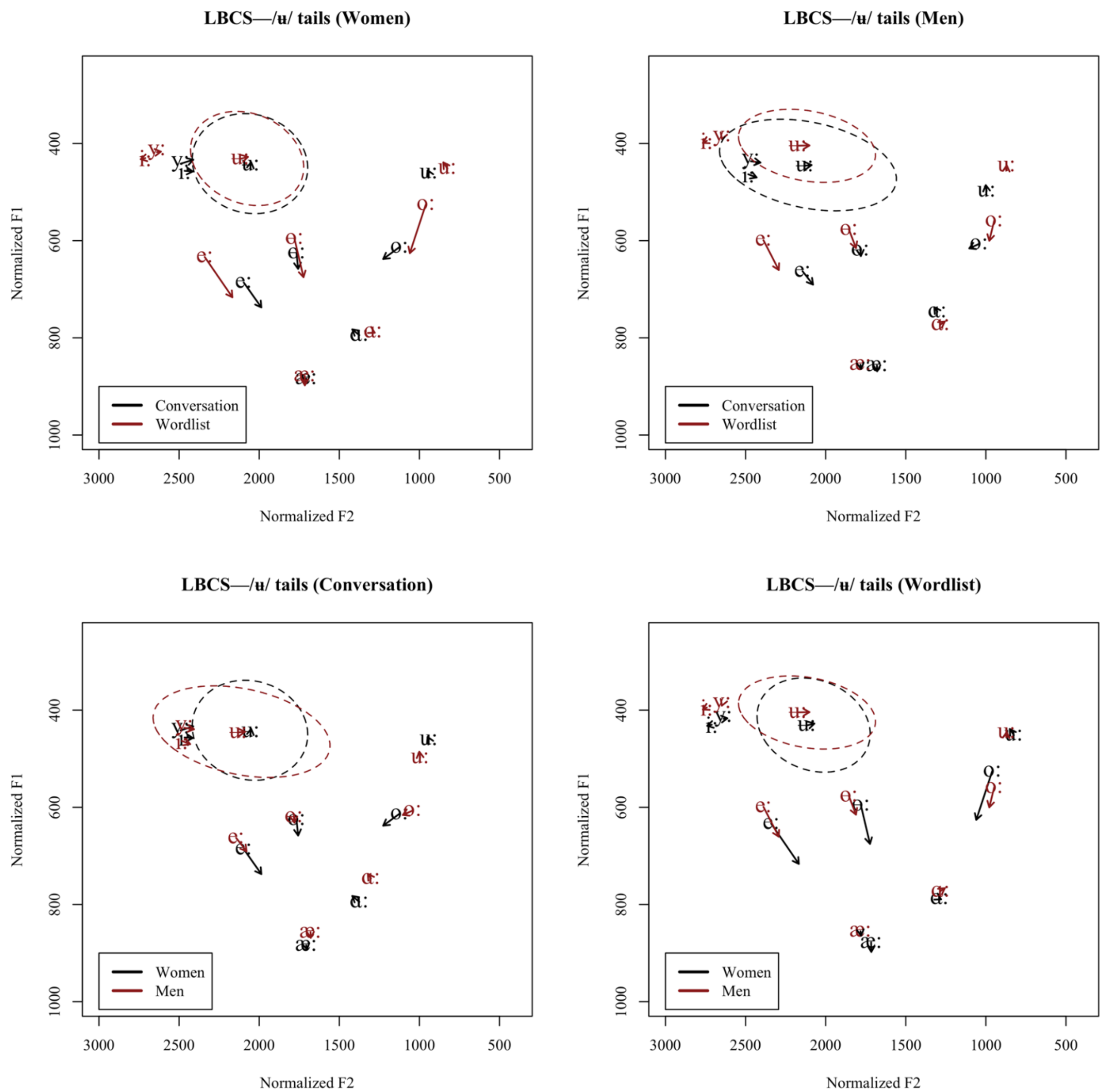

Figure 6.7. Long /ʉ/ plots by style and gender with vowel tail variance.

A Kruskal-Wallis test (Table 6.6) shows that gender and style are only statistically significant factors for F1 and F2 heads and F1 tails; differences in F2 tails and rates of formant change are not significant. Style is not a significant factor among women for any vowel measure and only for F1 heads and tails among men. Gender is statistically significant for F1 heads and tails in wordlists but only F2 heads in conversations. There is very little significant variation in

F2 measures, and the only group difference is that men's heads are slightly more advanced than women's in conversations, a result that rejects Prediction 4. These outcomes further suggest that long /ʉ/ is not continuing along the horizontal track of the LBCS for university-aged Norwegians. Like long /u/, women appear to conform to a more standard-like pronunciation for long /ʉ/ that maintains phonetic distance from long /y/. Therefore, the horizontal position of long /ʉ/ seems to be a stable sociolinguistic variable, and the vowel is no longer progressing along the LBCS track. Men extend the horizontal position of long /ʉ/ well toward the position of long /y/, crossing into the boundary between the vowels in conversations. Finally, the significant height variations — between men and women in wordlists and between styles for men — could be the result of men exaggerating the height of high vowels in wordlists compared to conversations; women, it seems, generally do not share this tendency.

Table 6.6. Kruskal-Wallis test and Dunn's *post hoc* test (with Bonferroni correction) for long /ʉ/ by style and gender.

	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2
χ^2 *p*-value	**58.012** **0.000***	**35.37** **0.000***	**18.264** **0.000***	6.940 0.07	1.543 0.67	6.622 0.08
W Con- W WL	1.555 0.360	1.544 0.368	-2.340 0.058	-0.797 1.000	-0.791 1.000	1.498 0.403
W Con- M Con	0.194 1.000	-0.383 1.000	**-3.178** **0.005***	-1.621 0.315	-0.282 1.000	2.010 0.133
W Con- M WL	**6.873** **0.000***	**5.243** **0.000***	**-3.888** **0.0003***	-2.395 0.05	-1.193 0.700	2.281 0.068
W WL- M Con	-1.055 0.874	-1.661 0.290	-1.494 0.406	-1.084 0.835	0.341 1.000	0.930 1.000
W WL- M WL	**6.022** **0.000***	**4.251** **0.0001***	-2.006 0.135	-1.853 0.191	-0.545 1.000	1.058 0.871
M Con- M WL	**5.620** **0.000***	**4.805** **0.000***	-0.185 1.000	-0.442 1.000	-0.733 1.000	-0.033 1.000

Note. *df*=3, for group comparisons, *Z* statistics shown above *p*-values.

6.2.4 Summary and implications of LBCS sociophonetics and phonological representation

Predictions 1 and 2 are supported by the data for style, but not for gender. Wordlist tokens tend to be raised relative to conversations for long /o, u/, although women have raised long /o/ variants relative to men in wordlists. The data, however, do not support Predictions 3 and 4, which presume long /u, ʉ/ fronting in wordlists and among women. Finally, women tend to have fronted long /o/ variants compared to men, a sociophonetic variation that diverges from movement patterns along the LBCS track and, therefore, not predicted. These results are summarized in Table 6.7.

Table 6.7. Summary of predictions and outcomes

Prediction	*Outcomes*	*Result*
1. /o/: Lower F1	Wordlist: raised Women, conversation: fronted	Supports prediction Not predicted
2. /u/: Lower F1	Wordlist: raised Women: raised in conversation	Supports prediction Supports prediction
3. /u/: Greater F2	Men, conversation: fronted Men: wide F2 variance	Rejects prediction
4. /ʉ/: Greater F2	Men in conversation: fronted Men: wide F2 variance	Rejects prediction

These results indicate some stylistic raising for long /o, u/, but neither long /u/ nor long /ʉ/ are continuing along the horizontal track of the chain shift. Raised wordlist /o, u/ variants and less horizontal variance for long /ʉ/ among women and men in wordlists likely comprise the more standard targets for the LBCS vowels. These sociophonetic LBCS patterns are consistent with a completed chain shift for university-aged Norwegians, a result supported by the lack of statistically significant regional differences in LBCS vowel dynamics, as this shift appears to have begun in Eastern Norwegian and then spreading westward. What is more, long /o/ gender patterns in conversations reveal differences in vowel advancement (fronting among women), not in the upper vowel height boundary. These findings show a further break from the LBCS track, suggesting that long /o/ may be in the process of shifting horizontally rather than vertically, possibly as a new post-LBCS change-in-progress. Additional investigation into the real-time or apparent-time changes in the position of this vowel is necessary to confirm whether or not long /o/ fronting is an active change in progress.

The data show further that two of the LBCS vowels, long /o, ʉ/, extend at least partially into the phonetic positions occupied by other phonemes (see Figure 6.8). There is a considerable amount of overlap between long /o/ and long /u/, primarily in wordlists where long /o/ is raised to a greater degree than long /u/. Furthermore, men spread long /ʉ/ into long /y/ phonetic space, especially in conversations, and also to a lesser extent in wordlists. Although these variations occur relative to unspecified phonological features for each vowel (i.e., /o/ is not specified for height and /ʉ/ is not specified for advancement), the data indicate that each vowel, at least partially (heads for long /o/) or in certain contexts (men for long /ʉ/), phonetically obscures its phonological contrast with a neighboring phoneme. The relationships between these vowels' heads and tails, however, may mitigate this phonetic overlap and, therefore, provide sufficient phonetic cues to maintain surface-level distinctions.

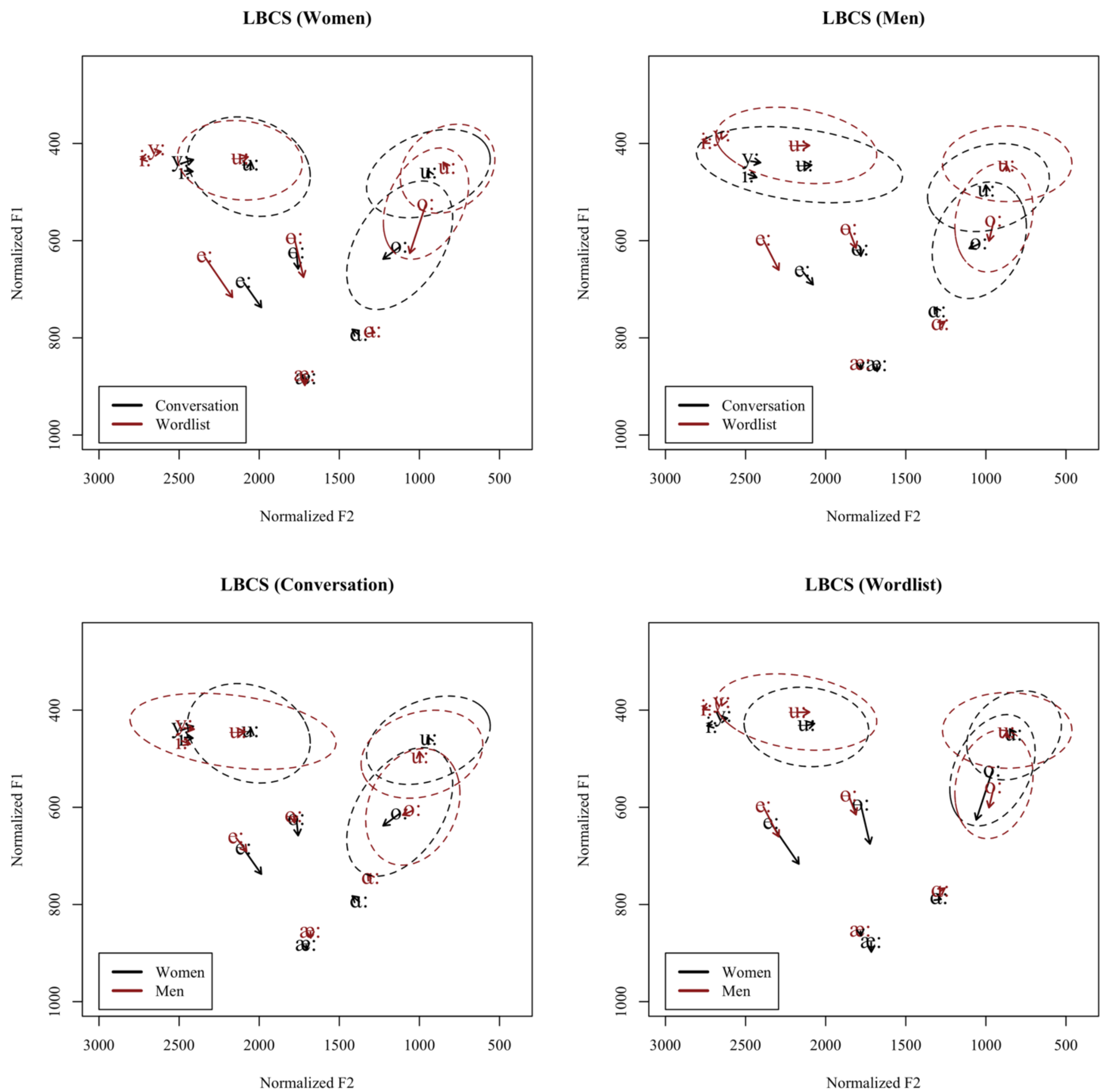

Figure 6.8. LBCS with vowel head variance.

Compared to the other LBCS vowels, long /o/ is more diphthongal, specifically with a falling trajectory. In fact, the gender-style group with the highest vowel head (W WL) also has the greatest positive (downward) ΔF1 ($\tilde{x}$=95.88 for W WL, $\tilde{x}$=21.24 for W Con, $\tilde{x}$=31.620 for M WL, $\tilde{x}$=11.76 for M Con). A pairwise comparison (Table 6.8) shows that these differences are statistically significant for all gender-style groups except W Con with M Con and W Con with M

WL. That is, women in wordlists, who have the most head raising also have a significantly greater downward trajectory when compared to all other gender-style groups. Likewise, men also have raised heads in wordlists relative to conversations and with a statistically significant greater positive ΔF1. These results suggest that although the head of the vowel may extend into long /u/ phonetic space, the contrast between the two vowels may be maintained through more downward diphthongization.

Table 6.8. Kruskal-Wallis test and Dunn's *post hoc* test (with Bonferroni correction) for long /o/ ΔF1 by style and gender.

Long /o/ ΔF1						
χ^2 *p*-value	W Con- W WL	W Con- M Con	W WL- M WL	M Con- M WL	F Con- M WL	M Con- F WL
134.082 **0.000***	**-9.542** **0.000***	2.220 0.079	**6.526** **0.000***	**2.970** **0.009***	-1.252 0.631	**10.410** **0.000***

Note. *df*=3, for group comparisons, *Z* statistics shown above *p*-values.

To test this position, the F1 heads of all long /o/ vowels are plotted against ΔF1 and rΔF1 in Figure 6.9. The plots show a general trend, whereby the higher the vowel head is (i.e., lower F1), the greater positive (downward) ΔF1. A Spearman Correlation test shows a negative correlation between the two variables (ρ=-0.563) and that this relationship is statistically significant (p<0.001*); vowels with raised heads also have a greater rate of downward trajectory (ρ=-0.363, p<0.001*). Conversely, long /o/s with low heads tend to raise over the duration of the vowel, although these appear to be less common than tokens with falling trajectories, as indicated by the vowel's central tendencies (Figures 6.2, 6.7). Therefore, although both long /o/ heads and tails cross into the phonetic territory of neighboring long /u/, it maintains a surface distinction by passing through the mid-region of the phonetic space over the course of its duration.

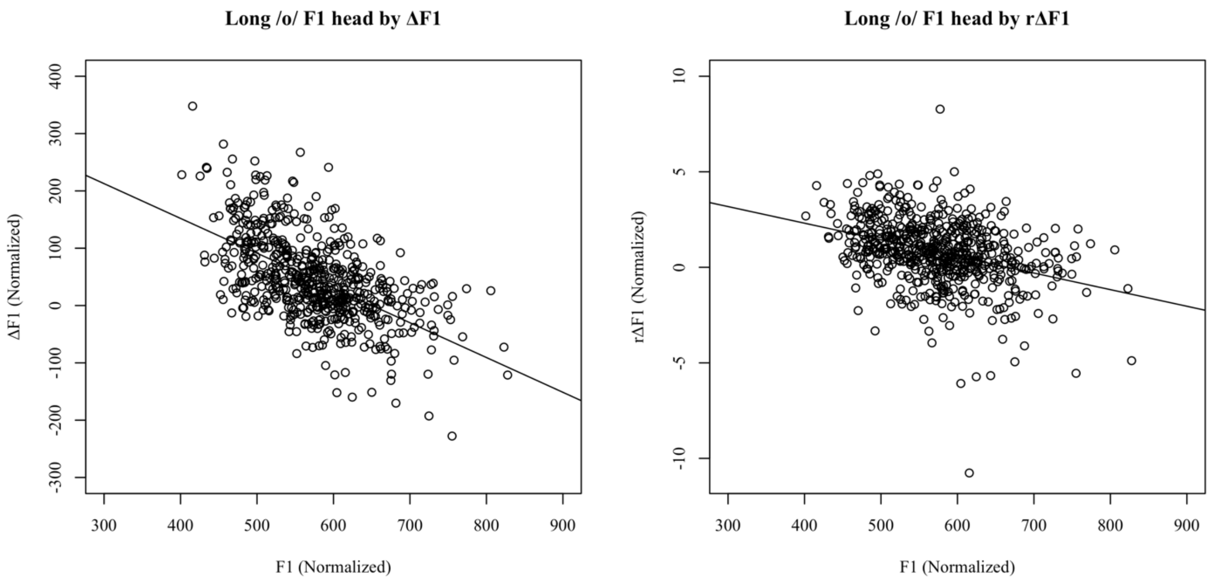

Figure 6.9. Regressions for long /o/ by ΔF1 and rΔF1.

Furthermore, because long /ʉ/ also crosses into long /y/ space, particularly for men, a greater negative (backward) ΔF2 is consistent with the maintenance of surface-level distinctions. Although men in conversation have a wider range of F2 variance, especially toward the front of the vowel space (Figures 6.6, 6.8), they have greater backward movement in wordlists ($\tilde{x}$=-49.936) than in conversations ($\tilde{x}$=-35.35), a pattern shared by women ($\tilde{x}$=-42.83 in wordlists, $\tilde{x}$=-10.081 in conversations). Pairwise comparisons (Table 6.9) show that only F Con variants are statistically significant with F WL and M WL; style is not a significant factor for ΔF2 among men, nor is gender significant for wordlists. Furthermore, rΔF2 is not statistically significant for any group comparison (see Table 6.6). Although M Con does not have greater backward movement than M WL (the style with more variance toward the front of the vowel space), the fact that W WL and M WL have similar negative ΔF2 shows that both men and women produce tokens that are more standard-like in the wordlist task because they either occupy the center of the vowel space or move toward it.

Table 6.9. Kruskal-Wallis test and Dunn's *post hoc* test (with Bonferroni correction) for long /ʉ/ ΔF2 by style and gender.

Long /ʉ/ ΔF2						
χ^2 *p*-value	W Con- W WL	W Con- M Con	W WL- M WL	M Con- M WL	F Con- M WL	M Con- F WL
13.874 **0.000***	**2.802** **0.015***	2.166 0.091	1.168 0.729	0.867 1.000	**3.527** **0.001***	0.039 1.000

Note. *df*=3, for group comparisons, *Z* statistics shown above *p*-values.

Even though ΔF2 is less in conversations than wordlists for men, a plot of all long /ʉ/ tokens' F2 heads against ΔF2 and rΔF2 (Figure 6.10) displays negative correlations between the heads and both variables (ρ=-0.454, p<0.001* for ΔF2; ρ=-0.345, p<0.001* for rΔF2). That is, the more forward the vowel head (greater F2), the greater the negative (backward) change in F2 and rate of that change. Even though M Con tokens do not generally have more backward movement than the other gender-style groups, these results suggest that those fronted variants — as well as the fronted variants in the other social categories — are more likely to move over its duration further toward the center at a greater rate than the tokens with more centralized heads. Finally, these trajectory patterns likely contribute a distinction between long /ʉ/ and long /y/ when /ʉ/ is advanced along a phonologically unspecified parameter (/ʉ/ is only specified as Tongue Height). Whether backward movement over the duration of long /ʉ/ is a salient characteristic that distinguishes it from long /y/, or if perceptual evidence suggests a merger-in-progress among men, requires more research. The present data indicate that the vowel's movement toward a target and away from a neighboring phoneme, not just the relative distance of the vowels' heads and/or tails, increases the phonetic distance between /ʉ/ and /y/. Therefore, the correlations between fronted onsets and backward movement provide evidence for the influence of phonological categories on acoustic outputs to preserve contrasts, even when phonetic variations weaken them.

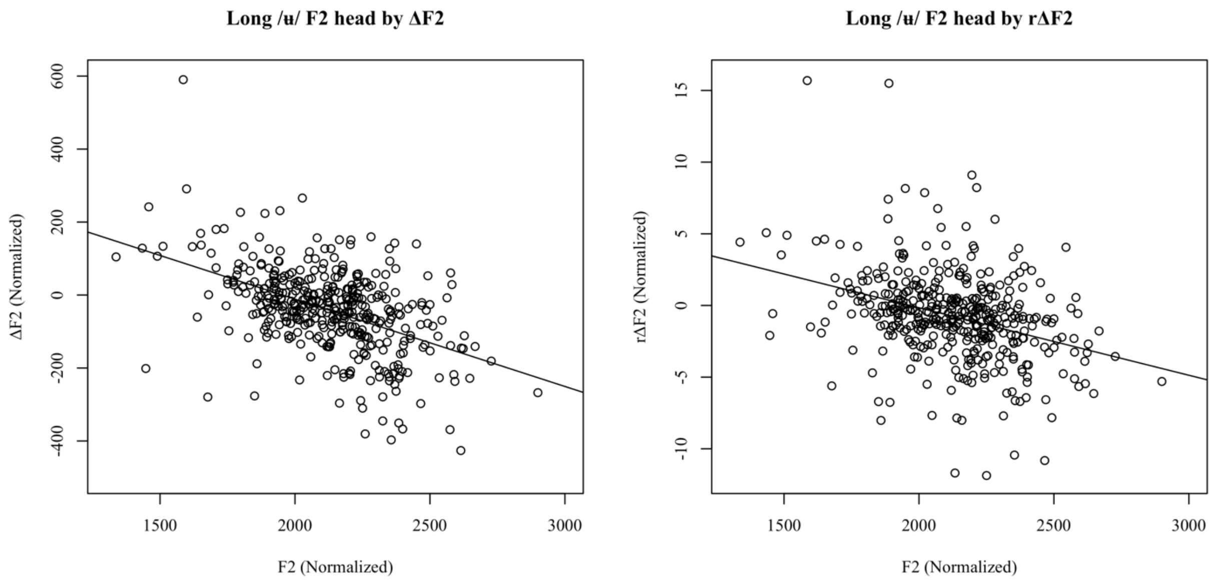

Figure 6.10. Regressions for long /ʉ/ F2 by ΔF2 and rΔF2.

Another indication of the role that phonology has in maintaining phonetic-level distinctions is found in a comparison of distances between adjacent phonemes and their distances across group variations within the same phonemic category. That is, sociophonetic variants of a single phoneme should generally be closer to each other than they are to a neighboring phoneme. The Euclidean distances of the median values of LBCS vowel heads across and within phonemic categories are shown in in Table 6.10; distances between phonemes (/o/ to /u, ɑ/; /u/ to /o, ʉ/; /ʉ/ to /u, y/) are calculated using the same gender-style group.

Table 6.10. Euclidean distances between median heads of LBCS vowels and neighboring phonemes and between gender-style groups of the same vowel.

Long /o/						
	Long /u/	Long /ɑ/	M WL	M Con	W WL	W Con
W Con	267.530	306.547	179.343	92.673	189.490	
W WL	169.390	433.390	36.598	106.830		
M Con	124.040	309.452	88.836			
M WL	150.916	422.444				
Long /u/						
	Long /o/	Long /ʉ/	M WL	M Con	W WL	W Con
W Con	267.530	1150.270	57.221	61.824	98.974	
W WL	169.390	1348.473	44.469	153.632		
M Con	124.040	1240.239	116.522			
M WL	150.916	1373.481				
Long /ʉ/						
	Long /ʉ/	Long /y/	M WL	M Con	W WL	W Con
W Con	1150.270	418.081	173.735	135.081	100.072	
W WL	1348.473	462.897	77.539	35.398		
M Con	1240.239	340.276	52.134			
M WL	1373.481	443.2918				

Regarding the social variation for each phoneme, all groups' Euclidean distances are within 200 normalized Hz from each other. The greatest across-group distances occur between the wordlist and conversational variants of long /o/ for both genders, which have raised vowel heads as well as men's advanced long /ʉ/ tokens relative to those spoken by women. Only distances between long /o, u/ (for the same gender-style group) are less than 300 normalized Hz, a result of the long /o/ head raising that is most evident for wordlist tokens. Finally, although men appear more likely than women to produce long /ʉ/ variants that approach long /y/ in F2, the central tendencies for these vowels nevertheless show greater distances between these two phonemes for all gender-style groups than for group variations of long /ʉ/. In sum, these data support the position that phonological representations contribute to greater distances — i.e., more phonetic distinction — across phonemes than within a single phonemic category due to social variation. The exception is that long /o/ approaches long /u/ not only in its head and tail variance, but also for the median positions of heads, a variation relative to an unspecified phonological feature for /o/.[1] Again, it appears that the tendency for raised long /o/ heads to have a greater degree and rate of falling diphthongization preserves the phonological distinction between the two phonemes even when the phonetic distances between the two fall within the range of social variation for a given phonological category.

6.3 Consonantal effects

In this section, I discuss the extent to which consonantal environments correlate with the social variations discussed above. Although the data show statistically significant interactions between consonantal environment and vowel dynamics, many of the acoustic measurements appear to be unaffected by the preceding and following consonants. Accordingly, the results presented in this section suggest areas of further research into the consonantal influences on patterns in LBCS vowels in particular and on Norwegian more generally. For the sake of statistical analysis, consonantal environments with samples sizes of five and below are removed. Following Allen (2015), I assume a fortis-lenis laryngeal system for Norwegian plosives. The fortis set (<p, t, k>) is phonologically marked with Glottal Width (completed with [spread glottis]; see §3.1, Table 3.2) and represented as aspirated /pʰ, tʰ, kʰ/. The lenis stops (<b, d, g>) are phonologically unspecified for laryngeal features and are accordingly represented as plain /p, t, k/.

[1] Euclidean distances are slightly greater between /o, u/ tails than heads, although men fall around 200 normalized Hz for both styles (197.325 for men in conversation, 206.194 for men in wordlists, 373.465 for women in conversation, 308.712 for women in wordlists).

6.3.1 Consonantal effects on long /o/

In §6.2, long /o/ was shown to raise in wordlists and fronted among women, especially in conversations. As a result, I investigate if preceding and following consonants influence vowel heads and tails, respectively, in these ways. A Kruskal-Wallis analysis of variance for all four gender-style groups is shown in Table 6.11. For W Con, consonants have a statistically significant effect on F1 and F2 heads and tails, although there are no significant pairwise comparisons for the following consonants' influences on F1 tails (Table 6.12). In W WL, however, there are significant consonantal effects on both F2 measures, but none for F1. Similar to women, M Con also have statistically significant interactions between consonantal environments and long /o/ formant measures, except for the following consonant on F1 tails. Finally, the preceding consonants in M WL only contribute to differences in F2 heads.

Table 6.11. Kruskal-Wallis results for consonantal effects on long /o/ F1 and F2 heads and tails.

