

Menominee Vowels: Quality, Quantity, and a Hierarchical Model of Representation

By

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Abstract

This dissertation presents a phonetic and phonological analysis of Menominee vowels, consisting of a duration study, a vowel quality study, and a proposal of a new Bifurcated Ranking Model to a contrastive feature hierarchical framework.

The duration study shows that long and short monophthongs are statistically significantly different from each other. The long and short diphthongs are significantly different from the long and short monophthongs, as well as each other. The duration study also shows that the underlying vowel length has a significant effect on the surface duration for the short vowels, but not the long ones.

The vowel quality study shows that there is a great deal of overlap in the acoustic realizations of not only the short vowels, but also the long vowels. This study indicates that the patterns of variation within the vowel acoustic realizations is not consistent with previous literature (Bloomfield 1962; Miner 1979; Milligan 2005) and suggests that previous descriptions of Menominee vowel allophony do not capture the full spectrum of vowel variation in Menominee.

The phonological analysis of Menominee vowels presents a contrastive feature ranking of the inventory. I argue that the *u* [u] and *ū* [u:] are not part of the underlying phonological system of vowels, but are derived at the phonetic level.

The underlying hierarchy ranks the vowel features that are active to establish a contrast between phonemes. While underlying length is contrastive in Menominee vowels, length itself is not a feature (Kenstowicz 1994). To incorporate contrastive length in a contrastive feature hierarchy model (Dresher et al. 1994), I propose a Bifurcated Ranking Model. This model incorporates length as a structural element that is contrastive, while keeping it separate from the contrastive featural hierarchical ranking. The Bifurcated Ranking Model separates the long and

short vowel systems of a language, allowing for asymmetry between the two. In this model the short and long systems share nodes where the feature rankings are parallel, but the bifurcated nature allows the two systems to diverge, as they would for a language with asymmetrical short and long inventories.

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To my second advisor Eric Raimy, I would also like to extend special thanks. Our conversations about phonetics, and phonology, and Menominee were integral to the development of this dissertation and without all your feedback and support, this project would be vastly different.

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Table of Contents

<i>Abstract</i>	<i>i</i>
<i>Acknowledgements</i>	<i>iii</i>
<i>Table of Contents</i>	<i>v</i>
<i>List of Abbreviations</i>	<i>vii</i>
<i>List of Tables</i>	<i>viii</i>
<i>List of Figures</i>	<i>ix</i>
<i>List of Images</i>	<i>xii</i>
Chapter 1: Introduction	1
1.1. Menominee Language Today	2
1.2. History of Study	5
1.3. The Dissertation Project	7
Chapter 2: The Sound System of Menominee	11
2.1. Menominee Orthography	11
2.1.1. Bloomfield's Orthography	13
2.2. Vowels	14
2.2.1. Short Monophthongs	19
2.2.2. Long Monophthongs	19
2.2.3. Diphthongs	19
2.3. Previous Work on Menominee Phonetics and Phonology	20
2.4. Vowel Rules	23
2.4.1. Vowel and Glide Alternations	23
2.4.2. Lengthening and Shortening	25
2.4.3. <i>ae</i> Raising	30
2.4.4. <i>e</i> Epenthesis	32
2.4.5. Vowel Harmony	33
2.5. Relevant Consonant Patterns	34
2.5.1. Palatalization	34
2.5.2. Glottal Effects on Vowels	36
2.6. Conclusion	37
Chapter 3: Acoustic Phonetics and Generative Phonology of Menominee	38
3.1. Background on Menominee Acoustic Phonetics	38
3.1.1. Miner 1975	38
3.1.2. Milligan 2005	42
3.2. Theoretical Framework	47
3.2.1. Length in Distinctive Feature and Contrastive Frameworks	67
3.3. Conclusion	72
Chapter 4: Menominee Vowel Phonetics	74
4.1. Methods	74
4.1.1. Participants	75
4.1.2. Procedure	77
4.1.3. Measurements	79
4.2. Vowel Quantity	82
4.2.1. Diphthongs as a Variable	82
4.2.2. Underlying Length as a Variable	92

4.2.3. Conclusions on Duration	94
4.3. Vowel Quality	96
4.3.1. Conclusions on Acoustic Space	135
4.4. Case Studies	135
4.4.1. Native Speaker 2	139
4.4.2. Native Speaker 3	160
4.4.3. Native Speaker 4	179
4.4.4. Conclusions from the Case Studies	197
4.5. Issues and Limitations with the Data Set	198
4.6. Conclusion	200
Chapter 5: Menominee Vowel Phonology	202
5.1. Vowel Hierarchy	203
5.1.1. Length within a Contrastive Feature Hierarchical Model	212
5.1.2. High Back Vowel(s)	218
5.1.3. Diphthongs (Vowel + Glide Alternations Revisited)	224
5.2. Other Menominee Rules Supporting the Contrastive Hierarchy	237
5.2.1. <i>ae</i> Raising Revisited	238
5.2.2. Vowel Epenthesis Revisited	239
5.2.3. Menominee Vowel Harmony Revisited	239
5.2.4. Palatalization and Glottal Effects Revisited	243
5.3. Conclusion	246
Chapter 6: Contributions and Conclusion	248
6.1. Introduction	248
6.2. Value to the Menominee	250
6.3. Future Research and Conclusion	251
References	254
Appendix I: F1 and F2, Head and Tail Measurements	264
Appendix II: Lexical Items and Formant 1 Measurements	299

List of Abbreviations

(an)	animate	SL	Short Long (vowel)
[cons]	consonantal	SP	Soft Palate
[son]	sonorant	SL	Short Long (vowel)
3	third person	SP	Soft Palate
ATR	Advanced Tongue Root	SR	surface representation
C	any consonant	SS	Short Short (vowel)
COR	Coronal	SSL	Second Syllable Lengthening
DOR	Dorsal	SSP	Secondary Stress Placement
EPEN	epenthesis	SSS	Second Syllable Stress
ESL	Even Syllable Lengthening	TA	transitive animate (verb)
ESR	Even Syllable Rule	TC	Tongue Curl
ESS	Even Syllable Shortening	TG	Tongue Groove
F0	Formant 0	TH	Tongue Height
F1	Formant 1	TR	Tongue Root
F2	Formant 2	TT	Tongue Thrust
F3	Formant 3	UR	underlying representation
FSD	Final Syllable Destressing	UW	University of Wisconsin
G	glide in the adjunct of a syllable	Ṽ	any long vowel
GLITC	Great Lakes Inter-Tribal Council	V	any short vowel
GT	Glottal Tension	WNALP	Wisconsin Native American Language Project
GW	Glottal Width		
H	heavy syllable (long vowel)		
Hz	Hertz		
II	inanimate intransitive verb		
IPA	International Phonetic Alphabet		
L	light syllable (short vowel)		
LAB	Labial		
LAR	Larynx		
LH	Larynx Height		
LL	Long Long (vowel)		
LS	Long Short (vowel)		
LSV	Lengthening of Stressed Vowels		
MCS	Modified Contrastive Specification		
MD	Menominee Database		
ms	milliseconds		
N.final	noun final (morpheme)		
OP	Oral Place		
PA	Proto-Algonquian		
PCD	Post-Cluster Destressing		
PCS	Post-Cluster Shortening		
RTR	Retracted Tongue Root		
sd	standard deviation		
SDA	Successive Division Algorithm		

List of Tables

Table 2.1	Menominee Consonants
Table 2.2	Menominee Vowels
Table 2.3	Menominee Phonemes and Orthography
Table 2.4	Menominee Vowels and Allophones
Table 2.5	Vowels in combination at morpheme boundaries
Table 2.6	Glide + Vowel alternations
Table 2.7	Open and Closed Syllables
Table 2.8	Light and Heavy Syllables
Table 2.9	Menominee Vowel Length Rules
Table 3.1	Menominee Vowel Tokens and Frequency for Milligan's Study
Table 3.2	Vowel Duration Results from Milligan's Study
Table 3.3	Syllable Stress Results from Milligan's Study
Table 3.4	Syllable Open/Closed Duration Results from Milligan's Study
Table 4.1	Native Speaker Linguistic Profiles
Table 4.2	Total Number of Tokens by Speaker
Table 4.3	Individual Vowel Numbers by Speaker
Table 4.4	Vowel Length by UR and SR Length
Table 4.5	Means and Standard Deviations of the Short Monophthongs
Table 4.6	Means and Standard Deviations of the Long Monophthongs
Table 4.7	Means and Standard Deviations of the Short and Long Diphthongs
Table 4.8	Significance Values between Variable Vowel Durations
Table 4.9	Significance Values between Diphthong Durations
Table 4.10	Means and Standard Deviations of the Underlying and Surface Vowel Lengths
Table 4.11	Significance Values between Underlying and Surface Durations
Table 4.12	Vowel Means and Ratios for Duration
Table 4.3	Individual Vowel Numbers by Speaker
Table 4.13	Means and SD of F1 Head, Tail and F2 Head, Tail by vowel
Table 4.14	Menominee Vowels and Allophones
Table 4.15	Individual Vowel Numbers by Case Study Speaker
Table 4.16	Vowel Means and Ratios for NS_2
Table 4.17	Vowel Means and Ratios for NS_3
Table 4.18	Vowel Means and Ratios for NS_4
Table 5.1	Phonetic Gestures: Menominee Short Vowels
Table 5.2	Phonetic Gestures: Menominee Long Vowels
Table 5.3	Morphemes containing \bar{u} [u:]
Table 5.4	Morphemes containing u [u]
Table 5.5	Mid and High Back Vowels in Other Algonquian Languages
Table 5.6	Vowels in combination at morpheme boundaries
Table 5.7	Glide + Vowel alternations
Table 5.8	All Glide + Vowel Alternations <i>or</i> Patterns of Hiatus Resolution
Table 5.9	Phonetic Gestures: Menominee Vowels

List of Figures

- Figure 1.1 Algic Languages
- Figure 1.2 Algonquian Languages with more detailed subgroupings
- Figure 2.1 IPA Vowel Inventory 1904
- Figure 2.2 IPA Vowel Inventory 1932
- Figure 3.1 Hypothetical Language 1
- Figure 3.2 Hypothetical Language 2
- Figure 3.3 Hypothetical Language 3
- Figure 3.4 PA1
- Figure 3.5 PA2
- Figure 3.6 Segmental Hierarchy
- Figure 3.7 Modern American English Long Vowels
- Figure 3.8 Segmental Hierarchy
- Figure 3.9 Old English with superordinate marking
- Figure 3.10 Feature Chain
- Figure 3.11 Proto-Algonquian Phonological Inventory
- Figure 3.12 Proto-Algonquian Bifurcated Ranking Model
- Figure 4.1 Short Monophthong Durations
- Figure 4.2 Long Monophthong Durations
- Figure 4.3 Diphthong Durations
- Figure 4.4 Short Vowel Durations
- Figure 4.5 Long Vowel Durations
- Figure 4.6 Underlying/Surface Vowel Durations
- Figure 4.7 Approximation of How the Formants Correlate to Tongue Height and Frontness/Backness
- Figure 4.8 Menominee Vowel Acoustic Quality
- Figure 4.9 High vowels (short and long) F1 Head
- Figure 4.10 High vowels (short and long) F2 Head
- Figure 4.11 Mid vowels (short and long) F1 Head
- Figure 4.12 Mid vowels (short and long) F2 Head
- Figure 4.13 Low vowels (short and long) F1 Head
- Figure 4.14 Low vowels (short and long) F2 Head
- Figure 4.15 Front vowels (short and long) F1 Head
- Figure 4.16 Front vowels (short and long) F2 Head
- Figure 4.17 Back vowels (short and long) F1 Head
- Figure 4.18 Back vowels (short and long) F2 Head
- Figure 4.19 Predicted Density Pattern of Short Front Vowels as described in Table 4.14
- Figure 4.20 Short front vowels F1 Head
- Figure 4.21 Short front vowels F1 Tail
- Figure 4.22 Short front vowels F2 Head
- Figure 4.23 Short front vowels F2 Tail
- Figure 4.24 Predicted Density Pattern of Long Front Vowels as described in Table 4.14
- Figure 4.25 Long front vowels F1 Head
- Figure 4.26 Long front vowels F1 Tail
- Figure 4.27 Long front vowels F2 Head

Figure 4.28	Long front vowels F2 Tail
Figure 4.29	Predicted Density Pattern of Short Back Vowels as described in Table 4.14
Figure 4.30	Short back vowels F1 Head
Figure 4.31	Short back vowels F1 Tail
Figure 4.32	Short back vowels F2 Head
Figure 4.33	Short back vowels F2 Tail
Figure 4.34	Predicted Density Pattern of Long Back Vowels as described in Table 4.14
Figure 4.35	Long back vowels F1 Head
Figure 4.36	Long back vowels F1 Tail
Figure 4.37	Long back vowels F2 Head
Figure 4.38	Long back vowels F2 Tail
Figure 4.39	A (ā) by Speaker
Figure 4.40	o by Speaker
Figure 4.41	NS_2 Vowel Acoustic Quality
Figure 4.42	Short front vowels F1 Head for NS_2
Figure 4.43	Short front vowels F1 Tail for NS_2
Figure 4.44	Short front vowels F2 Head for NS_2
Figure 4.45	Short front vowels F2 Tail for NS_2
Figure 4.46	Long front vowels F1 Head for NS_2
Figure 4.47	Long front vowels F1 Tail for NS_2
Figure 4.48	Long front vowels F2 Head for NS_2
Figure 4.49	Long front vowels F2 Tail for NS_2
Figure 4.50	Short back vowels F1 Head for NS_2
Figure 4.51	Short back vowels F1 Tail for NS_2
Figure 4.52	Short back vowels F2 Head for NS_2
Figure 4.53	Short back vowels F2 Tail for NS_2
Figure 4.54	Long back vowels F1 Head for NS_2
Figure 4.55	Long back vowels F1 Tail for NS_2
Figure 4.56	Long back vowels F2 Head for NS_2
Figure 4.57	Long back vowels F2 Tail for NS_2
Figure 4.58	NS_3 Vowel Acoustic Quality
Figure 4.59	Short front vowels F1 Head for NS_3
Figure 4.60	Short front vowels F1 Tail for NS_3
Figure 4.61	Short front vowels F2 Head for NS_3
Figure 4.62	Short front vowels F2 Tail for NS_3
Figure 4.63	Long front vowels F1 Head for NS_3
Figure 4.64	Long front vowels F1 Tail for NS_3
Figure 4.65	Long front vowels F2 Head for NS_3
Figure 4.66	Long front vowels F2 Tail for NS_3
Figure 4.67	Short back vowels F1 Head for NS_3
Figure 4.68	Short back vowels F1 Tail for NS_3
Figure 4.69	Short back vowels F2 Head for NS_3
Figure 4.70	Short back vowels F2 Tail for NS_3
Figure 4.71	Long back vowels F1 Head for NS_3
Figure 4.72	Long back vowels F1 Tail for NS_3
Figure 4.73	Long back vowels F2 Head for NS_3

Figure 4.74	Long back vowels F2 Tail for NS_3
Figure 4.75	NS_4 Vowel Acoustic Quality
Figure 4.76	Short front vowels F1 Head for NS_4
Figure 4.77	Short front vowels F1 Tail for NS_4
Figure 4.78	Short front vowels F2 Head for NS_4
Figure 4.79	Short front vowels F2 Tail for NS_4
Figure 4.80	Long front vowels F1 Head for NS_4
Figure 4.81	Long front vowels F1 Tail for NS_4
Figure 4.82	Long front vowels F2 Head for NS_4
Figure 4.83	Long front vowels F2 Tail for NS_4
Figure 4.84	Short back vowels F1 Head for NS_4
Figure 4.85	Short back vowels F1 Tail for NS_4
Figure 4.86	Short back vowels F2 Head for NS_4
Figure 4.87	Short back vowels F2 Tail for NS_4
Figure 4.88	Long back vowels F1 Head for NS_4
Figure 4.89	Long back vowels F1 Tail for NS_4
Figure 4.90	Long back vowels F2 Head for NS_4
Figure 4.91	Long back vowels F2 Tail for NS_4
Figure 5.1	Feature Geometry
Figure 5.2	Contrastive Hierarchy for Menominee Short Vowels
Figure 5.3	Contrastive Hierarchy for Menominee Long Vowels
Figure 5.4	Menominee Vowels with Two Height Contrasts
Figure 5.5	Menominee Bifurcated Ranking Model, Accounting for Length
Figure 5.6	Proto-Algonquian Hierarchy with [lng] as a Feature
Figure 5.7	Ojibwe Hierarchy with [lng] as a Feature
Figure 5.8	Ojibwe Bifurcated Ranking Contrastive Hierarchy
Figure 5.9	Menominee Syllable Structure-including diphthongs
Figure 5.10	Menominee Syllable Structure with C/V Slots Marked
Figure 5.11	Short and long vowels in Menominee
Figure 5.12	1SD of all speakers' short vowels
Figure 5.13	1SD of all speakers' long vowels

List of Images

- Image 1.1 Map of Menominee County in Wisconsin
Image 4.1 Intervocalic *n* boundaries in Praat
Image 4.2 Intervocalic *w* boundaries in Praat

Chapter 1: Introduction

1. Introduction

This dissertation presents an acoustic analysis of Menominee vowels in terms of quantity and quality, followed by an analysis of the underlying phonological vowel system. As part of the phonological analysis of Menominee vowels, I propose a Bifurcated Ranking Model which separates the short and long vowel systems into two separately ranked hierarchies of features.

The acoustic project shows that vowel duration differences are statistically significant (significant p -value <0.05) and looks at Menominee diphthong durations. There is a significant difference between vowels that are underlyingly short and surface short, and those that are underlyingly long and surface short as a result of vowel shortening rules. Short diphthongs are significantly different in duration than short monophthongs, as well as long diphthongs. The vowel quality project compares the allophonic variation reported in the Menominee literature to the measured vowels produced by native speakers. The vowel targets produced by the native speakers did not align with the predicted allophony reported in the literature (Bloomfield 1962; Miner 1979a; Milligan 2005). Only the short front vowels followed expected patterns of overlap within the acoustic space. Long vowels have rarely been reported to have much allophonic variation but the native speakers demonstrate a wide range of variation for both the long and short vowels. The theoretical analysis proposes a distinctive feature hierarchy model for the underlying vowel system of Menominee.

This chapter introduces the Menominee language and linguistic community. I present a brief history of the state of the language over the past few decades, as well as a history of the documentation and study of the language. I finish this chapter with a summary of the

dissertation project and a break-down of which aspects of the project are addressed in each chapter.

1.1. Menominee Language Today

Menominee is an Algonquian language spoken today in northern Wisconsin. The historic range of the Menominee covered parts of Wisconsin and Michigan in the United States and parts of Southern Canada around the western Great Lakes. The Menominee Reservation is 357.96 square miles (dpi.wi.gov), sharing nearly the same borders as Menominee County. Image 1.1 shows a map of the reservation/county within the state of Wisconsin.

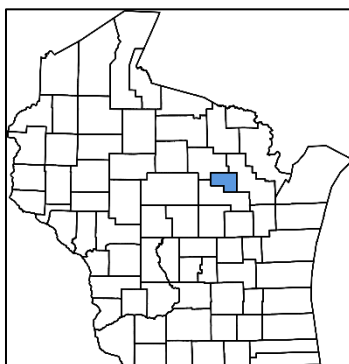


Image 1.1: Map of Menominee County in Wisconsin (usnews.com)

Figure 1.1 shows the generally accepted Algonquian language family tree showing Menominee as a direct branch off Proto-Algonquian. The only major genetic subgroup within the Algonquian languages in this view is the Eastern Algonquian subgrouping (Goddard 1994). In work currently in progress, Biedny et al. (2019a) show through a character-based analysis of Algonquian sound changes that there is enough evidence that the non-Eastern Algonquian languages form a subgroup of Western Algonquian languages (see Figure 1.2). There is some evidence of further internal subgroupings within the Western Algonquian languages such as a

Core Central group consisting of Ojibwe, Potawatomi, Shawnee, Miami, and Meskwaki
(Goddard 1994).

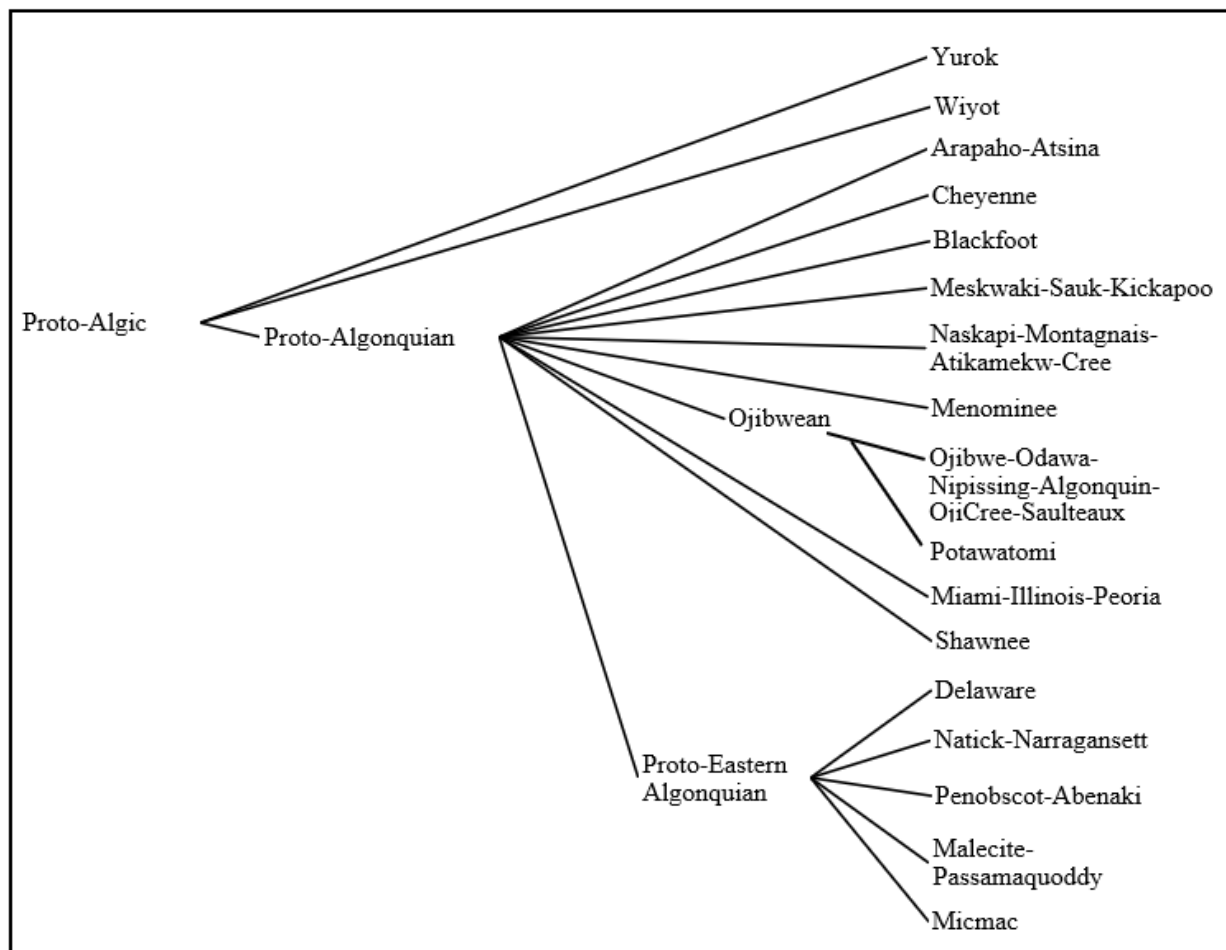


Figure 1.1: Algonquian Languages (Valentine 2001:14)

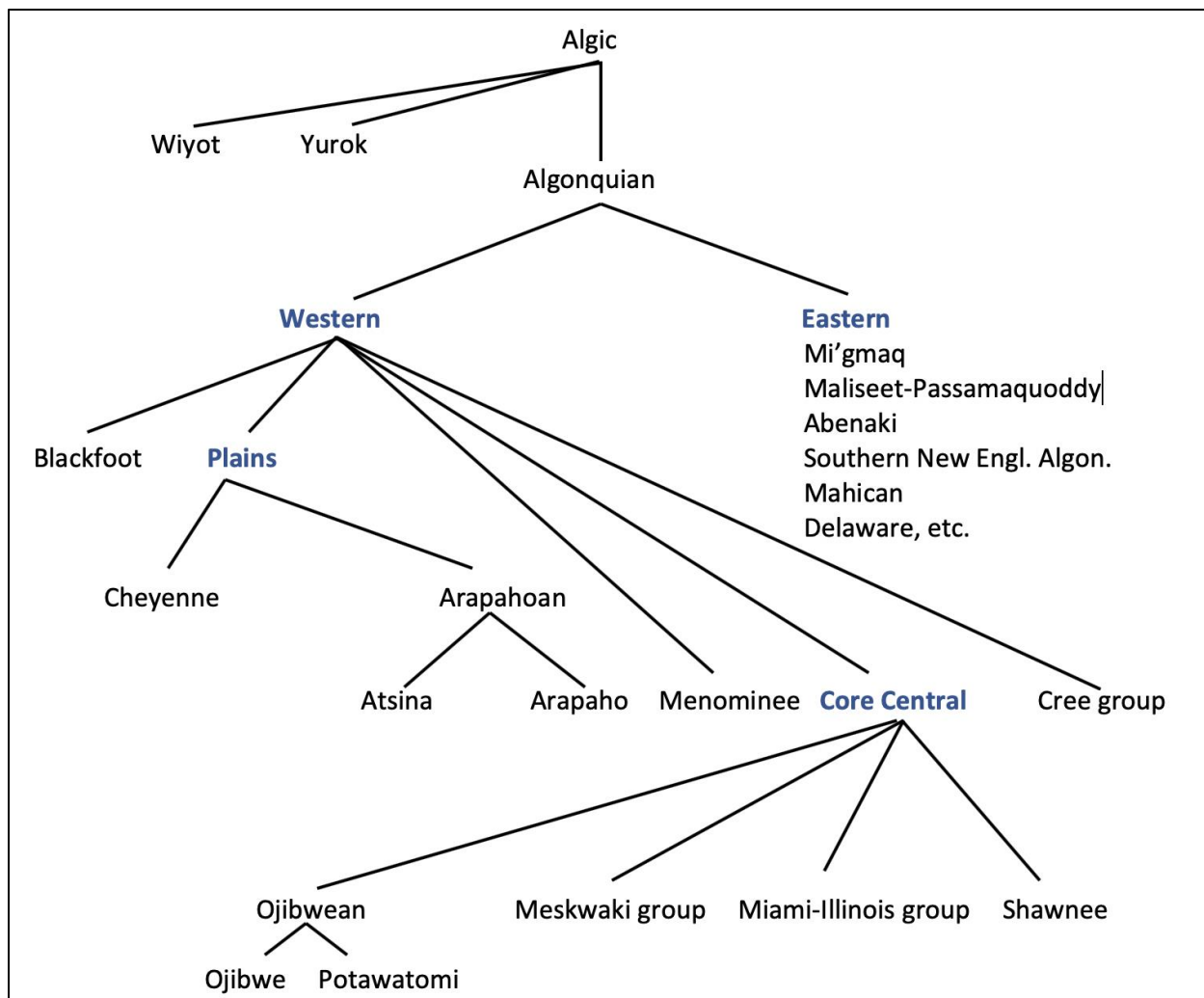


Figure 1.2: Algonquian Languages with more detailed subgroupings (from Biedny et al. 2019a manuscript)

Menominee is a severely endangered language. There are 8,720 enrolled tribal members (dpi.wi.gov) today, with only an estimated three to five native speakers of the language. Only one native speaker currently works with the language revitalization and preservation program in conjunction with the Menominee Language and Culture Commission and linguists from the University of Wisconsin – Madison, and she is in her early 90s. She has supported and participated in this program for almost 20 years, including elicitation sessions I conducted as part of this dissertation project.

The Menominee Legislature passed a tribal ordinance in 1996 stating that the Menominee language would be taught in every school on the Menominee reservation and that the language should be used as much as possible when conducting tribal business (Caldwell and Macaulay 2000). In 2015, the Menominee Language Revitalization Program (Kaehkēnawapataēq), funded by an Administration for Native Americans (ANA) grant, began an immersion program for teacher trainees who would then become immersion language instructors in a new language nest daycare (www.acf.hhs.gov). Today there is a growing community of fluent second language speakers. The fall of 2017 was the first modern Menominee language-only immersion daycare class on the reservation and the teacher trainee program continues to grow.

1.2. History of Study

There are several historical texts written throughout the 1800s on the Menominee language and about the Menominee people. Most of the Menominee language information from this time period consists of wordlists and brief descriptions that do not contain much grammatical information, such as Trowbridge (1823) and James (1827), and the archival materials housed at the Smithsonian Online Virtual Archives (MacCauley 1880; Rogers 1881; Densmore 1867-1957; Bridgman 1885; Jones 1871-1909; Gatschet 1888; Hoffman 1890). Some of these materials contain transcripts and descriptions of Menominee songs and dances, while others may be only one- or two-page wordlists.

Standing out from these ethnographic and brief descriptions of the language, Gachet conducted fieldwork on Menominee in the late 1850s and wrote a grammar of the language in French (Gachet 1954). This grammar has rarely been examined for historical Menominee information as it is written in French, not English, but it contains detailed sentences and

examples of the Menominee language. This grammar was transcribed by Gachet by ear; it contains insights into some of the historical pronunciation of Menominee sounds and vocabulary. For example, Cudworth (2019) shows historical evidence of the merger from Proto-Algonquian */s/ and */ʃ/ to a single phoneme in modern Menominee, with a range of [s] and [ʃ] productions by speakers. Gachet (1954) is one of the historical texts that provide evidence for the history of the merger.

Following about 60 years later, Bloomfield conducted fieldwork in the 1920s on Menominee and a subsequent grammar and lexicon of Menominee were published posthumously from his notes (Bloomfield 1962, 1975). Bloomfield's work is widely considered the most complete record of the language to date. It is the source of much of the information housed in the online Menominee language database and serves as a valuable reference in language revitalization efforts.

In the early 1970s the Pilot Linguistics Project in Native American Languages in Wisconsin (later the Wisconsin Native American Languages Project (WNALP)) was developed by the Great Lakes Inter-Tribal Council (GLITC) to conduct linguistic research and produce language education materials. The project was intended to train and support the tribal communities in developing teaching methods for instructing in their languages. The WNALP produced instructional materials as well as audio recordings and transcripts of much of the audio. The project worked on the Ojibwe, Menominee, Oneida, Potawatomi, and Ho-Chunk languages. For the Menominee portion of the project, three native speaker consultants were hired to work with linguist Kenneth L. Miner on producing audio and education materials as part of language preservation and revitalization efforts.

The Menominee Database (MD) contains a digital dictionary and morphological database, with lexical items, inflected forms, examples, and audio files in the language. This database has been developed by Monica Macaulay at the University of Wisconsin – Madison over the past 20 years, compiled from Bloomfield’s work, as well as elicitation and fieldwork with native speakers of Menominee.

Because there is only one native speaker working on the language programs, I also drew from the MD for my project. Most of the acoustic data for this dissertation come from the audio provided by this database. Any extra data come from recordings that have not yet been analyzed and uploaded to the database, and a small amount of elicited audio provided by the elder who works with linguists from the University of Wisconsin – Madison. Any audio I analyzed that was not already in the database I added to the database as part of the larger project goal of benefiting Menominee language revitalization efforts.

1.3. The Dissertation Project

Miner (1990) writes that many sources that cite Menominee for a phonological analysis are citing ‘bad data.’ He shows how data has been incorrectly interpreted from mid-century work on the language, without authors returning to the primary sources on the language. In an effort to avoid compounding misunderstandings of Menominee vowel phenomena, for this project I consulted Bloomfield’s 1962 grammar of Menominee, as well as modern recordings of native speakers of Menominee. This dissertation presents three projects on Menominee vowels. The two phonetics studies analyze Menominee vowels and examine quantity and quality patterns in the data. The phonological analysis is based on previous work on vowel patterns (such as Bloomfield 1962) as well as some of the results from the phonetics studies presented in this dissertation. With this

project, I hope to contribute to the greater linguistic understanding of the Menominee language, and also to contribute language data to the revitalization program.