Preceding consonant		Following consonant	
F1 head	F2 head	F1 tail	F2 tail
W Con			
χ^2=29.994 ***df*=8** ***p*=0.000***	**χ^2=50.280** ***df*=8** ***p*=0.000***	χ^2=14.877 *df*=7 *p*=0.04*†	**χ^2=42.146** ***df*=7** ***p*=0.000***
W WL			
χ^2=12.990 *df*=7 *p*=0.07	**χ^2=62.814** ***df*=7** ***p*=0.000***	χ^2=3.921 *df*=6 *p*=0.69	**χ^2=16.317** ***df*=6** ***p*=0.01***
M Con			
χ^2=14.350 ***df*=4** ***p*=0.01***	**χ^2=17.062** ***df*=4** ***p*=0.000***	χ^2=7.255 *df*=5 *p*=0.2	**χ^2=15.934** ***df*=5** ***p*=0.01***
M WL			
χ^2=8.153 *df*=7 *p*=0.32	**χ^2=25.877** ***df*=7** ***p*=0.000***	χ^2=3.061 *df*=6 *p*=0.8	χ^2=4.232 *df*=6 *p*=0.65

†No significant pairwise comparisons.

Table 6.12. Dunn's *post hoc* pairwise comparisons of following consonants on long /o/ F1 tails for women in conversation.

	/t/	/k/	/kʰ/	/pʰ/	/r/	/s/	/tʰ/
/k/	0.189 1.000						
/kʰ/	-0.005 1.000	-0.199 1.000					
/pʰ/	2.352 0.261	2.370 0.249	2.378 0.244				
/r/	-1.286 1.000	-1.454 1.000	-1.292 1.000	-2.855 0.060			
/s/	1.587 1.000	1.621 1.000	1.625 1.000	-1.337 1.000	2.279 0.317		
/t/	0.344 1.000	0.220 1.000	0.352 1.000	-1.831 0.939	1.428 1.000	-0.918 1.000	
/ʋ/	1.629 1.000	1.638 1.000	1.661 1.000	-1.093 1.000	2.319 0.286	0.235 1.000	1.029 1.000

Note. *Z* statistics shown above *p*-values.

With respect to long /o/ raising in wordlists, neither women nor men show consonantal effects for F1 measures. Conversational tokens, however, show significant consonantal interactions on F1. Pairwise comparisons in conversations show that heads preceding /ʋ/ ($\tilde{x}$=653.194, n=6) are lowered relative to /p/ ($\tilde{x}$=573.171, n=33; *Z*=-3.303, *p*=0.017*) for women and for /m/ ($\tilde{x}$=707.350, n=6) relative to /p/ ($\tilde{x}$=566.433, n=14; *Z*=-3.165, *p*=0.008*) for men.[2] Furthermore, women's long /o/ heads with preceding /r, ʋ/ are lower in conversations than in wordlists (/r/ $\tilde{x}$=548.903, n=16; /ʋ/ $\tilde{x}$=496.567, n=33 in wordlists); a Mann-Whitney *U* test shows that these stylistic differences are statistically significant (/r/ *U*=95, *p*<0.001*; /ʋ/ *U*=5, *p*<0.001*). Men have no tokens with preceding /m/ in wordlists, so statistical comparisons are not possible. However, the lowest median long /o/ onsets in this gender-style group occur with

[2] Differences between /p-r/ are also statistically significant, but because /r/ shows a great deal of regional and interpersonal variation, this environment is absent from discussion and one that suggests an avenue for additional research.

preceding /h/ ($\tilde{x}$=572.895, n=9), which are substantially higher than the conversational tokens with preceding /m/. Although these consonantal environments likely contribute to the long /o/ tokens with lower heads in conversation for both women and men, the results for head raising following /p/ are mixed: women show statistically significant differences across styles (U=194, p<0.001*), but men do not (U=91, p=0.090).[3] It appears, then, that consonantal environment partially contributes to stylistic long /o/ raising. However, because the pattern is present for men without significant F1 heads with preceding /p/ across style, it stands to reason that long /o/ raising is a characteristic of the wordlist style.

With respect to long /o/ fronting (F2 measures), consonantal effects are shown to be statistically significant on heads and tails for all gender-style groups except for F2 tails in M WL. Although there are a number of statistically significant pairwise relationships, the most consistent patterns for long /o/, i.e., those present for each gender-style group, are that F2 heads are fronted following coronals relative to labials, and that F2 tails are fronted before velars relative to coronals (see Tables 6.13, 6.14).

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[3] In wordlists, median F1 heads following /p/ are 497.842 (n=30) for women (cf conversation $\tilde{x}$=573.171) and 543.952 (n=20) for men (cf conversation $\tilde{x}$=566.433).

Table 6.13. Median long /o/ F2 head and tail values by consonantal environment and gender-style group.

Group	F2 head		F2 tail	
	Preceding consonant	$\tilde{x}$	Following consonant	$\tilde{x}$
W Con	/p/ (n=33) /p^h/ (n=48) /t^h/ (n=46) /s/ (n=13)	1030.577 1102.289 1145.786 1302.126	/k/ (n=48) /s/ (n=43) /t^h/ (n=15)	1119.762 1184.573 1094.498
W WL	/p/ (n=30) /s/ (n=15) /t^h/ (n=16)	892.0685 1070.789 998.2570	/k^h/ (n=32) /t/ (n=31)	1098.173 1074.311
M Con	/p^h/ (n=38) /t^h/ (n=28)	980.017 1151.072	/k/ (n=26) /s/ (n=39)	1191.472 1058.976
M WL	/p/ (n=20) /s/ (n=9) /t^h/ (n=9)	888.976 1031.889 1110.367	NS	

Table 6.14. Dunn's *post hoc* pairwise comparisons of labial vs. coronal effects on long /o/ F2 heads and velar vs. coronal effects on long /o/ F2 tails.

	F2 head			F2 tail		
Group	C-C	*Z*	*p*	C-C	*Z*	*p*
W Con	/p-s/ /p-t^h/ /p^h-s/	-4.864 -3.395 -3.445	0.000* 0.012* 0.010*	/k-s/ /k-t^h/	4.586 4.463	0.0001* 0.0001*
W WL	/p-s/ /p-t^h/	-4.605 -4.657	0.0001* 0.000*	/k^h-t/	3.360	0.008*
M Con	/p^h-t^h/	-3.861	0.001*	/k-s/	3.781	0.001*
M WL	/p-s/ /p-t^h/	-3.156 -4.325	0.022* 0.0002*	NS		

Because there are consonantal environments common across genders within the same style, gender-differentiated long /o/ fronting can be evaluated within a consistent consonantal group. For both genders, conversation groups share preceding /p^h/ and /t/, as well as following /k^h/ and /s/, and the wordlist group shares preceding /p/, /s/, and /t^h/. Table 6.15 shows the results of the Mann-Whitney *U* test for gender within each consonant-style group. F2 heads following labials in both styles are significantly greater for women compared to men; there are no significant differences for coronals. These results indicate that women advance long /o/ heads after labials to a greater extent than men do, which confirms the findings in §6.2 for gender differentiated long /o/ fronting. Furthermore, both /k^h/ and /s/ groups show statistically significant differences in F2 tails by gender. Although women have backed F2 tails relative to men, their tails preceding /s/ are further forward. This finding suggests greater tail fronting before coronals for women relative to men, but additional data and analysis are required to evaluate the extent of this pattern. In sum, these outcomes show advanced long /o/ formants for women compared to men, at least following labials, and support the results in §6.2.1. Though some consonantal environments appear to favor long /o/ fronting more than others, women generally display more advanced vowels than men in those conditions, although head fronting following the coronals investigated here seems consistent for both women and men.

Table 6.15. Mann-Whitney *U* test of long /o/ F2 heads and tails by gender, within consonant-style groups.

Style	Preceding C	*U*	*p*	Following C	*U*	*p*
Conversation	/p^h/	1358	<0.0001*	/k^h/	503	0.004*
	/t^h/	661	0.855	/s/	1194	0.001*
Wordlist	/p/	98	0.004*	NS		
	/s/	94	0.123			
	/t^h/	67	0.803			

6.3.2 Consonantal effects on long /u/

Social and stylistic variations for long /u/ (§6.2.2) show that the vowel is raised in wordlists for both women and men. It is also raised for women compared to men in wordlists, but not in conversations. Furthermore, men show a greater range of F2 values than women in both styles.

Again, a Kruskal-Wallis analysis of variance evaluates the effects of preceding and following on long /u/ F1 and F2 heads and tails, respectively; these results are presented in Table 6.16.

Table 6.16. Kruskal-Wallis results for consonantal effects on long /u/ F1 and F2 heads and tails.

Preceding consonant		Following consonant	
F1 head	F2 head	F1 tail	F2 tail
W Con			
χ^2=8.829 *df*=5 *p*=0.12	**χ^2=29.878 *df*=5 *p*=0.000***	χ^2=4.998 *df*=6 *p*=0.54	**χ^2=31.800 *df*=6 *p*=0.000***
W WL			
χ^2=17.051 *df*=5 *p*=0.000*	**χ^2=20.678 *df*=5 *p*=0.000***	χ^2=10.814 *df*=5 *p*=0.06	χ^2=8.157 *df*=5 *p*=0.15
M Con			
χ^2=5.019 *df*=2 *p*=0.08	**χ^2=14.128 *df*=2 *p*=0.000***	χ^2=6.073 *df*=3 *p*=0.11	χ^2=6.694 *df*=3 *p*=0.08
M WL			
χ^2=5.052 *df*=5 *p*=0.41	χ^2=13.760 *df*=5 *p*=0.02*†	χ^2=2.483 *df*=5 *p*=0.78	**χ^2=11.952 *df*=5 *p*=0.04***

†No significant pairwise comparisons.

Beginning with consonantal factors contributing to vowel height (F1), only F1 heads for women's conversation show statistically significant effects. Although these influences may contribute to stylistic height variations for women, this same raising pattern for men is unaffected by consonantal environment. For women, long /u/ heads seem to raise following /p/ ($\tilde{x}$=439.696, n=44) compared to /s/ ($\tilde{x}$=482.482, n=15; *Z*=-2.809, *p*=0.037*) and /f/ ($\tilde{x}$=483.461, n=16; *Z*=-2.947, *p*=0.024*) as well as following /t/ ($\tilde{x}$=425.420, n=14) relative to /f/ (*Z*=-2.756, *p*=0.044*). Although there are not enough examples with /t/ in women's wordlists (n=1) for a comparison by style, an analysis on the effect of style on F1 heads following /p/ ($\tilde{x}$=449.992, n=69 in conversations) shows no significant results (*U*=1188, *p*=0.052). Finally, the preceding and following consonants also do not appear to contribute to the finding that women raise long /u/ relative to men in conversations. Therefore, these results confirm the social effects on long /u/ raising patterns discussed in §6.2.2.

Consonantal effects, however, are much more robust for the horizontal measures of long /u/, where men show a tendency for more advanced and backed variants compared to women. Like long /o/, coronals induce head fronting relative to labials (although long /u/ after /p^h/ is the most advanced for women's wordlist tokens [$\tilde{x}$=852.906, n=15]) and tail fronting relative to velars (see Table 6.17). These relationships are significant for heads in all gender-style groups, though there are no significant pairwise comparisons for M WL (see Tables 6.18, 6.19); they are also significant for tails in W Con and M WL.

Table 6.17. Median long /u/ F2 head and tail values by consonantal environment and gender-style group.

Group	F2 head		F2 tail	
	Preceding consonant	$\tilde{x}$	Following consonant	$\tilde{x}$
W Con	/p/ (n=69) /t^h/ (n=27) /s/ (n=7)	855.271 1025.843 1183.023	/k^h/ (n=79) /s/ (n=24) /t^h/ (n=8)	847.361 1155.972 1197.545
W WL	/p/ (n=44) /t/ (n=14) /s/ (n=15)	820.171 830.108 849.451	NS	
M Con	/p/ (n=30) /t^h/ (n=20)	887.1715 1116.0615	NS	
M WL	NS pairwise comparisons		/k^h/ (n=18) /t^h/ (n=18)	765.152 888.03

Table 6.18. Dunn's *post hoc* pairwise comparisons of preceding consonants on long /u/ F2 heads for men in wordlists.

	/p/	/t/	/f/	/k^h/	/p^h/
/t/	-2.655 0.059				
/f/	0.202 1.000	2.333 0.147			
/k^h/	-0.511 1.000	2.279 0.170	-0.564 1.000		
/p^h/	0.348 1.000	2.321 0.152	0.138 1.000	0.677 1.000	
/s/	-2.461 0.104	0.159 1.000	-2.174 0.222	-2.086 0.277	-2.172 0.224

Table 6.19. Dunn's *post hoc* pairwise comparisons of labial vs. coronal effects on long /u/ F2 heads and velar vs. coronal effects on long /u/ F2 tails.

	F2 head			F2 tail		
Group	C-C	*Z*	*p*	C-C	*Z*	*p*
W Con	/p-t^h/ /p-s/	-3.959 -3.724	0.001* 0.002*	/k^h-s/ /k^h-t^h/	-4.069 -3.609	0.001* 0.003*
W WL	/p-t/ /p-s/	-3.183 -2.795	0.011* 0.039*	NS		
M Con	/p-t^h/	-3.740	0.0003*	NS		
M WL	NS			/k^h-t^h/	-2.963	0.023*

The only consistent stylistic gender-comparison of consonantal effects on the F2 of long /u/ is heads between W Con and M Con. For each gender, long /u/ F2 heads after /t^h/ are significantly advanced compared to heads after /p/. A Mann-Whitney *U* test shows that F2 heads following /t^h/ are not significantly different between women and men (U=224, p=0.331), but there are, however, statistically significant gender effects on F2 heads following /p/ (U=743, p=0.026*). These results suggest that women and men display similar fronting patterns following coronals, but that women have vowels that start more toward the back of the vowel space following /p/ than men do. Therefore, the differences between women and men in the horizontal positions of long /u/ may be the result of women maintaining more standard-like backed tokens in more phonological environments than men. These findings corroborate the gender differences in long /u/ F2 found in §6.2.2, although more work is required to investigate the full spectrum of consonantal interactions with this vowel's horizontal position.

6.3.3 Consonantal effects on long /ʉ/

Like long /u/, men tend to have advanced long /ʉ/ vowels relative to women, especially in conversations. Significant consonantal effects on F2 heads are found for both women and men, and on F2 tails for men (Table 6.20). However, unlike long /u/, the data do not reflect a consistent fronting pattern for women and men. For example, long /ʉ/ F2 heads are significantly greater following /h/ ($\tilde{x}$=2121.861, n=51) than /t^h/ ($\tilde{x}$= 1987.569, n=16; Z=3.118, p=0.003*) for W Con. On the other hand, for M Con the vowels following both /h/ ($\tilde{x}$=2301.354, n=18) and /t^h/ ($\tilde{x}$=2310.922, n=10) are more advanced than those following /r/ ($\tilde{x}$=1598.225, n=9; /h-r/ Z=3.150, p=0.005*; /t^h-r/ Z=-2.780, p=0.016*), as well as those following /h/ compared to /l/ ($\tilde{x}$=1905.092, n=8; Z=2.730, p=0.019*). It may be that men, but not women, present this pattern because the men's group is skewed toward Western speakers (see §6.1, Table 6.2), who are more likely to have uvular [ʀ] or [ʁ] rather than apical [ɾ] and less likely to have the 'thick-l' [ɽ] variants that occur in Eastern Norwegian; the women's group is more evenly distributed with respect to region. These results, then, indicate areas of further dialectal and phonetic investigation into how liquids affect following (and the tails of preceding) vowels. Finally, effects on F2 tails in M Con are consistent with patterns found for long /o/ and /u/, where vowel tails are advanced before coronals relative to velars (/s/ $\tilde{x}$=2168.359, n=25; /t/ $\tilde{x}$=2274.307, n=6; /k^h/ $\tilde{x}$=1920.7, n=8; /k^h-s/ Z=-2.558, p=0.032*; /k^h-t/ Z=2.522, p=0.035*). These differences were not statistically significant in the data for W Con, W WL, or M WL.

Table 6.20. Kruskal-Wallis results for consonantal effects on long /ʉ/ F1 and F2 heads and tails.

Preceding consonant		Following consonant	
F1 head	F2 head	F1 tail	F2 tail
W Con			
χ^2=1.085 *df*=2 *p*=0.58	**χ^2=11.875** ***df*=2** ***p*=0.000***	χ^2=2.597 *df*=3 *p*=0.46	χ^2=2.721 *df*=3 *p*=0.44
W WL			
χ^2=4.800 *df*=6 *p*=0.57	χ^2=12.506 *df*=6 *p*=0.05	χ^2=6.000 *df*=6 *p*=0.42	χ^2=9.513 *df*=6 *p*=0.15
M Con			
χ^2=10.193 ***df*=3** ***p*=0.02***	**χ^2=15.906** ***df*=3** ***p*=0.000***	**χ^2=9.640** ***df*=3** ***p*=0.02***	**χ^2=10.013** ***df*=3** ***p*=0.02***
M WL			
χ^2=20.897 ***df*=6** ***p*=0.000***	χ^2=11.973 *df*=6 *p*=0.06	χ^2=4.309 *df*=6 *p*=0.63	χ^2=4.048 *df*=6 *p*=0.67

Comparisons are possible for long /ʉ/ F2 heads following /t^h/ and /h/ by gender, at least in the conversational style. A Mann-Whitney *U* test shows significant gender differences in both categories: following /t^h/, *U*=10, $p<0.001$*; and following /h/, *U*=257, *p*=0.006*. These results support the findings in §6.2.3 that men have fronted long /ʉ/ relative to women because the pattern is consistent within two identical consonantal environments that were shown to contribute to significant in-category F2 head differences. The data in general and a comparison of two preceding consonantal environments in particular show that men have advanced long /ʉ/s relative to women's tokens. Though more work is required to track the effects of Norwegian consonants — and their regional and social variants — on surrounding vowels, their influences on LBCS vowel formants are by and large consistent with the social patterns found in §6.2.

6.4 Summary

In this chapter, I investigated the sociolinguistic variations of the three vowels of the Norwegian LBCS: long /o, u, ʉ/. An analysis of region on the vowels' heads, tails, and rates of formant change show surprising consistency between Eastern and Western Norwegian. Only long /u/ F2 tails and rΔF2 show regional effects, but that these differences are likely not substantial in terms of each group's LBCS progression. Stylistic and gender comparisons demonstrate that long /o/ is raised in wordlists, but that consonantal environment may contribute to this pattern for women. Women also tend to have more advanced long /o/s than men, suggesting that this vowel may be undergoing sociophonetic variation separate from those that contributed to the chain shift in Old Scandinavian. Furthermore, long /u/ presents with raised variants in wordlists and for women compared to men in conversations; and the vowel is further back for women relative to men. Likewise, long /ʉ/ is further advanced for men compared to women. The gender differentiations in the horizontal positions of long /u, ʉ/ are consistent with a stable sociolinguistic variable in that women produce more conservative variants (Labov 2001:367). The sociophonetic results indicate that the LBCS has reached completion among university-aged women, although their male peers front both /u/ and /ʉ/, especially in conversations.

It appears, however, that a new vowel change is emerging in the wake of the LBCS: long /o/ fronting. Unlike a similar back vowel fronting pattern in English, where /u/ is followed by /o/ in a 'solidarity chain' (Jacewicz, Fox & Salmons 2011:49), only /o/ fronting — and NOT /u/ fronting — in Norwegian is characteristic of the speech of women, who tend to lead changes-in-progress. These differences are likely attributable to the overt norms regarding the horizontal positions of these vowels. It follows that divergence from a back pronunciation of long /u/, but not long /o/, breaks with prescribed linguistic norms, and that women will be more conservative than men for the former, but more progressive for the latter (cf. Labov 2001:367). Finally, preceding coronals are shown to be leading environments for long /o/ fronting, but with minimal gender differences. However, an analysis of the trailing environment (preceding labials) shows that women are fronting long /o/ more than men in this environment. This finding suggests that women are leading the change by expanding the consonantal environments in which fronting occurs, where men are not. And though long /o/ fronting is not at present influencing the horizontal position of long /u/, it may have an effect on the fronting of long /ɑ/, an already-present occurring dialectal feature for short /ɑ/ (§§5.1.2, 5.2.4). These differences are likely attributable to social speech practices with respect to the horizontal positions of these vowels and the extent to which female and male patterns reflect changes-in-progress is worthy of further investigation. Likewise, how these changes interact with the rest of the vowel system, i.e., whether fronting is isolated to /o/ or spreads to the other non-front vowels in the future, is a clear avenue for additional research.

Chapter 7: Conclusion

In this dissertation, I investigate central issues in Norwegian linguistics and phonological theory. The first deals with whether or not vowel patterns in contemporary Norwegian dialects can accurately be represented within a uniform phonological system (*Hypothesis 1*). The second concerns the extent to which that system models sociophonetic variation (*Hypothesis 2*). Specifically, do phonologically specified features — through their roles as defining categories that distinguish linguistically meaningful units — result in phonetic invariance? The results based on nonparametric statistical analysis do not support a strong relationship between phonological and phonetic representations, although the most robust patterns of variation are present in relation to acoustic parameters that are phonologically unspecified. The fact that statistically significant phonetic variation occurs for features associated with phonological specifications (e.g., F1-related variation for the Tongue Height phonemes, /u, ʉ/; see below) owes to fundamental differences in the nature of the units over which these two levels of representation operate and their non-linear relationship (Purnell 2009). After all, the abstract dimensions that define phonological categories are converted to continuous, physical phonetic variables (Keating 1996:263) in the same manner as the enhancing gestures that fill in the unspecified portion of a phoneme's structure.

With respect to *Hypothesis 1*, the data are consistent with a single system of phonological representations for the varieties investigated, i.e., 'Modern Norwegian.' That is not to say, however, that there are no regional or dialectal differences in vowel patterns. However, these lie primarily, I argue, in sets of lexical variants that can be traced to early distinctions between East and West Scandinavian (§§2, 5), which represents two extremes for linguistic trends in a North

Germanic dialect division; Norwegian, it so happens, found itself at the intersection of many of those tendencies, which are still reflected in its contemporary varieties.

Though lexical variation encompasses a great deal of the regional and dialectal variations in Modern Norwegian vowels, there ARE dialect-sensitive differences in vowels' positions in acoustic space. The clearest examples are short /e/ lowering in Bergensk — and to a lesser extent in Trøndsk — and Southwestern short /ɑ/ fronting (§§5.1.2, 5.2.3, 5.2.4). In both cases, these deviations from the other dialects' patterns occur with respect to the vowels' unspecified representations. The /e/ phoneme, specified with Tongue Thrust (i.e., [front]), varies in height and /ɑ/, specified as Tongue Root (i.e., '[low]'), varies horizontally. Judging just the surface forms, these dialects have 'different' vowels; Bergensk may even be described as lacking surface [ɛ], having [æ] in its place. However, the analysis of the vowel system as a whole — the distributions of long and short vowels and the prosodic processes by which length is calculated (§3.2.3) — that suggests that these differences result from surface-level variation in the implementation of phonetic gestures and not at the level of phonological representation. That is, the long and short series draw from one set of underlying phonemes with one representational system; gaps in surface-level forms, therefore, must be interpreted within the context of the entire sound system.

Likewise, social variations in LBCS vowel acoustics (long /o, u, ʉ/) occur with respect to the parameters that are phonologically unspecified for these vowels. Specifically, long /o/ (Labial) varies both in terms of its height and its advancement, and long /u/ (Tongue Height, Labial), and long /ʉ/ (Tongue Height) show the most robust variation along their horizontal positions in acoustic space (§6.2). The gender-differentiated results show that long /o/ fronting is more prominent among women than men, whereas the horizontal variance of the high vowels is a characteristic of male, rather than female, speech. These patterns suggest that the variations index different sociolinguistic norms. Both sets of variation occur relative to unspecified phonological features and, therefore, there is little to suggest a STRUCTURAL cause for the distributions of those patterns. Rather, these variations are subject to social evaluation, which influences the ranges in which they vary among different social groups. Whether regional, gender-based, or stylistic variation in vowel phonetics occur, these differences do not compromise the distinctiveness of the vowels within the phonological system.

It is, however, not the case that phonologically specified features are statistically invariant. Long /u, ʉ/, for example, both show significant gender-style effects on their F1 heads and tails (Tables 6.5, 6.6), the acoustic correlates of their Tongue Height specifications. Based on these results, the strong version of *Hypothesis 2* (*Hypothesis 2a*) — that phonological categoricity is represented by phonetic invariance — is not supported. This does not suggest, however, that we should abandon the notion that phonological representations are categorical. It merely indicates that we need a more nuanced understanding of what 'categoricity' conveys at different levels of representation, a position consistent with *Hypothesis 2b*. For /u, ʉ/, as well as /i, y/, the Tongue Height specification at the Phonological level means that this dimension is completed with the gesture [high] at the Phonetic-phonological level. In turn, [high] is implemented at the Phonetic level as a physical representation that occurs within a range of continuous variables. It is unsurprising, then, that statistically significant variation may occur WITHIN the category 'high.' Because vowels lack closure between articulators and because tongue position is an approximation for vowels, the category itself is largely defined in relation to the other categories within the system.

Furthermore, evidence of near-mergers indicates that perceptual and productive categories do not overlap; speakers may systematically produce separate sounds, yet perceive them as one (e.g., Labov 1994:368). Although a full account of the relationship between phonological and perceptual categories is outside the scope of this dissertation, it is clear that what constitutes a 'category' is relative and subject to specific domains (e.g., levels of representation; perception vs. production) and the principles by which they operate. On the one hand, because phonological representations mark phonemes based on the presence or the absence of a contrastive dimension, the phonological category is discrete and dualistic: there either IS or IS NOT a specification. On the other hand, phonetic representations are continuous, and the boundaries between phonetic categories are often more fluid and dependent upon a variety of cues and interrelated features (e.g., ΔF1 and rΔF1 for long /o/, ΔF2 and rΔF2 for long /ʉ/; §6.2.4).

As a whole, the results show that sociophonetic variation is possible both within phonological categories and irrespective of them (i.e., variation with respect to phonological underspecification). These patterns call into question the appropriateness of relying on phonetic data to answer phonological questions, as Ohala (1990) advocates. Rather, the data support a model in which phonetics and phonology are separate domains with distinct functions that operate on different types of units. Therefore, attempting to answer how a language organizes sounds into categories based on gradient data with substantial areas of acoustic overlap across different sounds can only yield limited insights. For example, the lowering of short /e/ to [æ] in Bergensk does not of itself provide evidence for whether or not there is a structural change to the broader system, i.e., if the short series lacks an /e/ phoneme. In this case, it is an analysis of vowel length assignment that suggests that this change does not target abstract representations, but in how they are produced on the surface.

It is thus the phonological analysis of the sounds' representations and their relationships within a system that provide real gains for sociophonetic investigations — not just for those findings' implications on fine-grained phonetic changes-in-progress, but also for their impacts on system-wide phonological change. Because the horizontal variations among long /o, u, ʉ/ occur with respect to unspecified phonological features, their progressions along this track currently have minimal impact on the phonological system, insofar as they preserve some distinction from their phonetic neighbors, and the horizontal positions of long /u, ʉ/ appear to be sociolinguistically stable. On the other hand, vertical variations in /u, ʉ/ point to a type of variation with potential structural consequences. Although there is no evidence in the present data that these vowels are undergoing a change-in-progress with respect to height, it is clear that similar within-category variations resulted in the realignment of phonological representations; the phonologization of the LBCS from Old Scandinavian to Modern Norwegian is one example. In this case, speakers produced enough variation of the [RTR] gesture for the long /ǫ/ Tongue Root dimension that learners ceased to generalize it as a category-defining feature.

This scenario is in harmony with Weinreich et al. (1968), who argue that variation is a necessary precursor to change. Because phonological change is a fact of human language, it is unsurprising that variation occurs relative to phonologically specified features. The strength of the present model — with clear and distinct levels of representation — is that it provides us the opportunity to be specific about the type of change an observed sociophonetic variation provokes. Does a change-in-progress target the phonetic implementation of an enhancement, such as long /o/ fronting? Or in the implementation of a gesture that completes a phonological dimension, as in Old Scandinavian long /ǫ/? The generalizations that future language learners make with respect to these phonetic variations will have different effects on the phonological system. For the former, if the change-in-progress continues along its current trajectory, it may result in the loss of a [back] enhancement for /o/, a change at the Phonetic-phonological level of representation. For the latter, the outcome of the change targeted the Phonological level of representation, which induced, I argue, the reordering of contrastive phonological features (§3.3.2). Furthermore, Phonetic-phonological change motivates Phonological change, e.g., the phonologization of [high] as Tongue Height for Modern Norwegian /u/ (from Old Scandinavian /o/), but this change was in response to Phonological change elsewhere in the system, specifically the loss of Tongue Root on Old Scandinavian long /ǫ/. Again, this speaks to the importance of understanding sociophonetic variation and changes-in-progress within the broader structure of the sound systems in which they occur.

Of course, understanding how variation affects sound systems requires a consistent phonological framework and clear diagnostics for determining the relationships between sound categories and their phonetic realizations. To this end, I adopt the architecture put forth by Purnell & Raimy (2015), in which the sound system is composed of (at least) three distinct levels of representation: The Phonological level, which governs abstract contrasts; the Phonetic-phonological level, which operates on gestures; and the Phonetic level, which implements those gestures into continuous, physical variables. Phonological-level representations consist of underspecified dimensions (e.g., Avery & Idsardi 2001; Purnell & Raimy 2015; Purnell, Raimy & Salmons forthcoming), which are assigned to sets of phonemes based on the Successive Division Algorithm (SDA), creating a contrastive hierarchy of distinctive features (Dresher 2009). Phonological activity is the primary factor in determining if a feature is present in phonological representations (Dresher 2009). In the absence of strong evidence for phonological alternations in contemporary Norwegian vowels, I draw on historical phonological patterns — Tongue Thrust assimilation (i-umlaut) and Labial assimilation (u-umlaut) — as well as structural changes, such as splits, mergers, and chain shifts, to argue for the Modern Norwegian contrastive hierarchy of Tongue Thrust > Tongue Height > Tongue Root > Labial (§3.3.2).

In developing the arguments in §3, I assume the diachronic stability of the contrastive hierarchy for a given language (Purnell, Raimy & Salmons forthcoming) unless the evidence suggests otherwise. Therefore, the majority of structural changes target the phonological features with the smallest contrastive scope, i.e., those features at the bottom of the hierarchy (Oxford 2015). Additions and losses of contrasts (splits and mergers, respectively), then, provide evidence for the last feature in a hierarchy that distinguishes (or distinguished) contrastive pairs, as in the addition of Labial in the split of Proto-Germanic /a/ to Proto-Scandinavian /o, a/, the addition of Tongue Root in the subsequent additions to the Common Scandinavian phonemic inventory through Tongue Thrust and Labial assimilations, and the loss of Tongue Root in the merger of /ø̜/ to /ø/ in Old Scandinavian (§3.3.1). The development of Modern Norwegian was marked by the Long Back-Vowel Chain Shift (LBCS) and the segmental reanalysis of /ø/ to /ɵ/. The former suggests an adjustment to the ordering of phonological features. I therefore posit that such a reranking occurs among the two features with the smallest contrastive scope (MINIMAL CONTRAST SHIFT HYPOTHESIS). The latter presents evidence for a merging process distinct from Oxford's (2015) SISTERHOOD MERGER HYPOTHESIS, in that the vowel loses ALL of its phonological features (CONTRASTIVE NEUTRALIZATION HYPOTHESIS). These proposals, laid out in §3.3.2, demonstrate additional ways in which phonological representations may change diachronically, which are testable with other languages and data sets.

Lastly, I elaborate on the structural distinction between completed and enhancing features in §3.3.3 based on whether the gesture is introduced as a completion of a phonological dimension (completion) or draws on superordinate structure introduced at the Phonetic-phonological level of representation (enhancement). Likewise, this is an initial proposal that is intended to be tested and evaluated cross-linguistically. Developing clarity around the processes through which gestures enter the sound system — whether this particular proposition holds or not — allows for more precise analyses of the effects of sociophonetic variation and change on sound systems. In turn, greater precision on how variation affects phonological representations can uncover explicit motivations for the types of structural changes proposed in this dissertation and in Oxford (2015).

In addition to investigating the relationships between sociophonetic variation and phonological structure, there are substantial opportunities for further research on Norwegian — and Scandinavian — vowel systems. Firstly, a complete examination of the sociophonetic patterns of the vowels not detailed in this dissertation is warranted and would yield a fuller picture of variations and their possible effects on the system as a whole. What is more, age differentiated effects on formant dynamics are necessary to understand the context in which sociophonetic variation currently occurs and to track changes over real or apparent time. An analysis of old recordings with speakers born in the first quarter of the 20th century and earlier, like those collected by Hallfrid Christiansen and Johan Storm, would provide further contextualization and nuance to vowel changes in Norwegian, especially with respect to the spread of the LBCS and its variation relative to shifting phonological representations. Likewise, a substantial set of Norwegian dialects, including Northern Norwegian and many rural and mountain dialects, were excluded from statistical analysis. Although the results from the data collected are consistent with a single set of Norwegian vowel specifications, I cannot rule out the possibility that there are dialects with differing phonological systems. Therefore, a more complete and representative sample of Norwegian and its dialects is necessary. Finally, the historical analysis I put forward in §3 calls for similar comparative work on the other North Germanic varieties. Swedish, on the one hand, is likely very similar to Modern Norwegian because it too was affected by the LBCS. Danish, Faroese, and Icelandic, on the other hand, were not, and Danish experienced its own set of phonological changes in vowels and elsewhere. Research on the changes in these languages' phonological specifications over time will no doubt shed light on processes of contrastive change and refine and improve the present analysis.

This dissertation contributes to contemporary research in language variation and change, phonological theory, historical linguistics, and Norwegian dialectology. In addition to describing and analyzing a set of linguistic variables and their distributions, I situate that variation within historical and theoretical contexts. By doing so, I address how those variations and possible changes-in-progress may affect the structural domains of the sound system. The results lead me overwhelmingly to contend that variation is everywhere, but not all variation leads to change, and not all changes alter the system of contrasts. I hope that the present synthesis of sociophonetic inquiry, diachronic analysis, and phonological theory leads to a better understanding of the processes that underlie variation and its effects on linguistic systems.

Appendix 1: Wordlist with glosses and target vowel

Word	Gloss	Target vowel
begge	both	[ɛ]
ser	sees	[eː]
havre	oat	[ɑ]
spøk	joke	[ɵː]
flere	more (count)	[eː]
trodd	believed (pp)	[ʊ]
stig	ladder	[iː]
kjøtt	meat	[ɞ]
mer	more (non-count)	[eː]
spiker	nail	[iː]
tydde	resorted (p.)	[ʏ]
svært	big, great (n., adv.)	[æː]
skog	forest	[uː]
beket	the pitch (n.)	[eː]
fot	foot	[uː]
tørt	dry (n.)	[ɞ]
fat	barrel, tap	[ɑː]
pose	bag	[uː]
huset	the house	[ʉː]
gubbe	old man	[ʉ]
fyk	whizz	[yː]
vidde	plateau	[ɪ]
sjokket	the shock	[ɔ]
hvass	sharp (m., f.)	[ɑ]
skjedd	happened (pp)	[ɛ]
kube	cube	[ʉː]
vise	show (inf.)	[iː]
dyp	deep (m, f)	[yː]
tyde	indicate (inf.)	[yː]
bakke	hill	[ɑ]
vev	web	[eː]
dåd	dead, feat	[oː]
væske	liquid	[æ]
født	born (pp)	[ɞ]
beger	cup, beaker	[eː]
sukker	sugar	[ʊ]
buk	belly	[ʉː]
hygge	enjoy	[ʏ]

vætt	made wet (pp.)	[æ]
våte	wet (pl.)	[oː]
ståk	commotion, hubbub	[oː]
bytte	switch	[ʏ]
både	both (conjunction)	[oː]
søtt	sweet (n.)	[ɞ]
kjede	chain	[eː]
kvist	twig	[ɪ]
bodde	lived (p)	[ʊ]
hvitt	white (n.)	[ɪ]
sverte	blacken (inf.)	[æ]
dyd	virtue	[yː]
tupp	tip	[ʉ]
sote	dirty up (with soot; inf.)	[uː]
søt	sweet (m., f.)	[ɵː]
bekk	creek	[ɛ]
håve	rake in (capture with a net)	[oː]
tigge	beg	[ɪ]
bak	back	[ɑː]
skrudde	screwed (p)	[ʉ]
veske	bag, purse	[ɛ]
gutt	boy	[ʉ]
dugge	dew	[ʉ]
takk	thanks	[ɑ]
spade	shovel	[ɑː]
spydd	thrown up (pp)	[ʏ]
trøbbel	trouble	[ɞ]
fisk	fish	[ɪ]
husk	remember (imp)	[ʉ]
~~jobbe~~	~~work (inf)~~	~~[ɔ]~~
bod	stall, stand, shack, shanty	[uː]
sæte	collect hay into piles (inf.)	[æː]
stygg	ugly (m., f.)	[ʏ]
spådde	predicted (p.)	[ɔ]
stikk	stab, poke, sting (noun)	[ɪ]
huk	crouch, squat	[ʉː]
tråkke	trample	[ɔ]
skyve	push, slide	[yː]
kjøpe	buy (inf)	[ɵː]
våge	dare (inf)	[oː]
bråk	noise, trouble, racket	[oː]

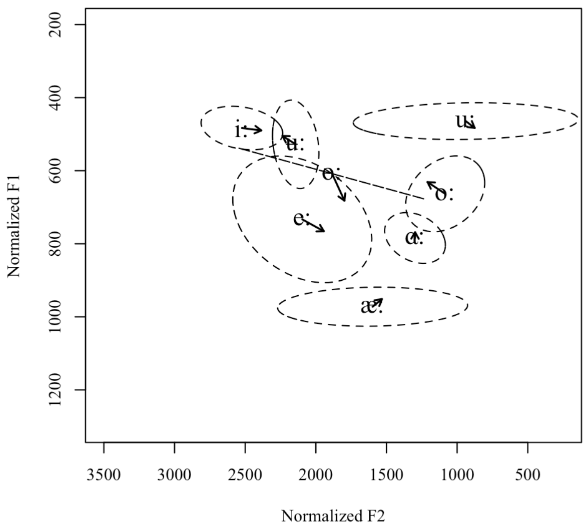
bade	swim, bathe (inf.)	[ɑː]
sukke	sigh	[ʉ]
bøker	books	[ɵː]
viss	certain	[ɪ]
svæv	make fall asleep (imp.)	[æː]
fiber	fiber	[iː]
båt	boat	[oː]
bøddel	messenger	[ɘ]
hav	sea	[ɑː]
tytt	oozed (pp.)	[ʏ]
kjapp	quick	[ɑ]
gud	god	[ʉː]
støtte	support (inf.)	[ɘ]
syk	sick (m., f.)	[yː]
sætt	collect hay into piles (pp.)	[æ]
sup	shot, swig, mouthful	[ʉː]
kibbe	toss (inf.)	[ɪ]
skive	slice (of bread)	[iː]
feber	fever	[eː]
gått	gone (pp)	[ɔ]
hug	mind, thoughts	[ʉː]
bukk	buck (male goat, deer)	[ʊ]
skiple	ruin	[ɪ]
nært	near (n.)	[æː]
steg	step(s)	[eː]
sær	quirky, weird	[æː]
budet	the bid (n.)	[ʉː]
buss	bus	[ʉ]
vest	west	[ɛ]
kjøkken	kitchen	[ɘ]
gås	goose	[oː]
heve	raise	[eː]
sopp	mushroom	[ɔ]
stått	stood (pp.)	[ɔ]
slått	beat (pp.)	[ɔ]
padde	toad	[ɑ]
tøv	nonsense	[ɵː]
tape	lose (inf.)	[ɑː]
vært	been (pp.)	[æ]
bukse	pant(s)	[ʊ]
hes	hoarse	[eː]

gløgg	punch (drink)	[ɵ]
tid	time	[iː]
bygg	building (or barley)	[ʏ]
dope	dope (inf.)	[uː]
glodde	stared, glared (p.)	[ʊ]
stykke	piece	[ʏ]
pøs	tub, bucket	[øː]
vert	host	[æ]
pute	pillow	[ʉː]
søppel	rubbish	[ɵ]
sekk	sack, bag	[ɛ]
dyppe	dip (inf.)	[ʏ]
bys	city's	[yː]
tabbe	mistake	[ɑ]
type	type	[yː]
hått	mind, perception, memory	[ɔ]
papp	cardboard	[ɑ]
bikkje	bitch (dog)	[ɪ]
tufs	fool	[ʉ]
byge	(rain)shower	[yː]
væte	wetness	[æː]
skyte	shoot (inf.)	[yː]
mærd	fish cage	[æː]
søke	search (inf.)	[øː]
loff	loaf	[ʊ]
værs	weather's	[æ]
kose	enjoy, cozy up, snuggle (inf.)	[uː]
dag	day	[ɑː]
løp	run (inf.; noun)	[øː]
kok	boil (inf.)	[uː]
katt	cat	[ɑ]
mætt	measured (var; pp.)	[æ]
boka	the book (f.)	[uː]
trodde	thought (p.)	[ʊ]
sak	thing, case	[ɑː]
fjøset	the barn	[øː]
skjebbe	perch (fish)	[ɛ]
skjegget	the beard	[ɛ]
glodd	stared, glared (pp.)	[ʊ]
diger	huge (m., f.)	[iː]
vaske	wash (inf.)	[ɑ]

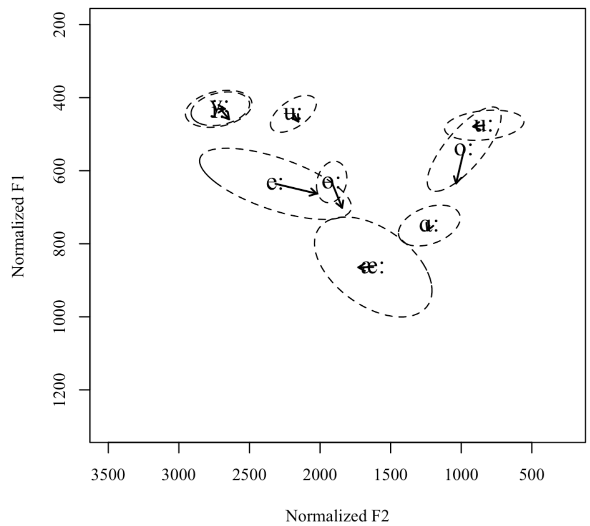
jage	hunt (inf.)	[ɑː]
føde	birth (inf.)	[ɵː]
bog	meat product (shoulder)	[uː]
puste	breath (inf.)	[ʉ]
skip	ship	[iː]
lære	learn (inf.)	[æː]
såpe	soap	[oː]
hvit	white (m., f.)	[iː]
sida	the page	[iː]
rute	route	[ʉː]
væpne	arm (v.)	[æː]
sådde	sowed (p.)	[ɔ]
tett	tight (m., f.)	[ɛ]
fabel	fable	[ɑː]
bodd	lived/resided (pp.)	[ʊ]
kyss	kiss (noun)	[ʏ]
veksle	exchange (inf.)	[ɛ]
fælt	awful (n.)	[æː]
ters	third (musical interval)	[æ]

Appendix 2: Long and short vowel plots for each consultant in both styles.

Grong1k Mean Long Vowels (Conversation)



Grong1k Mean Long Vowels (Wordlist)



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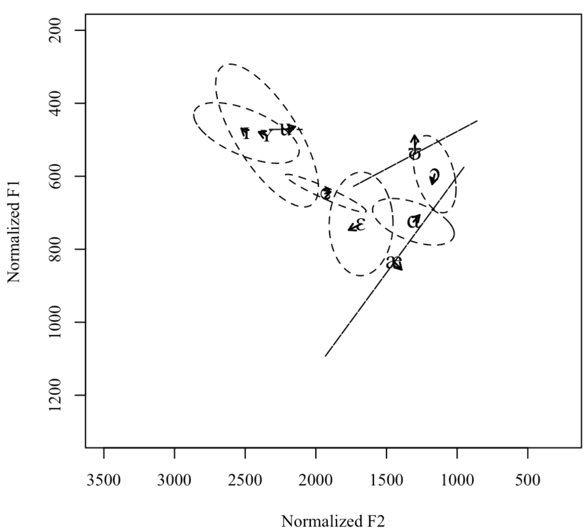
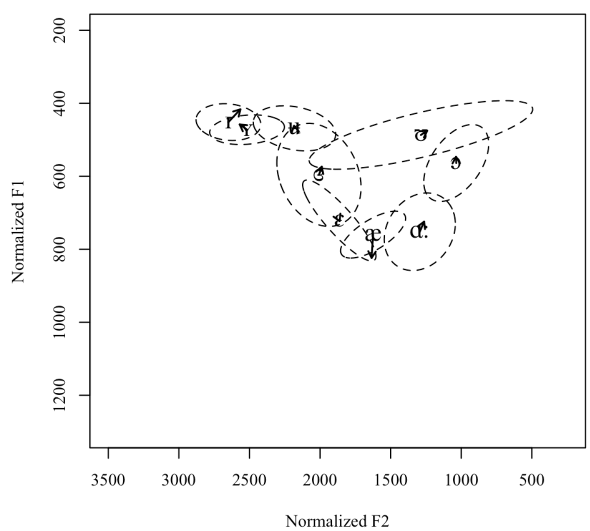
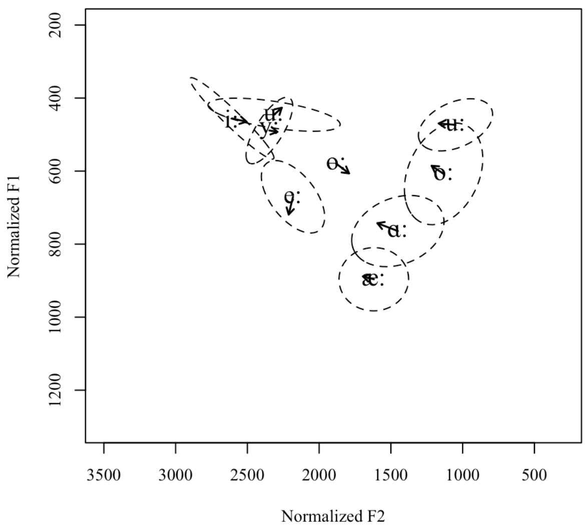


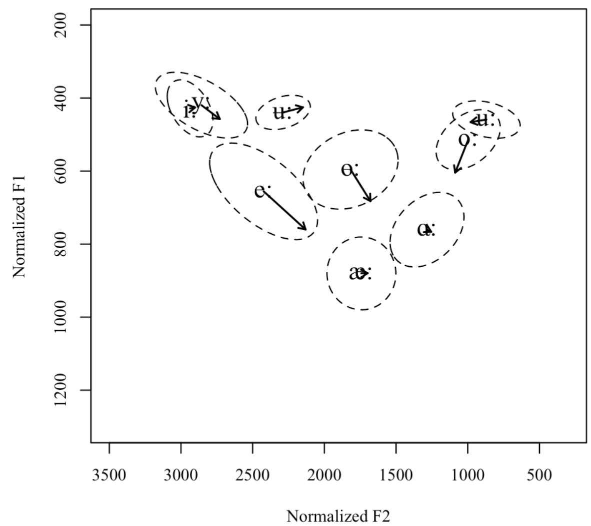
Grong1k Mean Short Vowels (Wordlist)



Trondheim1k Mean Long Vowels (Conversation)



Trondheim1k Mean Long Vowels (Wordlist)



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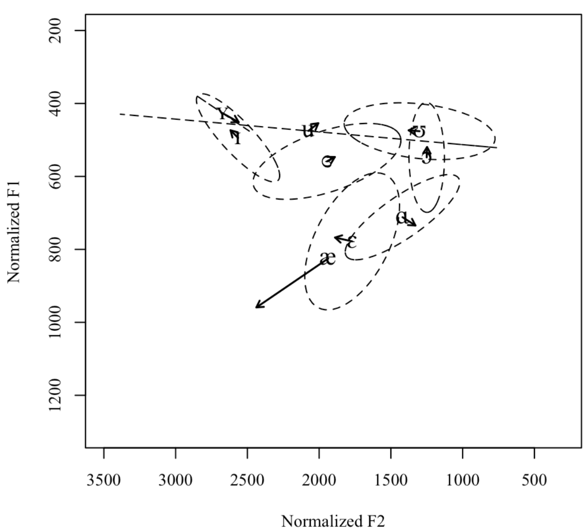

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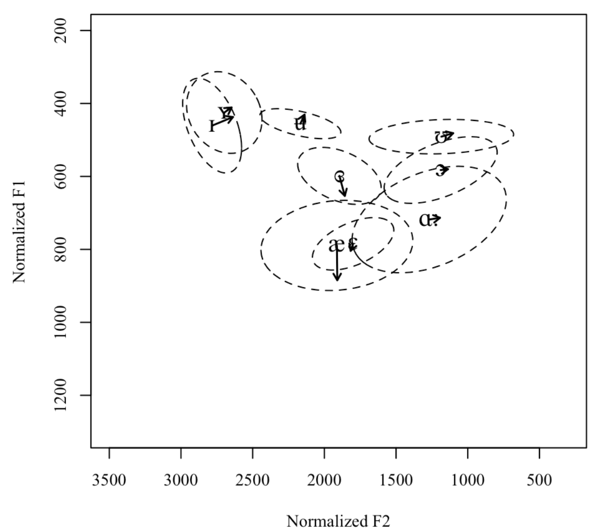
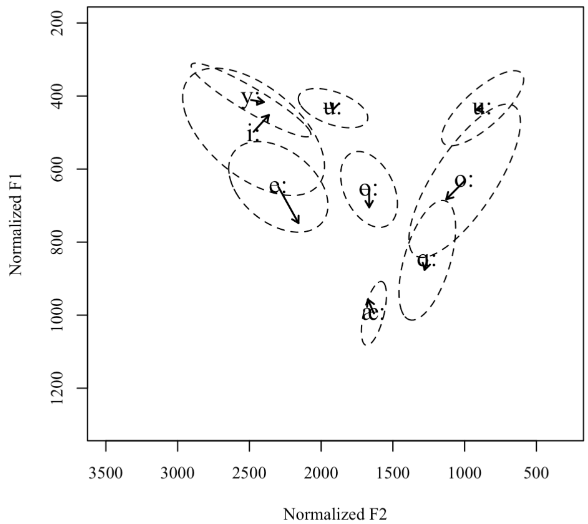
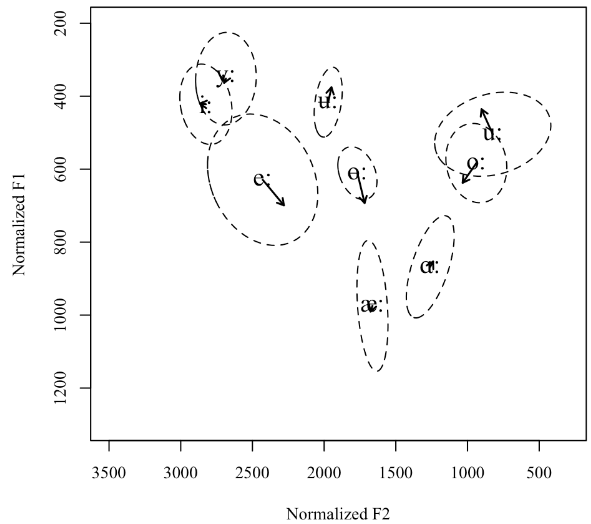


Melhus1k Mean Long Vowels (Conversation)



Melhus1k Mean Long Vowels (Wordlist)



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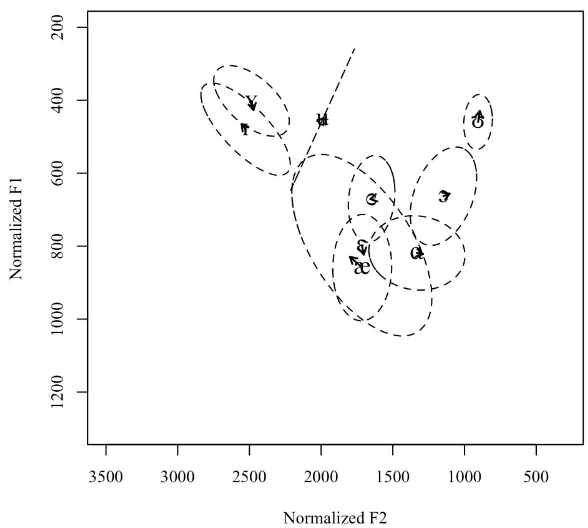
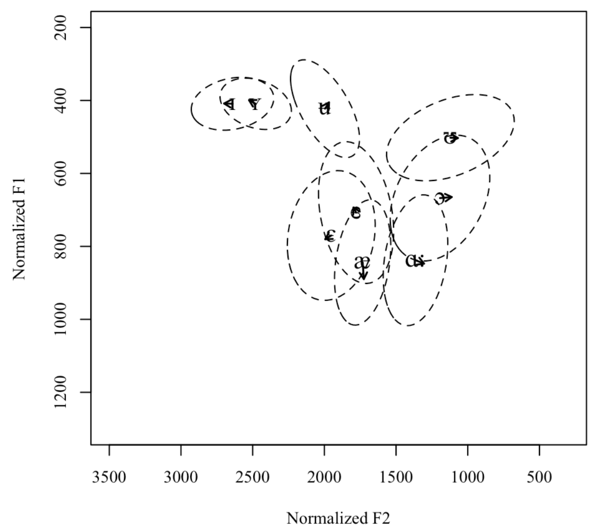
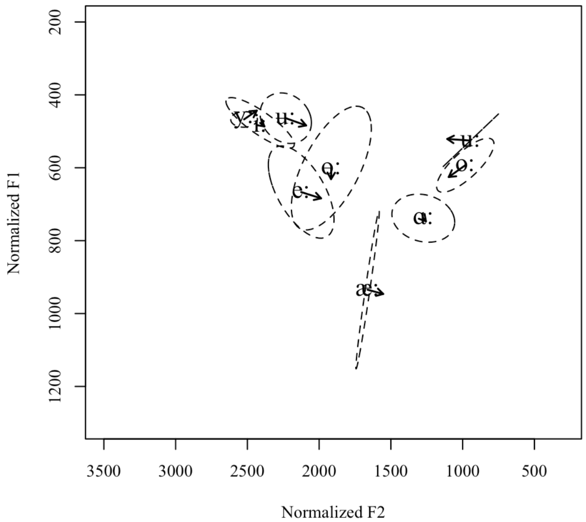