Chapter 2 of this dissertation presents the relevant vowel rules and patterns of Menominee. This includes a discussion of vowel lengthening and shortening rules, as well as glide+vowel alternations and vowel-change rules such as vowel harmony and *ae*-raising. This chapter also includes description of consonant-change rules that are triggered by vowels. These vowel alternations and groupings provide insights into the organization of the underlying contrastive hierarchy (analyzed in Chapter 5).

Chapter 3 presents the background literature on Menominee vowels as well as the theoretical framework that I employ in the phonological analysis of Menominee vowels (Chapter 5). This chapter shows previous work on Menominee vowel length, especially structural analyses attempting to incorporate the unique lengthening and shortening rules of Menominee into a larger vowel duration framework. Two of the shortening and lengthening rules in Menominee (or rather a single Even Syllable Rule, per Pesetsky (1979)) appear unique among the world's languages in that they follow the reverse of the expected pattern. In Menominee, the head of a disyllabic foot will be long if the syllable is closed and short if the syllable is open. This runs counter to typological expectations, which would predict lengthening in an open syllable and shortening in a closed syllable (Maddieson 1985). Pesetsky (1979) and Hayes (1995) offer structural and metrical solutions to incorporate this phenomenon into a larger cross-linguistic analysis.

This chapter also discusses the theoretical framework adopted in the analysis in Chapter 5. This approach to understanding the underlying system of contrastive features builds on the work of Dresher et al. (1994) and Avery & Idsardi (2001). The feature organization is language-

specific and predicated on the patterns of phonological behavior in the language. Only those features necessary to distinguish a contrast are active in this model (Avery & Idsardi 1994; Dresher 2009; Oxford 2015). The Purnell & Raimy (2015) and Purnell et al. (forthcoming) model of these hierarchical features (modified from Avery & Idsardi (2001)) breaks away from a binary representation of the features to provide privative analysis.

Previous acoustic analysis has examined Menominee vowel length and how it correlates with stress patterns (Milligan 2005). The vowel duration study presented in Chapter 4 of this dissertation looks at vowel length quantitatively, using different variables than the previous study, such as underlying length and lengthening or shortening of the surface vowel.

Chapter 4 also presents the first acoustic analysis of the Menominee vowel space. In this chapter I show the average vowel quality from five native speakers. I also present three case studies looking in closer detail at some of the idiolectal patterns from the individual speakers. These case studies provide insights into the individual speakers' language, but also suggests areas of future research on the vowel allophony that is so prevalent in the historical descriptions of the language.

Chapter 5 discusses the vowel patterns presented in Chapters 2 and 4, and shows how they support a single underlying hierarchical analysis of vowel features. In this chapter I propose a single distinctive hierarchy for Menominee vowels. I walk through the vowel phenomena presented in Chapter 2 and show how they inform the underlying hierarchy, as well as implications from the acoustic data. In this chapter I propose a new, Bifurcated Ranking Model to map the long and short vowel systems as a strategy to incorporate length within the feature hierarchy, in a way that reflects length as a structural element, rather than as a feature. Previous analyses have incorporated structural length within the featural hierarchy, in which it dominates

and is dominated by other features (e.g., Oxford 2015) or have linked length higher in the hierarchy with a different linking mechanism to represent its structural nature (e.g., Spahr 2016). The approach presented in Chapter 5 represents length within the phonological analysis, while still holding it separate from the features.

Chapter 6 discusses the contributions of this project to the Menominee language revitalization program and concludes the dissertation.

Appendix I contains a list of the tokens and the associated F1 and F2 head and tail measurements I used as my dataset. Appendix II contains the vowels within the lexical items and phonetic environment and the associated formant frequencies.

Chapter 2: The Sound System of Menominee

In this chapter I discuss the sound system of Menominee, focusing on the previous work in understanding the phonetics and phonology of the language. As is shown throughout this dissertation, the patterning of allophony and vowel change processes in the production of the language provide insight into the underlying phonological system. In this chapter I first examine the already-established phonetic and phonological rules in Menominee, and then discuss how these rules affect an underlying hierarchy.

2.1. Menominee Orthography

This section presents the consonant (Table 2.1) and vowel (Table 2.2) inventories of Menominee.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Stop	p	t		k	ʔ
Fricative		s [s~š]			h
Affricate		č [ts~č]			
Nasal	m	n			
Glide	w		y		

Table 2.1: Menominee Consonants (Table from Milligan 2005:3)

Menominee conventional orthography diverges very little from Table 2.1. The alveolar fricative is spelled as *s*, the affricate as *c* and the glottal stop as *q*. In keeping with Algonquianist literature, I present the phonemes here in the Americanist system. All other consonants are spelled as they are represented in the IPA/Americanist chart. The segment within the square brackets represents phonetic variation in pronunciation.

Table 2.2 shows the vowel inventory for both the long and short monophthongs and diphthongs. The following few subsections will discuss these differences in greater detail.

	Short Vowels		Long Vowels	
	Front	Back	Front	Back
High	/i/	/u/	/i:/	/u:/
Mid	/e/	/o/	/e:/	/o:/
Low	/æ/	/a/	/æ:/	/a:/
Diphthong	/ya/	/wa/	/ya:/	/wa:/

Table 2.2: Menominee Vowels (Table from Milligan 2000; 2005:3)

Table 2.3 shows the IPA symbol and each corresponding orthographic symbol used in the tribally-preferred Menominee orthography.

	Short Vowels				Long Vowels			
	Front		Back		Front		Back	
High	/i/	<i>	/u/	<u>	/i:/	<ī>	/u:/	<ū>
Mid	/e/	<e>	/o/	<o>	/e:/	<ē>	/o:/	<ō>
Low	/æ/	<æ>	/a/	<a>	/æ:/	<āē>	/a:/	<ā>
Diphthong	/ya/	<ya>	/wa/	<wa>	/ya:/	<ia>	/wa:/	<ua>

Table 2.3: Menominee Phonemes and Orthography

In the rest of this dissertation, I use the Menominee tribally-preferred orthography for consistency between examples, and in keeping with orthographic use within the Menominee community. Specifically, for the underlying representations of Menominee examples using words and morphemes, I use the tribal orthography (see (1)). For rules of vowel or consonant alternations, I use the phonetic symbols (see (10)). For other prose description and discussion I include both the IPA symbol and the tribal orthography of the specific phoneme being discussed.

In Menominee orthography, long vowels are marked with a macron, so a short high front vowel is written as *i* (/i/) but the long high front vowel is written as *ī* (/i:/). The short low front vowel is spelled *ae* and the long is spelled *āē*, instead of with the IPA symbol /æ/ or /æ:/.

Bloomfield and modern Algonquianists use the symbol <æ> to represent a morphophoneme in Menominee that has different morphophonological interactions than the <ae> (Bloomfield 1962). (In this dissertation I do not include the morphophonemes in my analysis, and therefore

they will not be discussed in any detail here.) The short diphthongs are written *ya* /ya/ and *wa* /wa/ and the long diphthongs are written as *ia* /ya:/ and *ua* /wa:/.

2.1.1. Bloomfield's Orthography

The conventions of the Americanist system and modern Menominee orthography differ in a few small ways from Bloomfield (1962 and 1975). Bloomfield writes *ae* /æ/ as <ε>, as do other older resources on Menominee, which can be misleading.

In the early part of the 20th century, when Bloomfield was conducting his field work with the Menominee, there was little variation in what symbol was used to represent the low front vowel(s). Figures 2.1 and 2.2 from 1904 and 1932 respectively, show the IPA vowel inventories released by the International Phonetic Association (IPA) during the time frame Bloomfield worked on Menominee. In general, the IPA conventions of ε and æ do not appear to be very controversial at the time.

<i>Front</i>	<i>Mixed</i>	<i>Back</i>
i y	ɨ ʉ	ɯ u
ɪ ʏ		ʊ
e ø	ë ö	ɤ o
	ə	
ɛ œ	ɛ̃ ɔ̃	ʌ ɔ
	æ ɶ	
	a	ɑ

Figure 2.1: IPA Vowel Inventory 1904
(API 1904)

<i>Front</i>	<i>Central</i>	<i>Back</i>
i y	ɨ ʉ	ɯ u
e ø		ɤ o
	ə	
ɛ œ		ʌ ɔ
	æ ɶ	
	a	ɑ ɒ

Figure 2.2: IPA Vowel Inventory 1932
(API 1932)

In his writings on the Menominee language, Bloomfield uses ε to represent the short low front vowel. Bloomfield originally used the symbol ä, as were other Algonquianists at the time. By 1920 Bloomfield had shifted to the use of ε and wrote in a letter, “I like to use ε for ä, whether long or short” (Goddard 1987; Milligan 2000). Bloomfield & Bolling (1927) explicitly state that

he uses ε to represent the vowel in English *man*. In 1930, Bloomfield wrote a short article entirely in IPA and used ε in words such as *end* ‘and’, *ðet* ‘that’, and *εz* ‘as’ (Bloomfield 1930:27). When describing the sound changes from Proto-Algonquian to Menominee, Bloomfield (1946) describes ε and $\varepsilon\varepsilon$ in Menominee as “very open vowel[s]” (Bloomfield 1946:86).

The use of both ε and e phonetically would imply a tense/lax distinction in Menominee, rather than a height distinction between the two. While there may be phonetic tenseness in some of the vowels (Bloomfield 1962; Milligan 2005), there is little evidence suggesting that there is a tense/lax phonological contrast in Menominee vowels. This orthographic disconnect affects the usefulness of historical and current research on Menominee to community members and non-linguists. What has followed is a series of authors choosing to follow Bloomfield’s conventions (particularly the Algonquianists who work on historical language data such as Goddard, Costa, Rhodes, Thomason, etc.), where others have misinterpreted the target vowel as part of a tense/lax distinction (Cole 1987; Cole and Trigo 1988).

2.2. Vowels

Menominee has both short and long vowels. This section briefly discusses the vowel space as it is represented by an IPA chart. Chapter 4 of this dissertation presents acoustic measurements and compares them to these assessments, and Chapter 5 presents a proposed underlying hierarchical structure of the vowel system that aligns with the acoustic measurements and patterns of vowel alternations. Bloomfield describes the short vowels as follows:

“Short a, as in *kanapac* ‘perhaps,’ varies from the vowel of German *hat* to that of American English *nut*. The variants of the latter type occur especially before dentals, as in *kan* ‘no, not’, *nēmat* ‘my brother (man speaking)’. The open variants (resembling German short a) occur especially before q and h: *aqtaew* ‘it is there’, *ahkāēh* ‘kettle’. Initial a (except before q) is in part indistinguishable from o. In the first syllable of a word before t or n, the a is occasionally fronted so far as to coincide with e: *natōmāēw* ‘he calls him’, *manāētōw* ‘game animal’.

The same fronting is usually made in the final syllable *yan*, as in *sūniyan* ‘money’, *pīyan* ‘if I come; if thou comest’” (Bloomfield 1962:7).

“Short ae in its most characteristic form appears before h and q; in this position it is a very open vowel, more open than the vowel of English *pet* and resembling perhaps the Finnish short ä: *naeqnaeh* ‘my elder brother’, *maehkām* ‘he finds it’, *awāēhsaeh* ‘bear’. Variants with the higher coloring, tending toward Menominee e appear in the personal prefixes before h plus p, t, k, c: *naehpāēhkwan* ‘my back’, *naehtāwak* ‘my ear’, *naehkāt* ‘my leg’, *naehcēwāēwak* ‘my upper arm’.

Before nonsyllabics [consonants] other than q and h, the short ae ranges from about the timbre of the vowel in English *pet* all the way to that of the vowel in English *pit*; in these last variants the ae coincides with Menominee e: *aqsaen* ‘stone’, *nōhtawaew* ‘he hears him’, *aqsekaenam* ‘he picks it up’. The higher variants which coincide with e seem to be favored in rapid speech, and they seem in part to be favored by the occurrence of morphologically related forms with e,

such as *nāēhnet* ‘if he breathes’ by the side of *nāēhnaew* ‘he breathes’. This partial coincidence makes it sometimes hard to determine where ae rather than e is to be set up in normal forms” (Bloomfield 1962: 7-8).

“Short e, as in *pēhcehsen* ‘he falls in’, resembles the vowel of English *pit, pin*. It is the favorite short front vowel, and, in surface fluctuation, especially in rapid speech, widely replaces normal ae and i and in certain positions, even normal a After an initial nonsyllabic [consonant], e is almost in complementary distribution with ae After short vowel plus h or w the e has often a tenser and slightly lengthened variant, resembling ē: *mōnahekan* ‘field, farm’; *masēnahekan* ‘paper, book’; *wēyawekaeh* ‘old woman.’ In words which contain i, there is some tendency to assimilate e to this vowel: *atāwāēwikamek* ‘trading-house, shop, store’, with occasional i for e in the last syllable” (Bloomfield 1962: 8-9).

“Short i, as in *enāēniw* ‘man’, *nīmit* ‘if he dances’, *ācemit* ‘if he narrates’, resembles, in its characteristic form, the vowel of French *fini*: it is decidedly higher than the vowel of English *pit, pin*. When it is slurred and relaxed, however, it is lowered to this latter type and coincides with e. As in the case of ae, speakers differ as to the frequency of the characteristic variants” (Bloomfield 1962:9).

“Short o, as in *kohkāew* ‘he angles’, *mēkon* ‘feather’, resembles the vowel of English *put*. The relaxed variants are even opener and approach Menominee a. For the slurring of initial o, as in *okāw* ‘pike’, an overcompensation sometimes leads to rhetorical lengthening with a sound like *ō* instead of the weak o.... After short vowel plus h, the o often takes on a tense and longer sound: *paeqtahosow* ‘he hurt himself by accident’” (Bloomfield 1962:9).

“Short u, as in *pītuwaew* ‘he brings it to him’, resembles the vowel of French *tout*, but is perhaps lower and less tense” (Bloomfield 1962:9).

Bloomfield describes the long vowels as:

“Long *ā*, as in *nāpān* ‘on one side’, is usually produced farther back than the vowel of English *father*; it ranges rather from the vowel of French *pâte* to that of English *saw*. Variants of the latter type prevail between labials, as in *wāpekan* ‘clay’” (Bloomfield 1962:4).

“Long *āē*, as in *pāēc* ‘properly’, ranges from a vowel like that of French *tête*, through the type of English *bad*, to opener variants approaching the vowels of French *brave* and English *father*” (Bloomfield 1962:4).

“Long *ē*, as in *nēk* ‘my house’, resembles the vowel of German *Tee*, and, except for the English diphthongization, the vowel of English *pay*” (Bloomfield 1962:4).

“Long \bar{i} , as in $p\bar{i}w$ ‘he comes’, is like the vowel of French *rive* or German *tief* and, except for the English diphthongization, resembles the vowel of English *see*” (Bloomfield 1962:5).

“Long \bar{o} , as in $\bar{o}s$ ‘canoe’, is rounded, like the vowel of French *chose* or German *wo*; except for this full rounding and the lack of diphthongization it resembles the vowel of English *go*” (Bloomfield 1962:5).

“Long \bar{u} , as in $s\bar{u}niyan$ ‘coin’, resembles the vowel of French *blouse* or German *Hut*, and, except for the full rounding and the absence of diphthongization, the English vowel of *do*” (Bloomfield 1962:5).

In Table 2.4, Milligan synthesizes this discussion, showing the phonological vowel to the left and the reported allophonic variation on the right, within the brackets.

	<u>Short Vowels</u>				<u>Long Vowels</u>			
		Front	Back		Front	Back		
High	/i/	[i] [ɪ]	/u/	[ʊ]	/i:/	[i:]	/u:/	[u:]
Mid	/e/	[i] [ɪ] [ɛ]	/o/	[o] [ʊ] [ə]	/e:/	[e:]	/o:/	[o:]
Low	/æ/	[ɪ] [ɛ] [æ]	/a/	[a] [ʌ] [ə]	/æ:/	[æ:]	/a:/	[a:] [o:]
Diphthong	/ya/	[yə] [yɪ]	/wa/	[wə] [ʊ]	/ya:/	[io] [ia] [iə]	/wa:/	[u:] [uə]

Table 2.4: Menominee Vowels and Allophones (Table from Milligan 2000; 2005:3)

This table includes the long and short diphthongs, which will be discussed in greater detail below, as well as in the following chapters. In this table Milligan appears to suggest that the

glide or first target of the short diphthong is an onglide where the first target of the long diphthong is a vowel.¹

2.2.1. Short Monophthongs

As Table 2.4 indicates, descriptive records of the short vowel system show evidence that the high vowels /i, u/ have less variation than the mid and lower vowels. However, as we can see with the discussion of the low front vowel, various records may have a different report on the vowel allophony. The short vowels are: /i, e, æ, a, o, u/ with a front/back, and high/mid/low distinction. The vowel inventory is listed here in Menominee tribal orthography, and all representations of the vowels are consistent with their IPA counterparts, except *ae* /æ/, as discussed above.

2.2.2. Long Monophthongs

The long vowels in Menominee have the same inventory as the short vowels: /ī, ē, āē, ā, ō, ū/.

Unlike the short vowels, past analysis of Menominee vowels has indicated that the long vowels have very little allophonic variation, with the exception of the low back vowel *ā* /a:/. The discussion surrounding the *āē* /ae:/ indicates that there may be more variation than Table 2.4 indicates. This too is an analysis that is examined in more detail in later chapters.

2.2.3. Diphthongs

Menominee also has four paired diphthongs: /ya, ya:, wa, wa:/. They are divided into front and back, and short and long. The front diphthongs are *ya* /ya/ and *ia* /ya:/ and the back are *wa* /wa/

¹ It is worth noting that only post-consonantal glide+a is considered a diphthong. As is discussed further below and in great detail in Chapter 5, post-consonantal glide+any other vowel undergoes alternation and vowel hiatus.

and *ua* /wa:/. These diphthongs are also divided by length: short, *ya* /ya/, *wa* /wa/; and long, *ia* /ya:/, *ua* /wa:/.

Diphthongs are vowels with two different targets. They begin in one vowel space and end in another (Ladefoged and Maddieson 1996:321). In languages with contrastive short and long vowels, diphthongs are typically expected to pattern with the long vowels, with a comparable length (as Baal et al. (2012) note for North Saami). Chapter 4 examines this length claim and compares the long and short diphthongs to the long and short monophthongs.

Bloomfield analyzes both the short and the long diphthongs as a combination of a glide plus a vowel, so the underlying representation of the long diphthongs, according to Bloomfield, are /yā/ and /wā/, for *ia* and *ua* respectively.² He indicates that the short and long diphthongs at least pattern with the short and long monophthongs in that they participate fully in the vowel lengthening and shortening rules; they are not exceptions to the rules. Short *wa* will lengthen to *ua* and short *ya* will lengthen to *ia*. Chapter 4 compares the durations of the diphthongs and monophthongs.

2.3. Previous Work on Menominee Phonetics and Phonology

Menominee is an understudied language and as a result does not have a large amount of previous work looking at the vowel system. The main researchers who have worked on the Menominee language have been Bloomfield, Miner, Macaulay, and Milligan, spanning nearly a century.

This dissertation is only the second to look at Menominee vowels acoustically. Previous work has focused on phonology, morphology, and syntax (Bloomfield), morphology, morphosyntax, syntax, and semantics (Macaulay) and phonology (Miner, Milligan).

² This underlying analysis plays a role in some of the phonological rules, discussed later in this section.

Bloomfield conducted field work with native speakers of Menominee during the 1920s, published collected bilingual Menominee-English stories (1928) and after his death his various writings were compiled to publish a Menominee grammar (1962) and a lexicon (1975), both edited by Hockett. He worked without the aid of recording devices or modern databases, and developed a deep understanding of complex Menominee morphological and phonological phenomena. Bloomfield's analysis is still cited as the most comprehensive and accurate record of the Menominee language. Subsequent researchers have conducted analyses, some confirming Bloomfield's accuracy, some modifying it, and some correcting small errors, but ultimately Bloomfield's work is the foundation of our modern understanding of Menominee.

The Great Lakes Inter-Tribal Council (GLITC) developed the Wisconsin Native American Languages Project (WNALP) (originally the Pilot Linguistics Project in Native American Languages in Wisconsin) in the early 1970s, funded by Title IV of the Indian Education Act (UW-Milwaukee Libraries, Archives). Miner was hired to conduct linguistic recordings and produce language education materials in Menominee. The recordings cover 1973-1976 in which three native speakers worked with Miner. This audio represents an invaluable historical record of the spoken language, as there are very few recordings that are older (a few recordings from the 1980s with linguist Tim Guile are housed by the Menominee Language and Culture Commission, and the occasional personal tape cover the extent of known recordings that predate the WNALP recordings in Menominee).

Miner (1981) discusses Bloomfield's vowel lengthening and shortening descriptions for Menominee. This publication contains the first instantiation synthesizing and 'naming' the vowel shortening and lengthening rules. The two vowel lengthening and shortening rules are typologically unexpected (Maddieson 1985:212-213) and as a result, they are often used as test

cases for various phonological theories, a survey of which will be presented in the next chapter alongside the discussion of the framework of this current dissertation.

Macaulay currently works with the Menominee community supporting the language preservation and revitalization programs. She has published a variety of detailed analyses of Menominee morphology, syntax, discourse, and synchronic and diachronic processes. Macaulay has also developed a digital dictionary and morphological database containing Bloomfield's analyses of underlying forms and examples from texts, as well as audio files, metalinguistic information from elders and community members, and examples provided by modern native speakers. This database is often used by younger members of the Menominee community, especially the language instructors and instructors-in-training for reference and revitalization efforts. It also includes supplemental Menominee language information and audio beyond that provided by the grammar (Bloomfield 1962). All the audio consulted for this dissertation project either came from the database, was identified from older tapes, or was recently elicited, and has since been added to the database as a result of this project.

Milligan (2005) shows through acoustic analysis that the vowel lengths described by Bloomfield (1962) are for the most part accurate—what Bloomfield claims are long vowels measure on average longer than the vowels Bloomfield recorded as short vowels (270ms vs. 183ms). This is a statistically significant duration difference. However, this is an average, and within a word or phrase, vowel length can sometimes be more variable (Milligan 2005). Milligan examines vowel duration and how it correlates with stress (primary stress for long vowels averages 152.6ms, secondary stress for long vowels averages 134.1ms. Secondary stress for short vowels averages 88.3ms and short vowels with no stress average 78.4ms—all of which are statistically significant differences from each other), and compares this to previous prosodic

analyses and Bloomfield's description of Menominee stress (Milligan 2005:102-103).

Milligan's work confirming Bloomfield's underlying analyses of vowel length offers support for following those same analyses in my study of Menominee vowel length.

2.4. Vowel Rules

Menominee has many phonetic and phonological rules affecting the surface behavior of the vowels. Bloomfield (1962) discusses each of these variations in great detail. For the purposes of this dissertation, I try to account for the majority of the vowel alternations, though I do not claim to present a comprehensive list. The following few sections will present the vowel phenomena primarily based on Bloomfield's early work on Menominee. I briefly touch on the implications of these rules for a feature hierarchy framework, but a more detailed analysis of how these rules affect the underlying hierarchy can be found in Chapter 5. For now, this section serves to introduce the complex and variable Menominee vowel behavior.

2.4.1. Vowel and Glide Alternations

Menominee does not allow vowel clusters. When a person prefix, each of which ends in a vowel, is affixed onto a stem that begins with a vowel, an epenthetic *t* is inserted. The following table summarizes what happens when two vowels meet at all other morpheme boundaries:

Vowel #1	+ Vowel #2	Outcome		
Long vowel (\bar{V})	Long vowel (\bar{V})	Epenthetic y	$\bar{V}_1 + \bar{V}_2 = \bar{V}_1y\bar{V}_2$	Except \bar{a} ($\bar{a}+\bar{a}=\bar{a}$)
Short vowel (V)	Long vowel (\bar{V})	Long vowel	$V_1 + \bar{V}_2 = \bar{V}_2$	
Long vowel (\bar{V})	Short vowel (V)	Long vowel	$\bar{V}_1 + V_2 = \bar{V}_1$	
Short vowel (V)	Short vowel (V)	2 nd short vowel	$V_1 + V_2 = V_2$	

Table 2.5: Vowels in combination at morpheme boundaries (Bloomfield 1962:82-83)

Table 2.5 shows that when two long vowels are in a sequence at morpheme boundaries, an epenthetic *y* /*y*/ is inserted between the two (1a), except for \bar{a} /*a:*/ + \bar{a} /*a:*/ which remains as a single \bar{a} /*a:*/.³ If a short and a long vowel are in a sequence, the long vowel prevails and the short vowel is deleted, regardless of whether it comes first (1b) or second in the sequence (1c⁴). When two short vowels are in a sequence, the second vowel remains and the first is deleted.

(1) Vowel hiatus at morpheme boundaries

- a. kaese-ap-ahaew → [keseyapahaew] ‘he or she wipes his or her eyes for him or her’
 b. mo-aehkon-aeuw → [mohkonaew] ‘he or she whittles it (animate)’
 c. none-akan → [nonanakan] ‘nipple, breast’

Postconsonantal glides plus vowels often change in the surface form as well. This plays a role in how the glides are represented in the underlying hierarchy, especially regarding features such as *labial* and feature spreading to the vowels. Table 2.6 summarizes the *Cw* + *V* alternations and *Cy* + *V* alternations where capital *C* stands for any (non-glide) consonant.

1	<i>Cw</i>	+	<i>ae, o</i>	→	<i>Co</i>		9	<i>Cy</i>	+	<i>o</i>	→	<i>Co</i>
2	# <i>w</i>	+	<i>ae / #__</i>	→	# <i>o</i>		10	<i>Cy</i>	+	<i>ae</i>	→	<i>Ce</i>
3	<i>Cw</i>	+	$\bar{a}\bar{e}, \bar{i}$	→	<i>C</i> \bar{i}		11	<i>Cy</i>	+	$\bar{a}\bar{e}, \bar{i}$	→	<i>C</i> \bar{i}
4	<i>Cw</i>	+	<i>e, i</i>	→	<i>Ci</i>		12	<i>Cy</i>	+	<i>e</i>	→	<i>Ci</i>
5	<i>Cw</i>	+	<i>e / __w</i>	→	<i>Cow</i>							
6	<i>Cw</i>	+	$\bar{e},$	→	<i>C</i> \bar{o}		13	<i>Cy</i>	+	\bar{e}	→	<i>C</i> \bar{e}
7	<i>Cw</i>	+	<i>a</i>	→	<i>Cwa</i>		14	<i>Cy</i>	+	<i>a</i>	→	<i>Cya</i>
8	<i>Cw</i>	+	\bar{a}	→	<i>Cw</i>\bar{a}		15	<i>Cy</i>	+	\bar{a}	→	<i>Cy</i>\bar{a}

Table 2.6: Glide + Vowel alternations (Bloomfield 1962:84-85)

Notice that in his analysis of glide + vowel alternations, Bloomfield shows the low back vowels (*a, ā*) only as part of the diphthong /*ya, yā, wa, wā*/ (in bold in Table 2.6). The exception is that

³ I could not find any examples of this that did not involve a diphthong.

⁴ This was the only example I could find with the long vowel second, and it comes directly from Bloomfield's discussion of the phenomenon (Bloomfield 1962:83).

in rapid speech, *wa* is often shortened to *o* (Bloomfield 1962:13) and postconsonantal *wa* becomes *o* “whenever the endings -ak or -an are involved (Bloomfield 1962:84). This irregularity will be discussed in more detail in Chapter 5.

Example (2) shows a few of these glide+vowel alternations:

(2) Glide+vowel alternations

- | | | | |
|--------------------------|---------------------------|---------------------------|----------------------|
| a. cēp-āhk <u>w</u> -e-w | → [cēpāhkow] | ‘he or she cooks’ | (Cw + e / __w → Cow) |
| b. pēkw-aeskā-w | → [pēk ^o skaw] | ‘it breaks up, is broken’ | (Cw + ae → Co) |
| c. kaen <u>w</u> -āēs/ | → [kenīs] | ‘for a long time’ | (Cw + āē → Cī) |

Example (2a) shows C + w + e when preceding a word-final w results in C + o + w. Example (2b) shows C + w + ae when preceding a word-final w results in C + o. Example (2c) shows a C + w + āē when preceding a word-final w results in C + ī.

2.4.2. Lengthening and Shortening

Menominee has very complex vowel lengthening and shortening rules. There are four main vowel lengthening and shortening rules in Menominee.⁵ The vowel length rules are understood based on the metrical structure of Menominee and the interactions of supra-segmental elements such as syllables and feet. Milligan (2005) shows that “heavy syllables get primary stress which correlates with high pitch” (2005:i), even if there are multiple heavy syllables in the word, and pitch is used to mark word boundaries with a rising pitch in the first syllable (2005:158).

Syllables are either open (no coda or post-vocalic consonant) or closed (post-vocalic consonant), and either heavy (long vowel) or light (short vowel). This results in a two-part

⁵ Not all words in Menominee undergo vowel lengthening and shortening. Most particles, pronouns, preverbs and pre-nouns do not follow expected lengthening rules. With very few exceptions, nouns and verbs do follow all expected vowel length rules.

description of each syllable, with four possible syllable types, in which a syllable is either *light and open*, *light and closed*, *heavy and open*, or *heavy and closed*. An instance of each type of syllable can be seen in the following tables. For example, the first syllable of *anāēm* ‘dog’ in the first line is both open and light.

Syllable Type	Specific	Example	
Open syllable	V	<u>a</u> -nāēm	‘dog’
	CV	<u>ke</u> -nēw	‘eagle’
	\bar{V}	<u>ā</u> -mōw	‘bee’
	$C\bar{V}$	<u>wā</u> -pos	‘rabbit’
Closed syllable	VC	<u>aq</u> -se-kan	‘bass’
	CVC	<u>kah</u> -kīk	‘chipmunk’
	$\bar{V}C$	<u>āeh</u> -se-pan	‘raccoon’
	$C\bar{V}C$	<u>kēs</u> -pen	‘if’

Table 2.7: Open and Closed Syllables (Table from Macaulay 2018:21)

In Table 2.7, the open syllables end in a vowel with no consonant coda, and the closed syllables have a consonant as the coda. Any consonant from Table 2.1 can be a coda, including *y* /y/ and *w* /w/. In Table 2.8 the light syllables are short vowels and the heavy syllables are long vowels.

Syllable Type	Specific	Example	
Light syllable	V	<u>a</u> -nāēm	‘dog’
	CV	<u>ke</u> -nēw	‘eagle’
	VC	<u>aq</u> -se-kan	‘bass’
	CVC	<u>kah</u> -kīk	‘chipmunk’
Heavy syllable	\bar{V}	<u>ā</u> -mōw	‘bee’
	$C\bar{V}$	<u>wā</u> -pos	‘rabbit’
	$\bar{V}C$	<u>āeh</u> -se-pan	‘raccoon’
	$C\bar{V}C$	<u>kēs</u> -pen	‘if’

Table 2.8: Light and Heavy Syllables (Table from Macaulay 2018:21)

Menominee feet are counted based on the weight, or vowel length contained in the nucleus of the syllable (Heavy (H) or Light (L)). The allowed feet in Menominee are: LH, H, LL, and L*.

Menominee is considered an iambic language (Hayes 1995; Milligan 2005) with disyllabic right-headed feet, though monosyllabic feet are also allowed.

The L* foot is a degenerate foot. It is typologically rare in the world’s languages and is only allowed in Menominee in the final syllable of the word if it is the only syllable remaining to be footed (Milligan 2005).

The following table shows the four main vowel length rules in Menominee, all of which are dependent on the footing and syllable weight and coda.⁶

Rule		
Second Syllable Lengthening	SSL	Word must have an initial light-heavy foot (LH) or a single heavy foot (H)
*Even Syllable Lengthening	ESL	The head of a disyllabic foot must contain a long vowel if the syllable is closed
*Even Syllable Shortening	ESS	The head of a disyllabic foot must contain a short vowel if the syllable is open
Post-Cluster Shortening	PCS	An open syllable which follows a closed syllable must contain a short vowel

Table 2.9: Menominee Vowel Length Rules (Table from Milligan 2005⁷)

In this table, the two rules with an asterisk, ESL and ESS, are typologically rare among the world’s languages – known as “crazy rules” (named by Bach & Harms 1972.) because they are the inverse of phonetic cross-linguistic tendencies (Miner 1981; Milligan 2005).

Words that have a glottal stop (*q* /ʔ/) in the initial light syllable, ‘glottal words,’ do not follow SSL or PCS. Glottal words contain a short vowel followed by a glottal stop in the *first* syllable of the word. Both these conditions must be met for a glottal word to block the SSL or PCS rules (Bloomfield 1939, 1962). Examples (3)-(6) demonstrate glottal ((3)-(4)) and non-glottal ((5)-(6)) words:

⁶ There is one final vowel length rule that is not of great importance to this project, but discussed at length by Miner (1975) and Milligan (2005). This rule applies to a disyllabic foot in the word that is the final foot. Menominee words end in a C, but instead of ESL applying, the vowel is instead shortened. Milligan (2005) shows that this is an extrametrical syllable.

⁷ These rules were first described by Bloomfield in his work on Algonquian languages (Bloomfield 1939, 1962), codified into unified rules by Miner (1981); and further developed by Milligan (2005).

- (3) aqcekātāēw
‘it is placed, put in a place’
- (4) aqnap
‘spider web’
- (5) enāqtuwaew
‘he or she places it so for him, her, it (an.)’

In (3) and (4), the second syllable remains light because the light first syllable contains a glottal stop coda, which blocks SSL.

Howard (1973) proposes the glottal stops in the initial syllable lengthen the vowels which prevents glottal stops from blocking SSL as SSL does not occur when the first syllable is long. However, as can be seen in (6), as well as (5) above, in words with a glottal stop in the first syllable, the first vowel can be either long or short, regardless of the presence of the glottal stop. Miner (1990) and Milligan (2005) reject Howard’s approach for being ad hoc and working with incomplete, and at times incorrect, data.

- (6) āqtiḥnetāw
‘he or she leans it on something’

As the discussion throughout the rest of this chapter shows, the first syllable is not the only environment where glottal stops block or affect vowel rules or alternations (for example, *ae*-Raising). It is possible the glottal stops add weight to the syllable without affecting vowel length, which could account for some of the patterns discussed here. Further work on this subject is needed, for as Milligan says, “the distinction between glottal and non-glottal words has not been satisfactorily accounted for in any analysis” (Milligan 2005:50).

This glottal stop interference causes issues for prosodic and feature frameworks of Menominee vowel lengthening, because glottal stops in other positions throughout the word

have no effect on the lengthening or shortening rules. Additionally, glottal stops do not block other rules in the same position (see example (7)). Example (5) shows normal SSL because the glottal stop is not in the coda of the first syllable.

The following examples show the rules in action: the underlying and surface forms before and after a vowel lengthening or shortening process has occurred.

(7) Even Syllable Shortening (ESS)

[koqtapāēwāēw] 'he is afraid of people, shy'

koqtāpāēwāēw

(koq. tā.)	(pāē.)	(wāēw)	ESS →	(koq. ta.)	(pāē.)	(wāēw)
L H H H				L L H H		

Example (7) shows Even Syllable Shortening. The second syllable is underlyingly heavy.

Normally, this would be expected to be long due to Second Syllable Lengthening, however, the first syllable has a glottal stop as the coda, therefore, SSL does not play a role in this word. ESS is not blocked by a first syllable glottal stop coda, so now the environment triggers ESS since SSL does not apply. The underlyingly heavy, open syllable as the head of the foot surfaces light.

(8) Second Syllable Lengthening (SSL), Even Syllable Lengthening (ESL)

[ahpāketāēqnaen] 'it is blown onto something'

ahpaketaeqnaen

(ah. pa.)	(ke.taeq.)	(naen)	SSL →	(ah. pā.)	(ke. taeq.)	(naen)
L L L L L				L H L L L		
			ESL →	(ah.pā.)	(ke. tāēq.)	(naen)
				L H L H L		

Example (8) shows what happens with the triggering environment of two rules in the same word:

Second Syllable Lengthening (SSL) and Even Syllable Lengthening (ESL). SSL requires the second syllable to be long if the first is short and not blocked by a glottal stop. That trigger is present in (8). In the next foot, ESL causes the head of an underlying closed light foot to surface

(11) *ae* Raising examples

- | | | |
|----------------------------|----------------|--|
| a. <u>a</u> esp-ahkīw | → [ɛspāhkiw] | ‘hill, high place in the land’ |
| b. p <u>a</u> em-e-cemāē-w | → [pɛmēcemaew] | ‘he, she, it (an.) paddles, swims on, along, past’ |
| c. s <u>e</u> k-aepī-qNaen | → [sīkɛpīqnɛn] | ‘there is a pouring rain’ |
| d. naeq <u>a</u> ew | → [naeqnaew] | ‘he or she kills him or her’ |

In examples (11a)-(11c), the underlined sequence in the left-most column shows the target environment for the *ae* Raising Rule to occur, with the raised final pronunciation shown in the middle column, also with the target segment underlined. Example (11d) shows the *ae* /æ/ in the initial syllable not raising to *e* /e/ because it is followed by the glottal stop *q* /ʔ/+C and the *ae* /æ/ in the second syllable does not raise because it is followed by a *w* /w/.

Example (12) shows *ae* Raising on an inflected and uninflected word, where inflection affects the triggering environment for the raising. In (12a), the underlying *ae* /æ/ in the first vowel is raised, as it is in the raising environment, as expressed in example (10) above. (12b) shows the same root, but with a first person prefix, showing *ae* when it is no longer in the first syllable (10b), and therefore not raised.

(12) *ae* Raising on an inflected and uninflected word

- | |
|--------------------------------------|
| a. p <u>e</u> kēw |
| p <u>a</u> ek-ew |
| ‘gum (of a tree), rosin, pitch, sap’ |
|
 |
| b. nep <u>a</u> ekiam |
| ne-p <u>a</u> ek-iam |
| ‘my rosin’ |

These examples support the analysis of the initial *e* /e/ vowel as underlyingly *ae* /æ/ (Bloomfield 1962). Also note that SSL occurs after the vowel alternation.

2.4.4. *e* Epenthesis

Menominee has one vowel epenthesis rule: *e*-epenthesis. The *e* /*e*/ is inserted at morpheme boundaries between two consonants. Menominee allows two consonants to cluster at syllable boundaries, but not when two morphemes are affixing. Syllable and morpheme boundaries are not always the same. Below is an example of vowel epenthesis in Menominee, with the epenthesized vowel in bold and underlined (Bloomfield 1962; Macaulay 2018):

(13) *e*-epenthesis

wāpemen
 wāp- -men
 white -berry, fruit, grain
 ‘corn’

(14) *e*-epenthesis and syllable boundaries

a. āhsepan
 āhs- -pan
 raccoon -N.final
 ‘raccoon’

b. āhsepan
 āh.se.pan

(13) shows *e*-epenthesis between two consonants at a morpheme boundary, as stated in the rule above. Example (14) shows the difference between consonant clusters at morpheme boundaries as opposed to syllable boundaries (which are discussed in 2.4.2 above). *e*-epenthesis only occurs at the morpheme boundary. (14a) shows that the initial morpheme ends with two consonants *hs* /*hs*/ and the second morpheme, the noun final (N.final)⁸, begins with a consonant. (14b) shows the syllable boundaries for āhsepan ‘raccoon’, showing that consonant clusters are allowed across syllable boundaries (14b), but not across morpheme boundaries (14a).

⁸ Menominee words are made up of three derivational morphemes: roots, medials (which are optional), and finals. See the works of Bloomfield, Goddard, and Macaulay for more detailed information on Menominee morphology.

2.4.5. Vowel Harmony

Menominee Vowel Harmony raises long mid vowels to long high vowels and pre-glottal short *o* /o/ to short *u* /u/ when followed later in the word by a high vowel or diphthong, unless *ae* /æ/ or *āe* /æ:/ occurs between the target (*ē* /e:/, *ō* /o:/, or *oq* /oʔ/) and the trigger (*i* /i/, *ī* /i:/, *u* /u/, *ū* /u:/, *Cy*, or *Cw*). *a* /a/ is transparent to the Vowel Harmony: it does not raise, it does not block, and it does not trigger the rule. This rule is represented in (15) (Bloomfield 1962; Macaulay 2018).

(15) Vowel Harmony Rule

/e:/ → [i:]	}	/ __ (...) {i, i:, u, u:, Cy, Cw} UNLESS <i>ae</i> /æ/ or <i>āe</i> /æ:/ intervenes
/o:/ → [u:]		
/oʔ/ → [uʔ]		

Since Menominee diphthongs are analyzed as underlyingly a glide plus the low back vowel, the Vowel Harmony Rule in (15) includes both the long *ia*, *ua* /ya:, wa:/ and short *ya*, *wa* /ya, wa/ diphthongs (Bloomfield 1962). Example (16a) shows vowel harmony in a word with a monophthong triggering the harmony, (16b) and (16c) shows a word with a diphthong *ia* /ya:/, and *wa* /wa/ triggering vowel harmony. (16d) shows vowel harmony on the initial *oq* /oʔ/. (16e) shows vowel harmony blocked by *ae* /æ/ (in bold). (16c) and (16f) show vowel harmony skipping over both *a* /a/ and *ā* /a:/.

(16) Menominee Vowel Harmony Examples

a. <i>sēk-anī-hsenāe</i>	→ [sīkanīhsen]	‘he/she has a hemorrhage’
b. <i>anēpy-āhkan</i>	→ [anīpihkan]	‘leaf; cabbage, lettuce’
c. <i>kēs kah-āhkwan</i>	→ [kīskahāhkwan]	‘logging’
d. <i>oqsaskw-akom</i>	→ [uqsās kwakom]	‘muskrat skin’
e. <i>kēwaskaepīw-ahamāsi-w</i>	→ [kēwaskaepīwahamāsow]	‘he/she sings a drunken song’
f. <i>kēs kah-āhkwan</i>	→ [kīskahāhkwan]	‘logging camp’

It is important to keep in mind that *ae* /æ/ and *āē* /æ:/ block a height-spreading feature rule, which will be discussed in further detail in Chapter 5.

2.5. Relevant Consonant Patterns

There are also a few consonantal phonological rules and other consonant interactions with vowels that are relevant to the analysis presented here. These rules involve vowels as part of the triggering environment or have consonants serving to block the vowel rules presented in §2.4, and as such, are relevant to the hierarchical analysis presented in Chapter 5. This section will cover the consonant rules that have vowels as a key triggering environment and the consonants that crucially block several vowel rules.

2.5.1. Palatalization

Menominee t-palatalization occurs before *e* /e/, *ē* /e:/, and *y* /y/. This is highly atypical in the world's languages. Cross-linguistic studies of palatalization show that often when “coronals palatalize then so do dorsals” (Bateman 2011:592). In other words, if *t* /t/ (coronal) as the target palatalizes, then often *k* /k/ (dorsal) will palatalize as well. It is less common, but occasionally a dorsal will palatalize without a coronal palatalizing (Chen 1973; Bateman 2007, 2011; Kochetov 2011). In Menominee, only *t* /t/ palatalizes, not *k* /k/. For the trigger of palatalization, cross-linguistic studies have consistently concluded that “if a language only has one vowel trigger, this vowel should be /i/” (Bateman 2011:596; Halle 2005; Hall et al. 2006; Bateman 2007; Kochetov 2011). The second-most common trigger is *y* /y/ (Bateman 2011). In fact, the universal has been proposed that if /y/ triggers palatalization, then /i/ must as well (Hall & Hamann 2006; Bateman 2011). Similarly, if lower front vowels trigger palatalization, it is only if the high front vowel

also triggers it (Bateman 2011; Kochetov 2011). Most importantly, cross-linguistic patterns predict that “we should not expect to find languages where the mid front vowel /e/ triggers palatalization while /i/ does not” (Bateman 2011:598). The Menominee palatalization rule is presented in (17). (18) shows one example of palatalization, and several without (Bloomfield 1962; rule formulation from Macaulay 2018:16).

(17) Palatalization rule

$t \rightarrow c / __ \{e, e:, y\}$

(18) Palatalization examples

a. ahpēht- e -qtā-w	→ [ahpēhceqtaw]	‘he, she, it (an) moves, works so fast’
b. ahpēht-yāhk-am	→ [ahpīhciahkam]	‘he or she deals with it to that point’
c. mamātāw-āpaht-am	→ [mamātāwāpahtam]	‘he or she looks upon it as miraculous’
d. akwāt-ikamekw	→ [akuatikamek]	‘roof’
e. naekot-āēs	→ [nekōtāēs]	‘all at once, suddenly’
f. awāētok-ēwe	→ [awāētokew]	‘he or she has spiritual power’

In (18a), the epenthetic *e* triggers palatalization in *ahpēhceqtaw*. In (18b) the diphthong *ia* /ya:/ triggers palatalization in *ahpīhciahkam*. Examples (18c)-(18f) show that *ā* /a:/, *a* /a/, *i* /i/, *āē* /æ:/, and *o* /o/ do not trigger palatalization. (18d) shows that *i* /i/ does not trigger palatalization. Thus, palatalization must be accounted for in the feature geometry framework discussed in Chapter 5.

Menominee has a consonantal morphophoneme, *N* /n/, that alternates between [n] and [s] at morpheme boundaries where the phoneme *n* /n/ does not exhibit these alternations. The rule in Menominee that addresses the alternations of the morphophoneme *N*, is shown in (19) (Bloomfield 1962:81).

(19) *N* Morphophoneme Rule
$$N \rightarrow s / ___ \{e, e:, y\}$$
(20) *N* Morphophoneme examples

- | | | | | |
|----|----------------|---|--------------|---|
| a. | sak-āqN-e-n-am | → | [sakāqsenam] | ‘he or she lights it’ |
| b. | tapā-N-āēw | → | [tapānāēw] | ‘he or she tries to keep him, her, it (an)’ |
| c. | kaen-ew | → | [kenēw] | ‘eagle’ |

(20a) shows the *N* [n] morphophoneme becoming *s* in front of *e* /*e*/. (20b) shows *N* [n] unchanged before *āē* /*æ*:/ . (20c) shows *n* [n] remaining [n] before *ē* /*e*:/ . The *N* is considered a morphophoneme because the alternation with *s* is at morpheme boundaries and thus has a morphological element to the phenomenon. This triggering environment is the same as that of palatalization, lending further evidence that the mid front vowels and *y* /*y*/ form a natural class distinct from the high front vowels.

2.5.2. Glottal Effects on Vowels

The two glottal phonemes in Menominee, *h* /*h*/ and *q* /*ʔ*/, frequently affect some of the vowel rules discussed above. The glottal stop blocks SSL in the first syllable of the word, but does not block the other lengthening and shortening rules elsewhere in the word (shown in (7) and (8) above). These two also block *ae*-raising (shown in (11d)). It is also worth noting that the glottal stop allows the short *o* to participate in Menominee Vowel Harmony (shown in (16c)). These glottal phones indicate the relevance of laryngeal features to vowels as well as the traditional vowel features.

2.6. Conclusion

This chapter presented a subset of the best-known vowel and consonant alternation rules in Menominee, as well as how vowels interact with glides, consonants, and other vowels in sequence. These alternations must all be accounted for within the framework of distinctive features and an underlying phonological vowel hierarchy of features that is presented in Chapter 5.

This chapter has also reviewed Menominee vowel lengthening and shortening rules. These rules are famously complex and an analysis of Menominee vowels would be incomplete without addressing vowel length. Chapter 4 examines Menominee vowels through a quantitative and qualitative lens, and vowel duration is a part of that analysis as well. Chapter 5 proposes an underlying feature hierarchy for Menominee. The hierarchy needs to allow sets of vowels to share the appropriate nodes and branches to allow groups to inhibit or trigger alternation rules. For example, (17) and (19) show that the proposed hierarchy must allow *e* /e/, *ē* /e:/, and *y* /y/ to form a set within a branching node that is distinct from other front or mid vowels.

Chapter 3: Acoustic Phonetics and Generative Phonology of Menominee

This chapter presents background on acoustic phonetics of Menominee and the generative phonological framework that I follow in this dissertation. Section 3.1 discusses the previous acoustic analysis of Menominee vowels that I partially replicate and expand upon and 3.2 presents the framework I will be working in for the phonological analysis of Menominee vowels.

3.1. Background on Menominee Acoustic Phonetics

There have been many attempts to account for Menominee vowel lengthening and shortening in various metrical theories. What makes Menominee unique is the ESS and ESL rules discussed in the previous chapter. It is typologically rare to have lengthened vowels in a closed syllable (ESL) and a shortened vowel in an open syllable (ESS) (Maddieson 1985).

In this section, I present two studies on Menominee vowels. Miner (1975) reanalyzes the underlyingly contrastive length system as an underlying stress system with only phonetic vowel lengthening rules. Milligan examines the acoustics of Menominee vowels and syllables.

3.1.1. Miner 1975

Miner (1975) presents rule interference relations in Menominee through an analysis of Menominee stress and vowel length. An interference relation occurs when two rules could be applied in two different orders. Miner predicts that “whenever a pair of rules stands in an interference relation for some input I, their order of application is predictable by general principles rather than having to be language-specifically stated” (Miner 1975:6). Additionally, “for any two rules R_1 and R_2 , it will never be necessary to allow one to apply at the expense of the other, unless the inputs of the two rules are contiguous” (Miner 1975:24).

Miner shows that surface vowel length in Menominee is predictable in some environments, listed in (1). This is contrasted with other instances of Menominee vowel length that is not predictable, and therefore represents contrastive underlying vowel length.

(1) Predictable Phonetic Vowel Length (Miner 1975:52-61)

- a. after a cluster in an open syllable
short vowel
rule: Post Cluster Shortening (PCS)
- b. the second syllable of a non-glottal word
long vowel
rule: Second Syllable Lengthening (SSL)
- c. in monosyllables
long vowel
- d. in an even-numbered syllable counting from the next preceding long vowel in non-glottal words and counting from the beginning of a glottal word
long vowel before a cluster
short vowel before a single consonant
rule: Even Syllable Rule (ESR)

ESR corresponds to the Even Syllable Lengthening and Even Syllable Shortening Rules presented in Chapter 2, which includes the unexpected pattern of the final closed syllable in a word becoming shortened. Miner turns to stress assignment in Menominee as an alternative analysis that addresses glottal words, the exceptional pattern of vowels becoming shortened in an open syllable (half of ESR), and the issue of the final shortened syllable in this formulism. Bloomfield (1962) applies Menominee stress rules after lengthening and shortening rules have applied. Where Bloomfield has assumed underlying length as playing a contrastive prosodic role in Menominee vowels, Miner (1975) instead suggests it is stress that is contrastive. Miner proposes reanalyzing length rules as stress adjustment rules. These stress-based rules are shown in (2)-(8).

(2) Post-Cluster Destressing (formerly Post Cluster Shortening; Miner 1975:89)

$$\begin{bmatrix} V \\ 1 \text{ stress} \end{bmatrix} \rightarrow [-\text{stress}] / \text{CC_CV}$$

In (2), a vowel with primary stress becomes de-stressed in an open syllable.

(3) Second Syllable Stress (formerly Second Syllable Lengthening; Miner 1975:89)

$$V \rightarrow [+stress] / \# C_0 \begin{bmatrix} V \\ -stress \end{bmatrix} [-glottal]_0 \text{ ___}$$

In (3) the second syllable is stressed as long as no glottal intervenes between the word-initial unstressed vowel and the second syllable.

(4) Even Syllable Rule (Even Syllable Lengthening & Even Syllable Shortening from Chapter 2; Miner 1975:89)

$$V \rightarrow [\alpha \text{ stress}] / \begin{bmatrix} V \\ -stress \end{bmatrix} C_0 \text{ ___ } C [-\alpha \text{ syll}]$$

(4) is a rightward directional stress rule. It says that a vowel gets a stress specification (either + or -) when it follows a destressed vowel in the previous syllable and precedes a syllable with the opposite specification (- or +) of the vowel undergoing stress change.

(5) Lengthening of Stressed Vowels

$$\begin{bmatrix} V \\ 1 \text{ stress} \end{bmatrix} \rightarrow [+long]$$

(5) is a phonetic lengthening rule. A vowel that has underlying primary stress becomes long in the surface.

(6) Destressing

$$V \rightarrow [-stress] / \text{___} C_0 [1 \text{ stress}]$$

In (6) a vowel becomes unstressed in the syllable preceding a primary stressed vowel.

(7) Secondary Stress Placement

$$\begin{bmatrix} \text{V} \\ \text{-stress} \end{bmatrix} \rightarrow [2 \text{ stress}] / \begin{bmatrix} \text{V} \\ \text{-stress} \end{bmatrix} \text{C}_0 \text{---}$$

In (7) an unstressed vowel gets secondary stress in a syllable following another unstressed vowel. This is a rightward directional rule.

(8) Final Syllable Destressing

$$\text{V} \rightarrow [\text{-stress}] / \text{---C\#}$$

In (8) a vowel becomes unstressed in a word-final syllable.

There two main advantages of a stressed-based analysis: 1) rather than a vowel being lengthened in a closed syllable, which is typologically unexpected, it is instead stressed, which is consistent with other well-attested languages such as Romance languages, Amharic, or West Greenlandic; and 2) the final shortened syllable can now be omitted from both ESR and PCS as an exception.

Where generative phonology orders rules linearly, Miner's proposed directional iterative rules operate differently. Generative phonology rules scan the input to identify the potential triggers to the stated rule and then all changes that have been triggered apply simultaneously. A directional iterative rule ((4) and (7) above) applies the change at each identified trigger, before continuing to scan the input for another trigger. The directional iterative rule does not halt its scan once it finds a trigger. It continues through to complete the scan before the next rule begins its scan. Directional iterative rules must be allowed to complete the scan if later triggers in the sequence are to be identified (Miner 1975:91-96). Finally, in order to avoid rules cancelling

each other out and interfering with each other, Miner's analysis requires the rules to be ordered as listed in Example (9), with the key being that two of them are directional.

(9) Directional Iterative Rule Ordering for Menominee (from Miner 1975:97)	
Second Syllable Stress, Post-Cluster Destressing	SSS, PCD
Even Syllable Rule (directional)	ESR
Lengthening of Stressed Vowels	LSV
Final Syllable Destressing	FSD
Secondary Stress Placement (directional)	SSP

For example, in (10) SSS occurs first, followed by LSV, and finally FSD. What is crucial in this example is that the lengthening of a stressed vowel must occur before the final syllable destressing, or the output would not have the expected length and stress pattern. In this example from Miner (1975:90), ' marks primary stress and " marks secondary stress.

(10) input	/nepoqsaehkaka'e'm/
SSS	nepo'qsaehkaka'e'm
LSV	nepō'qsaehkakaē'e'm
FSD	nepō'qsaehkakaēēm
SSP	nepō'qsaehka"kaēēm
output	[nepō'qsaehka"kaēēm]

With this rule ordering and re-analysis of vowel length as a phonetic effect of syllable stress, Miner shows that Menominee prosody is less atypical amongst the world's languages.

3.1.2. Milligan 2005

Milligan (2005) examines stress in Menominee by taking recordings from native speakers to conduct statistical analysis on the prosody, stress, and length of the vowels. Chapter 2 presented the phonological shortening and lengthening patterns in Menominee. In brief, short vowels as a head of a disyllabic foot are lengthened in closed syllables and long vowels as a head of a

disyllabic foot are shortened in open syllables (Bloomfield 1962). Milligan finds that long vowels in open syllables measure a longer duration phonetically than long vowels in closed syllables (Milligan 2005:83). Table 3.1 summarizes the token counts Milligan examines from two female native speakers of Menominee.

Vowel	Frequency (# of tokens)	Percent		Vowel	Frequency (# of tokens)	Percent
ī	49	13.6		i	12	1.8
ē	75	20.9		e	307	47.1
āē	103	28.7		ae	49	7.5
ū	6	1.7		u	0	0
ō	36	10		o	77	11.8
ā	65	18.1		a	203	31.1
ia	16	4.5		ya	2	.3
ua	9	2.5		wa	2	.3
Total	359	100			652	100

Table 3.1: Menominee Vowel Tokens and Frequency for Milligan's Study (Milligan 2005:96)

Since the vowel lengthening and shortening rules are dependent on the vowel's place in the foot (i.e. the head), Milligan also codes the syllable for location of foot in the word (initial foot, medial, or final foot), whether the syllable was open or closed, and the stress of the syllable (primary, secondary, no stress, or unknown). Stress is coded as the following: a heavy syllable followed by a light syllable is coded as primary stress. If a short syllable is the head of a foot, coded as heavy, and followed by another heavy syllable, it is coded as secondary stress. Final syllables do not carry stress (Milligan 2005:96-99).

Milligan uses a two-sample t-test for the bilateral comparisons in order to normalize the results since several of the tokens being compared have a great deal of difference in frequency within the data set. For example there are 223 tokens of long syllables with primary stress compared to 42 tokens of long syllables with secondary stress.

Table 3.2 summarizes the duration results from Milligan's acoustic study.

	# of tokens	Mean F0 (Hz)	Syllable Duration (ms)	Vowel Duration (ms)	Rhyme Duration (ms)
		p-value	p-value	p-value	p-value
All syllables					
Long	359	165.0	.003*	270.7	.000*
Short	652	157.0		183.2	.000*
Disyllabic LH Words					
non-head	34	154.3	.804		
head	38	157.6			
Disyllabic LL Words					
non-head	92	154.33	.60	91.3	.000*
head	91	157.5		267.4	.000*

Table 3.2: Vowel Duration Results from Milligan's Study (Milligan 2005:102, 107)

These results show that there is a significant durational difference between long vowels and short vowels, as well as long syllables and short syllables. Table 3.3 summarizes the stress results.

Recall that short syllables do not carry primary stress.

Stress	# of tokens	Mean F0 (Hz)		Syllable Duration (ms)		Vowel Duration (ms)		Rhyme Duration (ms)	
			p-value		p-value		p-value		p-value
All Syllables									
Primary	224	171.5	.000*	268.8	.000*	154.6	.000*	187.4	.000*
Secondary	212	157.2		220.7		97.3		154.3	
Secondary	212	157.2	.884	220.7	.000*	97.4	.000*	154.3	.000*
No Stress	491	156.7		173.5		80.8		121.1	
Primary	224	171.5	.000*	268.8	.000*	152.6	.000*	187.4	.000*
No Stress	491	156.7		173.5		80.8		121.1	
All Long Syllables									
Primary	223	171.4	.026*	268.6	.018*	152.6	.014*	187.3	.266
Secondary	42	157.1		230.9		134.1		174.2	
Secondary	42	157.1	.837	230.9	.133	134.1	.141	174.2	.382
No Stress	31	159.0		267.7		116.7		191.8	
Primary	223	171.4	.129	268.6	.965	152.6	.001*	187.3	.793
No Stress	31	159.0		267.7		116.7		191.8	
All Short Syllables									
Secondary	170	157.2	.855	218.1	.000*	88.3	.001	149.4	.000*
No Stress	460	156.6		167.1		78.4		116.4	

Table 3.3: Syllable Stress Results from Milligan's Study (Milligan 2005:103-107)

These results show that while there is no significant difference in pitch (F0) between syllables with secondary stress or no stress, primary stress is significantly higher in pitch (F0) than syllables with secondary stress or no stress. Milligan concludes that “pitch is the main correlate of primary stress” (Milligan 2005:109).

Languages that use pitch as a correlate for primary stress have been observed to develop into tone languages (see Caplow 2016a, 2016b for Tibetan). Biedny et al. (2019b) point out that many languages in the Great Plains from at least four language families are tonal languages, including several Algonquian languages. Tone is often an areal phenomenon shared by

languages from different families, supporting arguments for the effects of contact (Salmons 1992; Ratliff 2015) and Biedny et al. argue for the identification of a tonal area in North America that has previously been unidentified. In the Algonquian languages, tone appears to have arisen independently for each language (Biedny et al. 2019b). Biedny et al. (2019b) hypothesize that pitch in Algonquian languages could “prime the pump” for the development of tone from patterns of pitch cuing stress or duration.

In Menominee, long vowels with primary stress are statistically significantly longer than those with secondary stress, even though there is no significant duration difference between the primary stress and no stress for long vowels. Milligan concludes that for long vowels “duration ...[is] a secondary correlate of primary stress” (Milligan 2005:109).

For the short vowels, pitch is not significantly different between syllables with secondary or no stress, but duration is significantly different. This means that for short vowels “duration ...[is] the main correlate for secondary stress” (Milligan 2005:110).

Milligan finds that Menominee words can have two primary stresses. She also finds that a first primary stress will correlate with high pitch (measured by F0 frequency) and that secondary stress syllables are more likely to be longer. The measurements confirm that open syllables cause vowels to lengthen and closed syllables cause vowels to shorten. This is a key finding because it confirms previous analyses that have relied heavily on Bloomfield’s (1939, 1962) by-ear analysis of Menominee vowel length and stress.

Milligan’s study shows that final lengthening plays a role in Menominee and that most of the closed short syllables are in word-final position and therefore lengthened. This is a noted phenomenon in Menominee (Bloomfield 1962), as well as cross-linguistically (Wightman et al. 1992; Camber-Langeveld 1997; Byrd & Saltzman 2003; Turk & Shattuck-Hufnagel 2007;

Remijsen & Gilley 2008; Nakai et al. 2009 and many others). While most of Milligan’s data comes from connected speech, she focuses on word-level position for the syllable she analyzes, but not phrase-level. Future work on connected speech in Menominee may identify different patterns of primary and secondary stress throughout a phrase.

Milligan (2005) confirms Bloomfield’s (1962) analysis of short and long vowels in Menominee through acoustic analysis. The short vowels are statistically significantly shorter than the long vowels. Milligan also finds significant differences in vowel length for open and closed syllables (the importance of open vs. closed in Menominee vowel length analyses was shown in Chapter 2). These results are repeated here in Table 3.4.

Type of Syllable	# of Tokens	Vowel Duration (ms)	p-value	Syllable Duration (ms)	p-value
Long Syllables					
open	153	165.1		242.7	
closed	206	124.1	.000*	291.4	.000*
Short Syllables					
open	309	71.9		117.6	
closed	343	90.1	.000*	242.6	.000

Table 3.4: Syllable Open/Closed Duration Results from Milligan’s Study (Milligan 2005:103-107)

Long vowels in open syllables are significantly longer than long vowels in closed syllables.

Short vowels are significantly longer in closed syllables than short vowels in open syllables.

Milligan’s work confirming Bloomfield’s underlying analyses of vowel length offers support for following those same analyses in my study of Menominee vowel length.

3.2. Theoretical Framework

This dissertation analyzes the underlying phonological vowel system of Menominee within what is colloquially known as the “Toronto School of Contrast” which started with the Modified

Contrastive Specification (MCS) and formed out of the work of Dresher et al. (1994), along with the work of Avery & Rice (1989); Dresher & Rice (1993); Rice (1993); Rice (1996); Dresher (2009); focusing on understanding the structure of the underlying contrastively specified vowel features. The contrastive features are hierarchically organized in language-specific rankings. Phonological rules of a language are written based on the distinctive features of the contrastively specified phonemes of a language.

MCS is initially based on the arguments of Avery & Rice (1989) that features are organized and hierarchical, and that only contrastive features are specified for a particular phoneme (or set of phonemes) (Hall 2011).