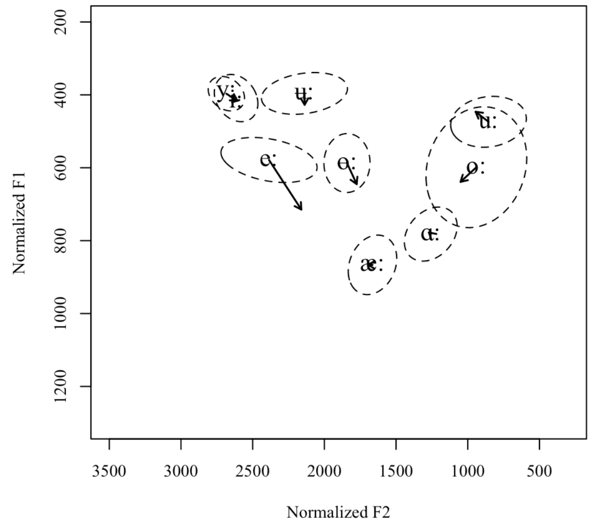
Melhus1k Mean Short Vowels (Wordlist)



Trondheim1m Mean Long Vowels (Conversation)



Trondheim1m Mean Long Vowels (Wordlist)



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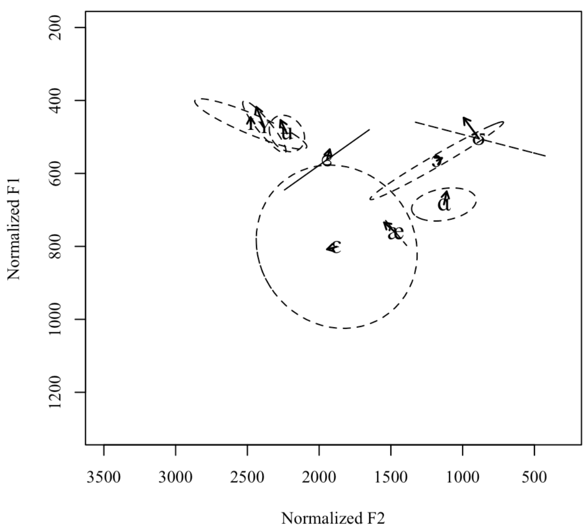
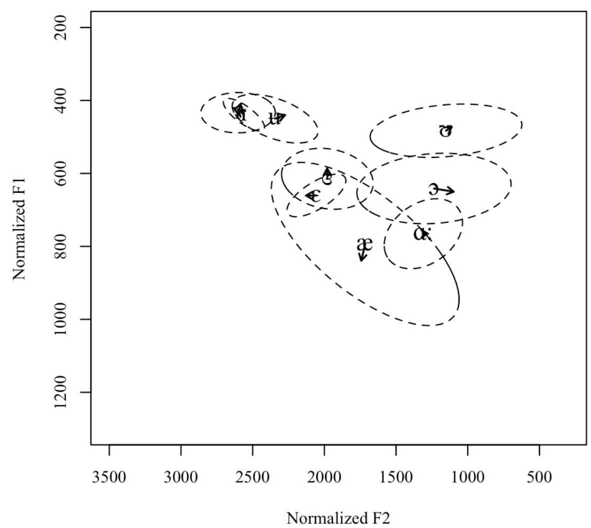
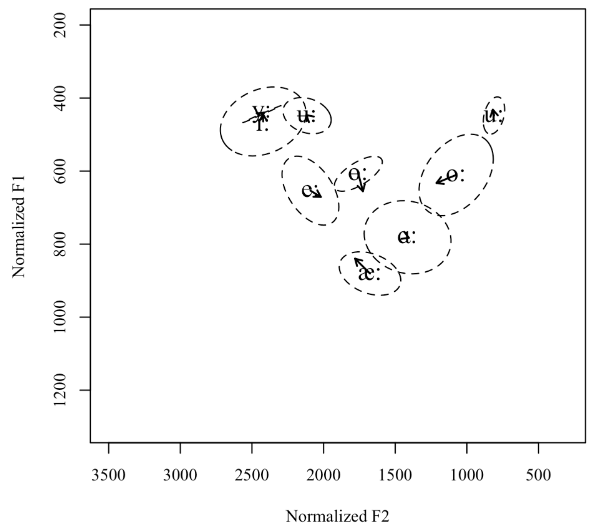


Trondheim1m Mean Short Vowels (Wordlist)



Oslo2k Mean Long Vowels (Conversation)



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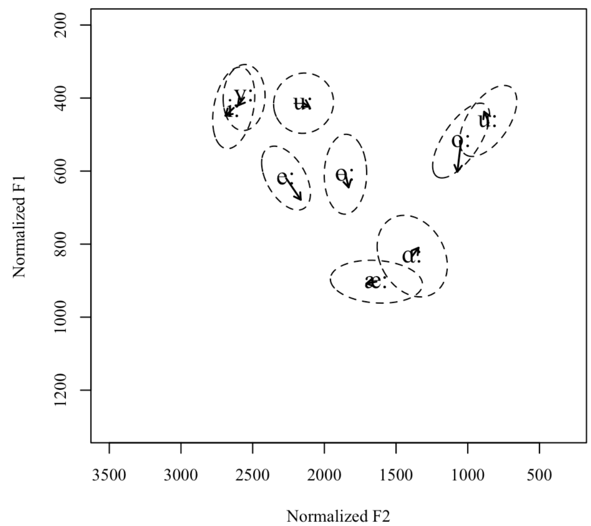
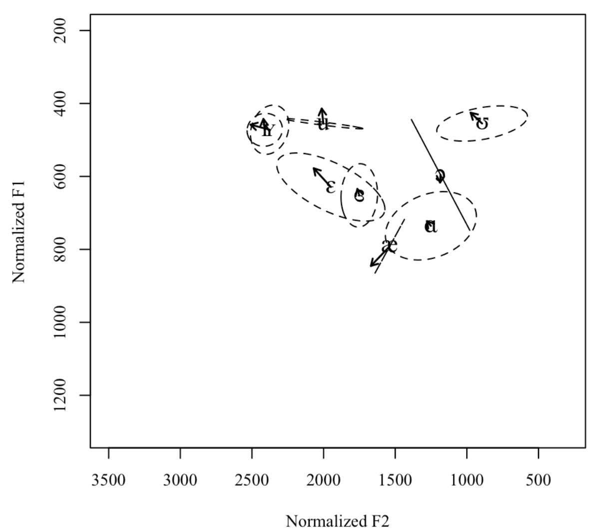
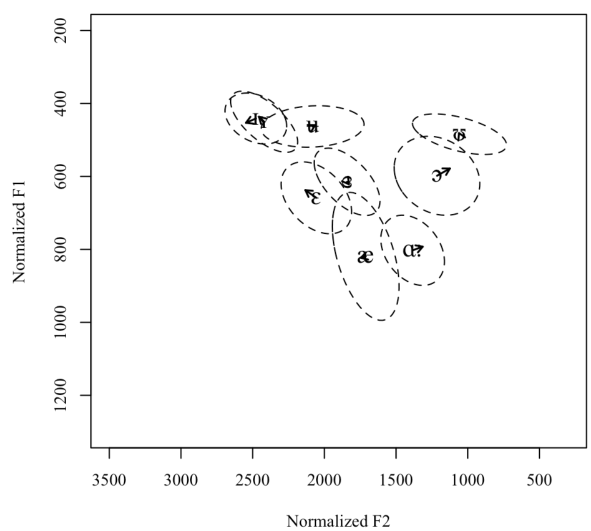
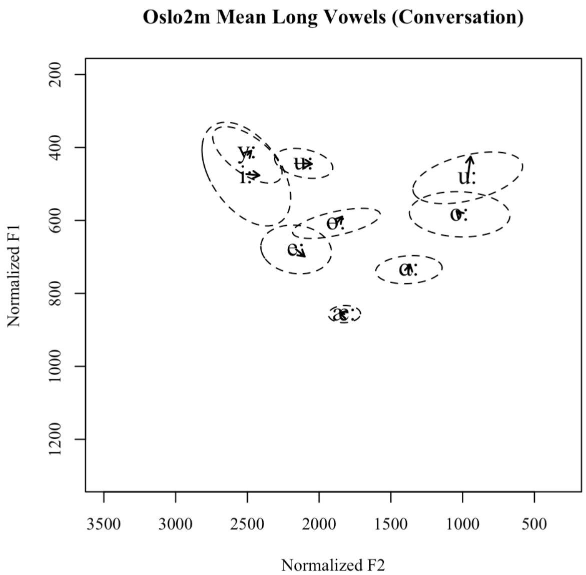


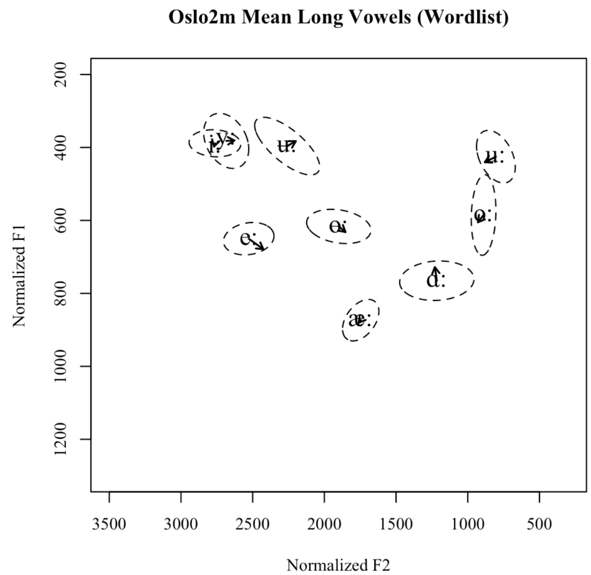
Oslo2k Mean Short Vowels (Conversation)

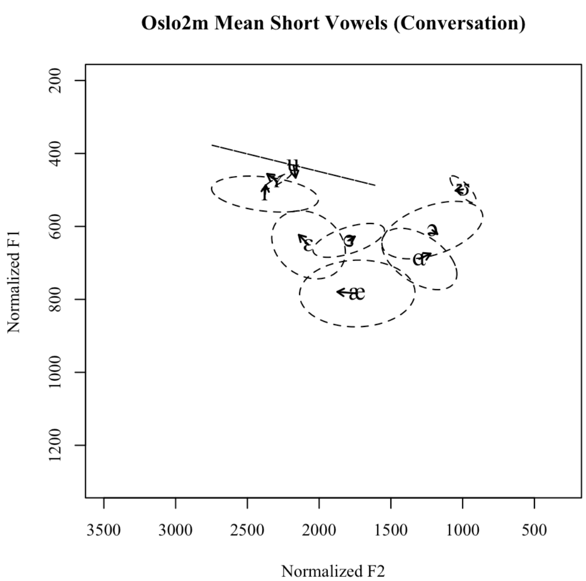


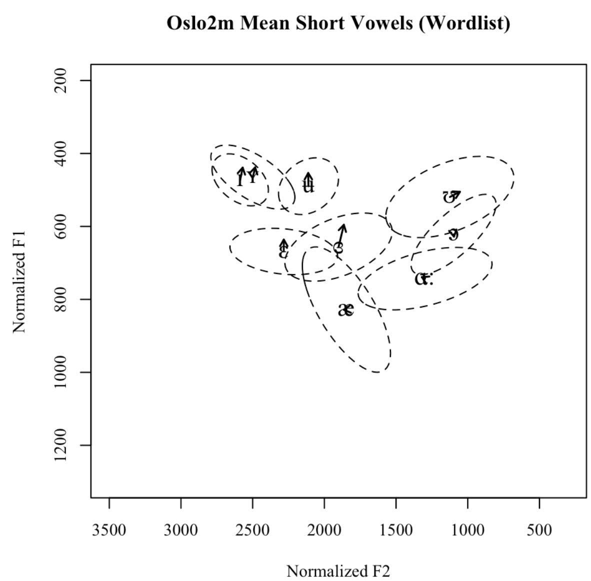
Oslo2k Mean Short Vowels (Wordlist)



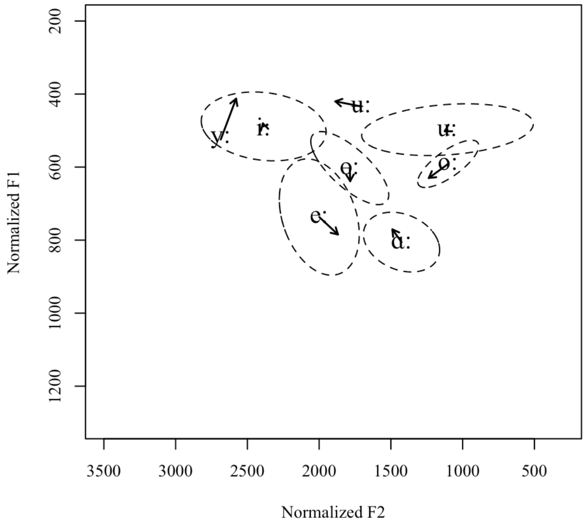

Oslo2m Mean Long Vowels (Conversation)
Normalized F1
Normalized F2


Oslo2m Mean Long Vowels (Wordlist)
Normalized F1
Normalized F2

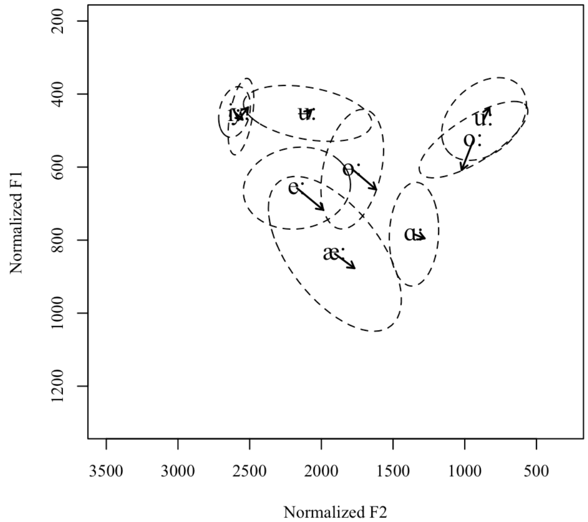

Oslo2m Mean Short Vowels (Conversation)
Normalized F1
Normalized F2


Oslo2m Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2

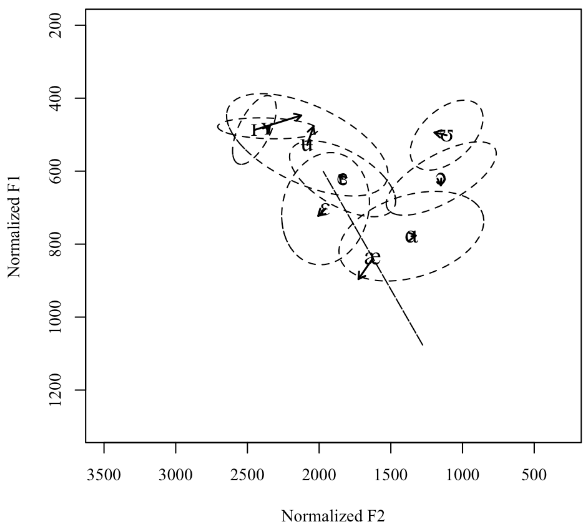
Oslo4k Mean Long Vowels (Conversation)



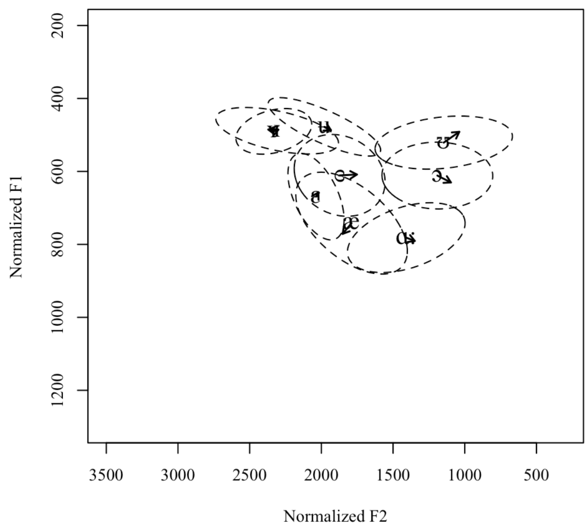
Oslo4k Mean Long Vowels (Wordlist)



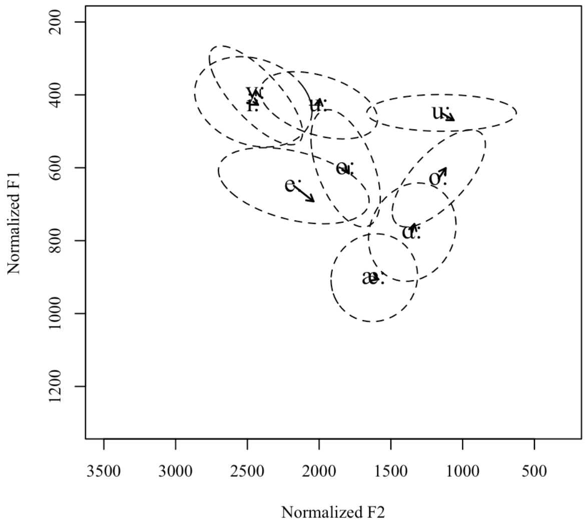
Oslo4k Mean Short Vowels (Conversation)



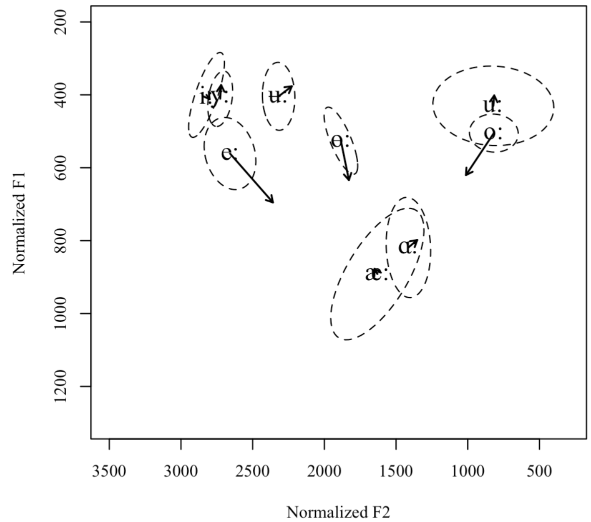
Oslo4k Mean Short Vowels (Wordlist)



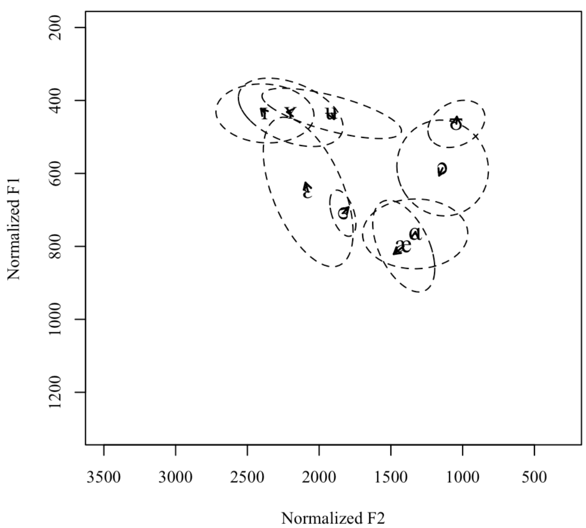
Oslo1k Mean Long Vowels (Conversation)



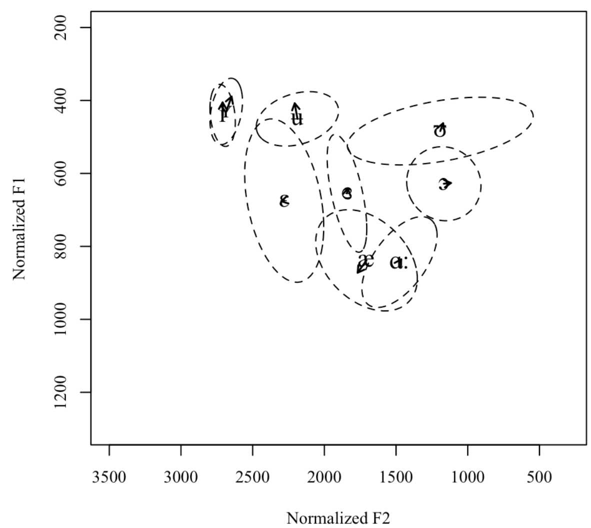
Oslo1k Mean Long Vowels (Wordlist)



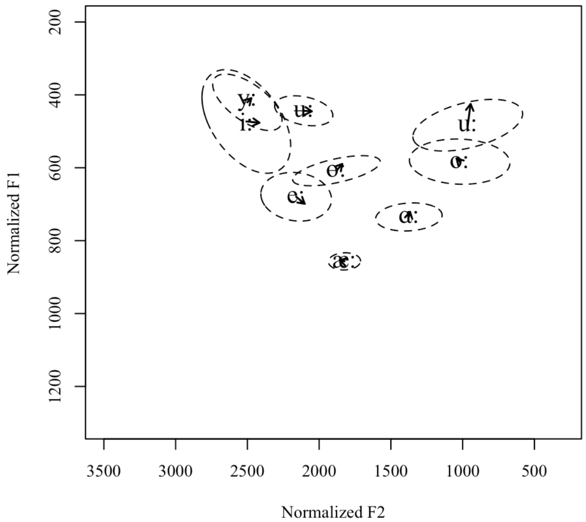
Oslo1k Mean Short Vowels (Conversation)



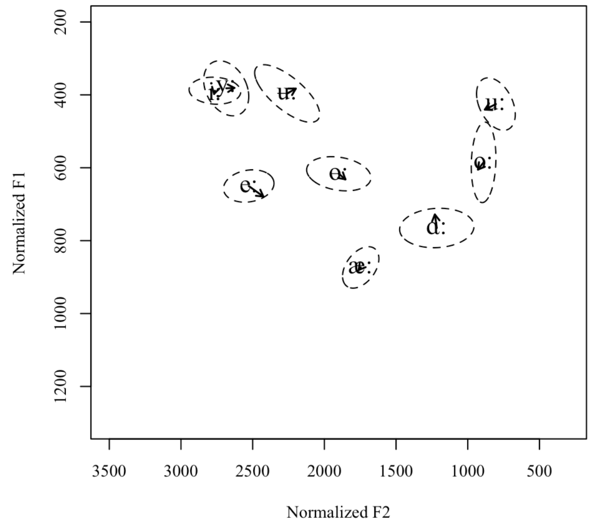
Oslo1k Mean Short Vowels (Wordlist)



Oslo2m Mean Long Vowels (Conversation)



Oslo2m Mean Long Vowels (Wordlist)



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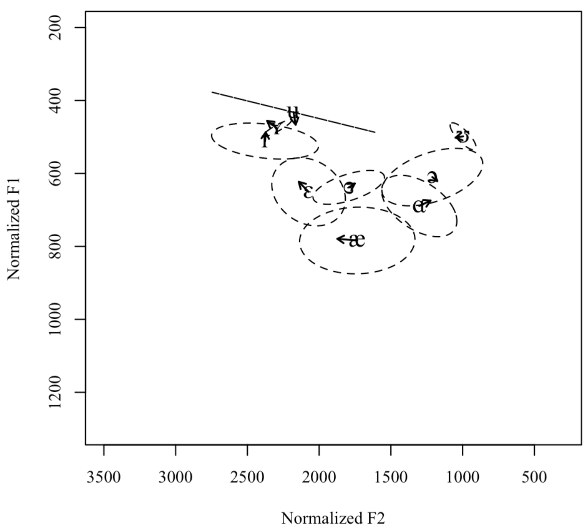
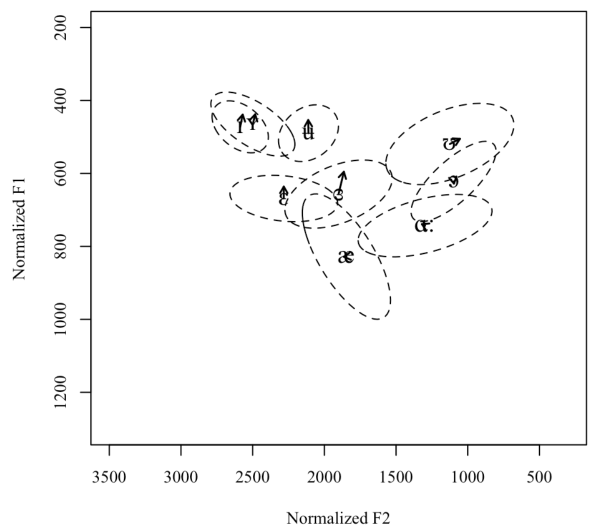
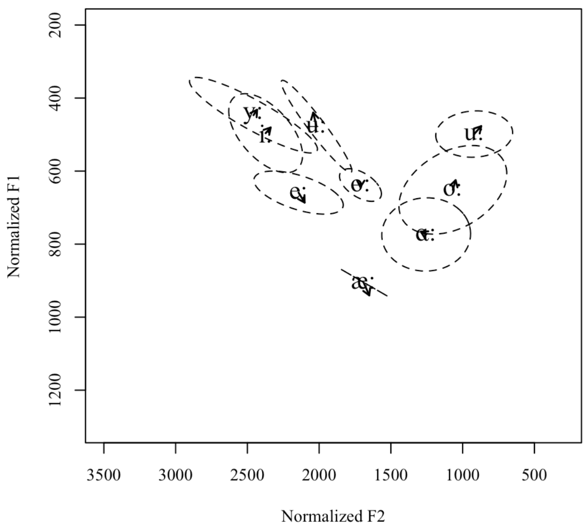


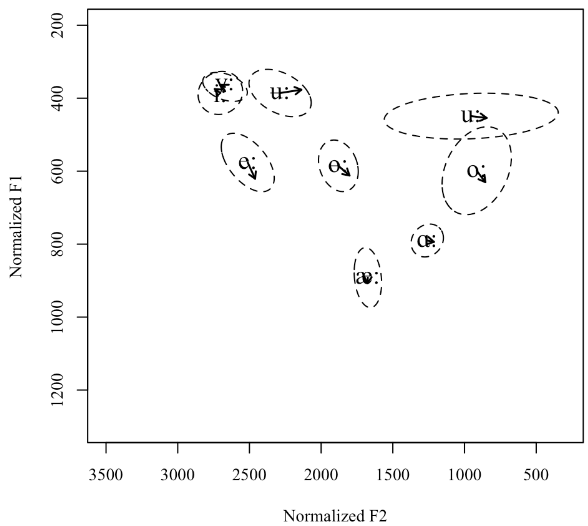
Oslo2m Mean Short Vowels (Wordlist)



Ås1m Mean Long Vowels (Conversation)



Ås1m Mean Long Vowels (Wordlist)



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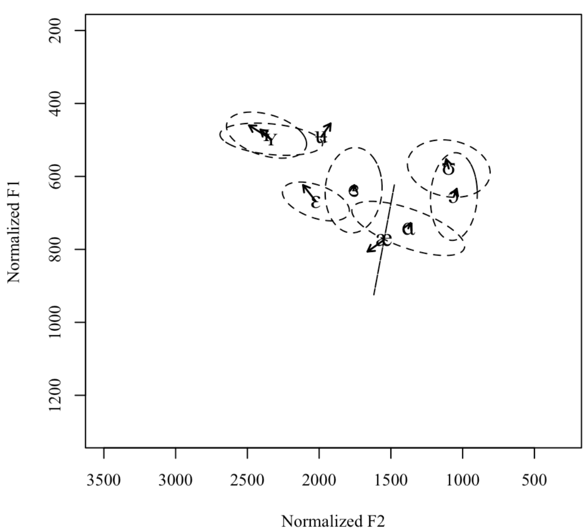
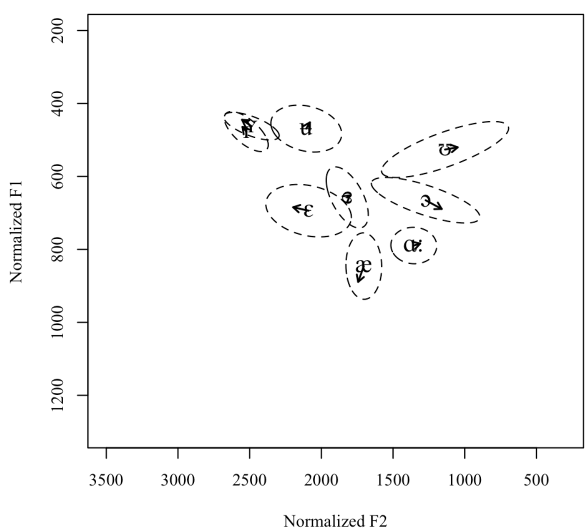
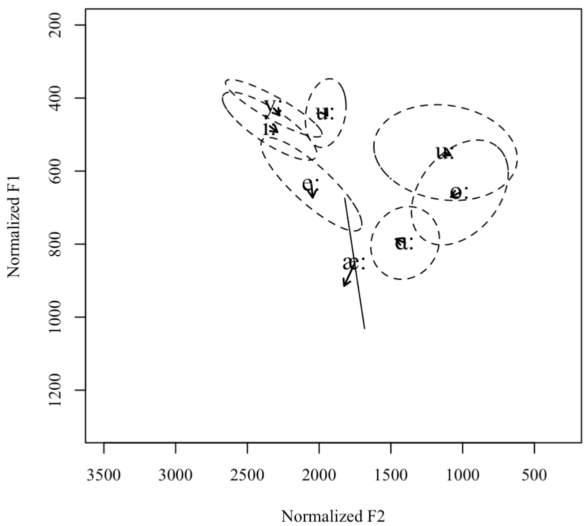


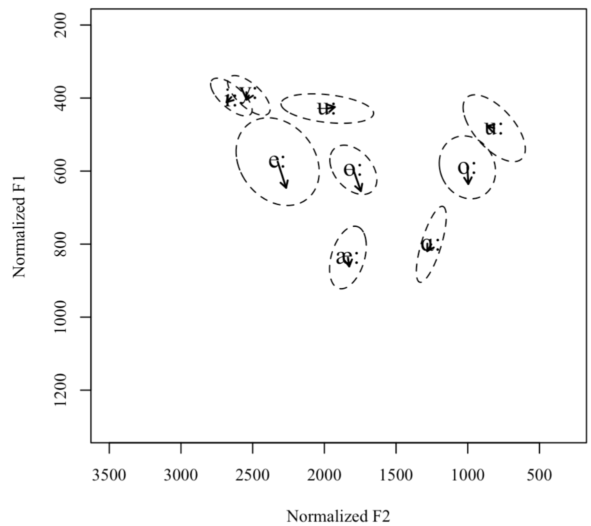
Ås1m Mean Short Vowels (Wordlist)



Ringebu1m Mean Long Vowels (Conversation)



Ringebu1m Mean Long Vowels (Wordlist)



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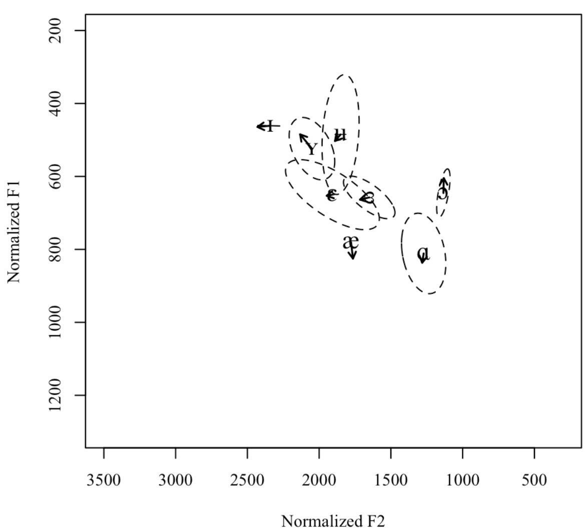
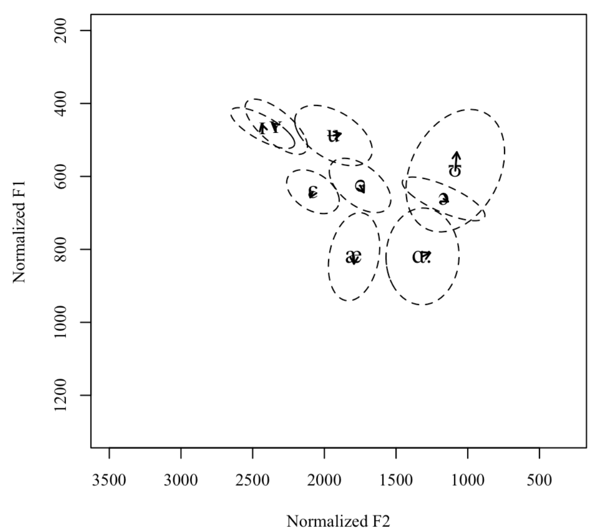
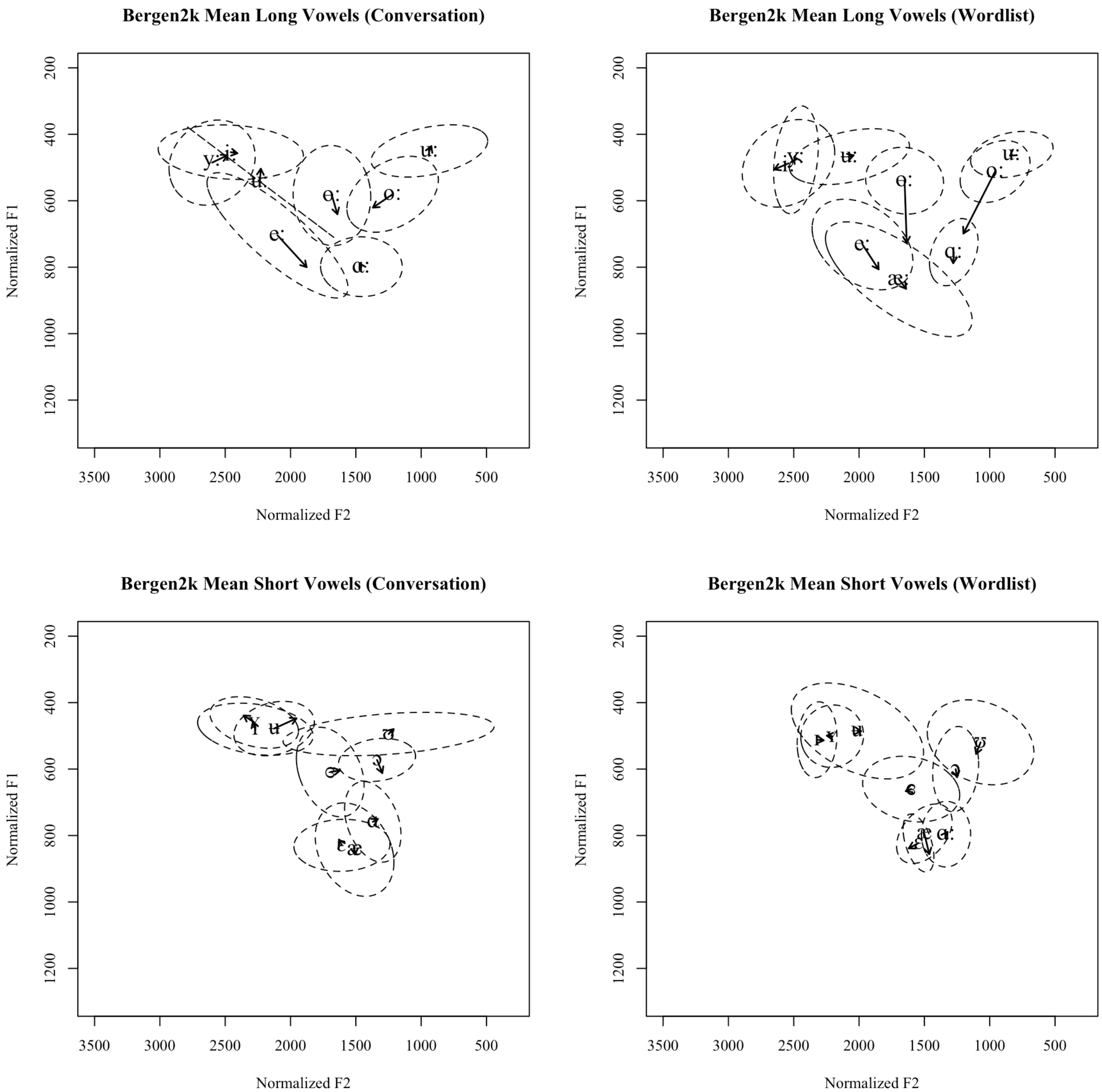


Ringebu1m Mean Short Vowels (Wordlist)




Bergen2k Mean Long Vowels (Conversation)
Bergen2k Mean Long Vowels (Wordlist)
Bergen2k Mean Short Vowels (Conversation)
Bergen2k Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2
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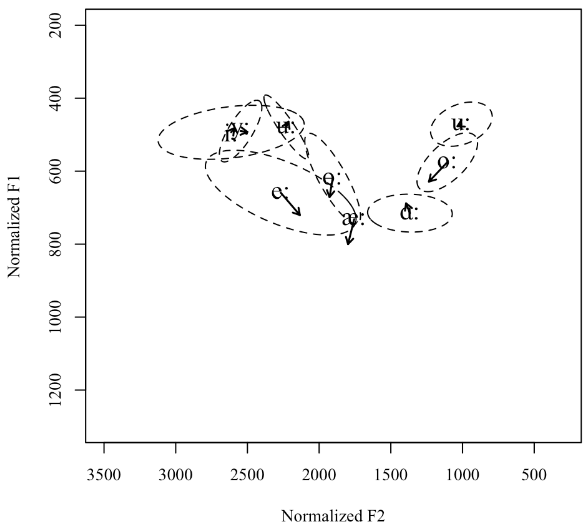
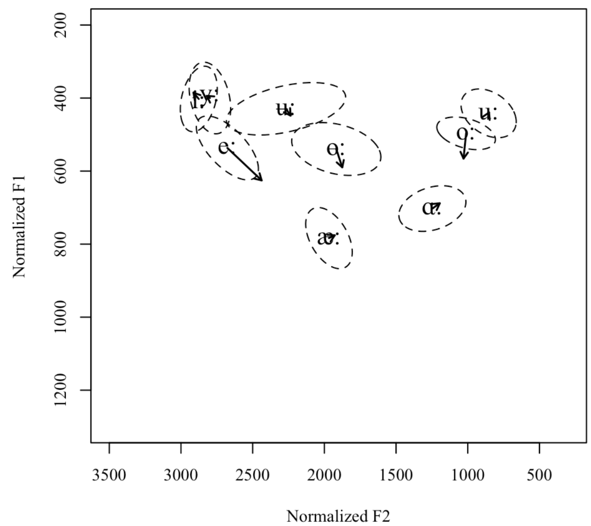
Bergen1k Mean Long Vowels (Conversation)



Bergen1k Mean Long Vowels (Wordlist)



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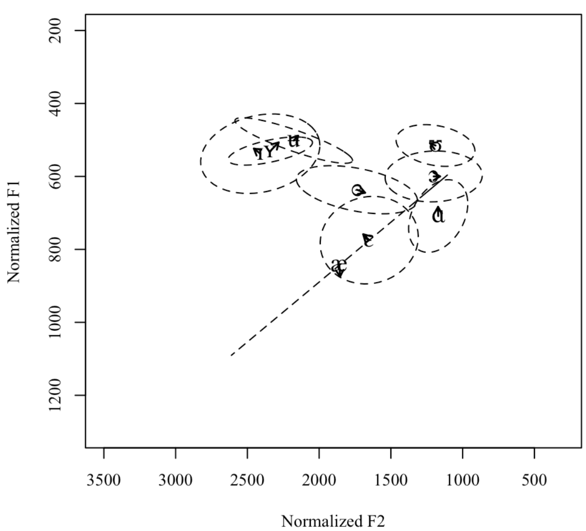
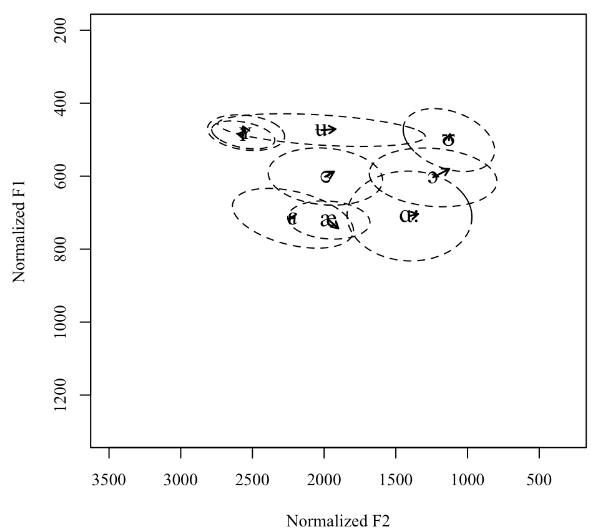


Bergen1k Mean Short Vowels (Wordlist)



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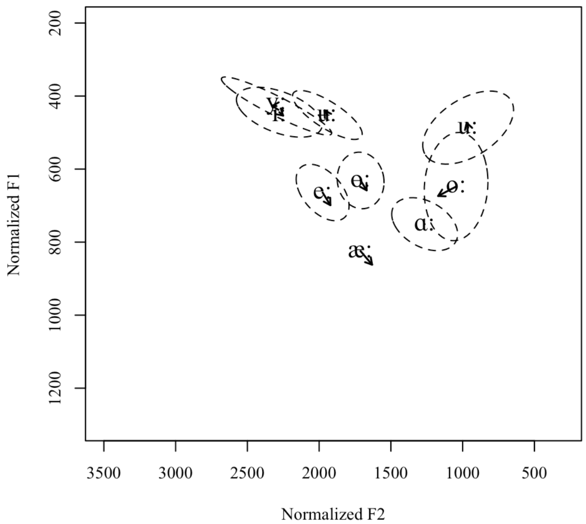
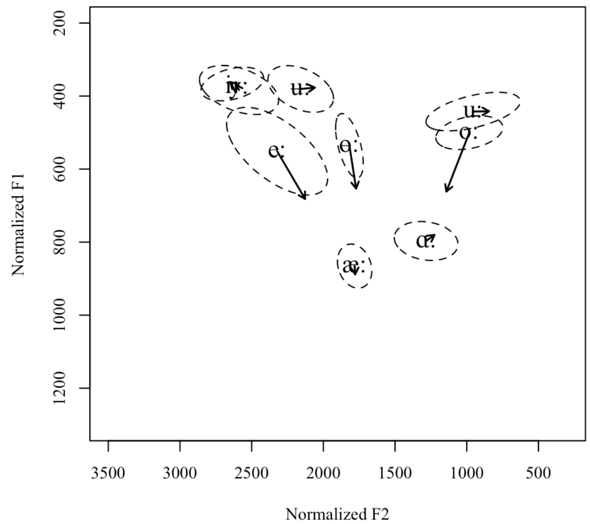


Bergen1m Mean Long Vowels (Wordlist)



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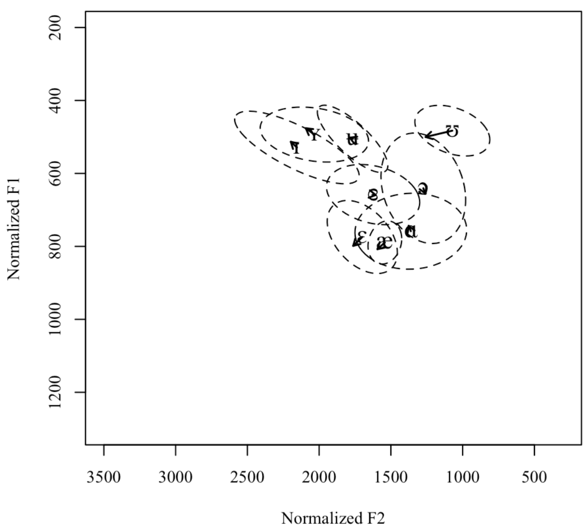
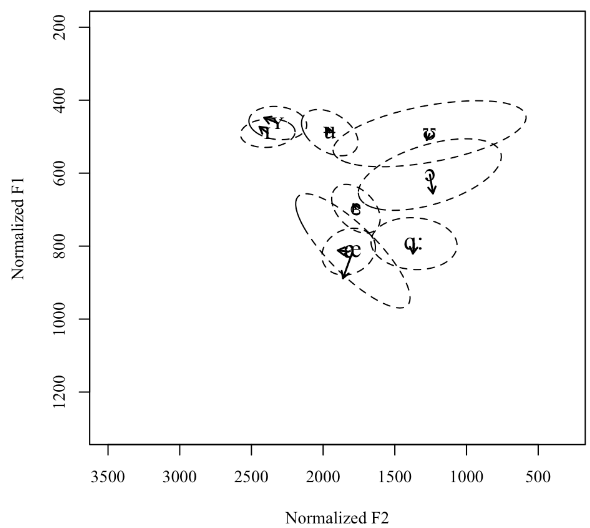
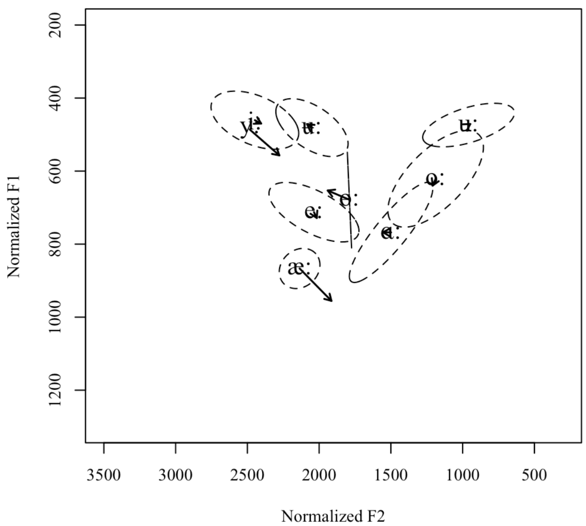


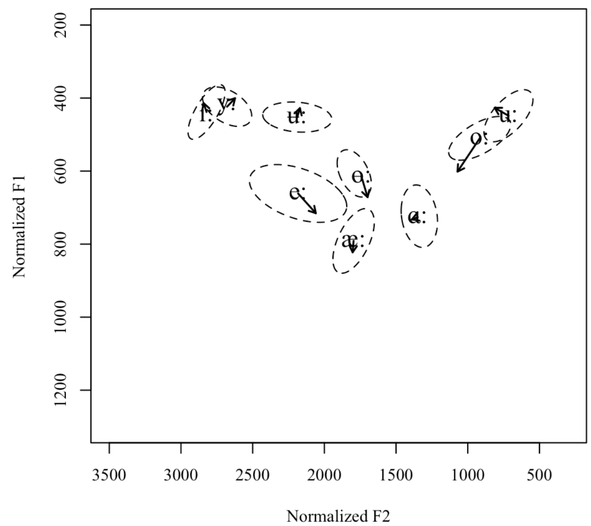
Bergen1m Mean Short Vowels (Wordlist)



Stavanger1k Mean Long Vowels (Conversation)



Stavanger1k Mean Long Vowels (Wordlist)



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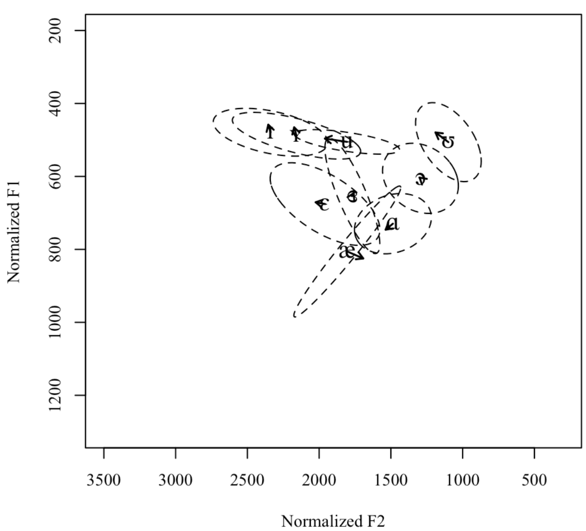
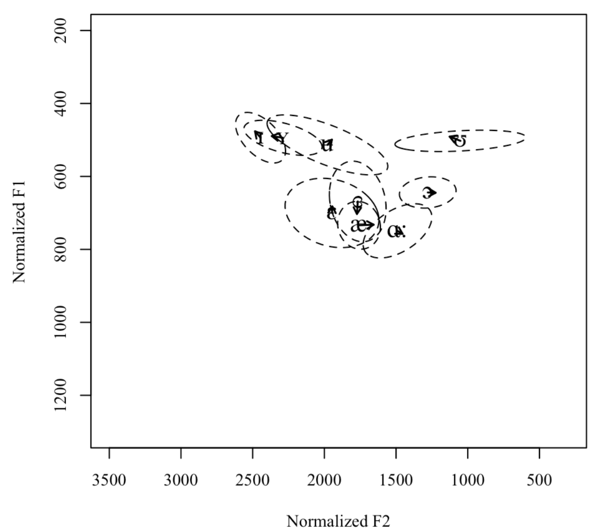


Stavanger1k Mean Short Vowels (Wordlist)



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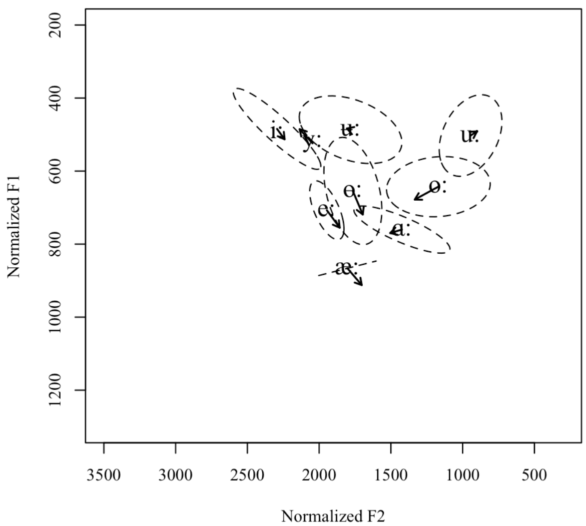
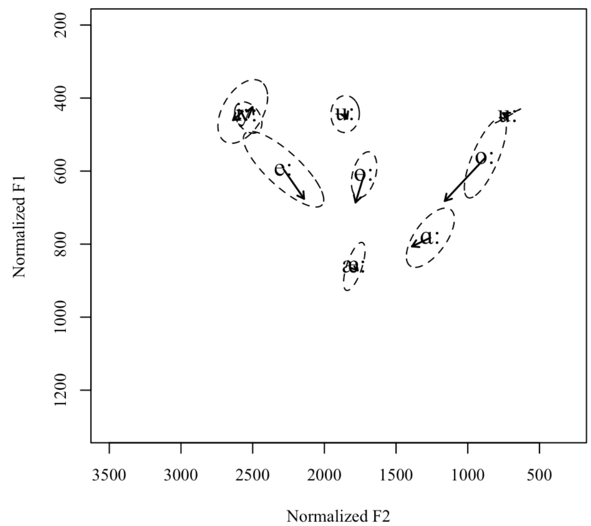


Stavanger2k Mean Long Vowels (Wordlist)



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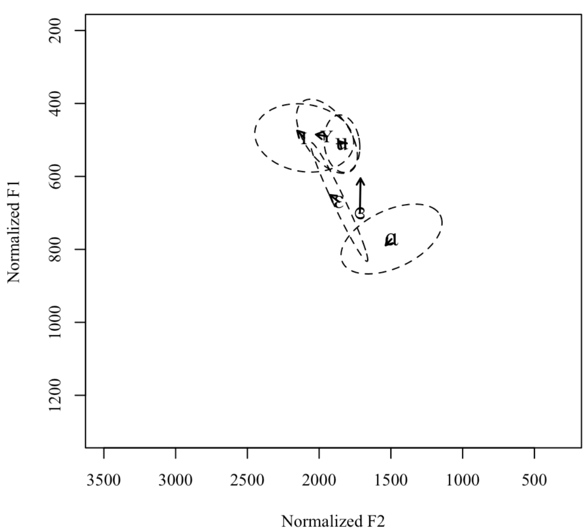
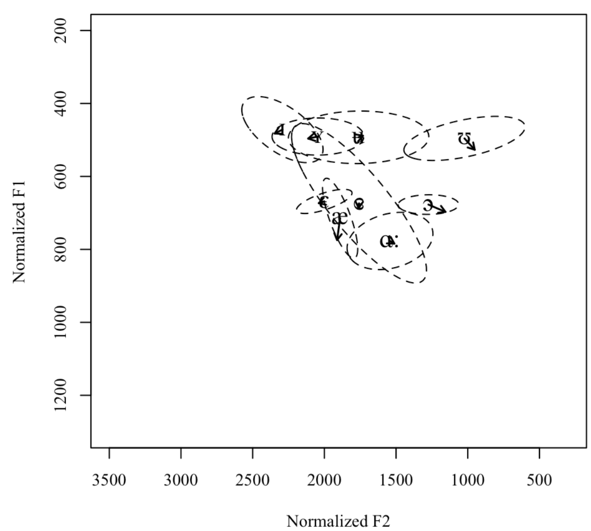
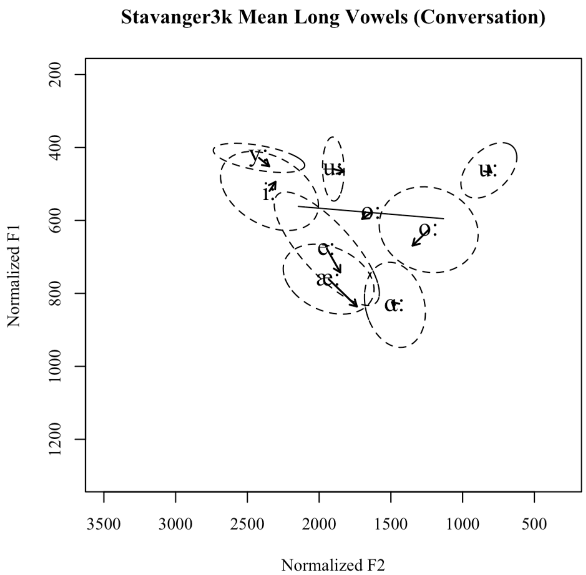


Stavanger2k Mean Short Vowels (Wordlist)