Phonemes in a language's inventory consist of distinctive features, which are unique building blocks that together serve to distinguish one phoneme from another (Jakobson, Fant & Halle 1952). The features themselves, while originally conceived as groupings, or unorganized "feature columns" or "sequences of feature columns" (later known as "feature bundles," Clements 1985) (Chomsky & Halle 1968), are not randomly organized. Matrices and various tiered analyses show that groups of features share patterns of behavior when affecting or being affected by various phonological or phonetic rules (Clements 1985:226). This premise that features are hierarchically organized, known as Feature Geometry (Clements & Keyser 1983), and the earlier Autosegmental Phonology (Goldsmith 1979) show that features can be hierarchically ranked on different tiers. Rules can affect a set of features on one tier, and not have any impact on features on another tier, which results in the analysis that groups of features can function as a unit (Clements 1985; Goldsmith 1979).

The theoretical framework of the "Toronto School" has its roots in distinctive feature and underspecification approaches to phonological systems. It has since developed into an approach

presenting hierarchies of underlying feature specifications that are tailored around the language-specific phonetic and phonological patterns that guide the hierarchical analysis. The structure proposed by Rice & Avery (1991) is very similar to the modern hierarchy followed in this dissertation. This initial hierarchy is shown in (11):

(11) Root > Air Flow > Sonority > Place

MCS posits a ranking of features within the hierarchy. By specifying those features necessary for contrast and allowing for underspecification as well, MCS allows for three-way contrasts (+, -, \emptyset) (Dresher et al. 1994). The features are monovalent (Avery & Rice 1989; Walker 1993) and “it is only presence *vs.* absence [of active features] that gives the appearance of binarity” (Avery & Rice 1989:180-181). In (11) Root dominates Air Flow, but it also dominates all features and subsequent nodes that Air Flow dominates, such as Sonority and Place. Dominance rankings are represented with > and read from left-to-right in which the feature or dimension to the left dominates those further right (i.e. Root dominates Air Flow with dominates Sonority and so on), and in which the feature furthest to the right is terminal and dominates nothing; it is at the bottom of the hierarchy. The higher the feature within the hierarchy, the more phonemes it affects, while a terminal contrastive feature will have the smallest impact on the inventory.

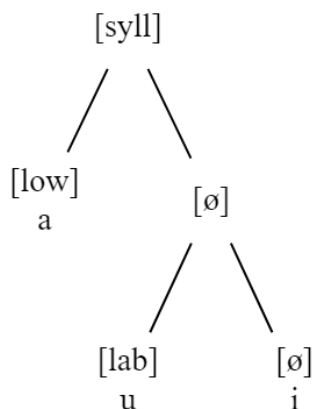
The following three figures show a hypothetical language with only three vowels and how the hierarchy of the features predicts different patterns in the language. Figure 3.1 shows a feature hierarchy of [low] > [labial].

Figure 3.1: Hypothetical Language 1 (Oxford 2016:8)

a. Feature Hierarchy:

[low] > [labial]

b. Contrastive Hierarchy:



c. Contrastive Segments:

/a/ [low]

/u/ [labial]

/i/ [∅]

The contrastive feature hierarchy in Figure 3.1 predicts a language that would allow /i/ or /u/ to lower by spreading the [low] feature from /a/, or /u/ to spread [labial] to /i/ and cause labialization. Since this hierarchy does not have [coronal] as a specified contrastive feature, palatalization, as a spreading of the feature [coronal], would not be predicted to occur in this hypothetical language.

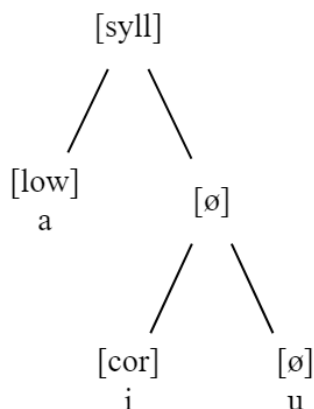
Figure 3.2 shows a second feature hierarchy of the hypothetical language with the same inventory of three vowels, with a ranking of [low] > [coronal].

Figure 3.2: Hypothetical Language 2 (Oxford 2016:8)

a. Feature Hierarchy:

[low] > [coronal]

b. Contrastive Hierarchy:



c. Contrastive Segments:

/a/ [low]

/i/ [coronal]

/u/ [∅]

In this hypothetical language with the feature hierarchy of [low] dominating [coronal], lowering would again involve the spreading of the feature [low] from /a/. This hierarchy also allows for palatalization by spreading the [coronal] feature from /i/. However, this hierarchy does not have [labial] as a specified contrastive feature, so labialization would not be an expected phenomenon in this language.

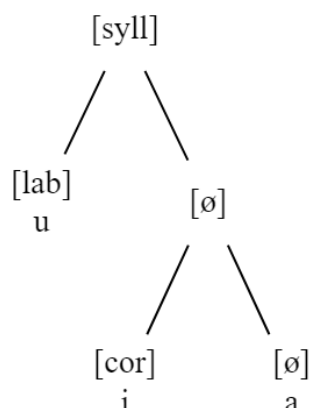
Figure 3.3 shows a third possible feature hierarchy in this hypothetical language with [labial] > [coronal].

Figure 3.3: Hypothetical Language 3 (Oxford 2016:8)

a. Feature Hierarchy:

[labial] > [coronal]

b. Contrastive Hierarchy:



c. Contrastive Segments:

/u/ [labial]

/i/ [coronal]

/a/ [Ø]

Figure 3.3 shows the contrastive hierarchy in which labialization would be predicted based on spreading of the feature [labial] from /u/. This language would also be predicted to allow palatalization as spreading of the feature [coronal] from /i/. Unlike the previous two figures, this hypothetical hierarchy does not have [low] as a contrastively specified feature, so this language would not allow lowering as a phonological process.

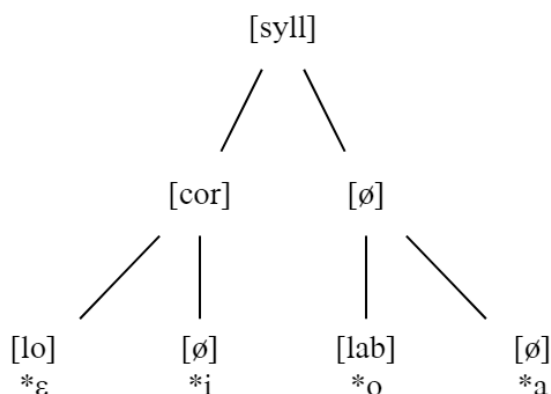
The following two contrastive hierarchies show the importance of these dominance relations in Proto-Algonquian. Oxford employs data from modern, attested Algonquian languages to understand the contrastive hierarchy of the proto-language. Figures 3.4 and 3.5 show two potential contrastive hierarchies for Proto-Algonquian (PA) as presented by Oxford (2015). The data from the modern languages is used as a guide to understanding the underlying phonological feature hierarchy.

Figure 3.4: PA1 (Oxford 2015:322)

a. Feature Hierarchy:

[coronal] > [labial] > [low]

b. Contrastive Hierarchy:



c. Contrastive Segments:

*/ε/	*/i/	*/o/	*/a/
[coronal]	[coronal]	[∅] (non-coronal)	[∅] (non-coronal)
[low]	[∅] (non-low)	[labial]	[∅] (non-labial)

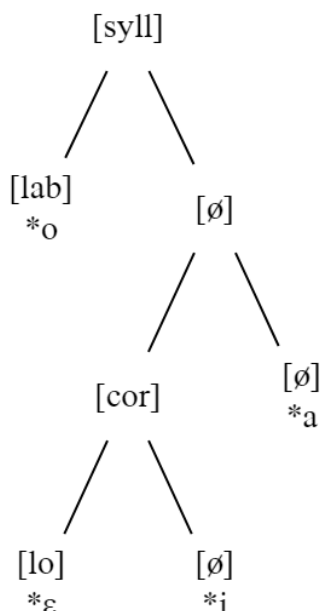
Figures 3.4 and 3.5 show a different contrastive hierarchy of features for the same inventory of Proto-Algonquian. The different hierarchies show that the same inventory can have different specified features, which affects the interactions between sets of vowels. Data from the modern Algonquian languages indicates that in the PA inventory */i/ must be specified for [coronal] and */o/ must be specified for [labial]. Both Figures 3.4 and 3.5 establish these requisite contrasts (Oxford 2015:322).

Figure 3.5: PA2 (Oxford 2015:322)

a. Feature hierarchy:

[labial] > [coronal] > [low]

b. Contrastive hierarchy:



c. Contrastive segments:

*/o/	*/ε/	*/i/	*/a/
[labial]	[∅] (non-labial)	[∅] (non-labial)	[∅] (non-labial)
	[coronal]	[coronal]	[∅] (non-coronal)
	[labial]	[∅] (non-labial)	

The hierarchy in Figure 3.4 has [coronal] dominating [labial] which dominates [low]. This ranking causes */ε/ and */i/ to be sisters, and */o/ and */a/ to be sisters as well. For the hierarchy in Figure 3.5, in which [labial] and [coronal] have reversed rankings in the hierarchy, only */ε/ and */i/ are sister nodes. Oxford proposes a diachronic Sisterhood Merger Hypothesis in which only the sister nodes in the parent language can merge in the descendant language (this is discussed in further detail below). Data from modern Algonquian languages supports the

hierarchy in Figure 3.5 over Figure 3.4, as it more accurately represents mergers and neutralizations in modern Algonquian languages (Oxford 2015).

The two example hierarchies here show the impact different organization of the features will have on the phonological analysis of a language's inventory. This is the key argument of MCS (Dresher et al. 1994; Dresher 2009; Purnell et al. forthcoming). The contrastive features and hierarchies are language specific. The phonetic behavior of phonemes in a language demonstrate how the phonological system is organized. These patterns reflect and provide insight into the underlying rules, active features, and hierarchy of features, not the other way around (Avery & Rice 1989). Since the surface patterns of phonemes provide insight into the underlying featural organization, a potential contrastive hierarchy must be able to account for the phonological processes in the language.

In this dissertation I present contrastive hierarchies by (a) showing the hierarchical ranking of the features in the example, (b) by showing the hierarchical ranking of features within a tree model, and (c) by listing the contrastive features that are uniquely specified for each phoneme in the inventory of the example (following Purnell et al. (forthcoming)). Figures 3.4 and 3.5 above show (a) the feature hierarchy, (b) the contrastive hierarchy, and (c) the contrastive segments of the PA examples from Oxford (2015).

Avery & Idsardi (2001) present a new way of analyzing specification: the underlying phonological representations are as underspecified as possible, while the phonetic representations are "tremendously over-specified" (Avery & Idsardi 2001:41). They introduce *dimension* and *gesture* in addition to *feature* and crucially discuss how the phonological representations specify completion in the phonetic dimensions. The gesture is the motor instruction to the articulator, dictating the action of a single muscle (or grouping of muscles). In

this framework, gestures are inherently oppositional, because logically an articulator cannot complete two motions simultaneously. For example, the tongue root cannot be both advanced (ATR) and retracted (RTR) for a single phoneme. Avery & Idsardi (2001) follow previous work on identifying various dimensions (such as Halle et al. 2000), though this differs from other theoretical frameworks in that the gestures are privative, and in obstruents, it is only the dimension that is contrastive. Figure 3.6 presents the segmental hierarchy based on this addition of dimension and gesture into the phonological feature analysis (Avery & Idsardi 2001:66).

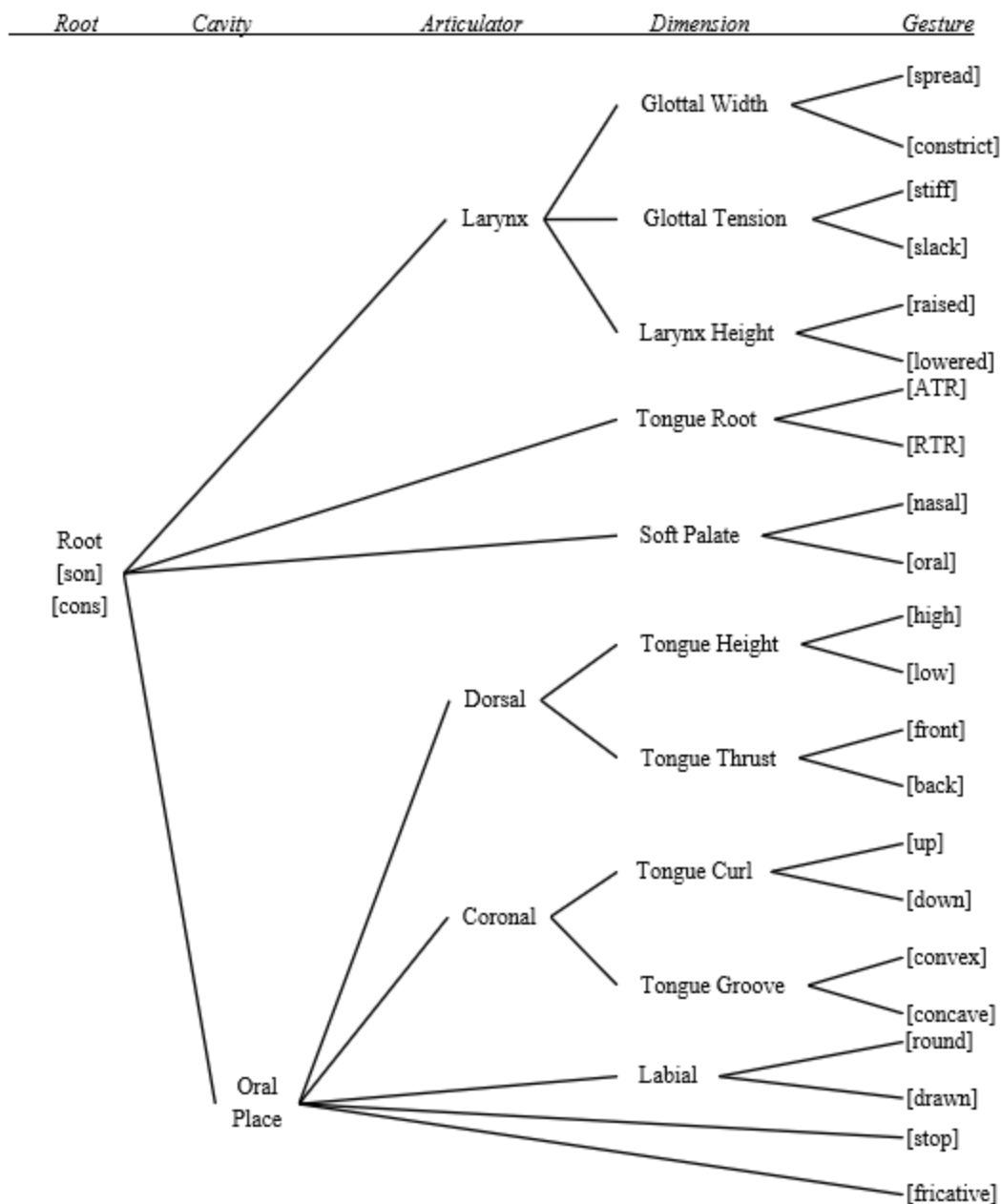


Figure 3.6: Segmental Hierarchy (Avery & Idsardi 2001:66)

The segmental hierarchy in Figure 3.6 represents the place and manner of articulation more closely aligned with the physical articulators and muscle groups within the human articulatory system than the more traditional IPA chart. Where the IPA chart is organized along the axes of manner and place of articulation, the segmental hierarchy is organized around muscle groups and

physical articulators that affect the place and manner of articulation through activation and/or constriction within the oral cavity. The superordinate node, the Root node can be specified as either sonorant [son], which specifies vowels, consonant [cons], which specifies obstruents, or both [son] and [cons], which specifies approximants. Oral Place (OP) is the oral cavity that dominates several places of articulation, such as the Dorsal (DOR) articulators, the Coronal articulators (COR) and Labial (LAB). The dimensions associated with each articulator indicate the movement of the activated articulator, such as Tongue Height (TH), which can be [high] or [low] or Tongue Thrust (TT) which can be [front] or [back] for the DOR articulation. A COR articulation is specified if the dimension is either Tongue Curl (TC) with the [up] or [down] gesture, or Tongue Groove (TG) [convex] or [concave]. LAB is either [round] or [drawn]. The completion of how the dimension is specified, marked within the square brackets, specifies the physical phonetic gesture of the dimension that forms the phonological rule. These gestures are organized into antagonistic pairs, in that only one can physically be occurring at any one time. For example, a TC cannot be simultaneously curled both [up] and [down]. Thus, in the contrastive hierarchical feature trees, it is unnecessary to specify within the tree which gesture is occurring. It is sufficient to specify the dimension that is active.

The other articulator that does not have an OP activation is the Larynx (LAR) with the dimensions of Glottal Width (GW), which can be [spread] or [constrict], Glottal Tension (GT), which can be [stiff] or [slack], and Larynx Height (LH), which can be either [raised] or [lowered]. Tongue Root (TR) and Soft Palate (SP) are dimensions that are only dominated by the Root, which is either sonorant [son] or consonantal [cons] or both. They have no other dominating articulator. TR can be either advanced [ATR] or retracted [RTR], and SP can be either [nasal] or [oral].

The muscle movement of antagonistic pairs, dimensions, limits which muscles can be activated at a certain time. As a result, the activation node, gesture, is less important in a contrastivist theory than the dimension itself. Dimensions are either marked or \emptyset (not marked), resulting in a phonological contrast determined by the “presence versus the absence of a single node” (Avery & Idsardi 2001:45). Once the contrastive dimension is determined, it is completed by specifying which additional gestural information needs be specified. For example, English is a Glottal Width (GW) system in which aspirated, or [spread], is contrastive with unaspirated, or plain. The dimension node is where the elements are phonologically contrastive and the gesture node is where completion provides phonetic information for the mapping from phonology to phonetics. Gestures will have typologically default completions, such as [slack] for Glottal Tension (GT) and [spread] for Glottal Width (GW) (Avery & Idsardi 2001).

The Successive Division Algorithm (SDA) is a guide for how a feature hierarchy specifies contrast (Dresher 2009). Only the features that are active in establishing a contrast are represented within the hierarchy by a uniquely specified node (Purnell et al. forthcoming). (12) shows the algorithm for determining a contrast for each segment of an inventory, as presented in Dresher (2009).

- (12) Successive Division Algorithm (SDA, Dresher 2009 :22)
- a. In the initial state, all tokens in inventory I are assumed to be variants of a single member. Set $I = S$, the set of all members.
 - b.i) If S is found to have more than one member, proceed to (c).
 - ii) Otherwise, stop. If a member, M, has not been designated contrastive with respect to a feature, G, then G is *redundant* for M.
 - c. Select a new n -ary feature, F, from the set of distinctive features. F splits members of the input set, S, into n sets, $F_1 - F_n$, depending on what value of F is true of each member of S.
 - d.i) If all but one of $F_1 - F_n$ is empty, then loop back to (c).
 - ii) Otherwise, F is *contrastive* for all members of S.
 - e. For each set of F_i , loop back to (b), replacing S by F_i .

Dresher (2009) guarantees this algorithm to work in all inventories, by contrasting all tokens of an inventory, and using the hierarchy to determine contrastive and redundant features, rather than implement “auxiliary mechanisms for multiple logical redundancies,” as previous approaches had done (Dresher 2009:22). Hall (2011) synthesizes the Successive Division Algorithm a little more succinctly:

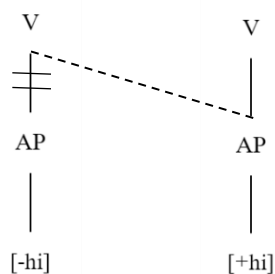
- (13) The Successive Division Algorithm (Hall 2011:13)
- a. Begin with *no* feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.
 - b. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets 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.

Hall (2011) shows how the SDA allows for cross-linguistic variation by not specifying the order of features outside of language-specific patterning. Dresher’s (2009) approach allows for language-specific prioritization of features within the hierarchy. Some features are of less importance to the phonology of a particular language, and may be of greater importance to another one (Nevins 2015). Additionally, the SDA allows the daughter and granddaughter nodes of a branching mother node to be asymmetrical (Purnell et al. forthcoming).

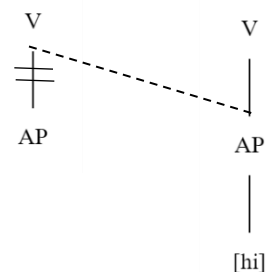
Various approaches to feature analysis have employed binary, unary, and privative ways of representing contrastive features of the phonemes in question. The binary analysis represents sets of phonemes as either + or - an activated feature. For example, *i* is [+high] or [+front] where *a* would be [-high] or [+back], depending on how the analysis is presented. A unary feature analysis only addresses the features necessary for the analysis, and the features that are unnecessary, or redundant are not included. (14) shows parallel analyses of Menominee Vowel Harmony using binary and unary features.⁹

⁹ For a list of abbreviations, see the Abbreviations in the front matter.

(14) a. Menominee Vowel Harmony (binary)
(Oxford 2016:12)



b. Menominee Vowel Harmony (unary)
(Oxford 2016:12)



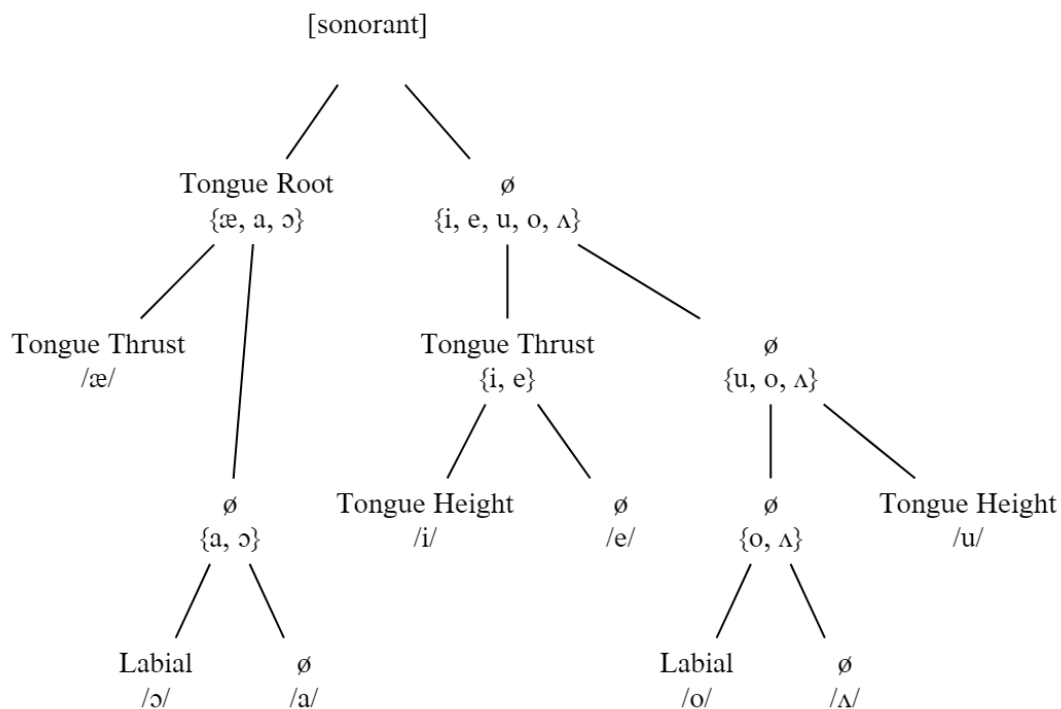
Employing privative features depends on only specifying the features that are necessary to represent the contrast (Oxford 2015). In other words, only active features are represented (Dresher et al. 1994; Dresher 2009). Privativity more accurately represents which features are phonologically active since only the marked features are available for activation (Oxford 2015). For the segments that are part of the set, but are unmarked for the specified contrastive feature, a null marker is used, instead of a negative feature. A [-] feature would still be considered phonologically activated, where a null feature will be skipped over by the articulators for activation. This approach seeks to represent unactivated features, rather than marking them as negatively activated features (Iverson & Salmons 2003; Oxford 2015; Purnell et al. forthcoming). A privative approach to representation of the active features is more transparent in the sense that “markedness is read directly off of the phonological representations” (Purnell et al. forthcoming). Binary representation is more opaque because both the +feature and -feature are marked and therefore further investigation must be conducted to determine which is the contrastively active specification (Purnell et al. forthcoming). Figure 3.7 shows a contrastive hierarchy of modern American English with a privative representation of features in which the only given features are those that are contrastively active and the unspecified node is marked null (\emptyset), just as Figures 3.4 and 3.5 above did.

Figure 3.7: Modern American English Long Vowels (Purnell & Raimy 2015:533)

a. Feature Hierarchy:

Tongue Root > Tongue Thrust > Tongue Height > Labial

b. Contrastive Hierarchy:



Contrastive Segments:

/æ/	/ɔ/	/a/	/i/	/e/	/o/	/ʌ/	/u/
Tongue Root	Tongue Root	Tongue Root	∅ (non-TR)	∅ (non-TR)	∅ (non-TR)	∅ (non-TR)	∅ (non-TR)
Tongue Thrust	∅ (non-TT)	∅ (non-TT)	Tongue Thrust	Tongue Thrust	∅ (non-TT)	∅ (non-TT)	∅ (non-TT)
			Tongue Height	∅ (non-TH)	∅ (non-TH)	∅ (non-TH)	Tongue Height
	Labial	∅ (non-LAB)			Labial	∅ (non-LAB)	

Minimal specification and underspecification are more economical ways of presenting underlying phonological systems (Avery & Idsardi 2001). If a universal markedness theory obligatorily underlies a theory of underspecification, then language-specific hierarchies can have different features present or absent in the underlying phonological system (Kiparsky 1982; Avery & Rice 1989).

The Sisterhood Merger Hypothesis put forth by Oxford (2015) follows the Contrastivist Hypothesis (Hall 2007) in that “only contrastive features are phonologically active” (Oxford 2015:315). He further develops this by requiring that diachronic changes such as mergers, which affect the structure of the hierarchy, can only apply to contrastively specified sisters (Oxford 2015:315). Two phonemes that have a single shared node (a parent node) are considered sisters. In the Sisterhood Merger Hypothesis, only sisters can merge. This allows hierarchical frameworks to readily account for a merger of formerly distinct phonemes or classes of phonemes with a loss of a single direct, hierarchical contrast, within a diachronic analysis (Oxford 2015).

Purnell & Raimy (2015) modify Avery & Idsardi (2001) to add a non-binary *neutral* gesture, shown in Figure 3.8, as well as providing a phonetic realization guide to how the marked dimension and gesture will instantiate when activated, or specified.

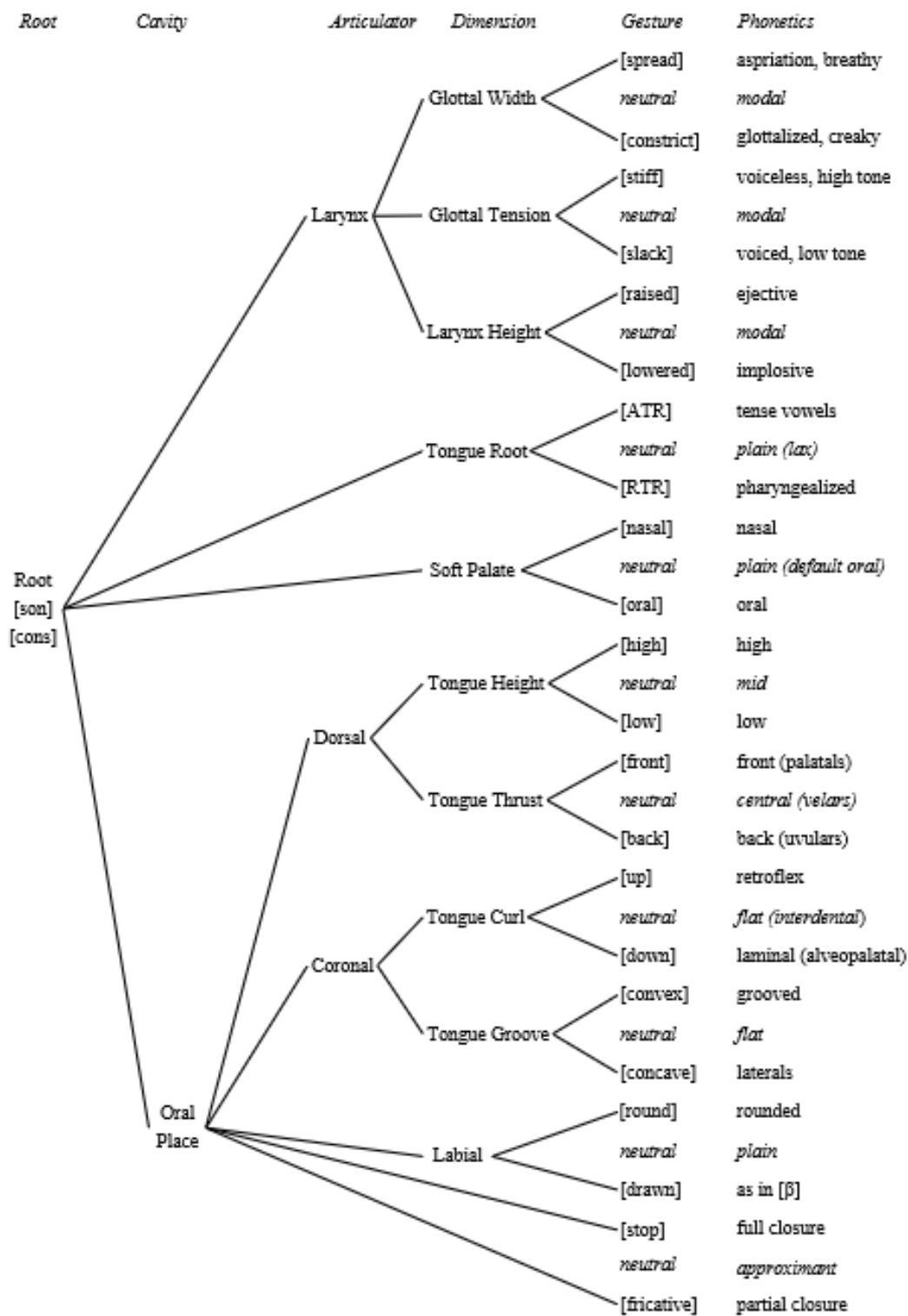


Figure 3.8: Segmental Hierarchy (Purnell & Raimy 2015:526, modified from Avery & Idsardi 2001:66)

Figure 3.8 shows the dominance relations between the root, cavities, articulators, and dimensions. These are the organizational nodes which are used to establish contrastive hierarchies. This model restricts contrasts to a minimum (highly underspecified), where ‘neutral’ as a gesture allows a dimension to be phonologically unmarked, rather than the previous \pm binarity (Purnell & Raimy 2015). Purnell & Raimy (2015) discuss three levels of representation: 1) the phonological level representing only contrastive dimensions (following Avery & Idsardi 2001); 2) the phonetic-phonological level representing only gestures; and 3) the phonetic level in which the gestures are completed in language-specific patterns. While each of these levels is inherently underspecified, the phonological level has the least amount of specification and the phonetic level the most. Instead of marking the privative unspecified feature node with a null marker, in the following figure the unspecified phoneme is instead marked with the corresponding superordinate node (based on the feature geometry presented in Figure 3.8 from Purnell et al. (forthcoming)). Thus, the dorsal node is marked Dorsal_TT or Dorsal_TH to denote the superordinate dorsal articulator which corresponds to either a Tongue Thrust (TT) or Tongue Height (TH) specification. Figure 3.9 shows the modified contrastive representation for Old English proposed by Purnell et al. (forthcoming) employing the superordinate marker as the privative feature.¹⁰

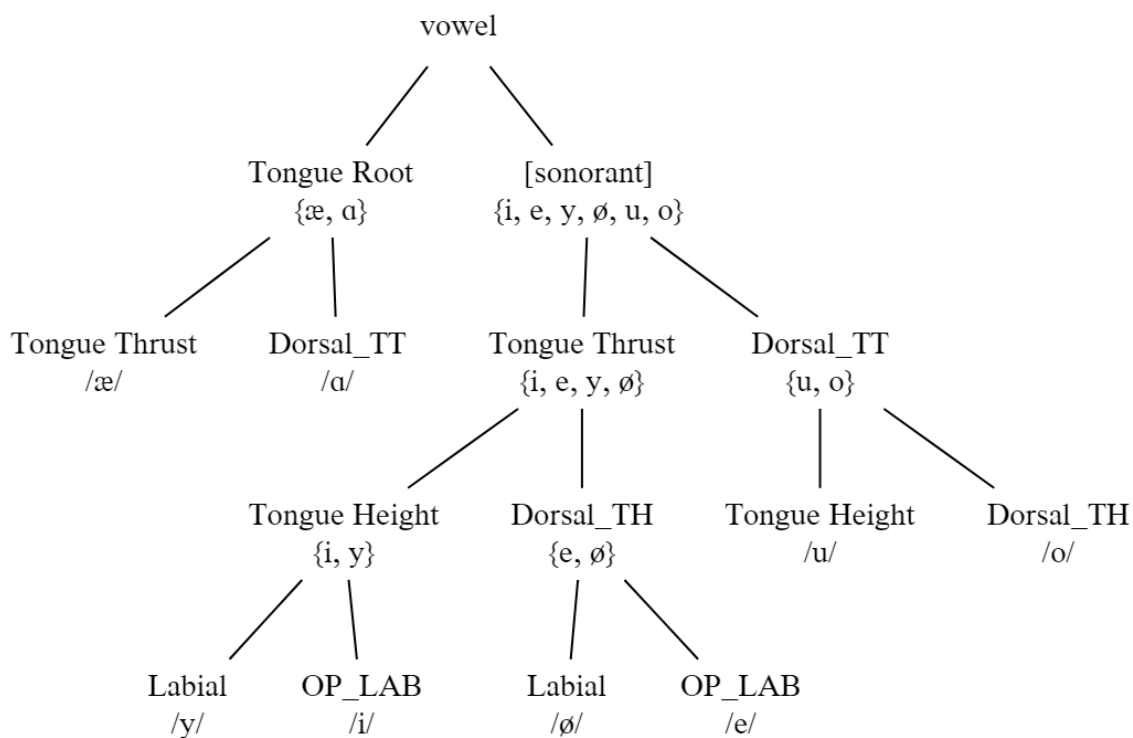
¹⁰ Purnell et al. use superscript to designate the specified feature that the underspecified Dorsal node corresponds to (ex: Dorsal^{TT} or DorsalTH). I used Graphviz to draw the trees throughout the dissertation and the program does not accept superscript text. Thus, in Figure 3.9 I represent the same node with an underscore instead (ex: Dorsal_TT or Dorsal_TH).