Stavanger3k Mean Long Vowels (Conversation)
Normalized F1
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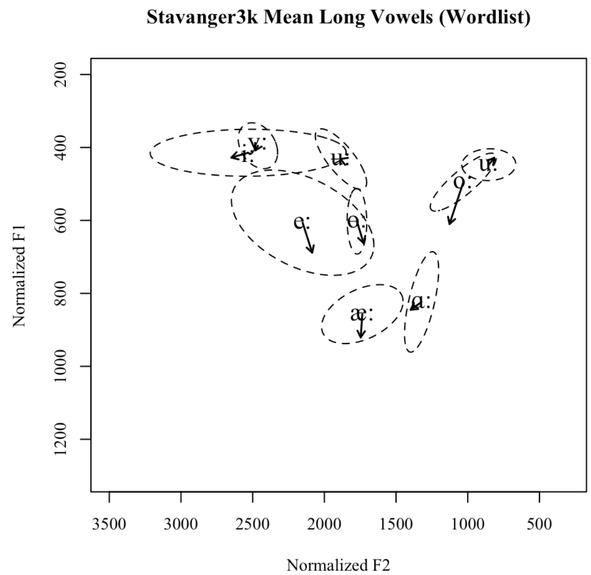
Stavanger3k Mean Long Vowels (Wordlist)
Normalized F1
Normalized F2
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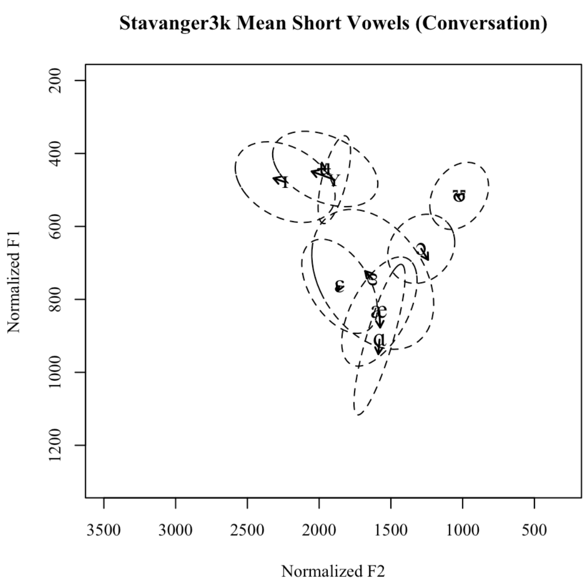
Stavanger3k Mean Short Vowels (Conversation)
Normalized F1
Normalized F2
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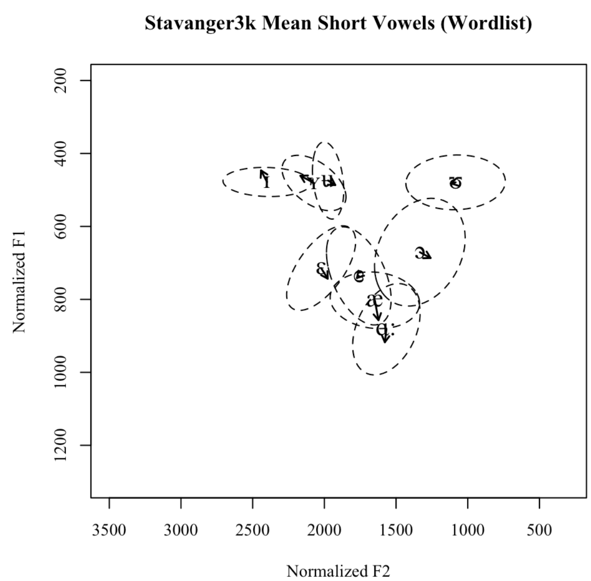
Stavanger3k Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2
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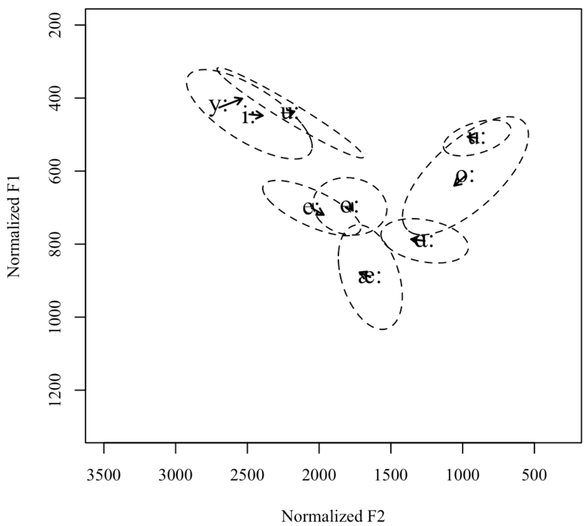
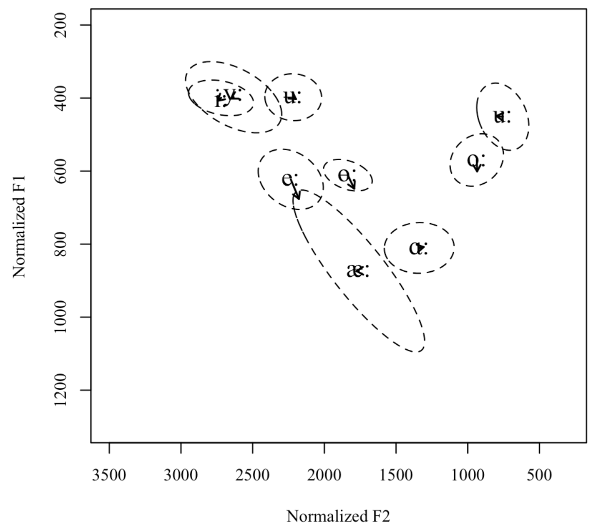
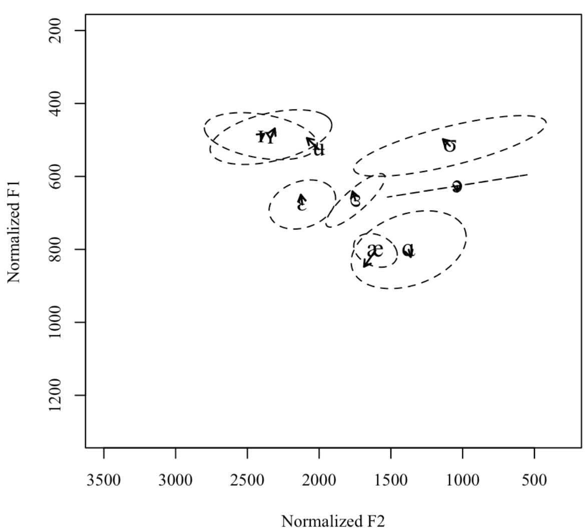
Haugesund1m Mean Long Vowels (Conversation)



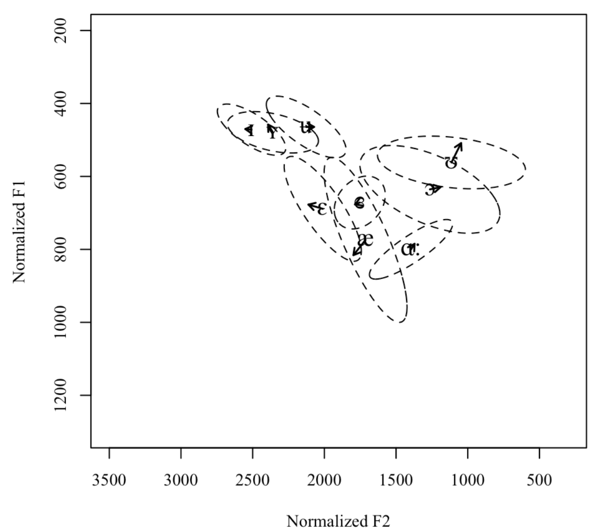
Haugesund1m Mean Long Vowels (Wordlist)

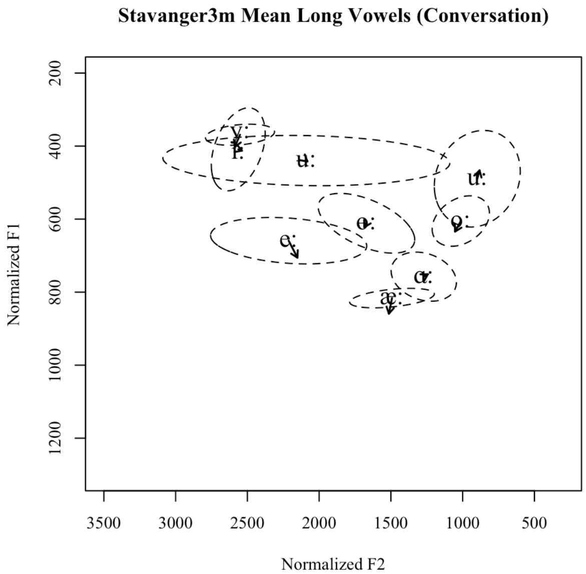


Haugesund1m Mean Short Vowels (Conversation)



Haugesund1m Mean Short Vowels (Wordlist)




Stavanger3m Mean Long Vowels (Conversation)
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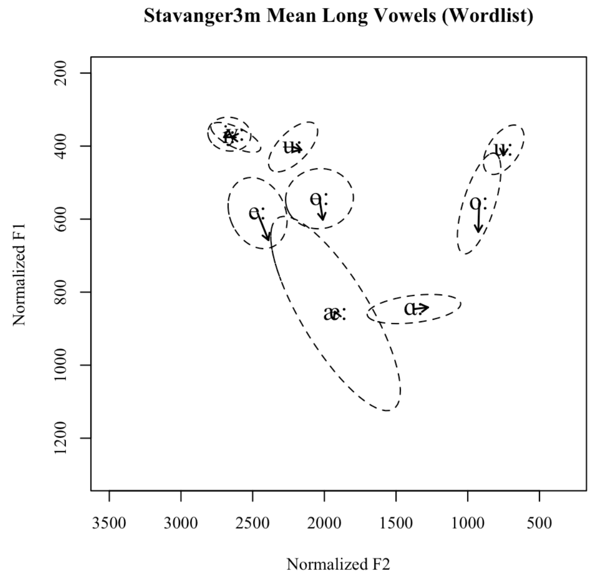
Stavanger3m Mean Long Vowels (Wordlist)
Normalized F1
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Normalized F2
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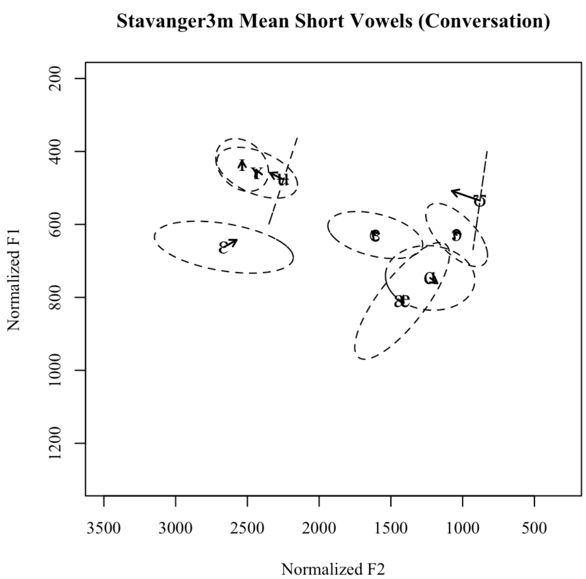
Stavanger3m Mean Short Vowels (Conversation)
Normalized F1
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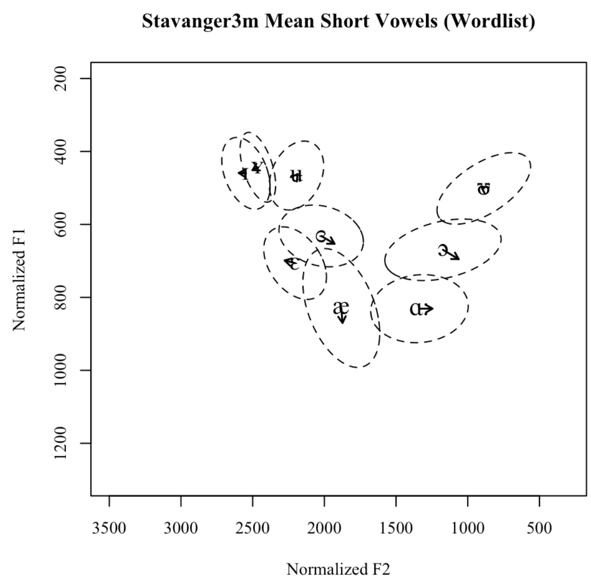
Stavanger3m Mean Short Vowels (Wordlist)
Normalized F1
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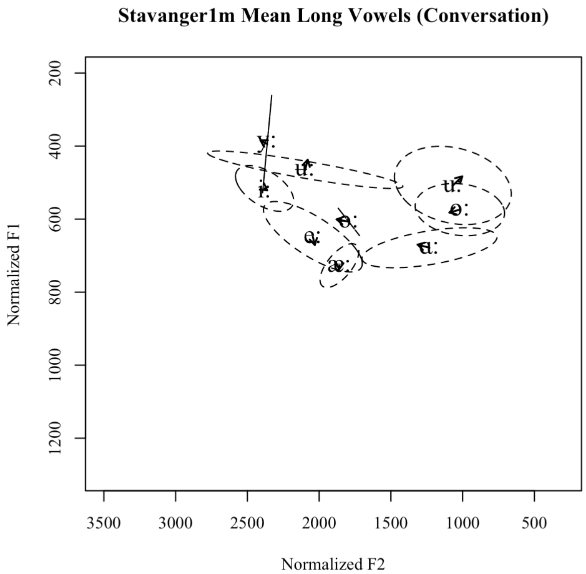
Stavanger1m Mean Long Vowels (Conversation)
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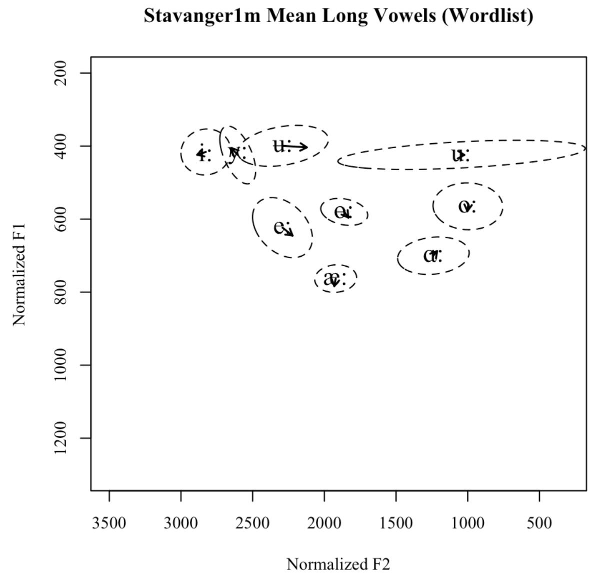
Normalized F2


Stavanger1m Mean Long Vowels (Wordlist)
Normalized F1
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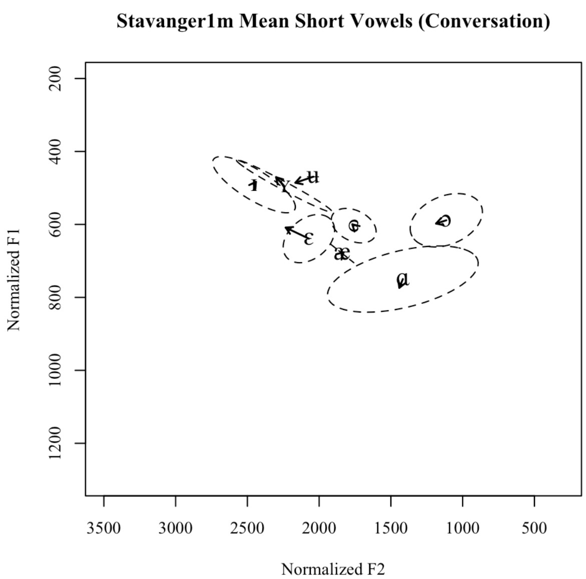
Normalized F2


Stavanger1m Mean Short Vowels (Conversation)
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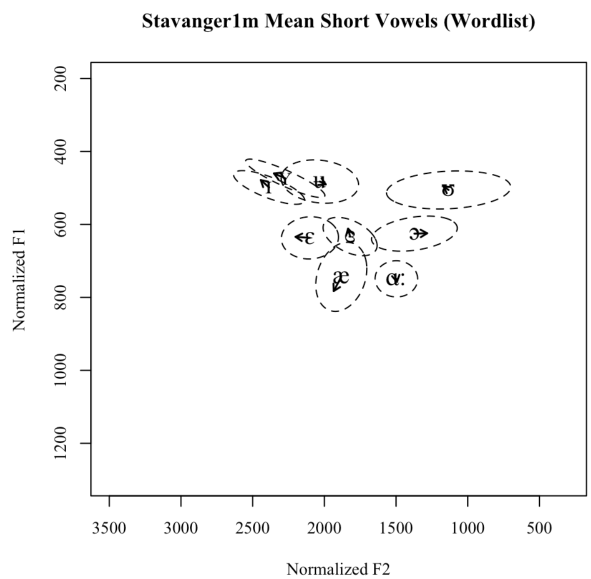
Normalized F2


Stavanger1m Mean Short Vowels (Wordlist)
Normalized F1
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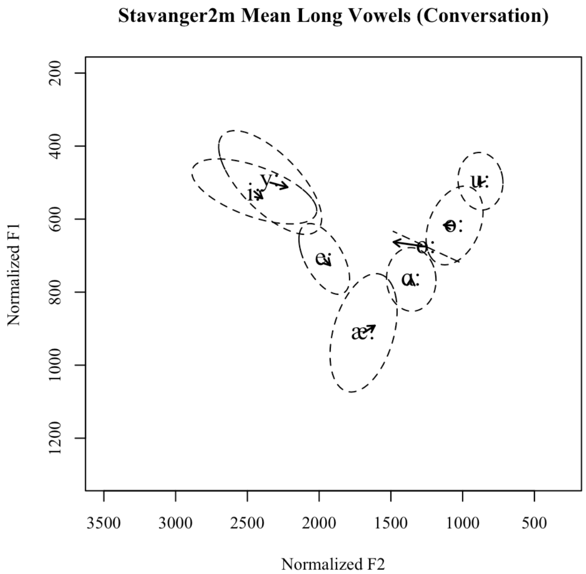
Normalized F2


Stavanger2m Mean Long Vowels (Conversation)
Normalized F1
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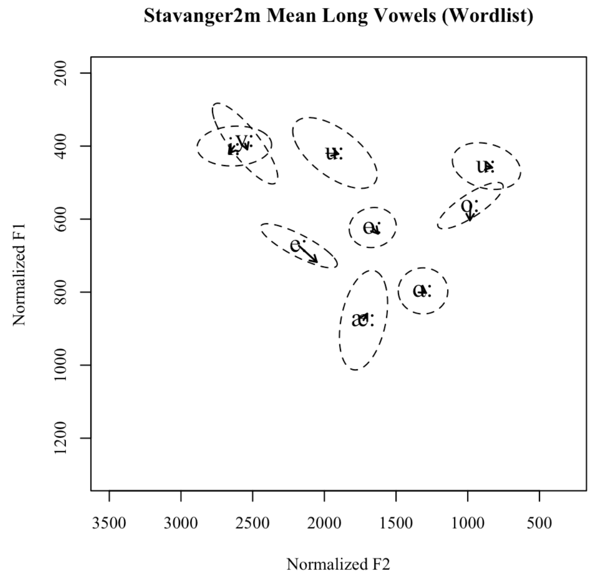
Normalized F2


Stavanger2m Mean Long Vowels (Wordlist)
Normalized F1
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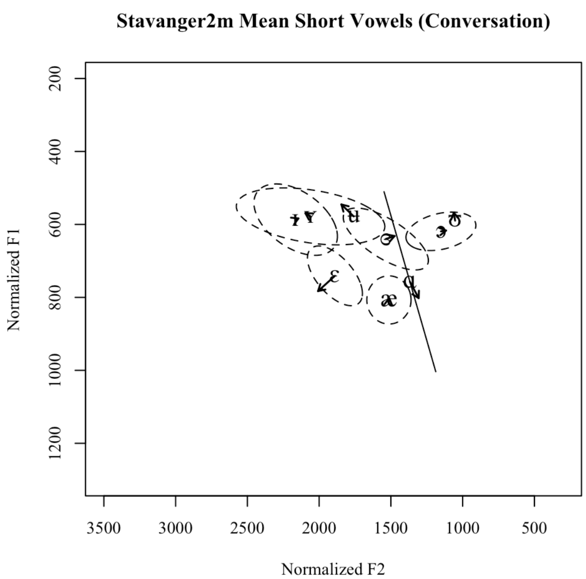
Normalized F2


Stavanger2m Mean Short Vowels (Conversation)
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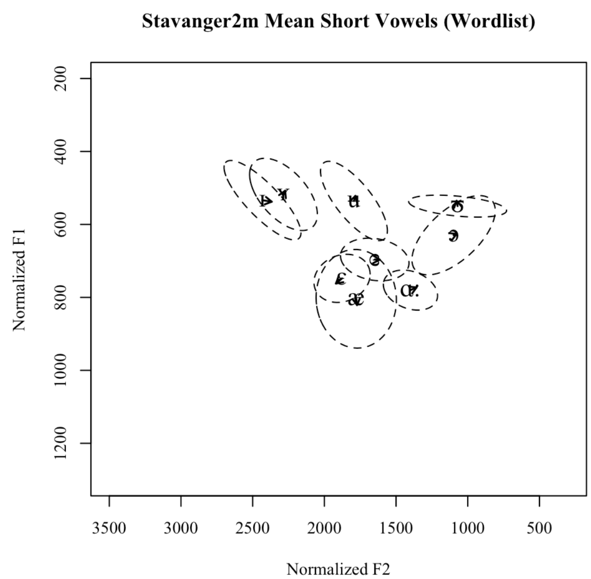
Normalized F2


Stavanger2m Mean Short Vowels (Wordlist)
Normalized F1
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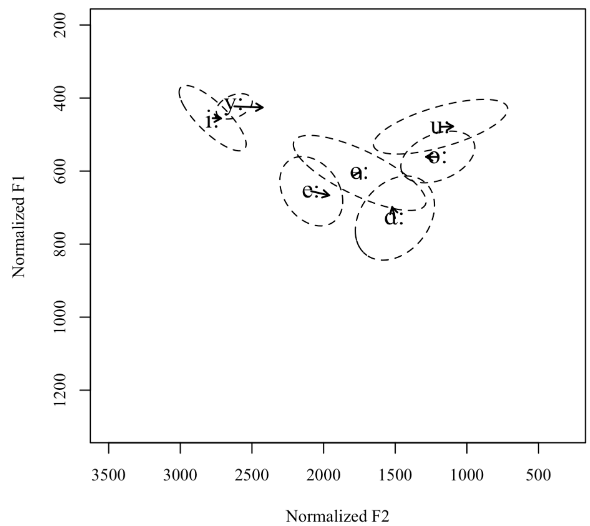
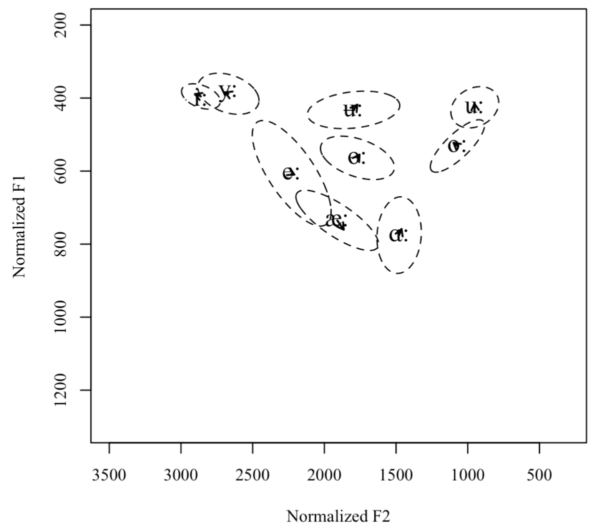
Normalized F2

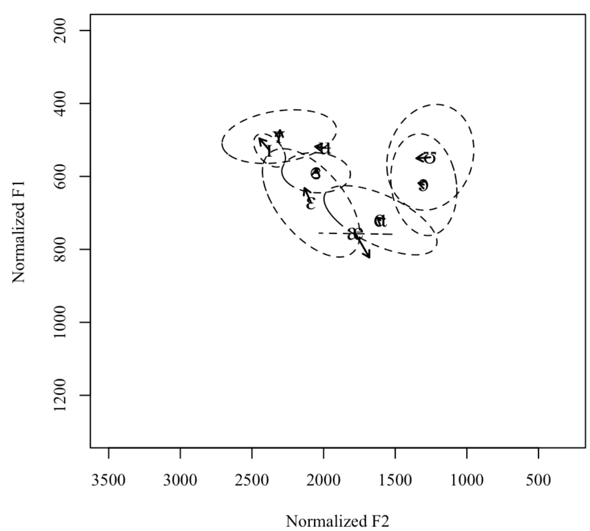
Flekkefjord1m Mean Long Vowels (Conversation)



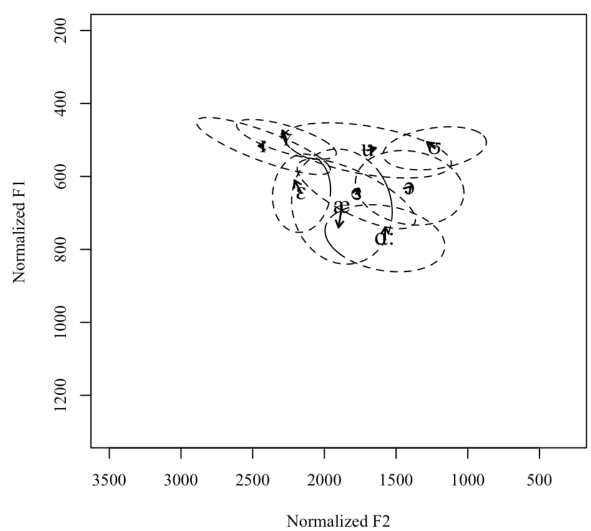
Flekkefjord1m Mean Long Vowels (Wordlist)

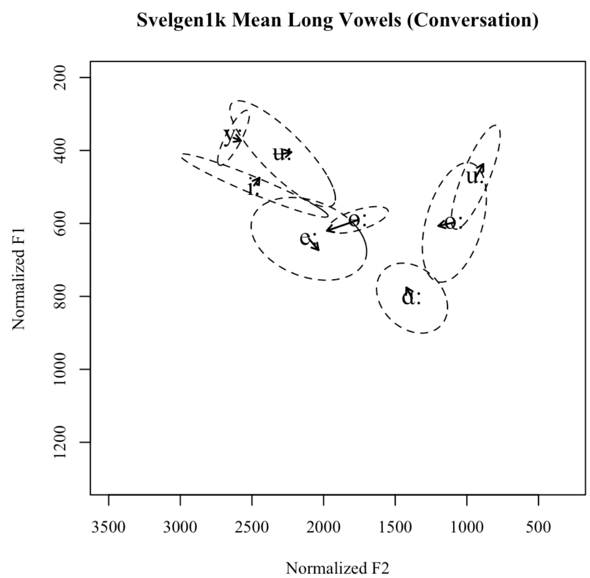


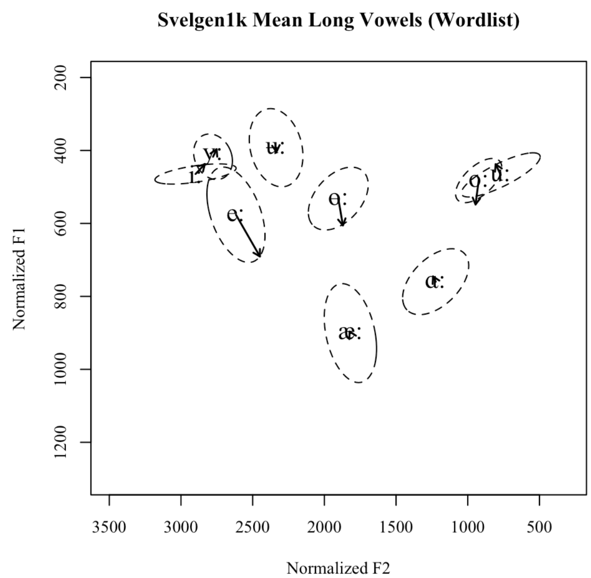
Flekkefjord1m Mean Short Vowels (Conversation)