Figure 3.9: Old English with superordinate marking (Purnell et al. forthcoming: ex (25)-(26))

a. Feature Hierarchy:

Tongue Root > Tongue Thrust > Tongue Height > Labial

b. Contrastive Hierarchy:



Contrastive Segments:

/æ/	/ɑ/	/y/	/i/	/ø/	/e/	/u/	/o/
vowel	vowel	vowel	vowel	vowel	vowel	vowel	vowel
Tongue Root	Tongue Root	[sonorant]	[sonorant]	[sonorant]	[sonorant]	[sonorant]	[sonorant]
Tongue Thrust	Dorsal_TT	Tongue Thrust	Tongue Thrust	Tongue Thrust	Tongue Thrust	Dorsal_TT	Dorsal_TT
		Tongue Height	Tongue Height	Dorsal_TH	Dorsal_TH	Tongue Height	Dorsal_TH
		Labial	Oral Place_LAB	Labial	Oral Place_LAB		

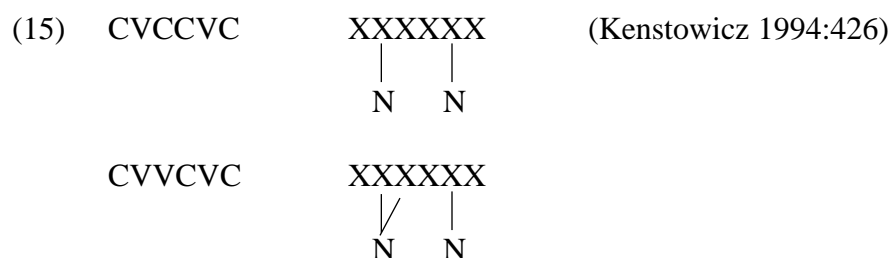
Purnell et al. (forthcoming) combine the distinctive feature hierarchy of Purnell & Raimy (2015) (Figure 3.8) and the hypotheses proposed by Oxford (2015), especially the Sisterhood Merger Hypothesis, to show further support of the Contrastivist Hypothesis and privative features within this adjusted framework. Instead of marking the inactive feature in the contrastive set as [-feature] as earlier privativity analyses did, Purnell et al. mark the feature by its superordinate node, or rather the nearest active feature higher in the segmental hierarchy (Figure 3.8). This is the approach I take in the contrastive hierarchies I present for Menominee in Chapter 5 as well.

3.2.1. Length in Distinctive Feature and Contrastive Frameworks

Vowel length can be either phonetic or phonological in the world's languages. Vowel length, or duration, can be affected by stress or tone, but it can also be phonological in its own right (Spahr 2016). Phonological representations of length are typically understood as affecting syllable weight (Ringen & Vago 2011), and are typically incorporated into structural analyses. This is also the stance I take when studying the phonological system of Menominee: length is structural and not featural. This project focuses on the phonological feature hierarchy of Menominee vowels as a holistic system. The previous chapter showed the foot and syllable structure analysis of Menominee vowel length, and Chapter 5 presents length structurally when discussing the underlying phonological hierarchy. This section will briefly cover how featural hierarchies have accounted for phonological length of vowels.

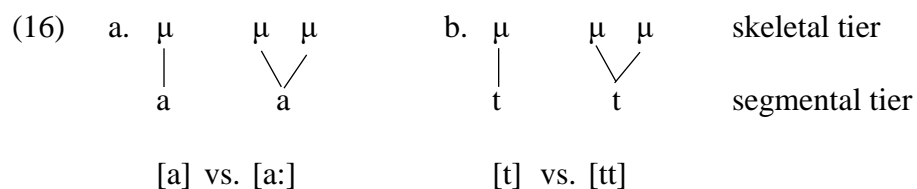
The 'X-slot' theory projects an extrametrical skeleton where each empty slot is 'X' which more accurately represents the potential for either a consonant or a vowel, rather than the CV theory which marked the skeleton as [\pm consonantal] (McCarthy 1979; Halle and Vergnaud 1980; Clements and Keyser 1983; Kaye and Lowenstamm 1984; Levin 1985; Kenstowicz 1994).

Following CV theory (McCarthy 1979, 1981; Halle and Vergnaud 1980), Levin (1985) posits that the X-slots are linked to an individual nucleus in place of the previous V-slots. Vowels constitute the nucleus of a syllable and the consonants are then linked to the remaining non-nuclear slots (Kenstowicz 1994). Phonological weight, typically correlated with length, is represented by how many links to X-slots a segment has. Long vowels and geminate consonants link to two X-slots while short vowels and non-geminate consonants will only link to one (Kenstowicz 1994). This can be seen in (15).



In (15), the first example shows a nucleus (N) linking to one X-slot, but in the second example, the first vowel is long and thus links to two X-slots.

The moraic model focuses more on the prosody of the skeleton (Hayes 1985; Kenstowicz 1994). In this approach to extrametrical structure, syllables are either light ‘monopositional’ or heavy ‘bipositional’ (the positions being the moras). Similar to the X-slot model, long vowels correspond to two moras where a short vowel would only link to one (Kenstowicz 1994). An example of moraic structure is in (16) from Kenstowicz (1994:429).



X-slot approaches focus on the segments where moraic approaches focus on the prosody (Kenstowicz 1994). They both analyze length of vowels and consonants as “some element of quantity existing on some suprasegmental tier” (Spahr 2016:41) and share the notational representation of short or light segments linking to one structural element (X-slot or mora) and a long or heavy segment linking to two. This is generally agreed, in fact “all theorists agree,” that this is the best way of representing length within a structural framework (Kenstowicz 1994:428). For example, Ringen & Vago (2011) place phonological length as branching off the timing tier of a metrical structure, in which two nodes will share a single segmental specification (i.e. two timing units).

Spahr (2016) proposes a “chain” of features in order to incorporate phonological length into a hierarchical analysis of distinctive features. Segmental root nodes are “X-slots” (\times) and are not separate from the feature structure. Features on X-slots are part of the segmental inventory set and features on π -slots (the prosodic root node) are part of the autosegmental inventory. In Figure 3.10 Spahr (2016) represents prosodic features (tone, stress, length) above π -slots (prosodic elements) at the top of the hierarchy. Spahr (2016) predicts that a language can encode only two of the three potential prosodic contrasts.

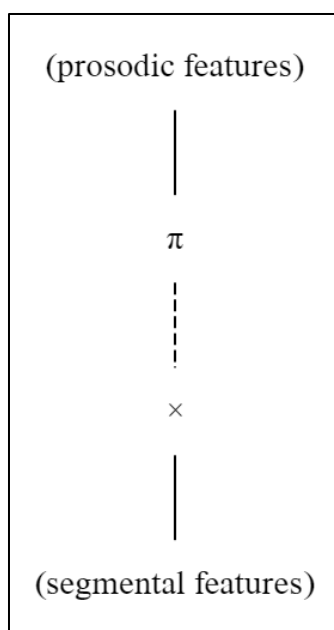


Figure 3.10: Feature Chain (Spahr 2016:63)

In Figure 3.10 segmental features link to an X-slot. The features link down one at a time in a ‘chain’ until the terminal node, where no further contrasts can be specified. In this chain the features are still hierarchical, and thus ordered. Spahr posits no branching in the segmental features: “rather the hierarchy reflects a set of one-dimensional feature chains” (chain vs. tree) (Spahr 2016:66). The π -node which links directly to the prosodic features is a different kind of root node than X-slots (hence the dashed line) and therefore “their hierarchy is formed in isolation from that of segmental features” (Spahr 2016:67). This allows for Spahr’s analysis to continue to encode length as in some way structural and not featural, and also removes length from the ‘top’ of the hierarchy—prosodic features are not superordinate to segmental features. This approach includes the binary \pm feature representation, but is still minimally specified because only contrastive (and therefore active) features are selected, whether that is a +feature or -feature activation. A feature chain only encodes the active features hierarchically with the contrasts directly encoded, rather than represented through branching nodes (Purnell et al.

forthcoming). The limitation of this approach is that it does not closely represent the actual movement of language-producing articulators. Avery & Idsardi (2001), Purnell & Raimy (2015), Oxford (2016), Purnell et al. (forthcoming), and others employ a feature geometry that portrays features as extensions of the physiological articulators within the human vocal tract (Figures 3.6 and 3.8 above).

Oxford (2015) continues work on feature hierarchies within the school of contrast presented in this chapter. Oxford incorporates vowel length directly into the hierarchical features. Unlike Spahr's (2016) proposal, which is to maintain the structural analysis of vowel length, while still integrating it within a featural hierarchy, Oxford (2015) presents length as a 'feature' within the branching hierarchy, parallel with the other, less controversial features such as [low] or [back]. An example of a phonological inventory in a feature hierarchy for Proto-Algonquian with *length* as a feature can be seen in Figure 3.11.

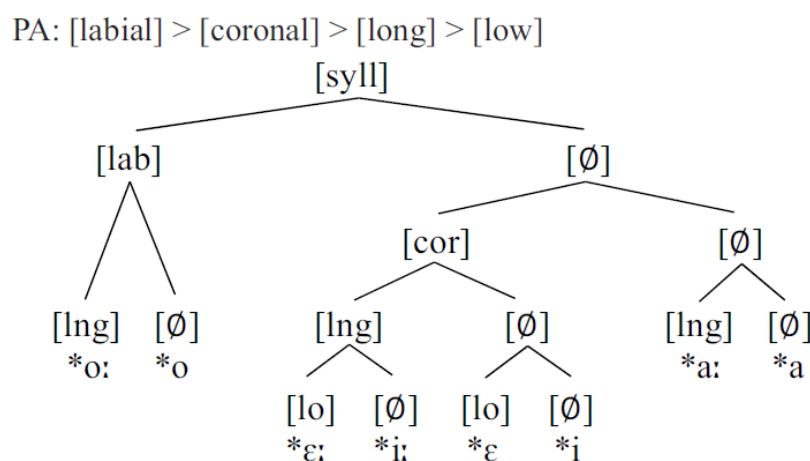


Figure 3.11: Proto-Algonquian Phonological Inventory (Oxford 2015:323)

As discussed above, it is generally accepted that vowel length is structural, and not featural (Kenstowicz 1994). While incorporating *length* as parallel to other features within the hierarchy, Oxford (2015) qualifies his representational format by “employ[ing] the feature [long] in this

abstract contrastive sense, with the assumption that the contrast is realized in underlying representations not as a feature, but as the appropriate skeletal or moraic structure” (Oxford 2015:311).

I propose a Bifurcated Ranking Model to separate the long and short systems. This model removes length from the hierarchical ranking of features and allows for asymmetrical short and long systems where a language does not have a parallel inventory, and therefore asymmetrical feature ranking. The ranking in Figure 3.11 can be presented with the Bifurcated Ranking Model as shown in Figure 3.12.

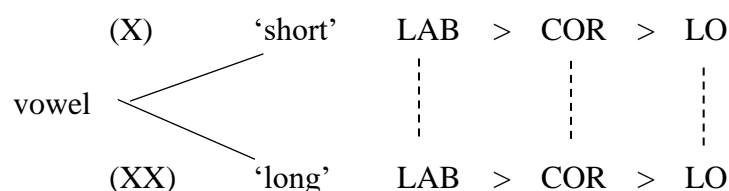


Figure 3.12: Proto-Algonquian Bifurcated Ranking Model

This reanalysis removes length from the hierarchy, but crucially still allows for Oxford’s Sisterhood Merger Hypothesis. The dashed lines in the model show that the two systems can be still linked. Where needed, the long and short vowels remain sisters at the same place or manner of articulation, and thus are still in the environment required for a diachronic merger. This proposal is discussed in more detail in Chapter 5.

3.3. Conclusion

This chapter has presented the background literature on Menominee vowel length, and the theoretical framework that this dissertation will adopt for the current analysis of Menominee vowel length. I have discussed the extrametrical approaches that have been posited for

understanding the vowel length shortening and lengthening rules, as well as a few other approaches that have been presented. Section 3.2 traced the theoretical framework leading to the development of the ‘Toronto School of Contrast.’ The hierarchical model proposed by Purnell & Raimy (2015) and Purnell et al. (forthcoming) is adopted in this dissertation as well.

This chapter has also shown recent work incorporating contrastive length within a phonological analysis of hierarchically ranked distinctive features. Contrastive length and a feature hierarchy is further addressed in the Chapter 5 discussion of Menominee phonology, where vowel length is not itself a feature, but still phonologically relevant.

4. Menominee Vowel Phonetics

This chapter presents an acoustic analysis of Menominee vowel quality, and also examines vowel quantity with different variables for examining vowel duration than previous acoustic work (Milligan 2005). The vowel quantity section of this study uses underlying and surface length as a variable. I look at whether the vowels that are underlyingly short and can surface as either short or long and the vowels that are underlyingly long and can surface as short or long (depending on a variety of Vowel Length Rules, discussed in Chapter 2) measure different durations. The vowel quality section of this study takes an acoustic look at the vowel spaces for the whole set of measured vowels, as well as a more detailed case study of three individual speakers.

4.1. Methods

In this section I discuss the sources of the acoustic data and present the procedures of data collection and analysis. The audio recordings used for the acoustic analysis primarily come from the Menominee Database (MD), with a small amount of elicitation conducted with one native speaker. The MD is an online resource and dictionary with almost 12,000 lexemes. 35% of the entries have examples of inflected forms and 24% have examples of the word in a sentence or expression. Almost 10% of the entries have audio of a native speaker saying the lexeme. 14% of the inflected forms also have audio of a native speaker saying that form, and 83% of the examples have audio of the speaker using the headword in a sentence. The audio recordings come from a variety of speakers who have participated in elicitation sessions over the past 20 years. The database also contains a morphological analysis of most of the lexical items based on past work by Bloomfield (1962, 1975) and extensive modern analysis by Monica Macaulay

(50% of the lexemes have analyzed initials, 9% have analyzed medials, and 63% have analyzed finals; in fact, only 26% of entries have no underlying analysis at all).

4.1.1. Participants

I analyzed vowel tokens from five female native speakers of Menominee. They were all born before 1930 and four were recorded while in their 70s and 80s, while the still-living speaker has been recorded while in her 70s, 80s and now her 90s. I chose these five native speakers because they were very dedicated to the language preservation and revitalization programs, and therefore I had access to a large amount of recorded audio from them. I restricted the speakers for this study to only the females because in the past ten years there has only been one male native speaker who has participated in the language preservation project, and there were not many analyzed recordings from him. Additionally, much of the male's audio had background noise that interfered with the recording so the sound file could not be analyzed. What remained were about ten audio files by the male speaker. Since sociolinguistic factors such as gender play a large role in acoustic analysis (Thomas 2011), and I only had a small number of tokens from the male speaker, I chose to only analyze the female speakers' audio. Table 4.1 shows the linguistic profile for each speaker whose vowels were included in the study.

Speaker	Gender	Born	Linguistic Background
NS_1	F	1915	Menominee L1, learned English from a young age, worked closely with Menominee language education programs
NS_2	F	1922	Menominee L1, went to English-only grade schools both on the Menominee reservation and in Kansas
NS_3	F	1926	Menominee L1, went to English-only grade schools both on the Menominee reservation and in Kansas, lived most of her adult life in non-Menominee-speaking communities in Illinois, works closely with Menominee preservation efforts today
NS_4	F	1929	Menominee L1, lived on the Menominee reservation most of her life, worked closely with Menominee language education programs
NS_5	F	1929	Menominee L1, went to English-only grade schools as a child, spent part of her adult life in Illinois, worked closely with Menominee language education programs

Table 4.1: Native Speaker Linguistic Profiles¹¹

From these five native speakers, 418 lexical items yielded 1496 vowel tokens. The distribution of vowel token by speaker is represented in Table 4.2. Since I was primarily working with previously recorded audio and not elicitation, the token counts between speakers are a bit uneven.

Speaker	Tokens
NS_1	116
NS_2	204
NS_3	529
NS_4	535
NS_5	112
	Total: 1496

Table 4.2: Total Number of Tokens by Speaker

I elicited about 60 tokens with the one remaining native speaker, but some tokens were extremely difficult to elicit, and also did not have a high frequency in the recordings. Table 4.3

¹¹ These linguistic profiles come from speaker biographies collected by Monica Macaulay 1998-present.

shows the individual vowel token numbers by speaker. Chapter 5 discusses potential reasons for some of the low token counts for specific vowels.

		NS_1	NS_2	NS_3	NS_4	NS_5	Total
short vowel	i /i/	2	11	15	16	3	47
	e /e/	25	63	87	117	31	323
	ae /æ/	8	8	41	41	6	104
	u /u/	0	0	2	0	0	2
	o /o/	9	9	38	47	10	113
	a /a/	25	27	121	90	17	280
	ya /ya/	0	1	6	1	1	9
	wa /wa/	1	1	15	12	1	30
long vowel	ī /i:/	3	8	25	25	7	68
	ē /e:/	12	18	31	32	3	96
	āē /æ:/	7	17	37	50	11	122
	ū /u:/	1	6	25	10	1	43
	ō /o:/	5	6	9	24	5	49
	ā /a:/	14	23	41	55	13	146
	ia /ya:/	0	5	19	8	1	33
	ua /wa:/	4	1	17	7	2	31

Table 4.3: Individual Vowel Numbers by Speaker

4.1.2. Procedure

I took audio samples from several different sources. 1) I identified the audio that had already been digitized, and uploaded to the MD, and had an underlying vowel analysis 2) for the audio on the MD of lexical items that did not have an underlying analysis, I ran an exhaustive search for vowels and speakers that had fewer tokens in the analyzed set, and 3) I extracted audio files from current and past elicitations that have not yet been processed for uploading to the MD.

Recall from Chapter 2 that due to lengthening and shortening rules, Menominee vowels that are underlyingly short can remain short in the surface (SS), or be lengthened (SL). Vowels that are underlyingly long can remain long in the surface (LL), or be shortened (LS). For this study I examine the four different underlying/surface vowel length combinations as a variable in measuring Menominee vowel length (SS, SL, LL, and LS). To this end, the MD contains thorough UR morphemic analyses for thousands of lexemes (approximately 74% of all lexemes in the database). I cross-searched those that had been analyzed with those that had sound files by the selected native speakers and the results were 955 vowel tokens from about 300 lexemes with a known underlying vowel duration in addition to the surface length.

I followed this up by searching the database for examples of the lexical items in use and unprocessed audio files of past and current elicitation in order to target more tokens by some of the speakers, and also to try to increase the numbers of some of the less frequently represented vowels. This resulted in an additional 541 tokens. However, these tokens do not have complete underlying analyses of the vowel durations, so §4.2. presents a holistic analysis of vowel durations for all vowels I measured, as well as a discussion of the underlying/surface length as a variable for duration only including the 1038 tokens that have a fully analyzed underlying length.

The tokens that had an underlying analysis were coded for the underlying duration and the surface duration. This allowed me to determine if there is a difference in phonetic vowel length depending on their underlying duration. The vowels were marked as follows: if they were underlyingly short with S, underlyingly long with L, surface short with S, and surface long with L. This coding is summarized in Table 4.4.

Underlying Vowel (UR)	Phonetic Vowel (SR)	Code	Number
Short = S ₁	Short = S ₂	SS	511
Short = S ₁	Long = L ₂	SL	101
Long = L ₁	Short = S ₂	LS	71
Long = L ₁	Long = L ₂	LL	272

Table 4.4: Vowel Length by UR and SR Length

Examples (1) and (2) show lexemes with their underlying vowel analysis, surface duration, and how I coded them.

(1) apēsamaepen ‘black sucker (fish)’

/apēs-amāēpen/

a = SS

ē = LL

a = SS

ae = LS

e = SS

(2) nekōtāēs ‘all at once, suddenly’

/naekot-āēs/

e = SS

ō = SL

āē = LL

4.1.3. Measurements

Once I identified the target sound files, I downloaded them and used Audacity to reduce background noises and hissing by running ‘normalize’ and ‘sound profile’ functions, then converted from .mp3 to .wav files.

Using Praat, I hand segmented the audio files in order to mark the boundaries of each vowel present. Following Ladefoged and Maddieson (1998), I marked vowels with nasalization boundaries where the waveform changed even if there was not much movement in the formants. An example of this can be seen in Image 4.1. I segmented all vowels at the peak of the waveform where the vowel begins or ends.

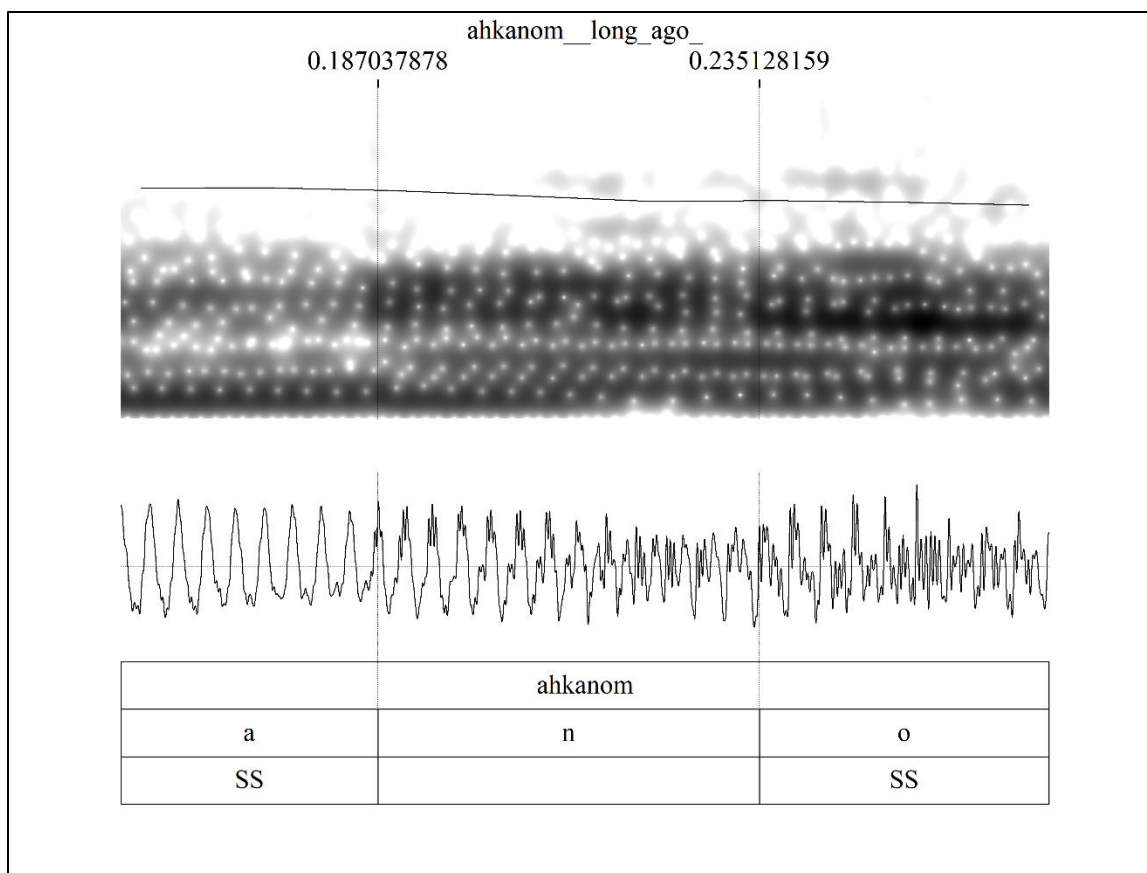


Image 4.1: Intervocalic *n* boundaries in Praat

Where the semi-vowels or glides appeared, especially intervocalically, as in Image 4.2, the vowel boundary was similarly marked at the change in waveform. Sometimes the F3 and F4 lines showed a lot of movement, but the most consistent and clearest place to mark the vowel boundary is where the intensity begins to rise back into the following vowel and the waveform changes,. I chose this point to be consistent with the nasalized vowel boundaries and where [h] began and ended as well. In this way I attempted to maintain a consistent marker of where I identified the vowel boundary. This results in more consistent holistic measurements across all the data points.

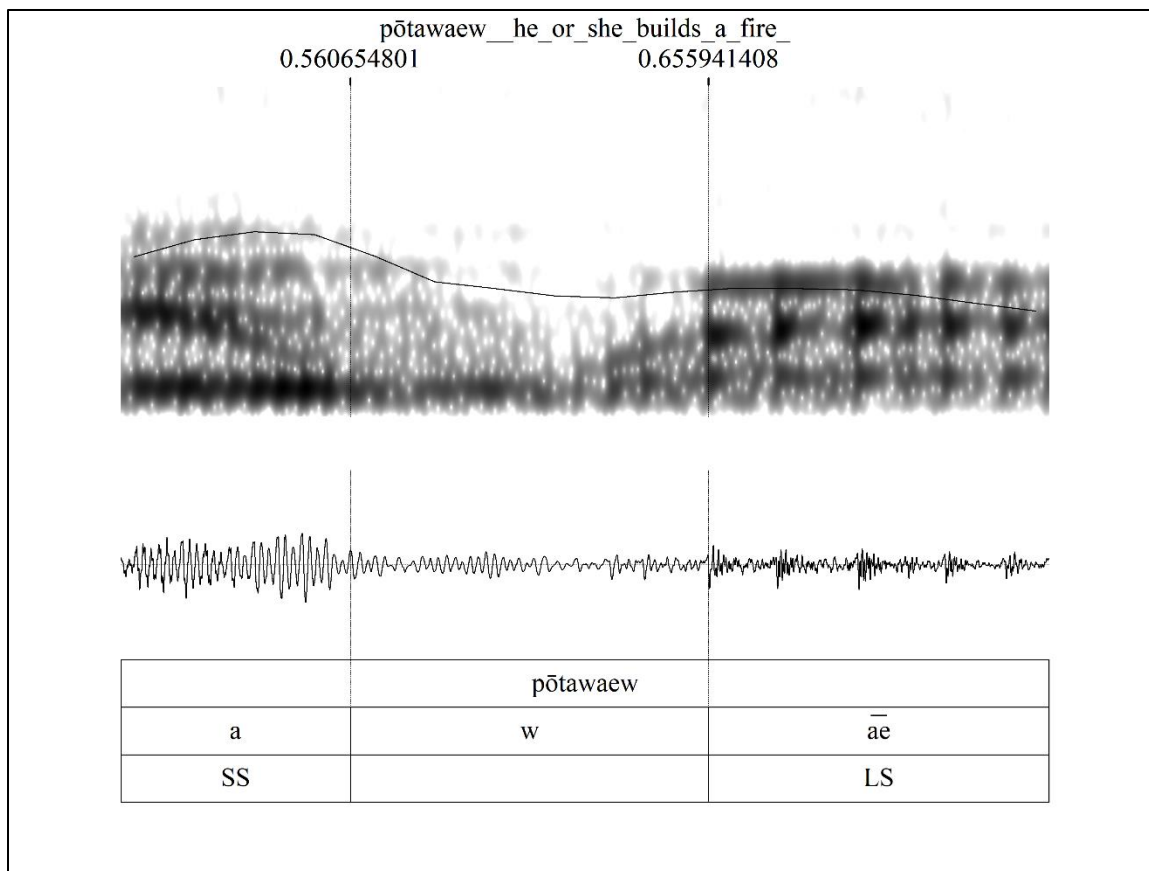


Image 4.2: Intervocalic *w* boundaries in Praat

Duration measurements for each vowel were taken using a Praat list function. This duration was based on the hand-segmenting I did of each vowel. The list function in Praat provides the beginning and end time of each segment on each tier. Head and tail measurements of the vowels were taken employing two Praat scripts written by Tom Purnell at University of Wisconsin – Madison. The first script automatically marked each vowel at 33% (the head) and 66% (the tail) of the vowel. After the heads and tails were marked by the script, I manually checked the marking to ensure accuracy of the formant markers (making sure that there was no formant doubling, that the extremely short vowels (less than 30ms, as the script specified) had the correct head and tail locations marked, etc.). The second script then generated an average formant measurement for the head and tail of formants 1-3 (F1, F2, and F3) for each vowel. From the list

function in Praat I extracted the vowel durations. The scripts provided formants 1, 2, and 3 measurements at both the head and tail of each vowel.

Statistical measurements and figures were run through RStudio.

4.2. Vowel Quantity

This section discusses the vowel duration results. First I present the duration results for all the vowel measurements, followed by a closer look at the durations of the short and long diphthongs, finishing with a discussion of the durations of the underlying/surface length variables.

4.2.1. Diphthongs as a variable

Figure 4.1 shows the short monophthong vowel durations and Figure 4.2 the long monophthongs. Due to complications getting R to accept the macron, for these and all following figures in this chapter, the uppercase letter represents the long vowel, and the lowercase represents the short vowel (excluding the diphthongs, which are represented in Menominee tribal orthography). Additionally, as discussed earlier, there were only two tokens of the short *u*, so I will not be including it in any of the analyses in this chapter. Chapter 5 goes into more detail on the status of *u* in Menominee. Table 4.5 presents the standard deviations (sd) and means (in milliseconds) for the short monophthongs in raw numbers (they have not yet been normalized). Figure 4.1 presents the same numbers in a boxplot.¹²

¹² In notched box and whisker plots, the notches are used for comparing medians across data sets. If the notches do not overlap, then the medians between the two vowels are different (Chambers et al. 1983). The reason *ya* looks different is that the notch, used for comparison to the other vowels, is larger than the two quartiles represented by the ‘box’ portion of the data (which represents roughly 50% of the data points).