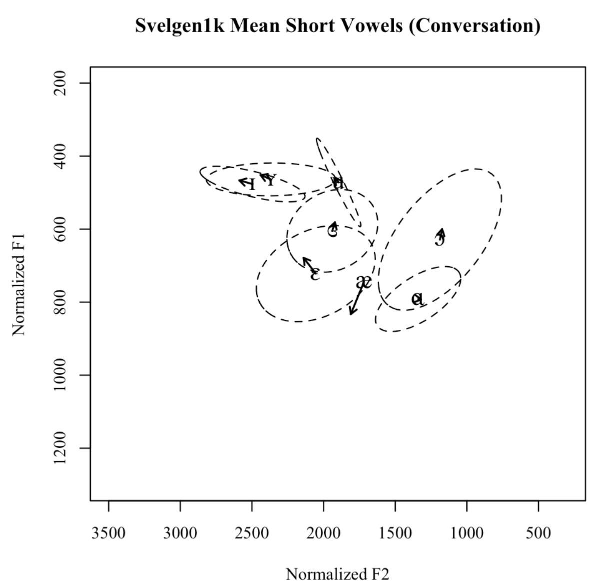


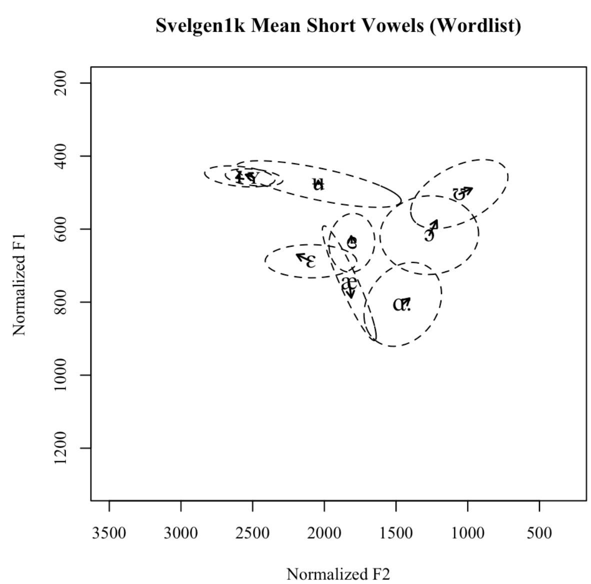
Flekkefjord1m Mean Short Vowels (Wordlist)

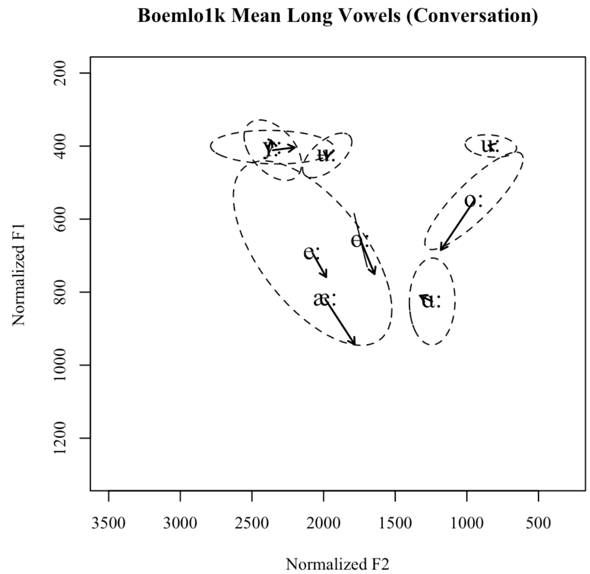


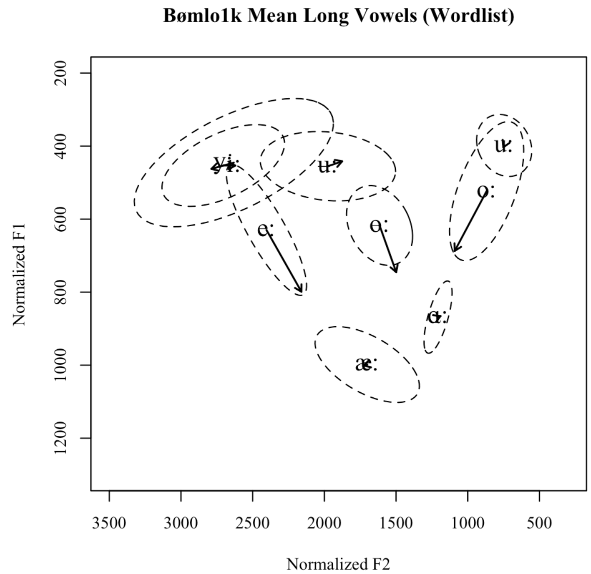

Svelgen1k Mean Long Vowels (Conversation)
Normalized F1
Normalized F2

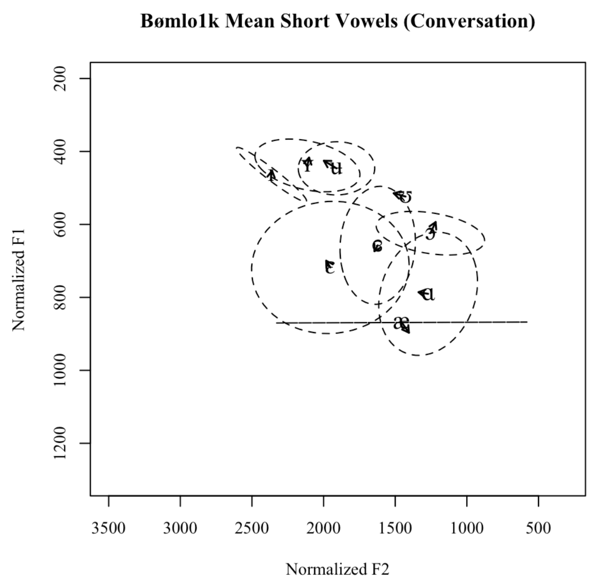

Svelgen1k Mean Long Vowels (Wordlist)
Normalized F1
Normalized F2

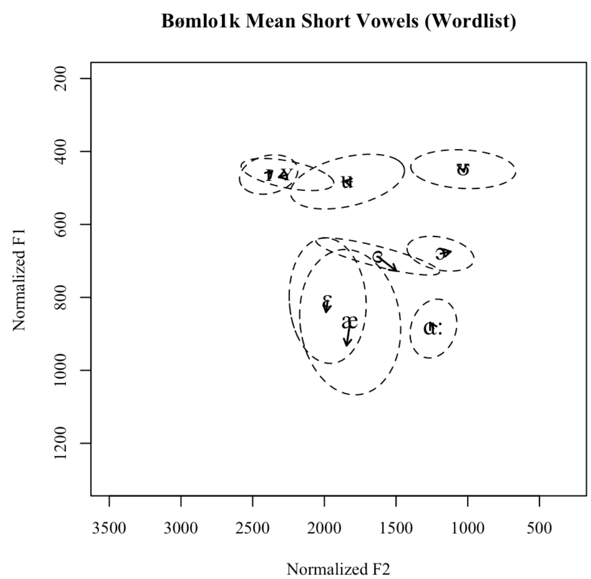

Svelgen1k Mean Short Vowels (Conversation)
Normalized F1
Normalized F2


Svelgen1k Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2

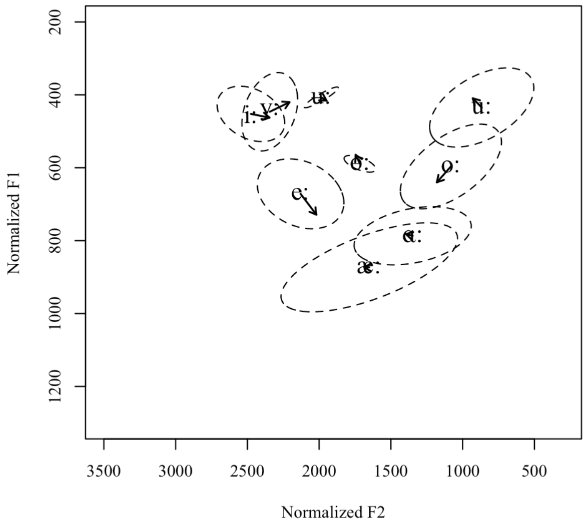

Boemlo1k Mean Long Vowels (Conversation)
Normalized F1
Normalized F2


Bømlo1k Mean Long Vowels (Wordlist)
Normalized F1
Normalized F2

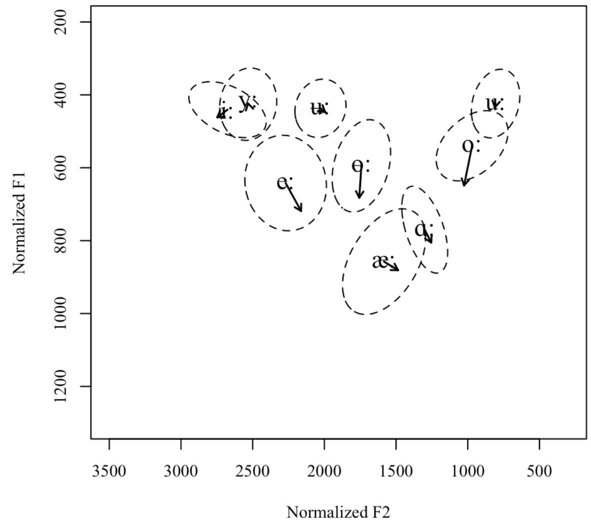

Bømlo1k Mean Short Vowels (Conversation)
Normalized F1
Normalized F2


Bømlo1k Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2

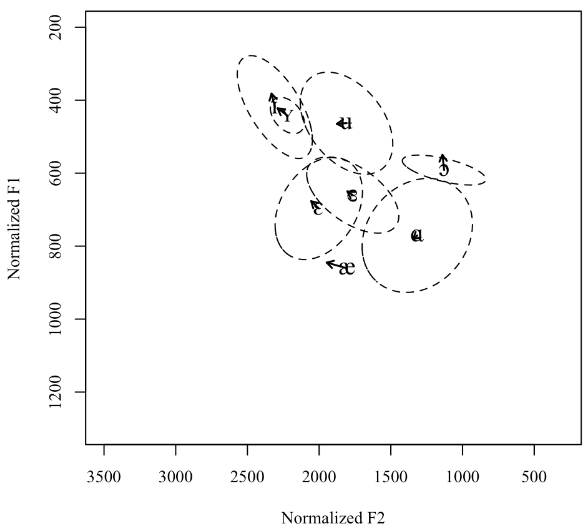
Sogndal1k Mean Long Vowels (Conversation)



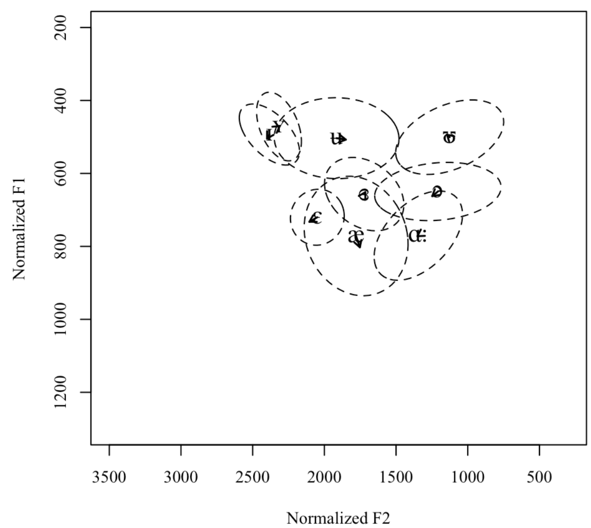
Sogndal1k Mean Long Vowels (Wordlist)



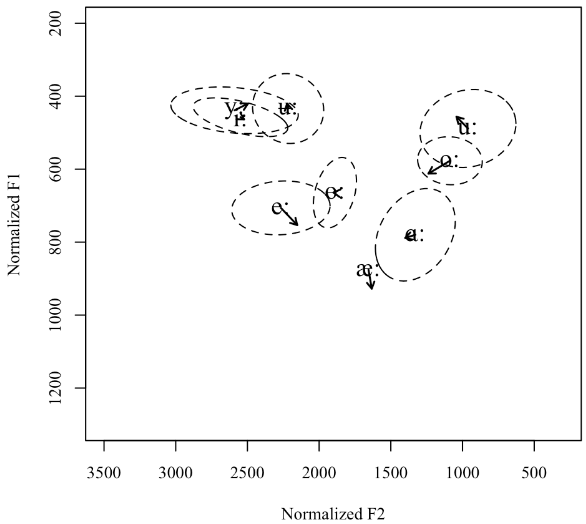
Sogndal1k Mean Short Vowels (Conversation)



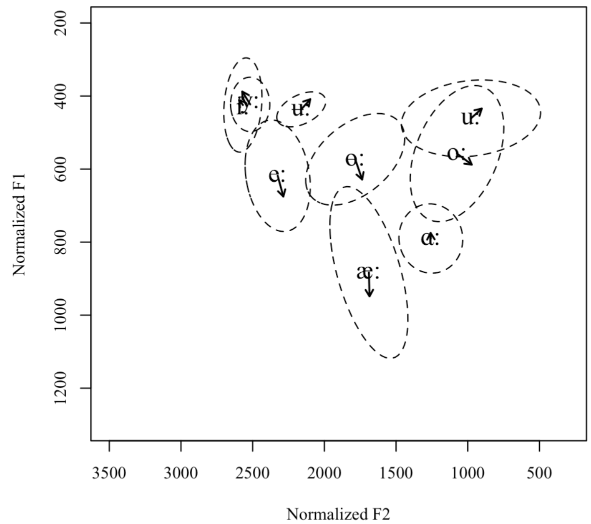
Sogndal1k Mean Short Vowels (Wordlist)



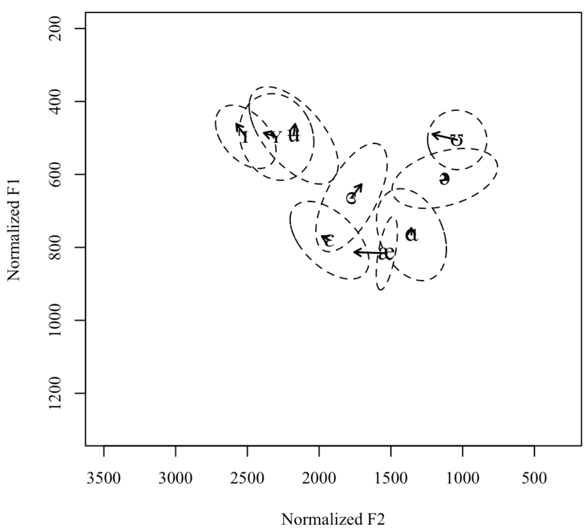
Volda1k Mean Long Vowels (Conversation)



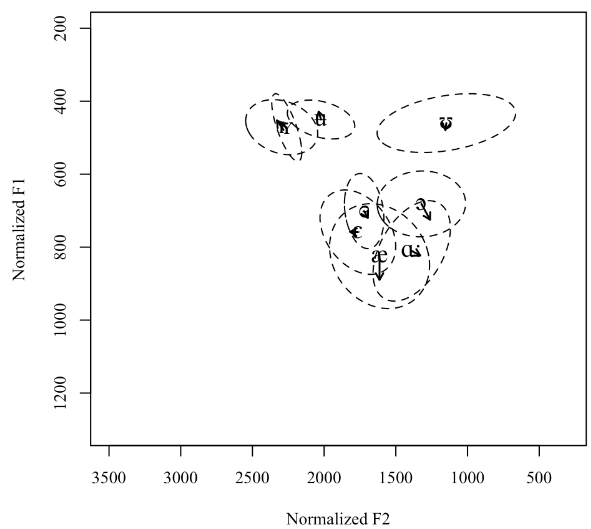
Volda1k Mean Long Vowels (Wordlist)

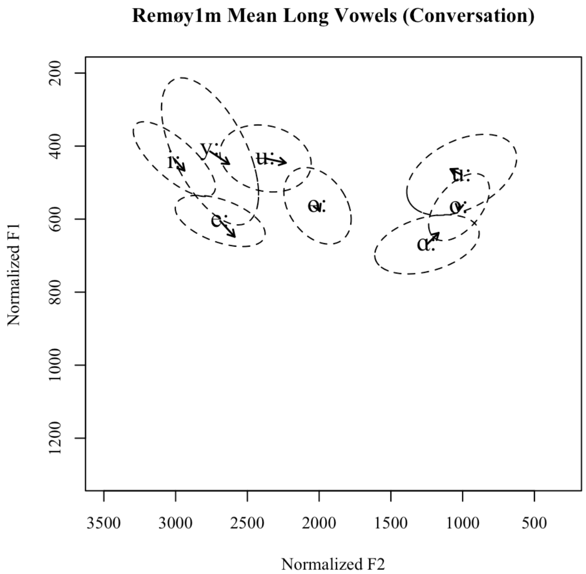


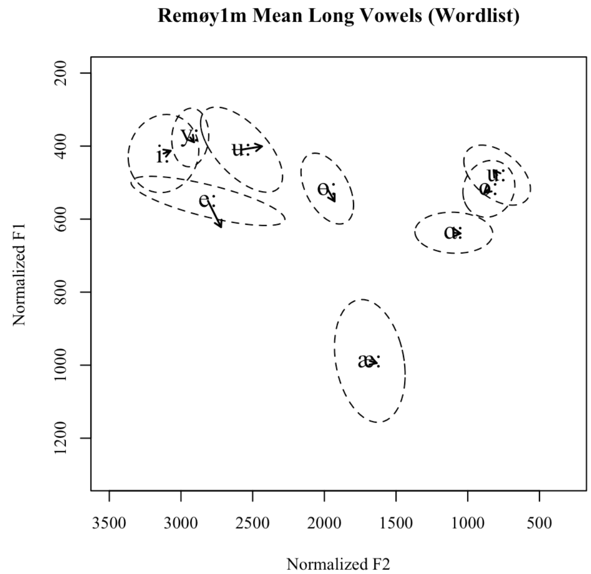
Volda1k Mean Short Vowels (Conversation)

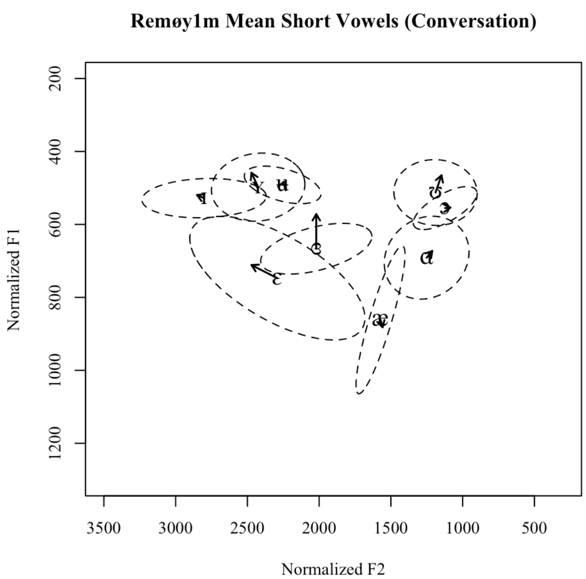


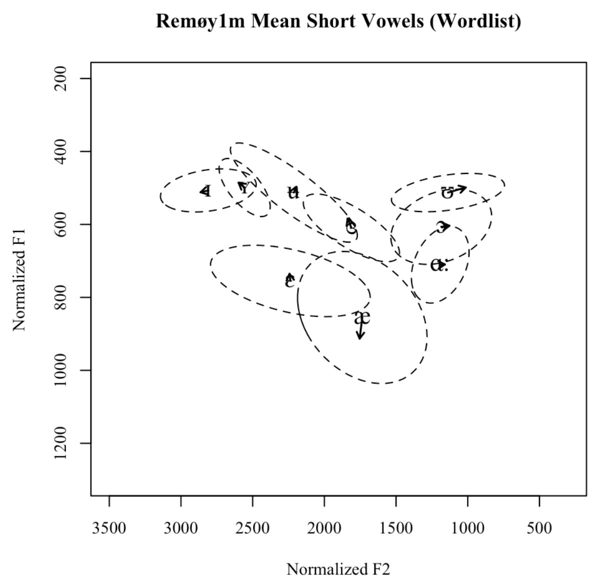
Volda1k Mean Short Vowels (Wordlist)



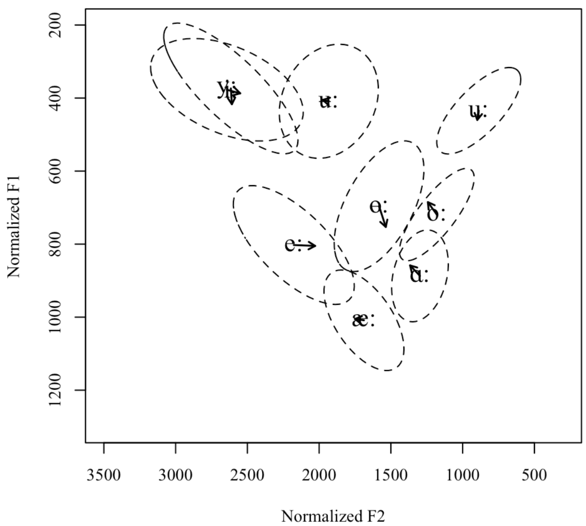

Remøy1m Mean Long Vowels (Conversation)
Normalized F1
Normalized F2


Remøy1m Mean Long Vowels (Wordlist)
Normalized F1
Normalized F2

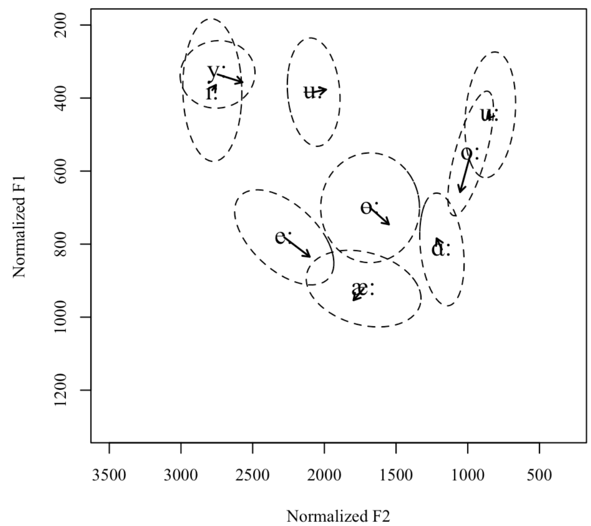

Remøy1m Mean Short Vowels (Conversation)
Normalized F1
Normalized F2


Remøy1m Mean Short Vowels (Wordlist)
Normalized F1
Normalized F2

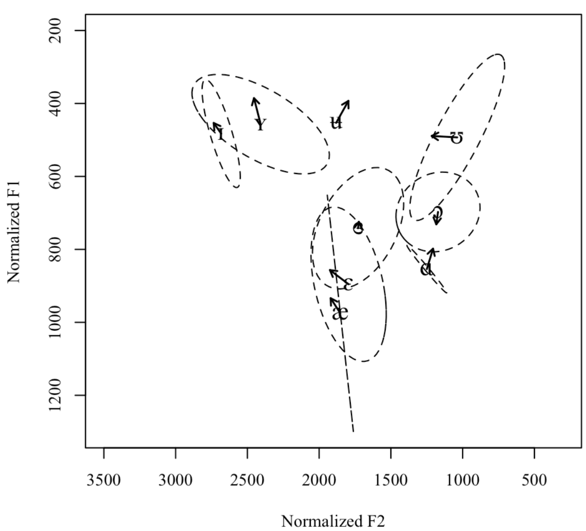
Tromsø1k Mean Long Vowels (Conversation)



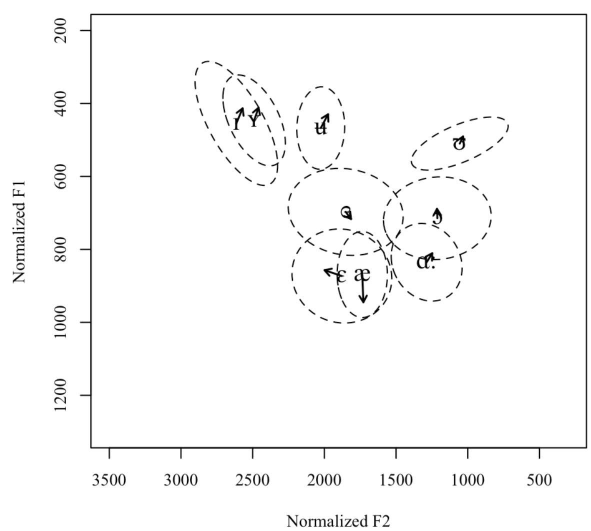
Tromsø1k Mean Long Vowels (Wordlist)



Tromsø1k Mean Short Vowels (Conversation)



Tromsø1k Mean Short Vowels (Wordlist)



Appendix 3: Descriptive statistics for each vowel by region, gender, and style

[ɑ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	751.5 753.8 57.25	759.2 749.5 78.94	1312 1346 176.1	1311 1325 167.1	-0.056 -0.315 2.688	-1.100 -0.980 4.441	66
East W WL	779.6 785.0 74.17	785.2 776.5 86.67	1360 1375 185.7	1315.9 1321.1 165.5	-0.567 -0.344 3.309	-1.327 -2.886 5.001	72
East M Con	680.3 687.0 31.97	658.1 661.1 33.88	1182 1211 146.98	1147 1164 133.3	-1.363 -1.217 1.018	-1.600 -2.267 2.355	15
East M WL	756.3 754.3 45.71	753.4 752.2 50.76	1292 1304 186.3	1266 1299 190.7	-0.199 0.101 1.726	0.202 -0.643 3.090	20
West W Con	755.6 762.4 66.65	751.3 754.4 88.59	1277 1305 154.5	1283 1306 163.0	-0.344 -0.428 2.952	-0.876 -0.147 4.254	69
West W WL	804.0 796.1 76.39	792.5 791.2 83.61	1330 1359 152.7	1309 1335 113.5	-0.239 -0.211 2.982	-1.513 -1.296 4.915	59
West M Con	702.5 721.1 63.62	686.3 704.3 81.79	1258 1300 175.8	1219 1285 161.0	-0.911 -0.952 2.917	0.189 -0.571 4.030	27
West M WL	757.1 751.8 60.93	755.0 765.1 73.74	1253 1279 153.1	1221 1267 163.8	0.294 0.577 1.783	-0.761 -0.637 3.240	20
Southwest W Con	760.6 783.7 87.12	781.1 805.0 95.94	1549 1508 148.0	1573 1546 78.73	1.364 1.239 3.254	2.263 2.334 8.087	26
Southwest W WL	794.6 805.5 76.61	825.2 823.6 98.88	1497 1532 127.0	1518 1515 129.8	1.248 1.255 2.883	-1.214 -0.903 4.876	27
Southwest M Con	748.0 752.3 55.40	752.8 766.2 73.28	1403.3 1398.0 239.0	1368 1390 246.7	0.655 0.683 2.150	-0.170 -0.202 4.067	50
Southwest M WL	787.4 785.9 46.23	773.0 777.0 52.16	1441 1441 165.3	1428 1409 170.3	-0.306 -0.535 2.743	-1.658 -1.711 4.819	50