Vowel	Standard Deviation (sd)	Mean (ms)
a	0.03518588	79.73059
ae	0.06116553	103.72862
e	0.03301587	68.14226
i	0.02664008	77.35094
o	0.03522445	89.21519

Table 4.5: Means and Standard Deviations of the Short Monophthongs

Figure 4.1: Short Monophthong Durations

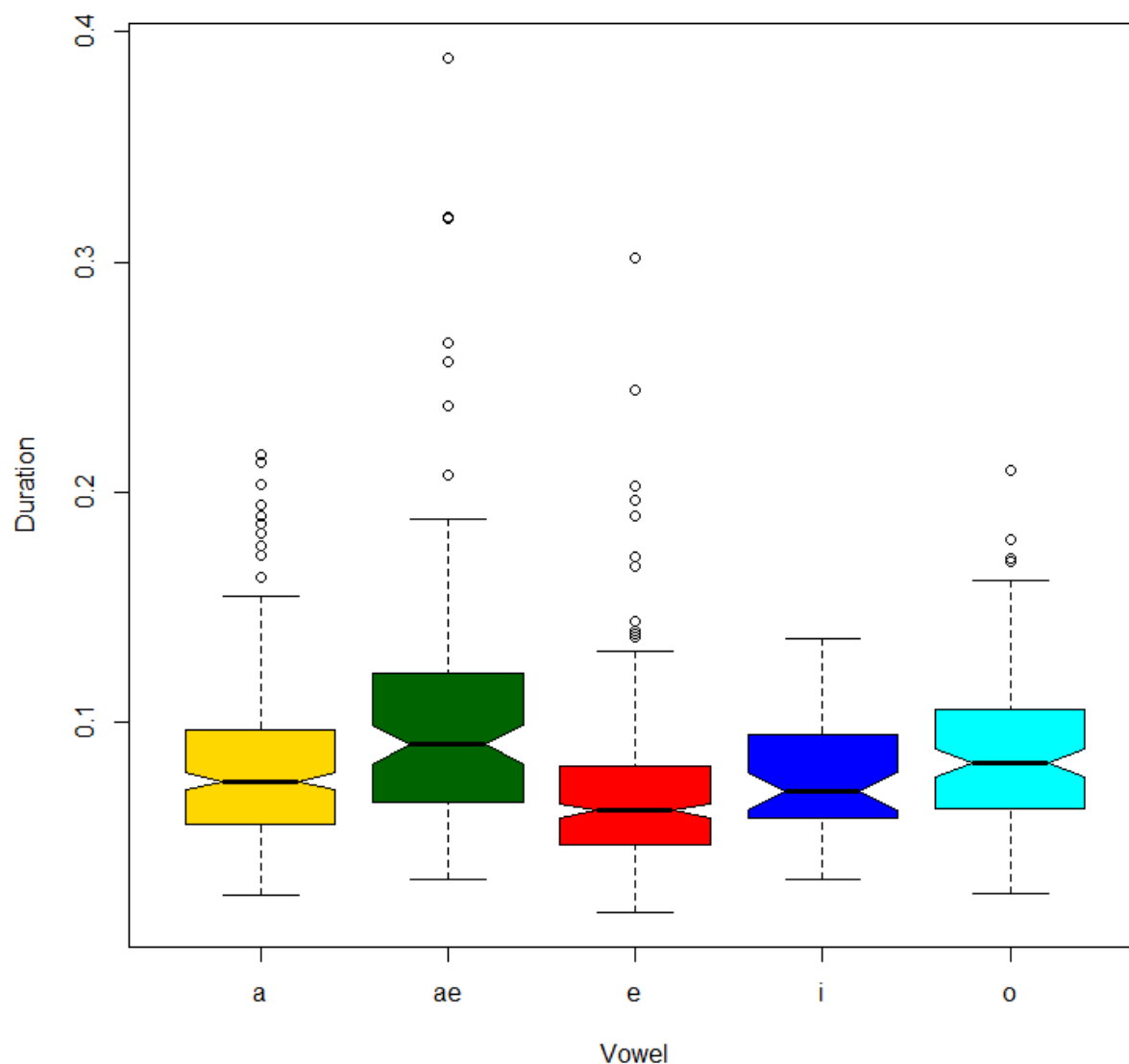


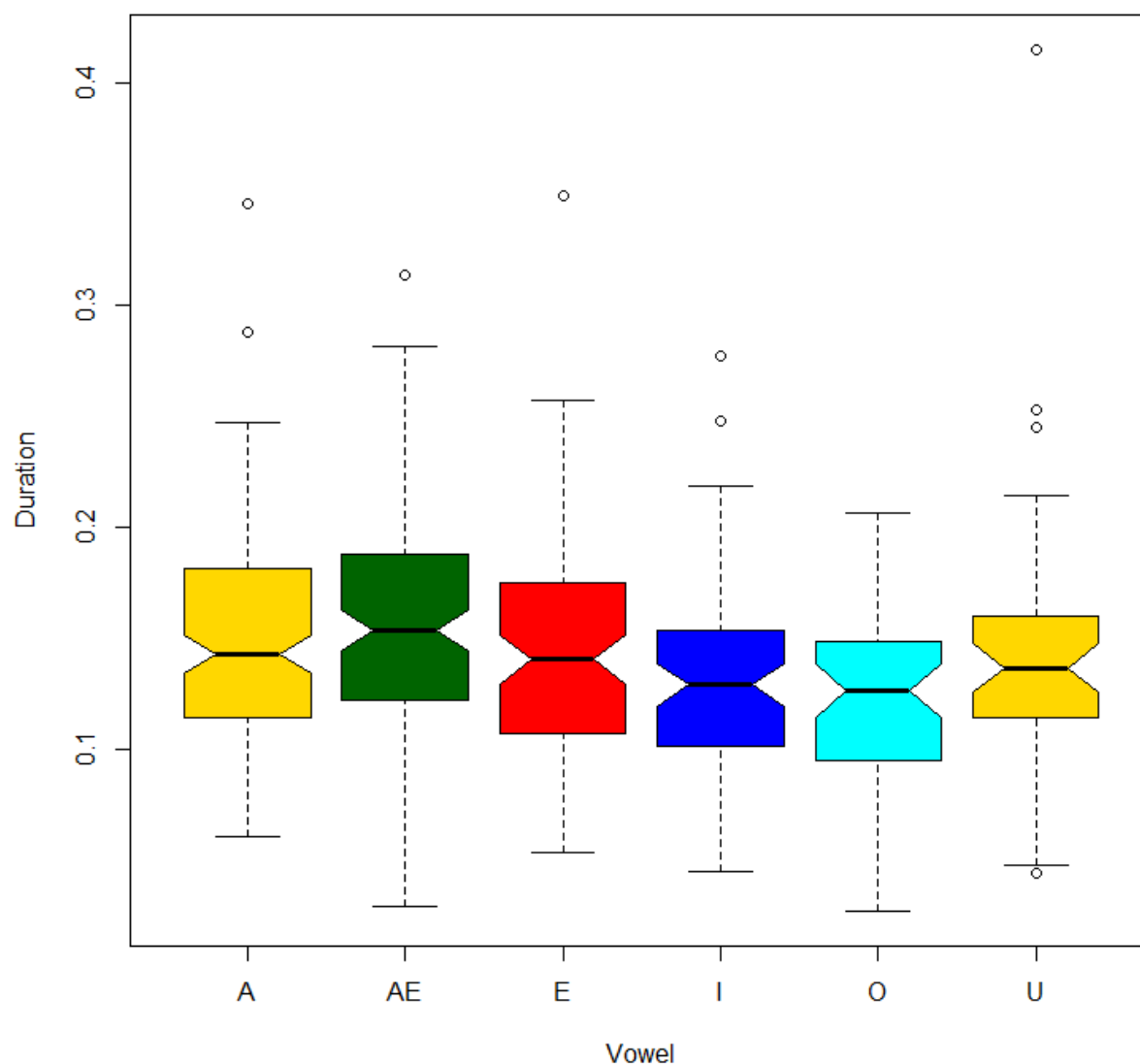
Table 4.6 presents the standard deviations and means (in milliseconds) of the long monophthongs in raw numbers. Unlike u for the short vowels, there were enough tokens of \bar{u} to

calculate in comparison to the other long vowels. Figure 4.2 presents the same numbers from Table 4.6 in a boxplot.

Vowel	Standard Deviation (sd)	Mean (ms)
A (ā)	0.04860893	151.19608
AE (āē)	0.05146854	157.28477
E (ē)	0.05142423	145.73982
I (ī)	0.0437214	129.82725
O (ō)	0.03870745	124.35804
U (ū)	0.06259196	143.33624

Table 4.6: Means and Standard Deviations of the Long Monophthongs

Figure 4.2: Long Monophthong Durations



In Figures 4.1 and 4.2, the notch in the boxplot indicates where the mean is. Each of these figures show that the vowel durations tend to be evenly distributed on either side of the mean.

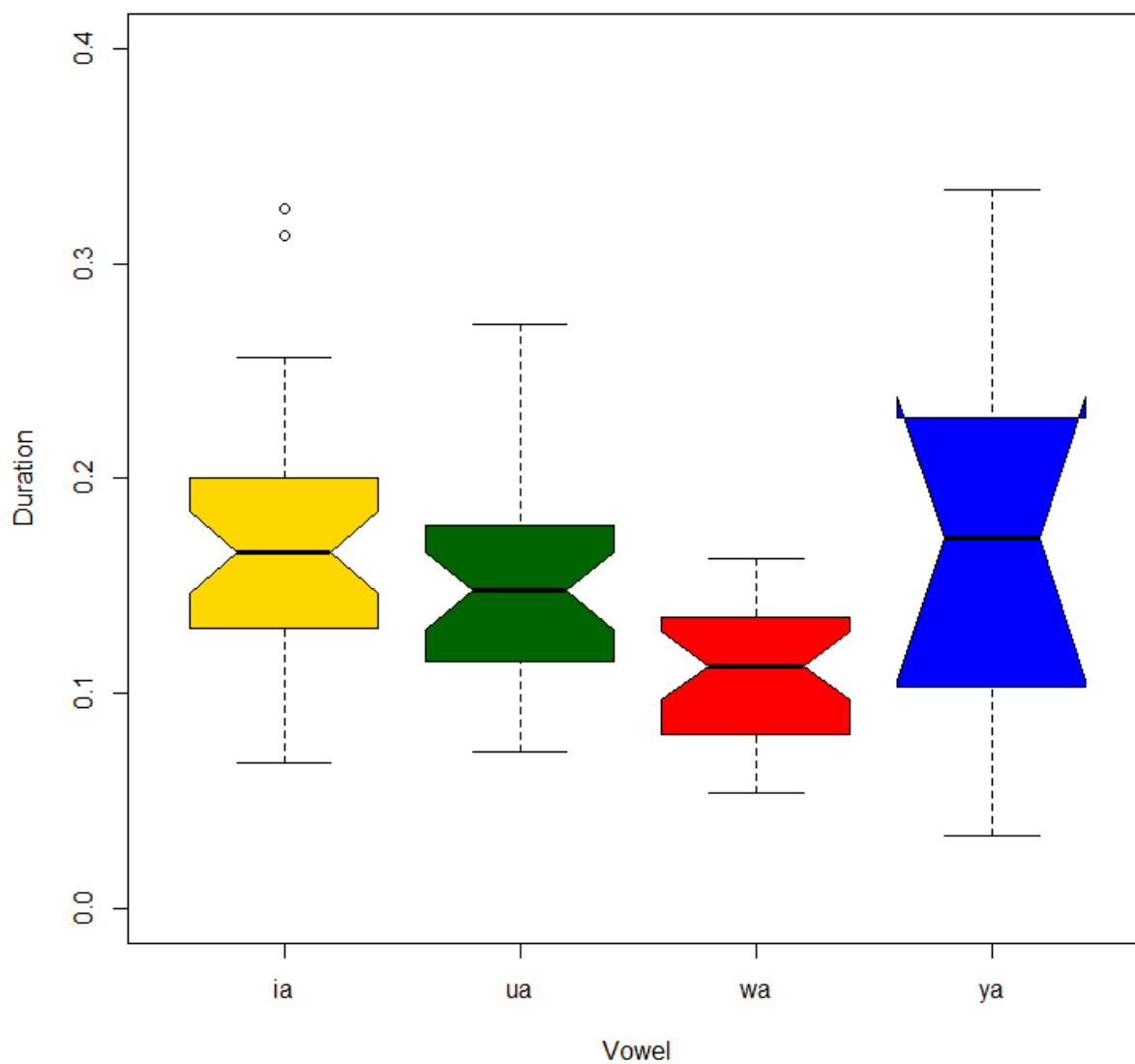
The long monophthongs have fewer outliers than the short monophthongs, but these plots do not show any unexpected results, based on the previous work on Menominee vowels and cross-linguistic patterns. Table 4.7 shows the diphthong duration standard deviations and means.

Figure 4.3 shows these measurements in a boxplot.

Vowel	Standard Deviation (sd)	Mean (ms)
ia	0.05631658	172.07496
ua	0.05304444	149.97446
wa	0.03315091	108.79729
ya	0.09387876	162.15499

Table 4.7: Means and Standard Deviations of the Short and Long Diphthongs

Figure 4.3: Diphthong Durations



In this Figure, *ya* /*ya*/ appears much longer than the other diphthongs, with a wider range of durations as well. This will be discussed in more detail below.

I also examined the short and long monophthongs compared to each other, as well as compared to the short and long diphthongs. In R, I ran a Tukey multiple comparison of means test with a 95% family-wise confidence level for these and all the following statistical significance measures. I normalized the duration measurements by using a log function with the default base (1). I follow the standard convention of <0.05 as a significant P-value. The following numbers show the statistical comparisons between the vowels based on length (all short vowels, all long vowels, short monophthongs, short diphthongs, long monophthongs, and long diphthongs). The ‘p adj’ column of numbers is the point of significance. If this number is below 0.05, the differences in duration are statistically significant.

\$length	diff	lwr	upr	p adj
short.all-long.all	-0.2778807	-0.2969374	-0.258824	0
long.monophthong-long.diphthong	-0.04624500	-0.1078642	0.01537422	0.21577
short.diphthong-long.diphthong	-0.14122029	-0.2357524	-0.04668814	0.00073
short.monophthong-long.diphthong	-0.32710266	-0.3873830	-0.26682231	0.00000
short.diphthong-long.monophthong	-0.09497529	-0.1722148	-0.01773579	0.00866
short.monophthong-long.monophthong	-0.28085765	-0.3066129	-0.25510239	0.00000
short.monophthong-short.diphthong	-0.18588237	-0.2620580	-0.10970671	0.00000

Table 4.8 summarizes the data and the significance of each of the comparisons between the data presented in Figures 4.1 through 4.3.

Variable	Duration mean	sd	Vs. variable	Duration mean	sd	P-value	Significant
short vowels	81.22	0.04144	long vowels	147.39	0.05134	0	Yes
long diphth.	161.37	0.05545	long monoph.	145.69	0.05061	0.21577	No
short diphth.	121.11	0.05668	long diphth.	161.37	0.05545	0.00073	Yes
short monoph.	79.43	0.03973	long diphth.	161.37	0.05545	0.00000	Yes
short diphth.	121.11	0.05668	long mono.	145.69	0.05061	0.00866	Yes
short monoph.	79.43	0.03973	long monoph.	145.69	0.05061	0.00000	Yes
short diphth.	121.11	0.05668	short monoph.	79.43	0.03973	0.00000	Yes

Table 4.8: Significance Values between Variable Vowel Durations

Table 4.8 shows that, holistically, all short vowels are significantly different than the long vowels, both the monophthongs and the diphthongs. Unsurprisingly, short monophthongs and long monophthongs are significantly different in duration. Short diphthongs and long diphthongs are also significantly different, as are short monophthongs and long diphthongs. Unexpectedly, short diphthongs and short monophthongs are also significantly different in duration, while long diphthongs and long monophthongs are not significantly different from each other in duration. Short diphthongs are still significantly longer than long monophthongs.

I also compared the diphthongs with each other since some of these results are unexpected. The following numbers show the results of the Tukey test from R with the final column 'p adj' showing the P-value indicating the significance of the duration differences.

```

$vowel
      diff      lwr      upr      p adj
ua-ia -0.0638987738 -0.213968311  0.0861707639  0.9864589
wa-ia -0.1979614819 -0.349315185 -0.0466077786  0.0008465
ya-ia -0.0862038343 -0.311828614  0.1394209452  0.9955215
wa-ua -0.1340627082 -0.287723766  0.0195983493  0.1724162
ya-ua -0.0223050605 -0.249484105  0.2048739839  1.0000000
ya-wa  0.1117576476 -0.116271727  0.3397870221  0.9514409

```

Table 4.9 shows the significance within the set of diphthongs.

Variable	Duration mean	sd	Vs. variable	Duration mean	sd	P-value	Significant
ua /wa:/	149.97	0.05304	ia /ya:/	172.07	0.05632	0.98646	No
wa /wa/	108.8	0.03315	ia /ya:/	172.07	0.05632	0.00085	Yes
ya /ya/	162.15	0.09388	ia /ya:/	172.07	0.05632	0.99552	No
wa /wa/	108.8	0.03315	ua /wa:/	149.97	0.05304	0.17242	No
ya /ya/	162.15	0.09388	ua /wa:/	149.97	0.05304	1.00000	No
ya /ya/	162.15	0.09388	wa /wa/	108.8	0.03315	0.95144	No

Table 4.9: Significance Values between Diphthong Durations

Table 4.9 shows that the two short diphthongs and the two long diphthongs are not significantly different in duration from each other (*wa/ya* and *ua/ia*). Short *wa /wa/* is significantly different from the long diphthong *ia /ya:/*, but not significantly different from the other long diphthong *ua /wa:/*. Similarly, short *ya /ya/* is not significantly different in duration from either long diphthong.

There is some inconsistency between the significance of the short diphthongs compared to the long ones, individually. The only significant difference between the short diphthongs and the long ones is *wa /wa/* with *ia /ya:/*. *wa /wa/* and *ua /wa:/* are not significantly different from each other, and neither are *ya /ya/* and *ia /ya:/*. This implies there may have been some irregularity in the hand-segmenting I did on the audio files. A spot check of about ten tokens for each short diphthong did not show any major issues with the segmenting. A future project would need to look at these diphthongs more carefully to either confirm or reject the significance of the duration differences that I have found in this data set. Figures 4.4 and 4.5 present all the short vowels and all the long vowels together, both monophthongs and diphthongs.

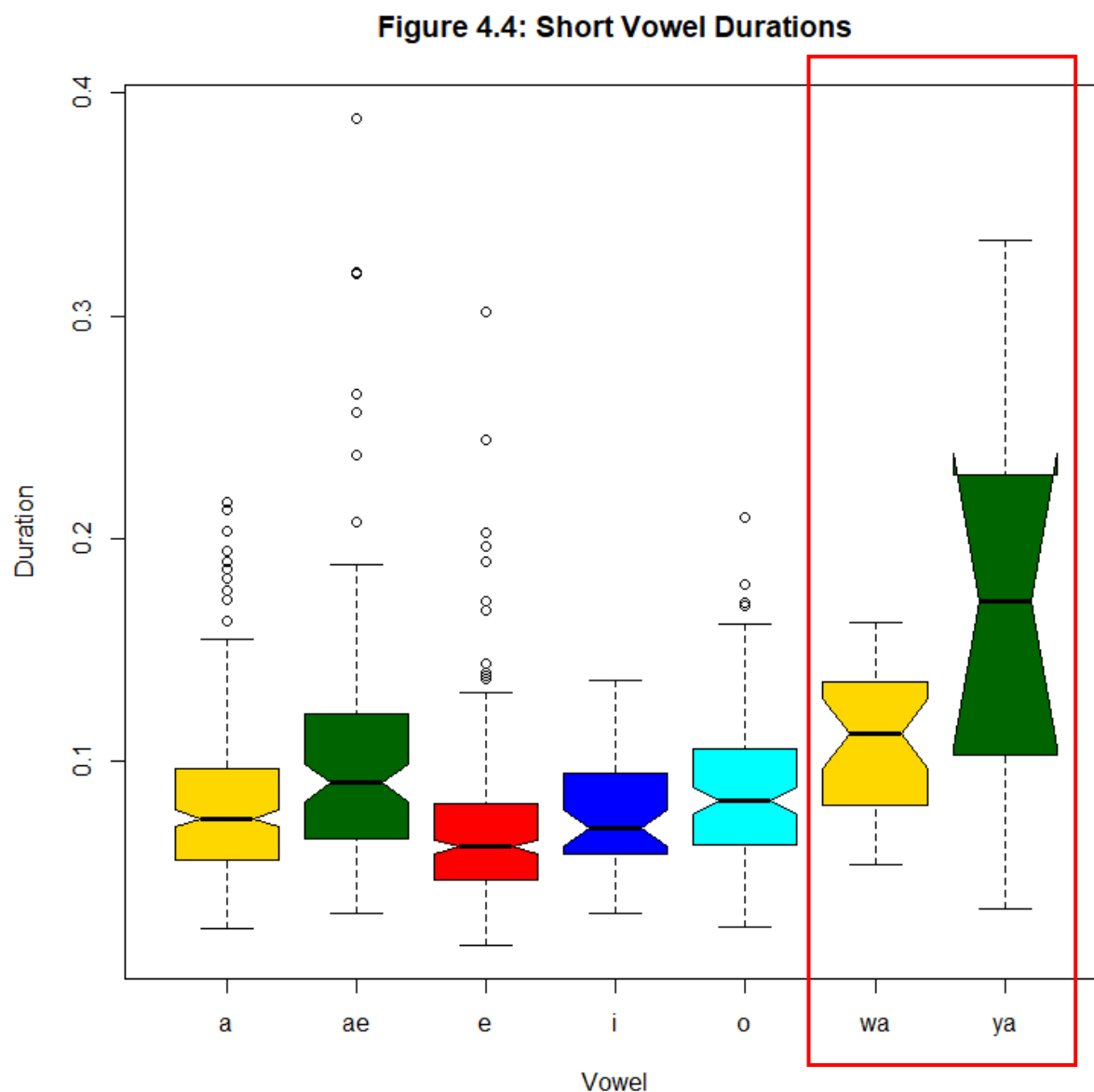
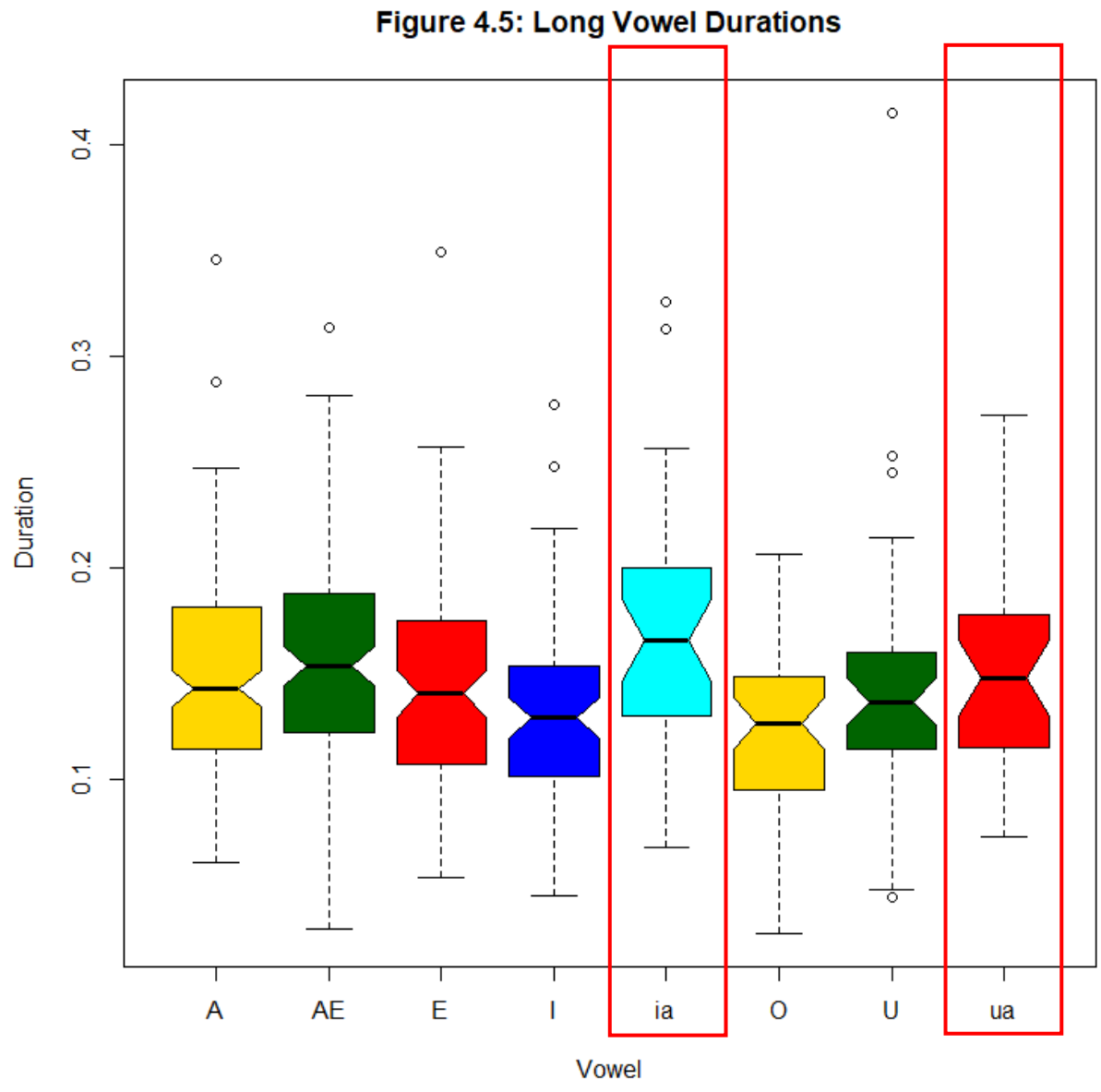


Figure 4.4 shows the short diphthongs side-by-side with the short monophthongs. The short diphthongs are significantly longer than the short monophthongs but *wa* /wa/ and *ya* /ya/ are significantly different from each other. It is possible there was an error in the segmenting of one of these diphthongs. The short diphthongs are still significantly longer than the short monophthongs, and significantly shorter than the long monophthongs. Thus, if *wa* /wa/ was segmented incorrectly, the diphthongs may be more similar in duration to the long

monophthongs. If *ya* /ya/ was segmented incorrectly, the short diphthongs may be closer to the short monophthongs in duration. Figure 4.5 shows the long diphthongs side-by-side with the long monophthongs. Again, the long monophthongs are not significantly longer than the long diphthongs.



4.2.2. Underlying Length as a Variable

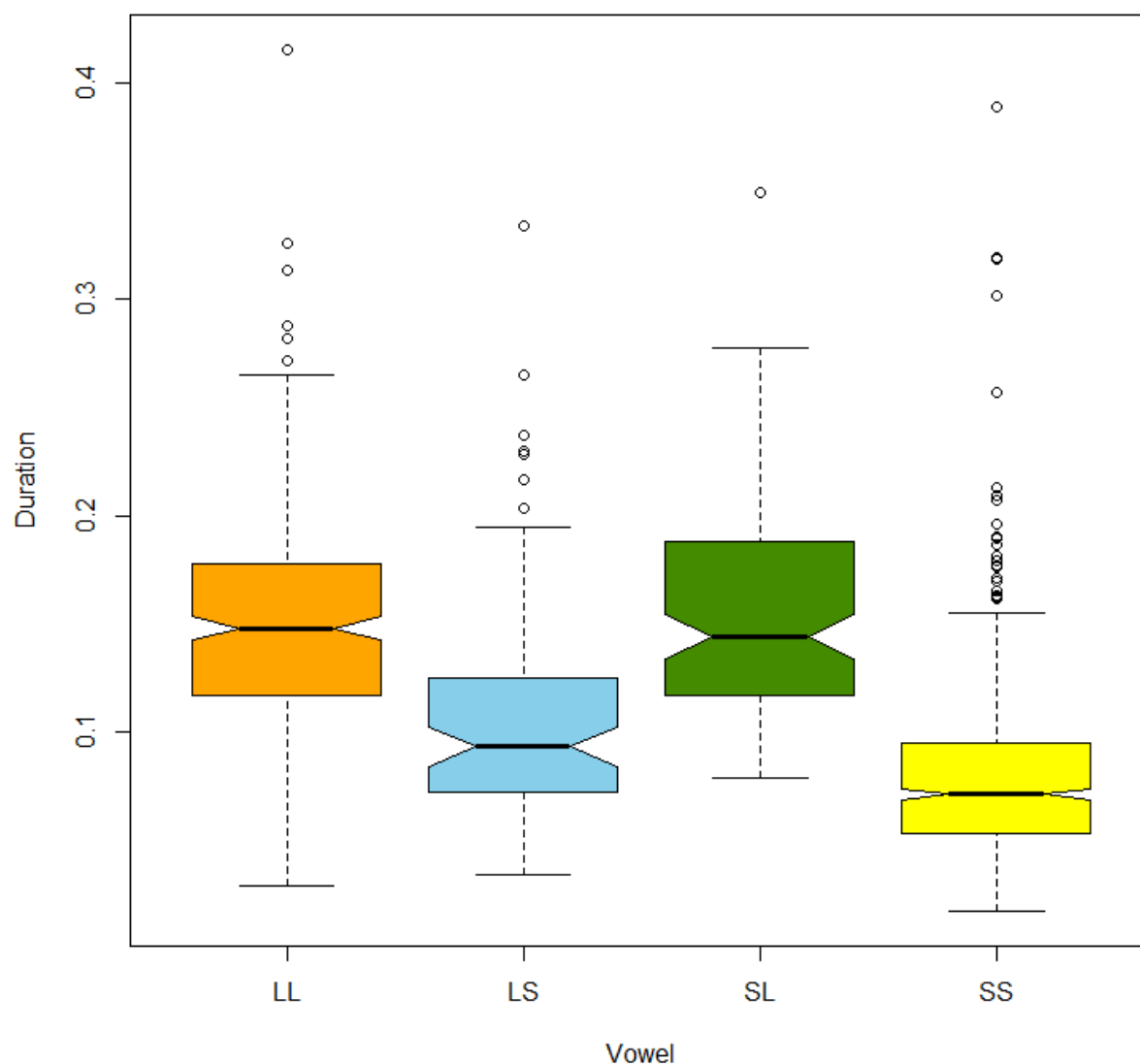
In addition to looking at the diphthong durations compared to the monophthong durations, I also examined the underlying length compared to the surface duration in the vowels. Table 4.10 shows the means and standard deviations of the underlying and surface vowel lengths.

Vowel	Standard Deviation (sd)	Mean (ms)
LL	0.05131182	151.184463
LS	0.05462997	109.4081
SL	0.04876003	155.02837
SS	0.04014346	79.23525

Table 4.10: Means and Standard Deviations of the Underlying and Surface Vowel Lengths

Figure 4.6 shows the durations of the SL, SS, LS, and LL vowels.

Figure 4.6: Underlying/Surface Vowel Durations



The vowels that surface short are significantly different from those that surface long, as expected, regardless of whether shortening or lengthening in the surface duration from the underlying length has occurred. Similarly, those that surface long are significantly different than those that surface short. Again, this is as expected. The vowels that are both underlying and surface short, SS, are significantly shorter than those that are underlyingly long, but undergo vowel shortening, LS. Conversely, vowels that are both underlying and surface long and those

that are underlyingly short and surface long are not significantly different. This indicates a greater degree of variation in short durations than in long ones.

```

$length_code
      diff      lwr      upr      p adj
LS-LL -0.16303669 -0.21905021 -0.10702318 0.0000000
SL-LL  0.01351305 -0.03621066  0.06323676 0.8974034
SS-LL -0.30285578 -0.33423484 -0.27147671 0.0000000
SL-LS  0.17654974  0.11088235  0.24221713 0.0000000
SS-LS -0.13981908 -0.19296421 -0.08667395 0.0000000
SS-SL -0.31636882 -0.36283750 -0.26990014 0.0000000

```

These results are summarized in Table 4.11.