[ɑː]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	783.2 788.9 67.18	765.5 774.2 82.01	1358 1370 145.5	1374 1408 190.4	-0.305 -0.424 1.484	0.449 0.945 3.430	125
East W WL	778.0 798.0 67.60	789.7 796.8 58.49	1320 1328 117.4	1270.7 1285.4 117.9	-0.085 0.052 1.129	-0.412 -0.785 1.903	71
East M Con	734.9 736.1 24.15	721.8 729.7 37.77	1327 1341 121.7	1322 1330 107.0	-0.342 -0.272 0.799	-0.432 -0.429 2.787	30
East M WL	777.4 773.6 32.76	760.7 752.9 52.77	1216 1237 111.6	1226 1250 134.2	-0.381 -0.316 0.795	0.310 0.121 1.178	20
West W Con	780.6 789.3 60.81	787.2 781.4 74.31	1381 1389 159.8	1416.3 1434.3 165.3	-0.177 -0.202 1.516	0.880 1.076 2.817	146
West W WL	771.8 775.5 68.12	783.2 783.6 70.60	1285 1272 94.31	1284.2 1282.8 128.7	0.3143 0.1252 0.930	0.151 0.028 1.815	81
West M Con	747.7 740.6 55.90	736.5 730.6 63.88	1282 1298 168.7	1287.0 1316.3 188.4	-0.251 -0.299 1.172	0.363 0.610 3.898	162
West M WL	783.2 766.2 74.27	774.0 759.7 76.01	1319.8 1303.4 159.4	1252.5 1261.0 145.6	-0.099 -0.144 0.769	-0.878 -0.842 2.232	70

[ε]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East Con	634.2 647.4 77.52	618.1 623.4 85.48	2017 2005 178.9	2067 2059 224.0	-1.322 -0.973 2.857	1.540 2.646 5.949	66 W=56 M=10
East WL	668.6 669.5 64.16	662.3 652.2 72.95	2110 2146 177.0	2167 2175 208.0	-0.661 -0.714 2.274	1.343 1.519 4.635	50 W=40 M=10
West Con	702.7 712.2 76.37	689.0 694.4 103.6	2038 2061 279.2	2113.5 2128.0 330.0	-0.698 -0.607 3.497	3.252 3.039 7.176	158 W=93 M=65
West WL	712.1 712.7 69.35	714.1 711.5 91.44	2038 2032 183.9	2075 2075 262.2	0.354 0.051 2.866	2.062 2.344 8.274	123 W=64 M=59
Trøndsk Con	787.2 783.6 104.8	777.9 794.4 111.3	1722 1748 209.2	1793 1799 236.4	0.283 0.609 2.194	2.929 3.033 5.569	25 W=22 M=3
Trøndsk WL	708.4 734.4 73.60	722.6 742.0 81.53	1925 1916 159.5	1970 1947 201.9	0.765 0.728 3.034	3.255 1.613 6.162	39 W=30 M=9
Bergen Con	788.9 791.0 55.40	779.1 791.5 64.00	1681 1658 158.31	1696 1703 203.0	0.099 0.336 2.616	2.270 2.856 6.584	50 W=29 M=21
Bergen WL	804.6 784.4 62.50	806.7 786.1 73.63	1817 1861 310.4	1876 1908 337.3	-0.198 0.269 2.349	1.212 1.760 6.890	30 W=20 M=10

[eː]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	670.2 679.1 70.88	737.9 726.6 81.66	2061 2094 217.5	1932 1979 226.1	0.893 1.098 1.752	-3.219 -2.953 3.971	91
East W WL	622.3 630.4 70.21	717.0 710.0 75.59	2352 2362 222.9	2158 2146 266.8	1.298 1.470 1.320	-2.675 -4.118 4.953	77
East M Con	674.9 673.8 48.16	699.1 692.2 63.19	2159 2144 117.6	2033 2049 146.1	0.661 0.544 1.306	-2.018 -2.568 4.484	20
East M WL	616.8 615.94 44.83	715.4 696.0 50.36	2470 2460 147.9	2254 2299 209.5	1.396 1.331 1.189	-2.052 -2.522 3.279	23
West W Con	681.7 684.5 76.39	736.2 741.2 77.21	2087 2095 229.5	1980 1990 214.2	1.558 1.369 2.006	-3.116 -2.613 4.350	132
West W WL	620.8 619.5 80.45	704.5 708.4 84.27	2336 2330 253.8	2225 2191 239.2	1.475 1.624 1.467	-2.258 -2.363 3.283	100
West M Con	661.6 663.6 50.67	695.1 692.5 59.06	2074 2152 285.61	1986 2083 284.2	0.936 0.770 1.369	-2.468 -2.016 3.172	93
West M WL	600.2 600.6 61.93	667.9 657.8 60.29	2320 2361 252.5	2227 2273 244.3	1.095 1.168 1.329	-1.571 -1.656 3.835	86

[ɪ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	452.3 463.12 50.67	438.1 448.2 56.15	2414 2416 171.6	2444 2428 197.3	-0.953 -0.848 1.881	1.135 0.666 8.126	79
East W WL	457.8 452.6 44.41	447.2 441.3 60.05	2584 2570 193.7	2573 2568 186.0	-0.354 -0.460 2.066	0.456 0.039 7.330	69
East M Con	498.2 490.0 37.20	473.7 468.2 38.57	2436 2422 187.8	2493 2420 197.2	-1.197 -1.093 0.925	-1.591 0.104 4.158	11
East M WL	451.6 456.6 33.88	422.5 432.5 37.87	2562 2574 85.41	2576 2585 101.2	-0.497 -0.748 0.964	0.968 1.115 2.764	19
West W Con	481.6 482.1 47.82	460.4 462.0 52.60	2344 2337 204.40	2384 2373 236.35	-0.795 -1.144 1.939	2.180 1.990 9.658	102
West W WL	479.9 481.2 37.79	469.1 475.2 51.92	2406 2408 149.8	2423 2428 187.26	-0.001 -0.264 1.797	1.731 1.115 5.307	87
West M Con	515.6 516.3 53.62	501.5 503.7 64.72	2385 2386 293.2	2365 2409 312.8	-0.711 -0.534 2.552	0.863 1.464 6.760	76
West M WL	496.1 497.4 43.31	488.8 492.8 51.13	2478 2496 195.4	2527 2529 208.5	-0.388 -0.119 1.875	2.121 1.281 7.162	72

[i:]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	459.3 453.80 60.33	458.4 451.6 56.49	2469 2451 185.7	2401 2395 197.0	0.002 -0.018 1.227	-1.001 -1.875 4.022	93
East W WL	431.5 426.7 46.27	433.0 433.0 55.90	2721 2743 142.9	2715 2738 154.8	-0.005 0.149 1.145	0.258 -0.008 2.573	69
East M Con	478.8 473.8 64.71	471.9 478.6 60.52	2508 2488 150.6	2417 2409 169.5	-0.029 0.047 1.042	-2.552 -3.095 2.328	20
East M WL	394.3 398.2 27.42	411.4 408.3 56.43	2686 2693 111.3	2678 2709 110.5	0.305 0.319 1.082	0.657 0.419 1.657	21
West W Con	460.8 463.7 43.93	458.5 465.6 48.69	2469 2470 217.2	2430 2421 239.5	-0.161 -0.069 1.302	-0.991 -1.630 6.272	98
West W WL	443.2 438.7 56.06	445.7 439.8 65.09	2703 2677 230.5	2749 2739 186.2	-0.022 0.041 1.402	0.919 1.014 3.895	86
West M Con	442.3 454.5 58.33	452.9 464.7 60.07	2519 2511 279.0	2447 2462 281.9	0.306 0.241 1.408	-2.085 -1.842 3.930	98
West M WL	396.3 394.4 34.88	396.6 397.7 41.11	2742 2776 189.1	2779 2800 163.3	0.074 0.090 1.258	0.662 0.781 2.153	67

[ɔ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	605.8 605.8 62.44	620.1 618.8 72.64	1164 1172 146.3	1185 1184 155.3	0.178 0.606 2.635	0.622 0.876 3.764	62
East W WL	597.8 607.2 62.23	606.b 603.9 72.43	1176 1194 177.7	1130 1129 153.8	-0.104 -0.145 2.762	-3.207 -3.660 5.576	63
East M Con	617.9 595.1 46.78	606.8 599.9 59.55	1142 1201 181.9	1123 1165 175.8	-0.231 0.264 2.076	-1.906 -1.940 6.490	9
East M WL	629.3 631.7 51.22	633.4 639.0 61.24	1157 1167 222.1	1080 1097 184.4	-0.026 0.408 1.899	-2.346 -6.398 10.84	18
West W Con	617.3 617.6 52.91	612.0 619.9 71.52	1216 1230 166.8	1205 1205 161.3	0.117 0.146 2.771	-0.278 -1.188 5.543	70
West W WL	653.1 646.6 53.75	648.6 652.0 67.87	1283 1264 154.8	1217 1208 109.1	0.426 0.246 2.427	-2.963 -3.101 6.409	79
West M Con	606.2 609.9 56.51	607.0 610.0 69.46	1139 1168 155.4	1157 1173 172.1	-0.081 0.001 2.486	0.296 0.985 6.080	65
West M WL	630.9 628.5 50.76	641.0 636.5 68.10	1237 1245 213.3	1156 1191 181.52	-0.056 0.446 2.441	-2.467 -2.535562 7.479	66

[o:]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	614.4 622.4 69.55	633.4 630.0 75.44	1105 1102 157.6	1177 1185 175.3	0.292 -0.100 2.273	1.862 1.869 4.174	93
East W WL	524.7 527.9 52.53	621.7 620.6 58.64	956.9 959.7 138.1	1074 1047 101.0	1.661 1.600 1.062	1.269 1.251 2.343	68
East M Con	582.8 587.9 33.47	601.0 598.6 48.47	1002 1002 142.1	1076 1068 130.4	0.224 0.114 1.398	1.476 1.584 1.858	19
East M WL	580.8 592.2 69.73	627.1 622.7 70.89	903.8 916.0 130.2	993.9 992.5 118.0	0.440 0.373 1.020	0.623 1.281 2.233	21
West W Con	601.1 599.7 62.03	636.6 640.5 66.44	1118 1138 170.0	1256 1256 161.8	0.729 0.906 1.831	2.411 2.550 4.420	123
West W WL	508.7 520.6 60.73	628.9 626.0 72.71	946.1 958.3 130.1	1079 1070 130.7	1.655 1.696 1.315	1.550 1.532 2.827	91
West M Con	591.3 601.2 63.54	605.3 614.7 59.42	1029 1048 147.6	1108 1119 169.9	0.328 0.371 1.607	2.098 2.404 4.000	105
West M WL	540.1 541.8 46.12	589.4 585.8 60.54	954.3 959.1 118.8	965.7 991.8 118.7	0.773 0.712 1.393	0.122 0.490 3.183	75

[ɞ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	636.1 633.0 62.74	629.4 627.9 73.83	1740 1770 185.0	1728 1762 177.2	-0.524 -0.326 2.026	0.417 0.006 6.827	63
East W WL	630.9 633.1 76.13	626.6 635.5 87.86	1829 1867 148.1	1796 1833 190.3	0.450 0.335 2.567	-0.632 -1.927 6.143	70
East M Con	636.7 621.5 41.52	619.7 606.9 45.36	1842 1828 137.4	1768 1790 99.96	-0.779 -0.748 1.359	-1.242 -1.939 3.802	9
East M WL	634.6 635.7 48.22	588.5 591.1 51.64	1928 1940 174.0	1927 1923 176.72	-1.214 -1.657 2.628	0.734 -0.418 4.304	20
West W Con	651.3 652.3 73.23	642.9 641.8 81.02	1763 1733 164.0	1701 1711 197.0	-0.314 -0.324 2.365	-0.501 -0.806 4.518	60
West W WL	669.9 669.8 64.23	683.5 679.3 73.31	1737 1748 185.6	1727 1730 199.9	0.812 0.818 2.854	-0.569 - 0.961 4.897	84
West M Con	634.9 638.8 43.10	625.6 628.8 56.69	1725 1697 213.3	1701 1691 241.4	-0.097 -0.251 2.051	-0.503 0.072 4.442	81
West M WL	658.9 657.6 47.24	656.5 651.9 58.62	1783 1799 166.9	1791 1791 172.7	-0.124 -0.003 2.424	-0.261 -0.454 4.567	68

<table>
<tr><th colspan="8">[ɵː]</th></tr>
<tr><th></th><th>F1 head</th><th>F1 tail</th><th>F2 head</th><th>F2 tail</th><th>rΔF1</th><th>rΔF2</th><th>n</th></tr>
<tr><td>East
W Con</td><td>606.0
613.1
59.24</td><td>637.2
650.1
72.07</td><td>1766
1770
125.3</td><td>1731
1743
125.0</td><td>1.052
0.941
1.568</td><td>-1.453
-1.036
3.112</td><td>47</td></tr>
<tr><td>East
W WL</td><td>601.4
596.7
58.80</td><td>675.6
673.7
54.29</td><td>1851
1824
133.8</td><td>1773
1747
156.1</td><td>1.326
1.518
1.249</td><td>-0.864
-1.709
3.373</td><td>70</td></tr>
<tr><td>East
M Con</td><td>596.6
603.6
65.26</td><td>606.8
615.6
46.73</td><td>1915
1902
134.5</td><td>1918
1888
197.9</td><td>-0.190
0.122
1.663</td><td>-0.362
-0.196
3.029</td><td>8</td></tr>
<tr><td>East
M WL</td><td>607.9
601.1
35.95</td><td>647.0
638.6
38.77</td><td>1836
1869
98.76</td><td>1803
1812
103.2</td><td>0.746
0.786
0.850</td><td>-0.999
-1.446
1.977</td><td>21</td></tr>
<tr><td>West
W Con</td><td>626.3
627.7
62.87</td><td>648.7
654.0
79.58</td><td>1794
1788
130.7</td><td>1787
1798
177.6</td><td>0.458
0.208
2.269</td><td>-0.489
-0.160
3.824</td><td>48</td></tr>
<tr><td>West
W WL</td><td>584.1
581.8
57.09</td><td>664.8
668.1
68.75</td><td>1758
1757
154.9</td><td>1740
1725
156.1</td><td>1.395
1.625
1.395</td><td>-0.473
-0.680
2.307</td><td>86</td></tr>
<tr><td>West
M Con</td><td>619.7
620.1
58.22</td><td>627.2
633.5
56.63</td><td>1767
1769
208.3</td><td>1736
1767
182.7</td><td>0.446
0.061
1.885</td><td>0.154
0.173
6.040</td><td>44</td></tr>
<tr><td>West
M WL</td><td>575.3
565.7
50.32</td><td>598.7
603.5
56.72</td><td>1849
1856
147.6</td><td>1821
1820
140.4</td><td>0.431
0.659
1.122</td><td>-0.602
-0.885
2.786</td><td>74</td></tr>
</table>

[ʊ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	473.9 480.2 43.17	459.9 464.0 47.59	1035 1078 187.1	1145 1127 209.3	-0.717 -0.736 2.025	0.926 1.561 5.344	37
East W WL	481.1 490.4 41.56	471.2 478.9 43.86	1201 1176 273.0	1104 1130 262.9	-0.372 -0.570 1.273	-0.847 -1.767 6.431	71
East M Con	490.3 501.0 17.96	496.5 480.1 46.15	983.8 952.3 134.0	1019 1027 177.3	0.422 -0.401 1.732	1.842 3.691 3.436	5
East M WL	494.0 502.1 49.94	492.6 489.6 42.17	1149 1137 237.2	1108 1082 205.8	-0.422 -0.655 1.847	-0.884 -2.669 5.372	19
West W Con	506.6 508.6 39.59	483.6 495.3 43.80	1082 11167 195.2	1158 1185 230.4	-0.117 -0.176 1.365	3.611 3.992 6.214	36
West W WL	489.4 488.7 45.61	490.8 493.6 56.68	1044 1082 191.6	1080 1090 173.3	0.254 0.177 1.639	0.048 -0.226 7.073	83
West M Con	508.2 515.7 55.67	497.6 511.4 73.44	1109 1125 215.9	1220 1230 237.1	0.018 0.001 1.920	0.609 3.187 7.622	42
West M WL	520.7 519.0 41.16	507.2 505.5 43.92	1111 1122 246.4	1066 1115 231.2	-0.215 -0.858 2.654	-0.369 -2.226 8.863	66

[u:]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	457.4 460.6 37.34	459.5 463.3 40.93	938.7 1001 243.0	962.9 1010 216.1	0.034 0.046 1.285	0.484 1.067 7.013	52
East W WL	453.4 462.1 48.24	438.6 442.1 57.14	801.2 831.7 147.9	859.0 880.8 150.2	-0.184 -0.288 1.381	0.591 1.028 3.108	71
East M Con	499.2 491.7 37.96	437.6 444.3 54.85	885.9 960.7 171.9	936.3 977.3 151.2	-1.184 -1.506 1.296	1.305 1.229 6.681	10
East M WL	446.5 448.3 42.59	447.4 443.2 37.40	824.2 828.1 103.6	897.0 911.4 133.5	-0.196 -0.037 0.976	1.347 1.760 3.228	19
West W Con	458.8 462.5 48.81	447.6 451.2 48.02	887.4 918.5 160.9	878.1 925.4 182.9	-0.298 -0.342 1.497	-0.370 0.819 5.194	117
West W WL	442.1 442.9 41.83	437.2 433.8 47.94	784.7 817.3 148.1	813.9 822.4 132.4	-0.139 -0.188 1.183	0.059 0.193 4.082	80
West M Con	498.7 490.6 46.51	476.8 481.2 53.01	953.0 987.6 193.5	961.0 1002.1 191.1	-0.126 -0.287 1.694	0.0286 0.733 5.482	69
West M WL	437.9 439.9 38.02	436.0 439.5 39.60	842.1 877.8 221.3	825.4 862.7 216.4	0.059 0.015 1.140	-0.008 -0.279 3.965	68

[ʉ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	458.1 452.1 48.08	447.8 441.8 58.51	1965 1995 244.7	1964 1955 224.1	0.075 -0.540 1.950	-1.938 -2.209 5.765	28
East W WL	463.1 459.2 41.74	449.9 446.4 49.08	2104 2098 179.6	2089 2081 180.6	-0.138 -0.593 1.644	-0.842 -1.863 5.255	68
East M Con	494.4 474.0 36.74	473.2 457.4 32.40	2214 2211 128.12	2243 2239 99.99	-0.436 -0.715 2.215	1.658 1.077 4.366	7
East M WL	470.95 469.83 40.66	450.8 446.8 37.69	2226 2227 173.2	2207 2194 151.9	-0.816 -0.702 1.248	-0.800 -2.477 5.604	18
West W Con	474.4 474.0 54.73	453.6 461.9 66.05	1914 1951 205.9	1944 1985 170.8	-0.376 -0.571 2.154	0.177 0.816 6.212	60
West W WL	485.3 483.5 44.86	476.2 478.5 49.57	1967 1953 244.1	1949 1924 259.0	-0.010 -0.373 1.482	-1.225 -1.884 6.077	87
West M Con	509.6 503.8 42.81	491.7 495.69 38.34	1981 1952 239.3	1883 1993 239.8	-0.948 -0.807 1.187	2.439 1.978 6.138	17
West M WL	490.6 498.0 51.87	485.2 491.2 53.01	1997 1993 247.3	2002 1969 256.7	-0.334 -0.287 1.564	-1.177 -1.675 4.991	68

[ʉː]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	440.4 446.2 47.23	430.7 438.1 47.24	2059 2053 181.1	2022 2054 165.5	-0.163 -0.398 1.361	-0.269 -0.383 3.503	44
East W WL	432.7 428.9 40.20	422.4 422.8 47.83	2181 2170 159.6	2117 2109 131.7	-0.126 -0.140 0.911	-0.968 -1.093 3.019	70
East M Con	440.8 451.3 26.38	477.8 459.8 36.41	2159 2154 111.2	2065 2066 65.23	0.062 0.309 1.047	-2.702 -3.283 2.384	8
East M WL	392.3 396.1 33.60	402.5 405.1 37.41	2209 2199 143.5	2170 2169 103.3	0.031 0.112 0.825	-0.942 -0.564 2.202	20
West W Con	446.7 448.7 54.32	440.3 443.9 54.68	2028 2073 200.1	2040 2061 191.7	-0.106 -0.410 1.705	-0.285 0.043 3.870	60
West W WL	441.1 438.9 41.17	430.1 437.0 48.32	2079 2082 211.1	2047 2049 201.9	-0.013 -0.086 1.111	-0.426 -0.439 2.122	90
West M Con	437.8 442.3 41.00	445.6 441.7 48.55	2209 2165 345.2	2144 2118 297.1	-0.213 -0.245 1.322	-0.660 -0.997 4.252	48
West M WL	398.9 406.1 40.75	403.6 404.8 37.96	2211 2179 274.6	2125 2102 234.4	-0.036 -0.110 0.937	-1.209 -1.302 2.627	71

[ʏ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	445.4 446.4 61.67	438.1 447.1 63.98	2340 2310 211.9	2376 2344 222.0	-0.240 -0.041 1.808	0.966 1.574 5.321	74
East W WL	455.0 449.5 44.53	447.4 436.3 61.72	2470 2496 172.6	2513 2498 195.2	-0.118 -0.541 2.075	0.411 0.365 5.539	70
East M Con	477.8 474.2 26.20	445.5 434.1 62.88	2323 2344 76.89	2417 2406 75.09	-1.644 -1.546 2.124	3.509 3.230 3.927	7
East M WL	448.1 449.2 39.17	420.8 423.6 48.37	2541 2550 144.8	2539 2533 175.5	-0.525 -0.854 1.215	0.351 -0.868 4.239	20
West W Con	471.0 476.2 46.91	456.8 458.1 54.37	2234 2210 210.1	2273 2268 229.6	-0.704 -0.994 1.849	2.296 1.898 7.006	72
West W WL	472.2 479.2 35.44	470.8 473.4 46.65	2280 2278 191.5	2299 2330 202.2	-0.082 -0.381 1.441	2.074 2.167 4.056	85
West M Con	487.7 496.6 46.65	472.7 476.1 51.97	2254 2240 248.2	2297 2269 249.3	-1.195 -0.904 1.761	1.287 1.211 4.788	69
West M WL	481.8 482.9 41.98	462.5 470. 3 43.02	2392 2364 159.9	2433 2407 192.4	-0.672 -0.547 1.415	1.670 1.415 5.738	73

[y:]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	437.4 428.1 59.44	425.1 418.9 60.24	2433 2447 150.6	2406 2426 167.7	-0.344 -0.227 0.808	-0.483 -0.696 3.204	24
East W WL	427.7 416.1 54.19	430.5 422.9 58.59	2660 2662 148.0	2641 2636 137.7	0.024 0.208 1.082	0.322 -0.584 2.979	70
East M Con	457.2 440.5 37.65	424.7 423.7 36.97	2502 2510 90.36	2432 2456 106.9	-0.760 -0.383 1.325	-2.156 -2.149 2.340	7
East M WL	379.1 389.8 31.18	398.0 399.5 47.16	2688 2684 68.96	2607 2617 101.7	0.005 0.257 0.957	-0.622 -1.556 2.526	19
West W Con	442.3 452.6 59.12	434.0 443.4 57.57	2482 2499 187.46	2391 2394 199.2	-0.247 -0.398 1.339	-2.608 -2.786 4.473	53
West W WL	422.7 428.6 52.51	416.6 418.1 52.61	2580 2606 158.8	2583 2599 151.1	-0.101 -0.282 1.077	0.240 0.190 2.654	81
West M Con	426.1 432.7 67.67	439.0 444.6 62.25	2535 2487 208.6	2459 2407 191.3	0.388 0.322 0.982	-2.521 -3.005 4.543	29
West M WL	386.0 391.8 40.54	382.7 390.4 34.94	2641 2650 154.6	2665 2666 148.0	-0.119 0.043 0.989	0.570 0.465 2.166	67

[æ]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	817.3 825.8 71.08	842.2 841.3 74.76	1575 1572 188.7	1660 1669 259.8	1.105 1.423 3.241	3.699 5.224 7.992	21
East W WL	788.6 792.9 82.05	831.5 834.2 91.17	1705 1743 187.7	1714 1763 179.7	1.960 2.280 3.612	0.709 0.886 4.425	60
East M Con	775.4 778.0 39.30	743.5 766.5 42.10	1640 16567 211.2	1685 1780 224.6	-0.878 -0.775 2.324	6.071 6.093 3.261	7
East M WL	822.9 810.7 98.38	851.9 834.0 81.63	1769 1781 257.3	1773 1803 219.1	0.802 1.420 2.130	1.871 1.730 3.299	18
West W Con	842.9 833.7 69.95	845.1 857.6 83.00	1580 1587 197.2	1600 1594 204.6	0.868 1.363 2.992	-0.520 0.805 8.707	39
West W WL	772.6 779.4 75.82	817.5 822.3 92.07	1748 1743 194.1	1741 1713 226.1	2.024 1.882 3.219	-0.169 -1.673 6.487	72
West M Con	790.3 795.7 52.04	809.7 815.3 60.16	1550 1560 124.7	1595 1588 120.3	0.866 1.254 2.107	2.142 1.638 3.341	47
West M WL	797.6 789.3 95.41	834.7 837.5 98.36	1811 1809 173.9	1828 1840 190.7	1.730 2.601 2.940	1.152 1.580 4.616	63

[æː]							
	F1 head	F1 tail	F2 head	F2 tail	rΔF1	rΔF2	n
East W Con	899.4 899.5 66.66	875.1 883.2 74.13	1622 1625 137.1	1665 1667 133.1	-0.075 -0.433 1.338	0.881 0.813 4.194	31
East W WL	886.8 887.3 82.17	911.7 898.9 79.97	1681 1675 184.4	1684 1681 139.0	0.137 0.329 1.423	0.358 0.152 3.507	70
East M Con	862.6 895.6 81.14	868.6 899.8 98.69	1745 1743 98.53	1700 1705 197.1	-0.0513 0.062 0.591	-0.604 -0.445 2.560	6
East M WL	870.1 869.7 34.75	872.6 872.9 33.68	1712 1703 84.52	1676 1726 127.6	0.261 0.0470 0.654	-0.018 0.292 2.203	19
West W Con	850.8 829.5 67.50	878.3 883.7 60.62	1900 1852 248.4	1771 1749 150.3	1.433 1.335 1.787	-2.496 -2.834 4.051	18
West W WL	859.5 863.4 91.52	888.1 889.3 86.98	1767 1753 179.2	1771 1736 181.8	0.563 0.808 1.485	0.001 -0.792 3.901	76
West M Con	830.7 842.3 84.67	858.8 849.5 75.71	1684 1655 165.4	1635 1660 144.9	0.316 0.178 0.995	0.218 0.095 2.702	22
West M WL	855.4 847.0 104.5	862.2 854.4 93.45	1808 1818 163.9	1798 1806 169.7	0.376 0.217 1.247	-0.199 0.026 2.381	59

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