Variable	Duration mean	sd	Vs. variable	Duration mean	sd	P-value	Significant
LS	109.40	0.05463	LL	151.18	0.05131	0.00000	Yes
SL	155.03	0.04876	LL	151.18	0.05131	0.89740	No
SS	79.24	0.04014	LL	151.18	0.05131	0.00000	Yes
SL	155.03	0.04876	LS	109.41	0.05463	0.00000	Yes
SS	79.24	0.04014	LS	109.41	0.05463	0.00000	Yes
SS	79.24	0.04014	SL	155.03	0.04876	0.00000	Yes

Table 4.11: Significance Values between Underlying and Surface Durations

4.2.3. Conclusions on Duration

This section confirms previous work on the significance of Menominee vowel length. It shows that long and short monophthongs are significantly different in duration. It also shows that the short diphthongs are significantly different from the short monophthongs, but the long diphthongs are not significantly different from the long monophthongs. Within the diphthongs, only short *wa* /wa/ is significantly different from the long monophthongs. Short *ya* /ya/ is not different from the long diphthongs, or short *wa* /wa/.

This section also showed that underlying length plays a role in duration produced. A vowel that is underlyingly short and surface short (SS), and a vowel that is underlyingly long and surface short (LS) are significantly different in duration produced by the speakers. Conversely, a vowel that is underlyingly short and surface long (SL), and one that is both underlyingly and surface long (LL) are not significantly different.

These duration comparisons can also be summarized as a ratio of the quantity of the short vowel compared to the long vowel. For example, $\bar{a}e / \text{æ}:/$ averages 1.5 times the length of $ae / \text{æ}:/$. This is represented as a ratio of 1 to 1.5, or 1:1.5, with the short vowels counted as ‘1’ in the ratio. These ratios are presented in Table 4.12.

	Mean (ms)	Ratio	Mean (ms)	
i	77.35094	1:1.7	129.82725	\bar{i}
e	68.14226	1:2.1	145.73982	\bar{e}
ae	103.72862	1:1.5	157.28477	$\bar{a}e$
u	100.18847	1:1.4	143.33624	\bar{u}
o	89.21519	1:1.4	124.35804	\bar{o}
a	79.73059	1:1.9	151.19608	\bar{a}
SS	79.23525	1:2	155.02837	SL
SS	79.23525	1:1.9	151.184463	LL
SS	79.23525	1:1.4	109.4081	LS
SL	155.02837	1:1	151.184463	LL
LS	109.4081	1:1.4	155.02837	SL
LS	109.4081	1:1.4	151.184463	LL

Table 4.12: Vowel Means and Ratios for Duration

The duration ratios presented in Table 4.12 show that some long vowels are much longer in relation to their corresponding short vowel than others. $\bar{e} / e:/$ averages more than double the

duration of *e* /e/. *ō* /o:/ and *ū* /u:/average almost 1.5 times longer than *o* /o/ and *u* /u/ respectively.¹³ The means for some of the vowels, however, run counter to previous claims that lower vowels will be longer than higher vowels (Lindblom 1968; Lehiste 1970; Myers 2005). By this claim, *ae* /æ/ and *a* /a/ should average longer duration than *i* /i/ and *u* /u/. *a* /a/ averages only 0.2 ms longer than *i* /i/, but is typically shorter than *u* /u/. *ae* /æ/ measures the longest duration of all the short monophthongs. Similarly, *āe* /æ:/ and *ā* /a:/ should average a longer duration than *ī* /i:/ and *ū* /u:/. For the long vowels, this expectation holds true.

4.3. Vowel Quality¹⁴

This section presents the first acoustic analysis of Menominee vowel quality. Table 4.3 from above is repeated here showing the number of tokens per speaker that are represented in the acoustic vowel space discussed in this section.

¹³ Keep in mind that no strong generalizations can be made involving *u*, as there were only two tokens in the data set.

¹⁴ In this section I use the square brackets to represent the target phonetic signal, rather than a close phonemic transcription.

		NS_1	NS_2	NS_3	NS_4	NS_5	Total
short vowel	i	2	11	15	16	3	47
	e	25	63	87	117	31	323
	ae	8	8	41	41	6	104
	u	0	0	2	0	0	2
	o	9	9	38	47	10	113
	a	25	27	121	90	17	280
	ya	0	1	6	1	1	9
wa	1	1	15	12	1	30	
long vowel	ī	3	8	25	25	7	68
	ē	12	18	31	32	3	96
	āē	7	17	37	50	11	122
	ū	1	6	25	10	1	43
	ō	5	6	9	24	5	49
	ā	14	23	41	55	13	146
	ia	0	5	19	8	1	33
	ua	4	1	17	7	2	31

Table 4.3: Individual Vowel Numbers by Speaker

The formant measurements in the following figures come from the same tokens that were analyzed in the previous section for duration. The rest of this chapter will present the vowel formant measurements first in a Bark normalized acoustic chart to visualize all the vowels in relation to each other, and second in density plots to observe patterning of the individual vowel realizations within the acoustic space. A Bark normalized chart represents the vowels as a correlation to the oral cavity and relative tongue movement, i.e. high, low, front, back. The x-axis represents formant 2 (front/back) and the y-axis represents formant 1 (high/low). Appendix 1 contains all the head and tail measurements that are summarized here. The formants demonstrate vowel height and front/back as an interaction between formant 1 (F1) and formant 2 (F2). F1 represents the relative height of a vowel and F2 represents the frontness/backness of a vowel. Low F1 (the x-axis) measurements correlate to the production of a high vowel and high

F1 correlates to a low vowel. High F2 (x-axis) correlates to front vowels and low F2 to back vowels. The following figure shows how the formants represent the movement of the tongue, and thus the acoustic signal being produced.¹⁵

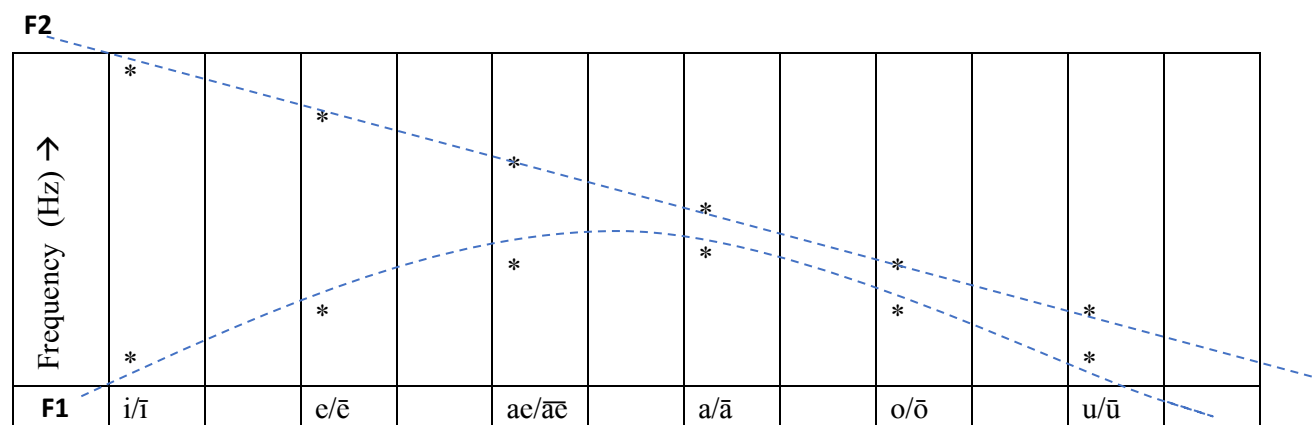


Figure 4.7: Approximation of How the Formants Correlate to Tongue Height and Frontness/Backness

Figure 4.8 shows the mean vowel formant measurements for all five speakers. This figure shows Menominee vowels visually as a representation of the acoustic space with high/low and front/back distinctions, which is the most typical way to analyze and discuss distinctive vowels (Ladefoged 1964; Lindau 1978; Ladefoged and Maddieson 1998; Ladefoged & Johnson 2015).

¹⁵ Figure 4.7 is synthesized from an example provided as part of a class discussion by Tom Purnell at University of Wisconsin – Madison in the fall of 2016.

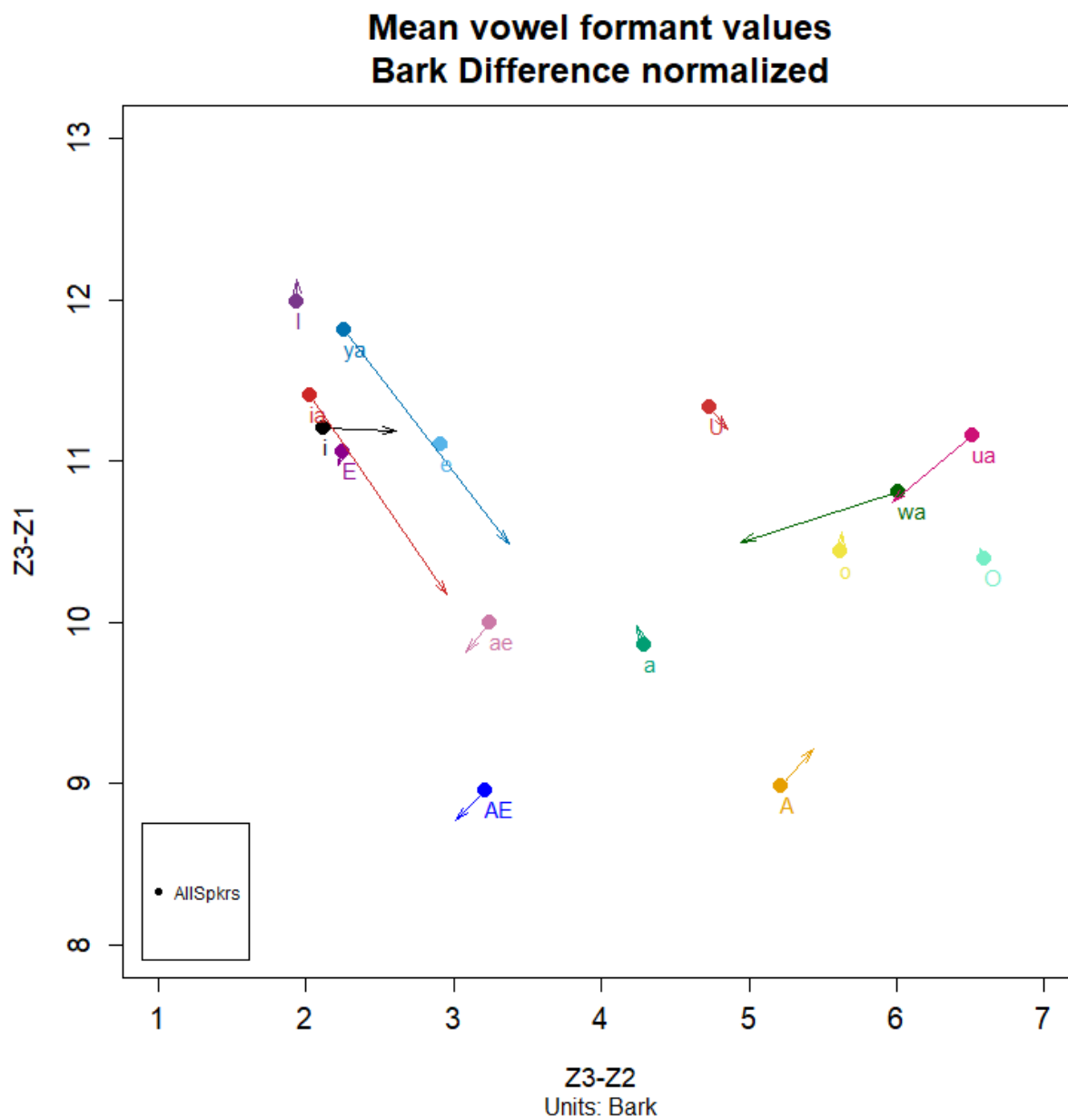


Figure 4.8: Menominee Vowel Acoustic Quality

The acoustic vowels present in a Bark difference normalized vowel space largely as expected based on the previous descriptive literature (Bloomfield 1962). Long vowels tend to be more peripheral than their corresponding short vowels. The *a* [a] is more mid and central than *ā* (again, the uppercase letters are the long vowels, *A* in the figure). The vowel that most stands out in this figure is *ū* [u:]. The high, back vowels are fronted, compared to the mid, back vowels

{*o*, *ō*} [o, o:]. *ae* [æ] and *āē* [æ:] are further back in the vowel space than the other front vowels {*i*, *ī*, *e*, *ē*} [i, i:, e, e:], which is not unexpected. *e* [e] is less fronted as well, though not to the same degree as the low, front vowels.

The dot by the vowel label is the head of the vowel, the formant measurements at the first third of the vowel, and where the arrow ends represents the tail of the vowel, the formant measurements at the last third of the vowel (i.e. head measurements at 33% of the vowel and tail measurements at 66% of the vowel). Head and tail measurements indicate movement of the vowel quality within the duration of the vowel produced. Figure 4.8 shows that some vowels, particularly the diphthongs, have a great deal of movement between the first and last third of the vowel. A diphthong is expected to have a great deal of head to tail movement as the vowel itself is made up of two vowel targets. The head of the diphthong measures the first vowel target and the tail measures the second. Monophthongs are expected to have less movement than diphthongs as there is only one vowel target (Ladefoged and Maddieson 1998).

Table 4.13 shows the mean frequency (in Hz) and standard deviations (sd) for each vowel's F1 head and tail, and F2 head and tail.

Vowel	F1 Head		F1 Tail		F2 Head		F2 Tail	
	mean (Hz)	sd	mean (Hz)	sd	mean (Hz)	sd	mean (Hz)	sd
i	471.0014	184.7149	445.1979	110.1753	2246.257	415.9524	2068.118	534.2084
e	470.6710	155.8312	472.1999	180.7726	1986.617	441.0879	1997.067	449.5969
ae	588.1693	149.5371	605.8851	194.7636	1848.250	362.6262	1863.128	351.7819
o	526.8457	159.7052	517.6476	144.9685	1302.403	443.7972	1314.028	463.0923
a	600.4546	179.5809	594.3135	210.3952	1582.091	423.6242	1600.122	422.2725
ya	437.9909	67.62012	578.0512	128.4389	2315.384	344.5309	1905.545	243.2576
wa	514.6988	114.9132	527.7136	166.2554	1265.931	377.1907	1421.573	292.0789
I (ī)	414.0302	58.47141	407.6730	77.84186	2431.003	415.1808	2444.442	365.8798
E (ē)	468.4121	68.15698	469.5380	116.8608	2201.502	498.0467	2194.205	540.9929
AE (āē)	706.5328	143.22	716.7032	160.5498	1823.202	356.7204	1838.641	331.2529
U (ū)	423.1436	84.15954	438.2812	143.7241	1485.224	425.8046	1450.251	448.3206
O (ō)	511.6644	101.3096	522.0301	145.7855	1069.289	295.3679	1111.964	412.9325
A (ā)	707.0001	164.37	707.7661	194.8396	1347.782	303.1906	1350.676	340.5856
ia	433.2350	90.12774	552.5655	133.1314	2229.743	292.6247	1882.371	278.4272
ua	460.3936	77.67923	518.0237	180.9051	1177.110	481.802	1263.493	389.8838

Table 4.13: Means and SD of F1 Head, Tail and F2 Head, Tail by Vowel

To examine the patterns of the individual vowels, I also looked at how the measurements of the vowel formants cluster within density plots, allowing an analysis of the vowels along different dimensions. The following figures show the vowels conventionally known as high (*i* [i], *ī* [i:], *ū* [u:]), mid (*e* [e], *ē* [e:], *o* [o], *ō* [o:]), low (*ae* [æ], *āē* [æ:], *a* [a], *ā* [a:]), front (*i* [i], *ī* [i:], *e* [e], *ē* [e:], *ae* [æ], *āē* [æ:]), and back (*ū* [u:], *o* [o], *ō* [o:], *a* [a], *ā* [a:]). The density plots show where the tokens cluster along the x axis (variously F1 head, F1 tail, F2 head, and F2 tail). A normal distribution of vowel tokens would look like a typical bell curve (gaussian distribution), with a larger number of tokens clustering together, forming a peak, and fewer tokens forming the right

and left slopes. This would indicate a single vowel target. A sharp peak indicates little variation in the vowel tokens and a broad, flatter peak represents vowel tokens across a broader frequency range. The lower, flatter peak is more likely to indicate allophones in free variation. Looking at the vowel realizations using vowel plots allows us to see how the vowels cluster within the acoustic range. The type of peak (steep, flat, etc.) can indicate how variable the realizations are. When comparing two or more vowels, we can see not only which vowels are more variable than others, but also which vowels overlap in acoustic realizations. Figures 4.9-4.14 show the F1 and F2 head measurements for the high, mid, and low vowels respectively. In this chapter I am looking at the vowels phonetically, rather than phonologically. For example, phonologically, *o* /*o*/, *ō* /*o:*/, *a* /*a*/, and *ā* /*a:*/ do not have a height specification, as is discussed in further detail in Chapter 5. Figures 4.9-4.18 examine the vowels holistically as height and front/back groupings. The following discussion will address in greater detail the patterns of overlapping measurements in the density plots and what the implications of these patterns are.

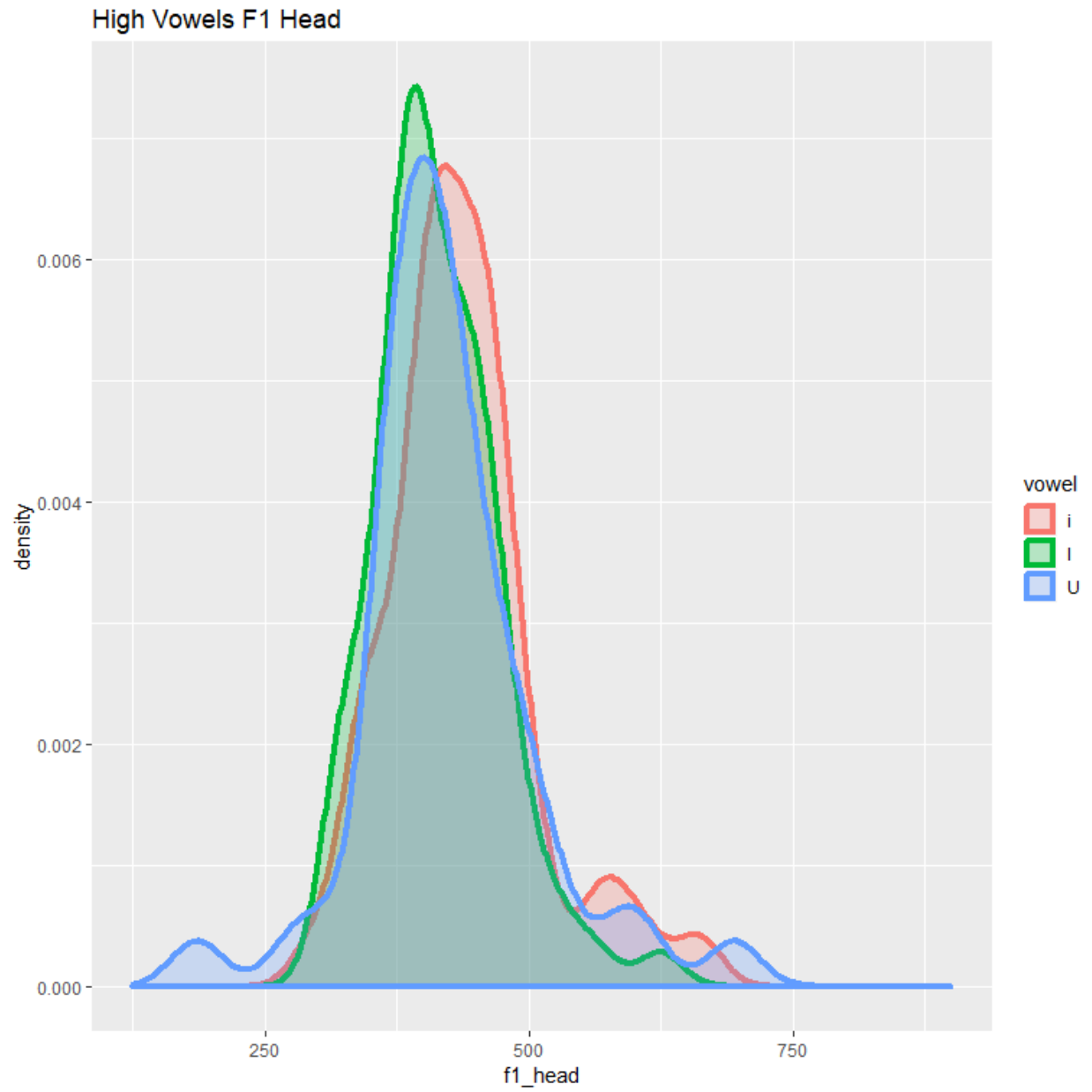


Figure 4.9: High vowels (short and long) F1 Head



Figure 4.10: High vowels (short and long) F2 Head

While the F1 head measurements in Figure 4.9 show very little variation between the three high vowels (to the point where the density plots overlap almost entirely), the F2 head measurements in Figure 4.10 tell a very different story. F1, correlating to vowel height, shows *i* [i], *ī* [i:], and *ū* [u:] at a very similar acoustic height. F2 in Figure 4.10 shows lower formant frequency

measurements for \bar{u} [u:], which correlates further back in the acoustic space than i [i], and \bar{i} [i:].

This is consistent with what I expect to see between these three vowels.

Figures 4.11 and 4.12 show the mid vowels: e [e], \bar{e} [e:], o [o], \bar{o} [o:].

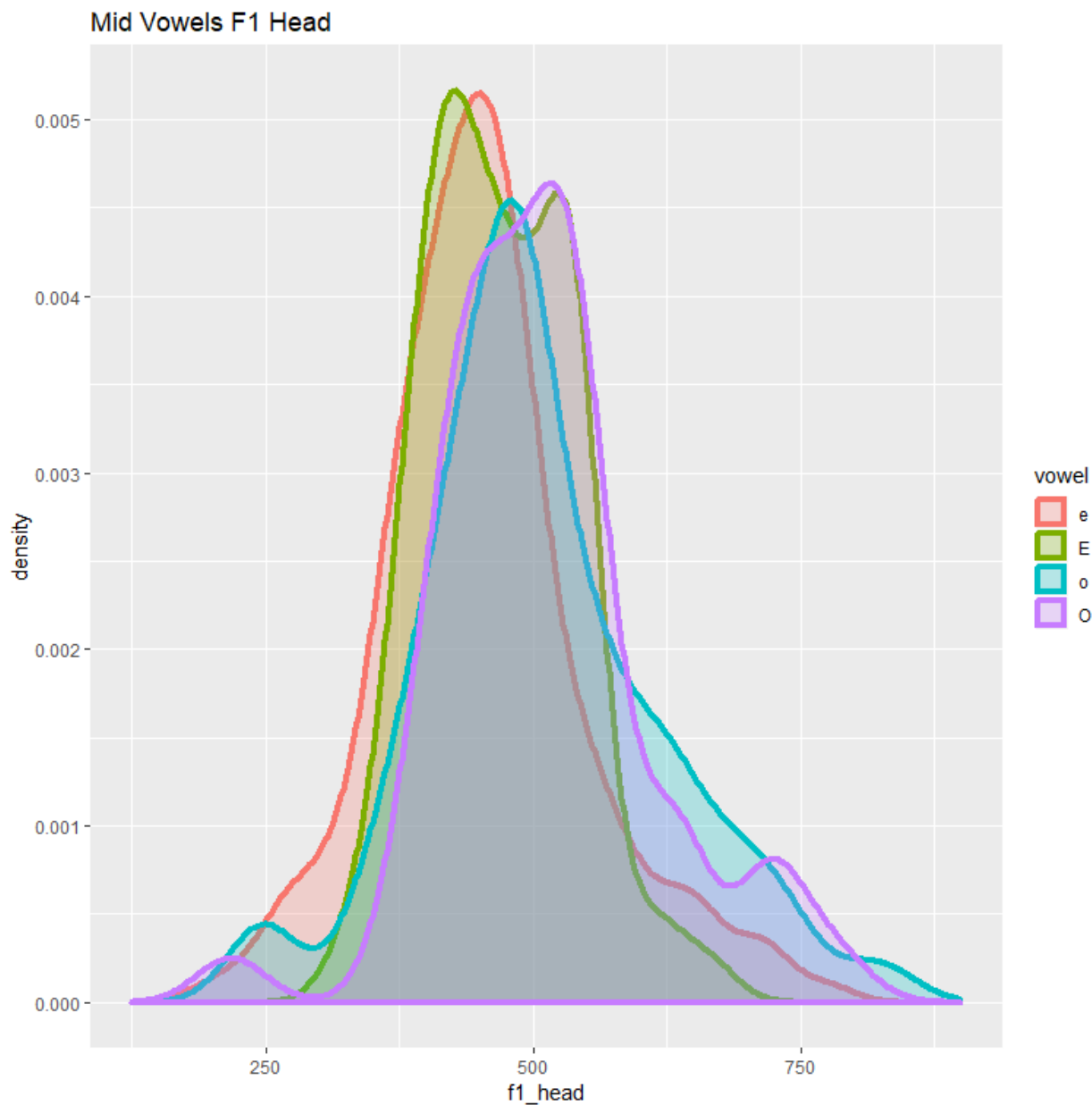


Figure 4.11: Mid vowels (short and long) F1 Head

Figure 4.11 shows again that the mid vowels have very similar heights in the acoustic space.

Figure 4.12 shows a clear split between the front vowels (higher F2 frequencies) and the back

vowels (lower F2 frequencies). *e* [e] is a little further back than \bar{e} [e:], and *o* [o] is a little further front than \bar{o} [o:]. This is consistent with expectations that the long vowels will be tenser, and thus more peripheral, than short vowels.

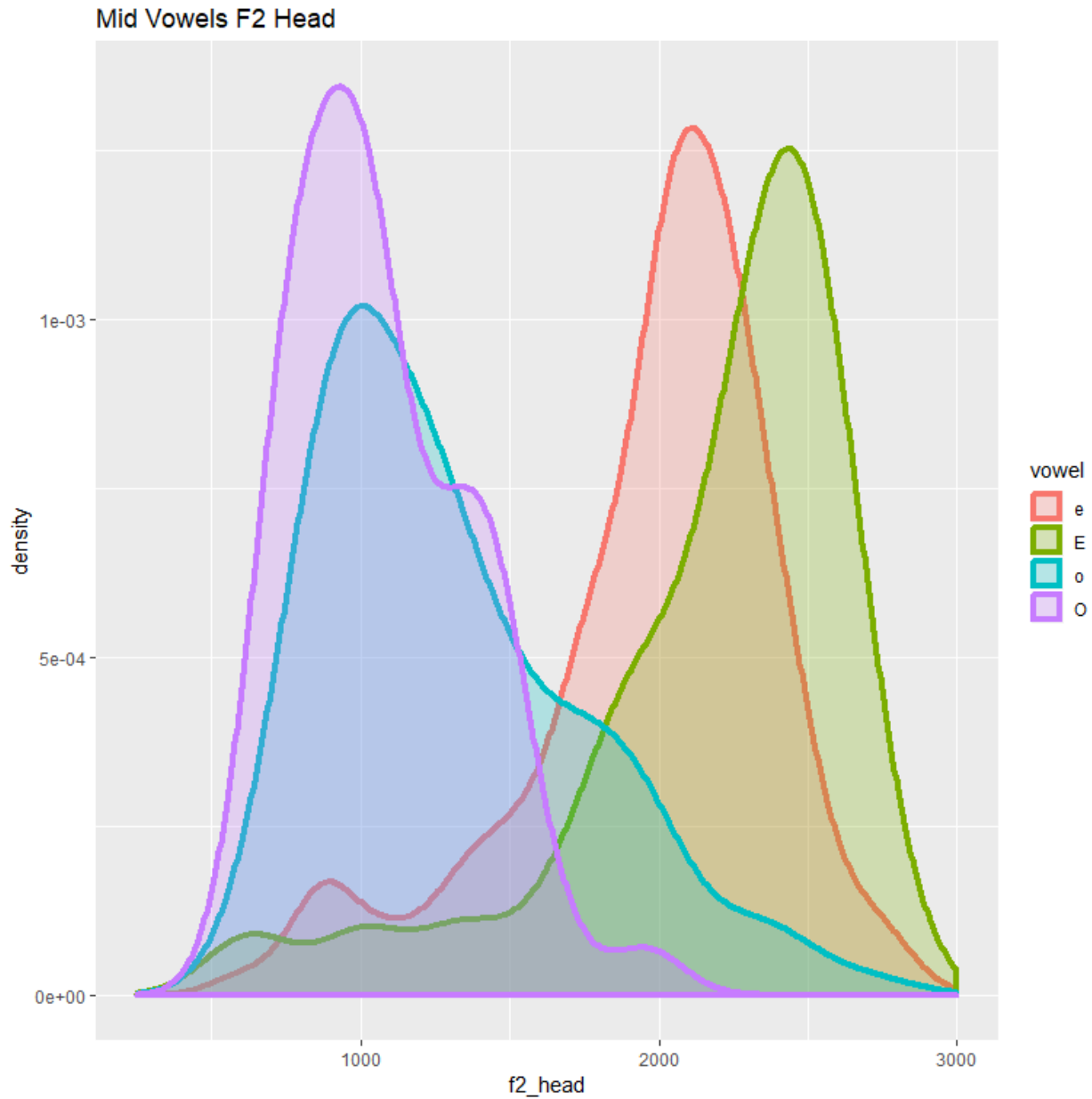


Figure 4.12: Mid vowels (short and long) F2 Head

Figures 4.13 and 4.14 show the low vowels' (*a* [a], *ā* [a:], *ae* [æ], *āē* [æ:]) F1 and F2 heads.

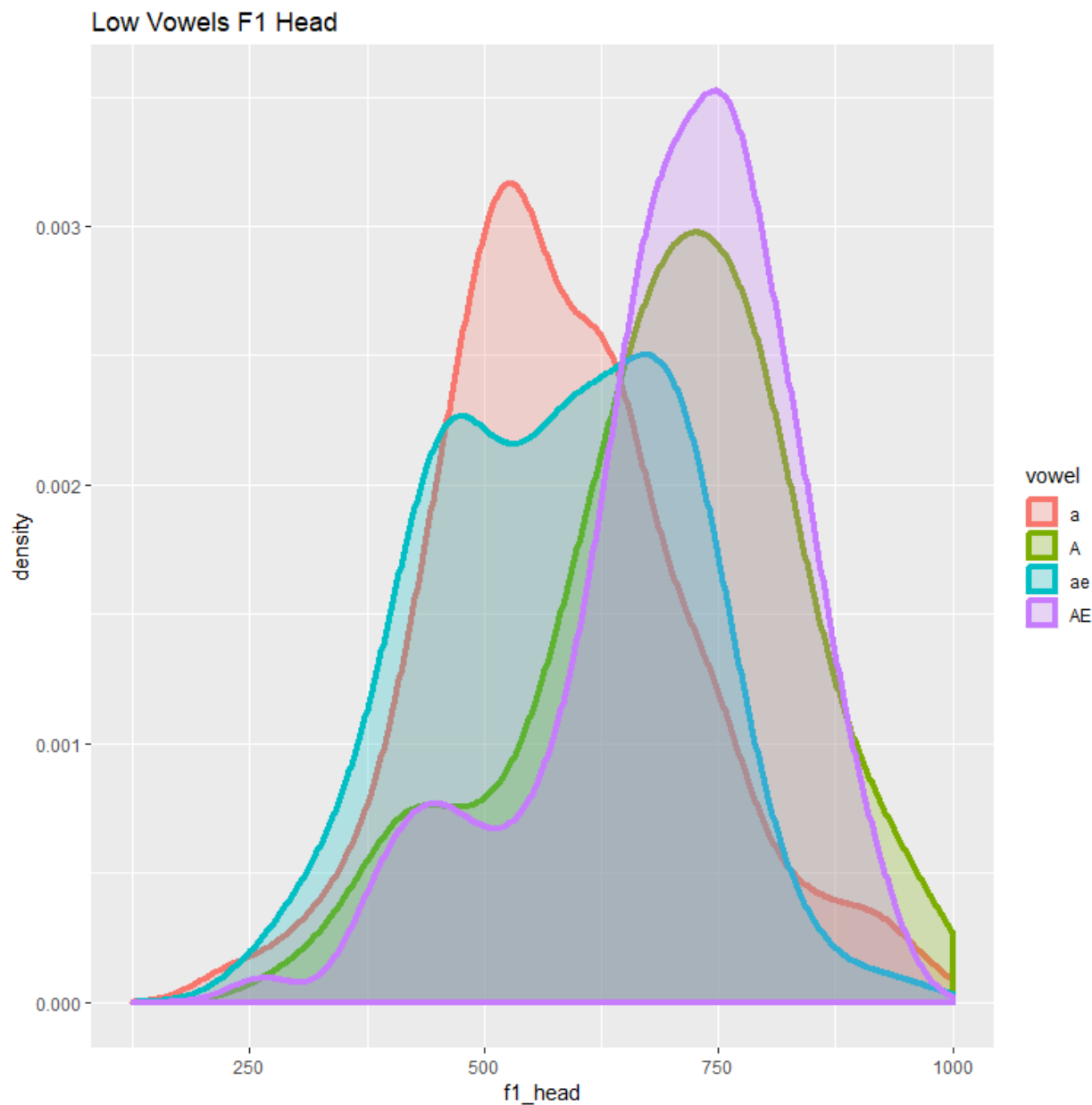


Figure 4.13: Low vowels (short and long) F1 Head

Unlike with the high and mid vowels, Figure 4.13 shows a height distinction between the low vowels. This distinction is along the length variable. Short *a* [a] and *ae* [æ] have a lower average F1 frequency, which indicates higher vowels in the acoustic space. Long *ā* [a:] and *āē*

[æ:] have a higher frequency, indicating they are lower in the acoustic space than their short counterparts. This is again consistent with expecting long vowels to be more peripheral than short vowels. Figure 4.14 shows the same vowels' F2 head measurements.

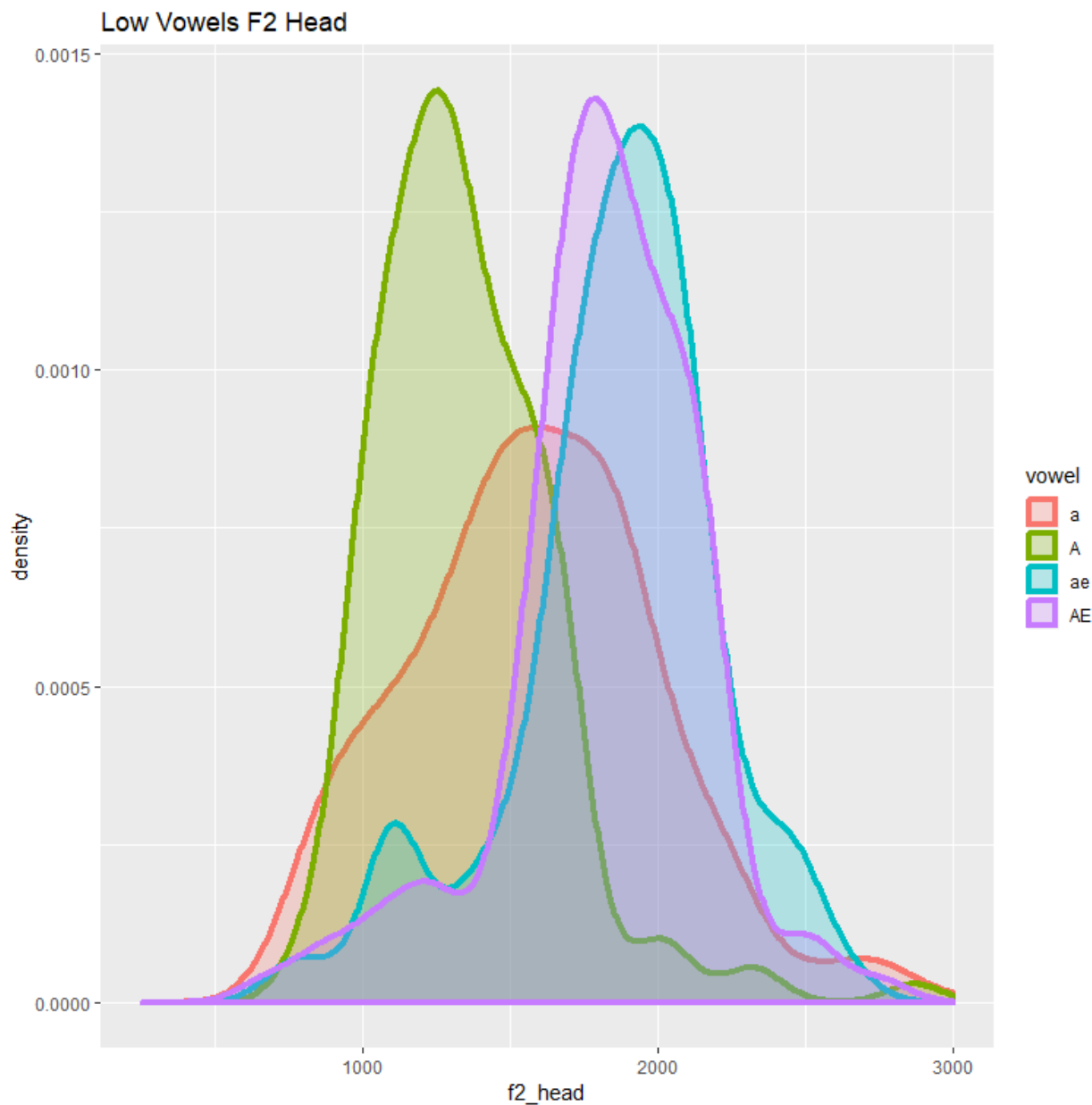


Figure 4.14: Low vowels (short and long) F2 Head

In this figure, there is quite a bit more overlap in the density plots for this set of vowels than in the previous sets. Specifically, *a* [a] overlaps with all three others, front and back. It has a much

lower and spread out distribution of tokens than the other three vowels. This indicates that \bar{a} [a], ae [æ] and \bar{ae} [æ] have less variation in the targets produced by the speakers than a [a].

In the next series of Figures I present these same tokens divided by front and back rather than height. Figures 4.15 and 4.16 show the F1 and F2 heads of the front vowels.

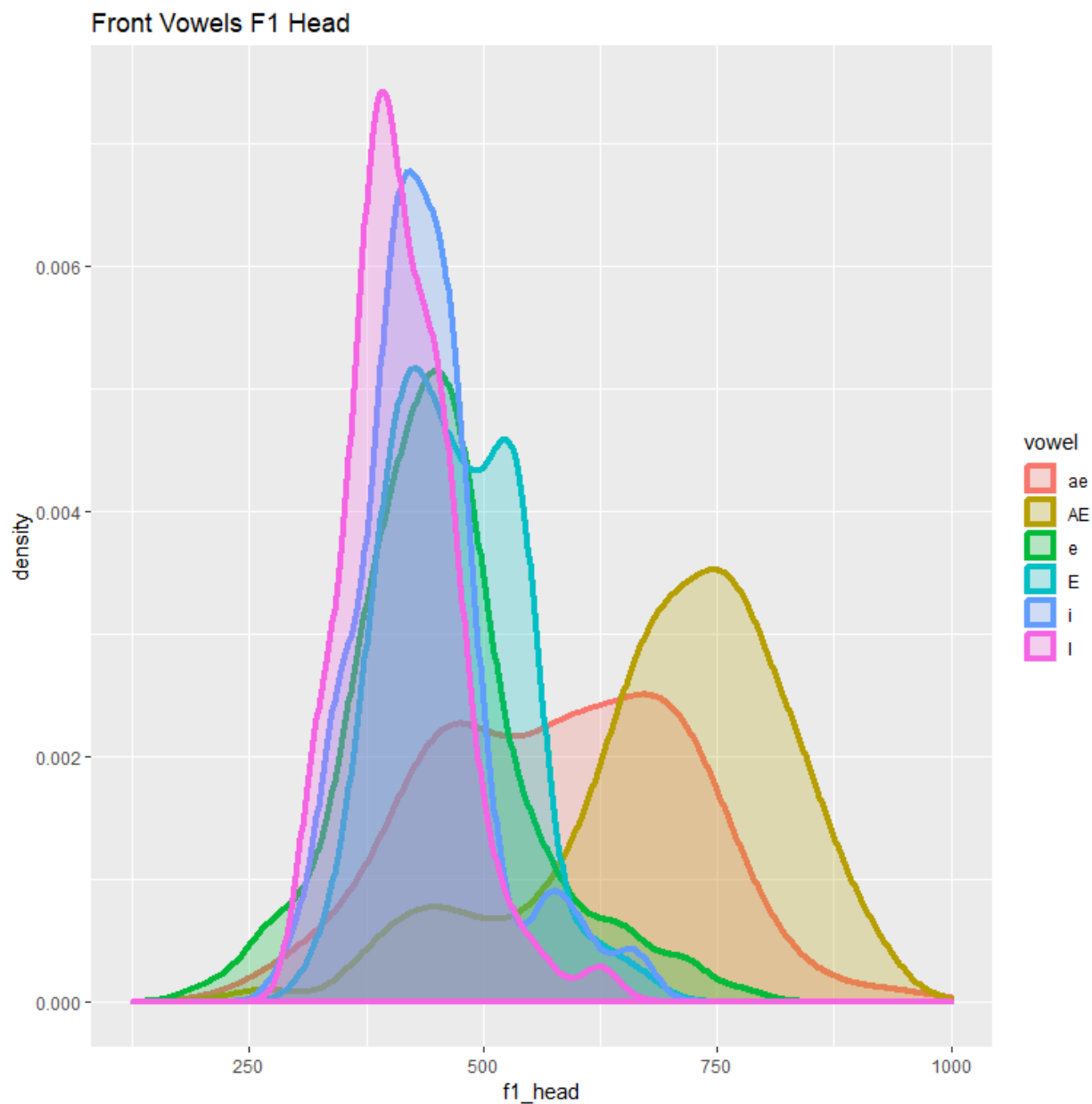


Figure 4.15: Front vowels (short and long) F1 Head

Figure 4.15 shows the F1 head measurements of the front vowels. As expected, the figure reflects a range of heights in the acoustic space. *i* [i] and *ī* [i:] have the lowest F1 frequency, which means they are highest within the acoustic space. *e* [e] and *ē* [e:] are in the middle, and *āē* [æ:] has the higher frequency, which means it is lowest within the acoustic space. *ae* [æ] shows a great deal of overlap with the other front vowels, indicating a greater degree of variation across the front range for *ae* than some of the other front vowels, such as *i* [i] and *ī* [i:] which have very sharp peaks.

Figure 4.16 shows the F2 frequencies of the front vowels. In this figure, *āē* [æ:], *ae* [æ], *e* [e], *ē* [e:], and *ī* [i:] each have relatively sharp peaks and most notably, each individual peak is clearly visible, indicating each vowel is distinctively further front/back in the acoustic space. Only *i* does not stand out with a peak distinct from the other vowels, indicating it shares much of the acoustic space with the other vowels, and does not necessarily occur in a space that is not occupied variously by another vowel.

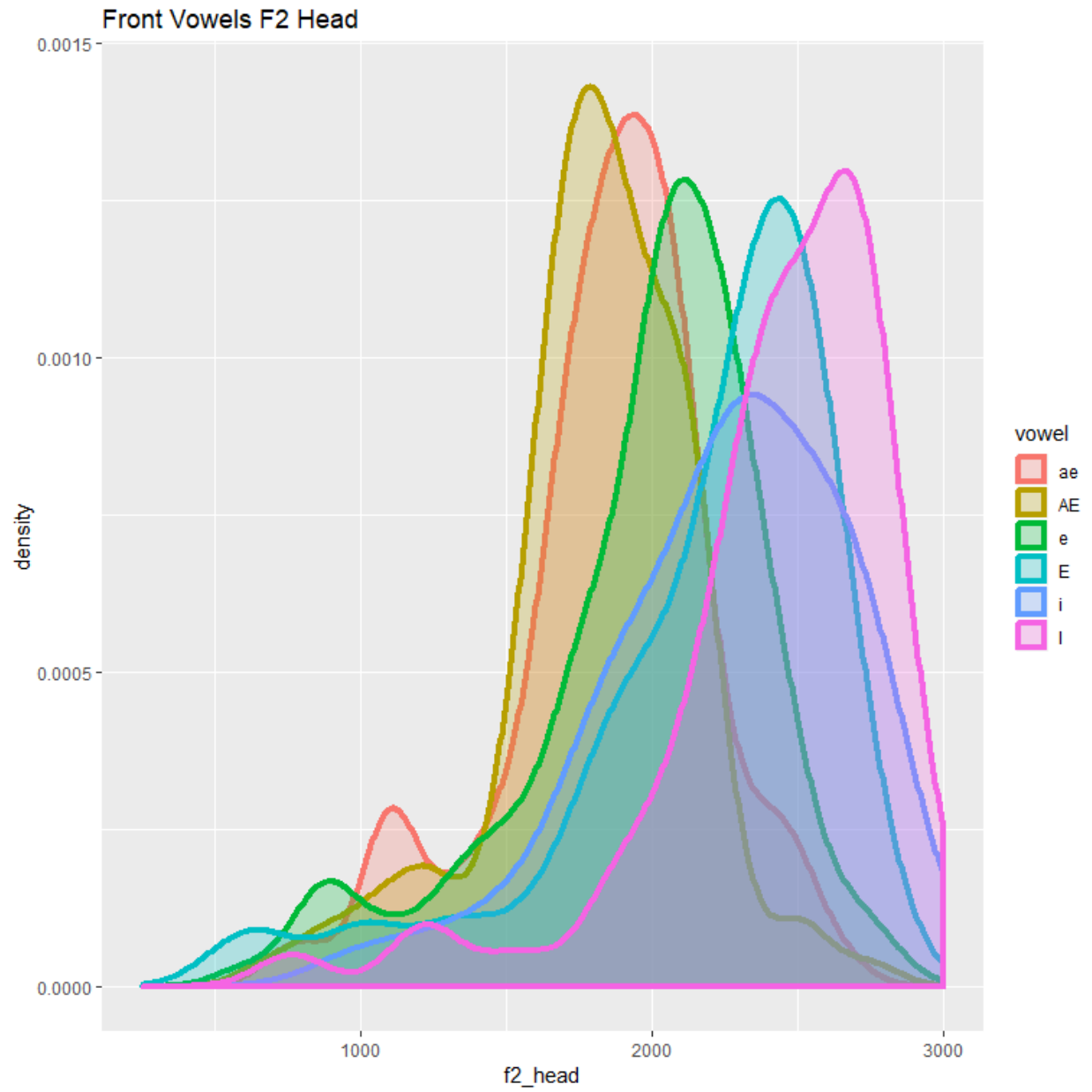


Figure 4.16: Front vowels (short and long) F2 Head

Figures 4.17 and 4.18 show the F1 head and F2 head of the back vowels.

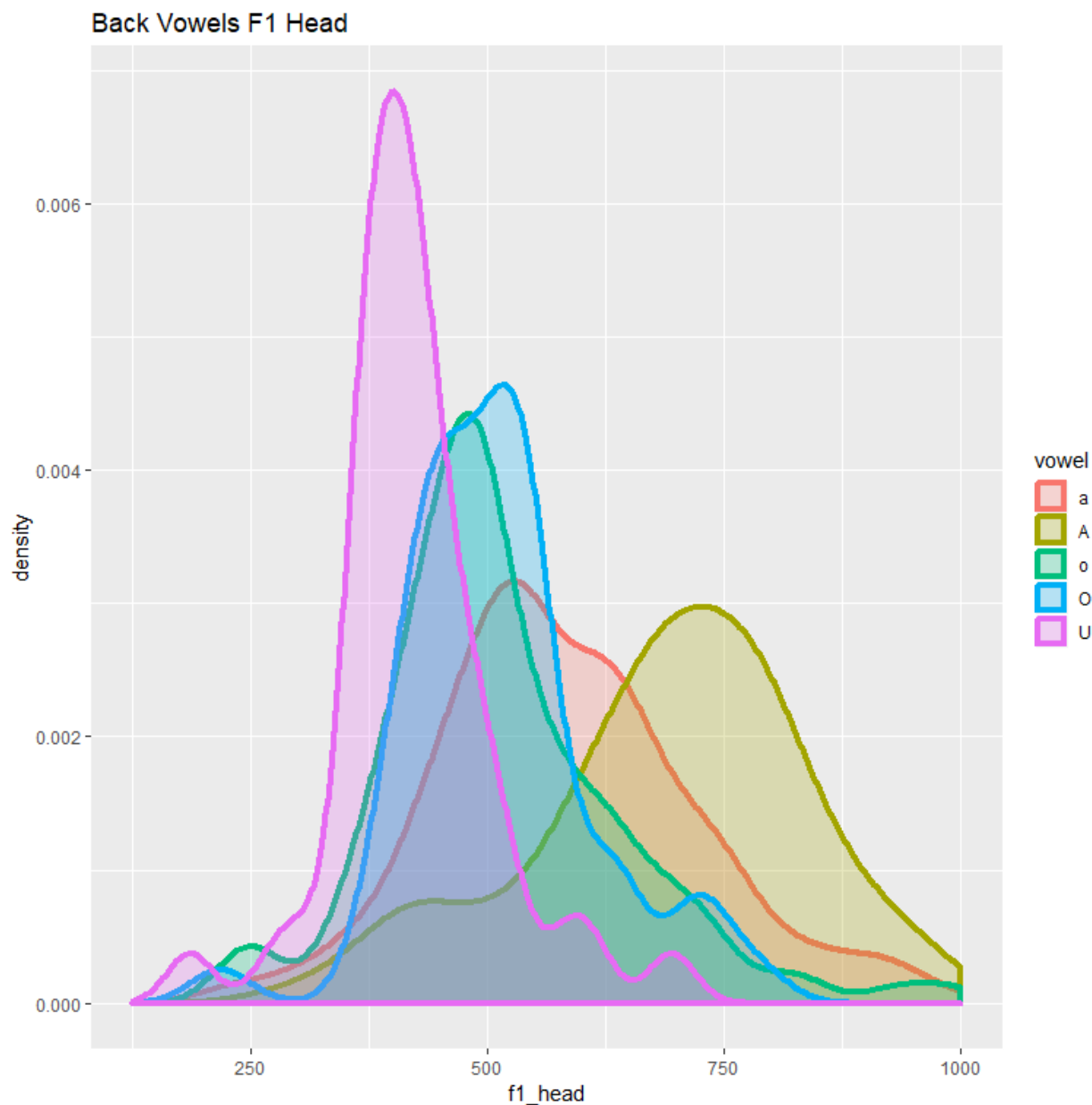


Figure 4.17: Back vowels (short and long) F1 Head

Figure 4.17 shows the F1 head frequency of the back vowels. F1 represents vowel height within the acoustic space. This image shows that \bar{u} [u:] has the lowest average frequency, meaning it is highest in the acoustic space. o [o] and \bar{o} [o:] are in the middle, and a [a] and \bar{a} [a:] for the most part have the highest frequencies, which means they are lowest in the acoustic space. Similar to

the *ae* [æ] and *āe* [æ:] pattern in Figure 4.15, short *a* [a] is distinct from *ā* [a:] in height within the acoustic space. The two do not overlap as much as *o* [o] and *ō* [o:] do.

Figure 4.18 shows the F2 head measurements of the back vowels. There is a great deal of overlap of the density plots in this image, indicating that there is not a lot of front/back distinction between these vowels. Figure 4.17 indicates that there is more distinction in height.

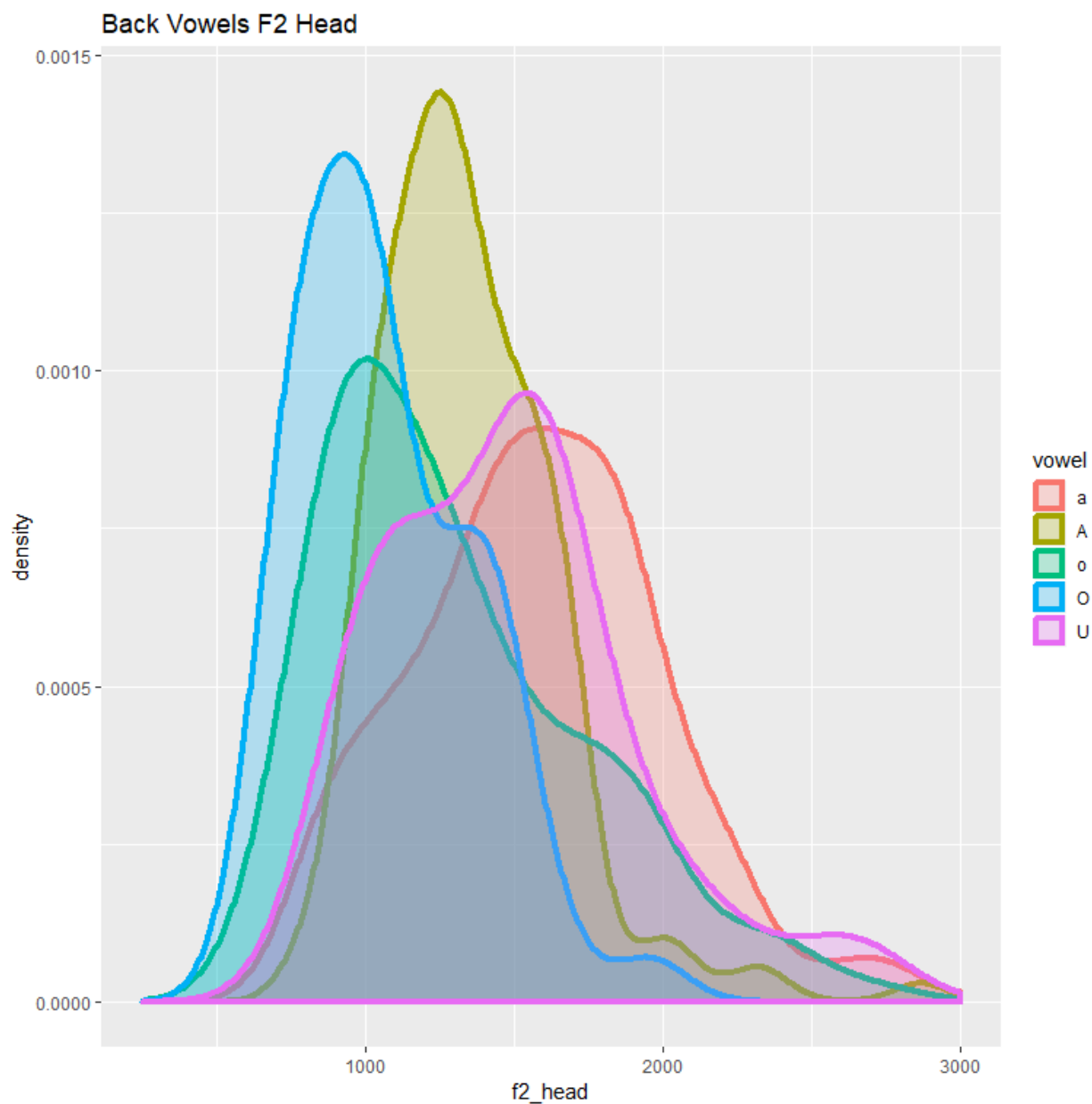


Figure 4.18: Back vowels (short and long) F2 Head

As mentioned earlier, overlap in the density plots can indicate patterns of free variation and possibly even predictable allophony. Table 4.14 repeats Table 2.4 from Chapter 2 with the summary of the expected allophonic variation for each of the monophthongs that are examined throughout this chapter.

	<u>Short Vowels</u>				<u>Long Vowels</u>			
		Front	Back		Front	Back		
High	/i/	[i] [ɪ]	/u/	[ʊ]	/i:/	[i:]	/u:/	[u:]
Mid	/e/	[i] [ɪ] [ɛ]	/o/	[o] [ɔ] [ə]	/e:/	[e:]	/o:/	[o:]
Low	/æ/	[ɪ] [ɛ] [æ]	/a/	[a] [ʌ] [ə]	/æ:/	[æ:]	/a:/	[a:] [o:]

Table 4.14: Menominee Vowels and Allophones (from Milligan 2000; 2005:3)

The following series of figures explores these claims. I compare the short front, short back, long front, and long back. For each set I examine the F1 and F2 heads and tails. The first set of vowels I look at are the short front vowels. Table 4.14 indicates that *i* and *e* should overlap almost completely since they share largely the same allophones ([i] and [ɪ]). *ae* should overlap with *i* and *e* since it is supposed to have [ɪ] as an allophone, it should overlap even more with *e* since it is also supposed to have [ɛ] as an allophone, as does *e*. *ae* should also have a range distinct from *i* and *e* since it has a realization not shared with the other two: [æ]. In sum, based on the description of Table 4.14, I expect a density pattern that looks similar to the prediction in the following figure.

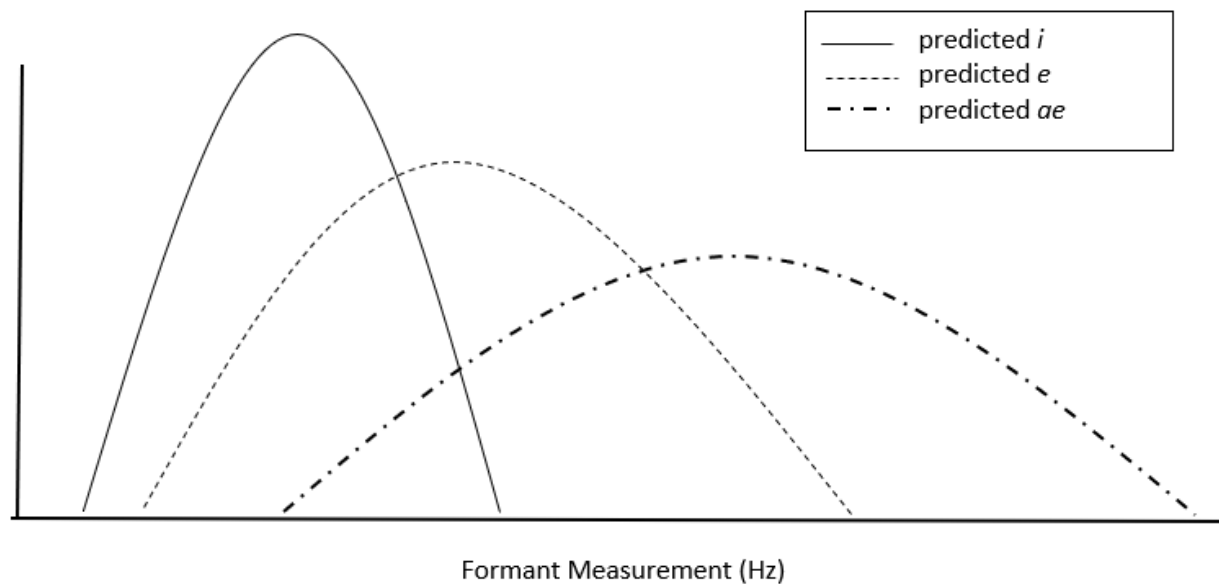


Figure 4.19: Predicted Density Pattern of Short Front Vowels as described in Table 4.14

This figure represents the overlap in density patterns indicated by Table 4.14. Figures 4.20-4.23 show the F1 heads and tails and F2 heads and tails of the short front vowels, respectively.

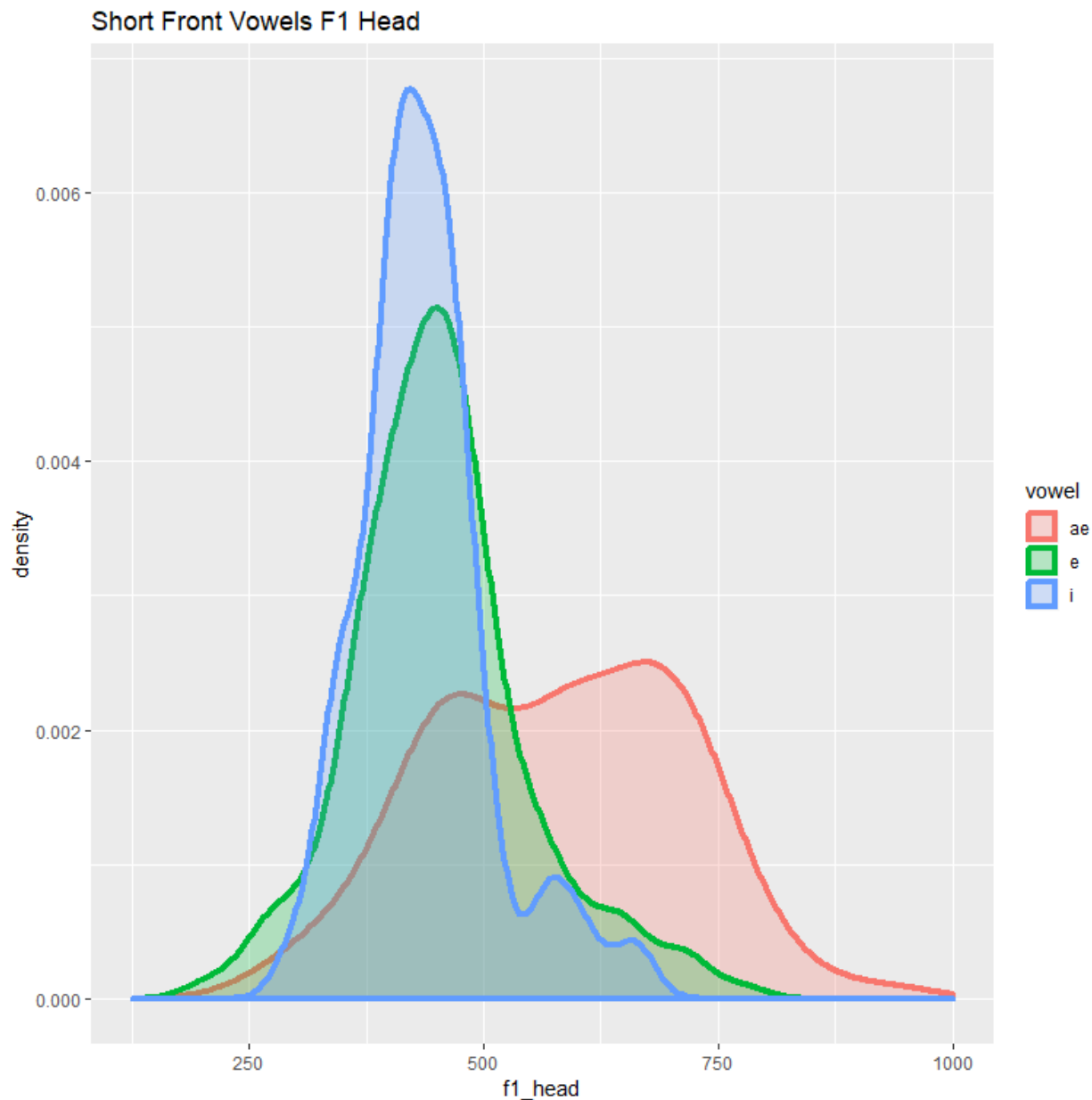


Figure 4.20: Short front vowels F1 Head

Figures 4.20 and 4.21 show the short front vowels' F1 heads and tails. These figures show a great deal of overlap between *e* [e] and *i* [i]. There is almost no height difference between *e* [e] and *i* [i]. As predicted, *ae* [æ] is quite a bit lower, flatter, and wider than the other two tokens, covering the entire range of *e* [e] and *i* [i], as well as maintaining a distinct range. These two

figures roughly follow the predicted pattern of the density plots, though *e* has less variation independent from *i* [i] variation than predicted.

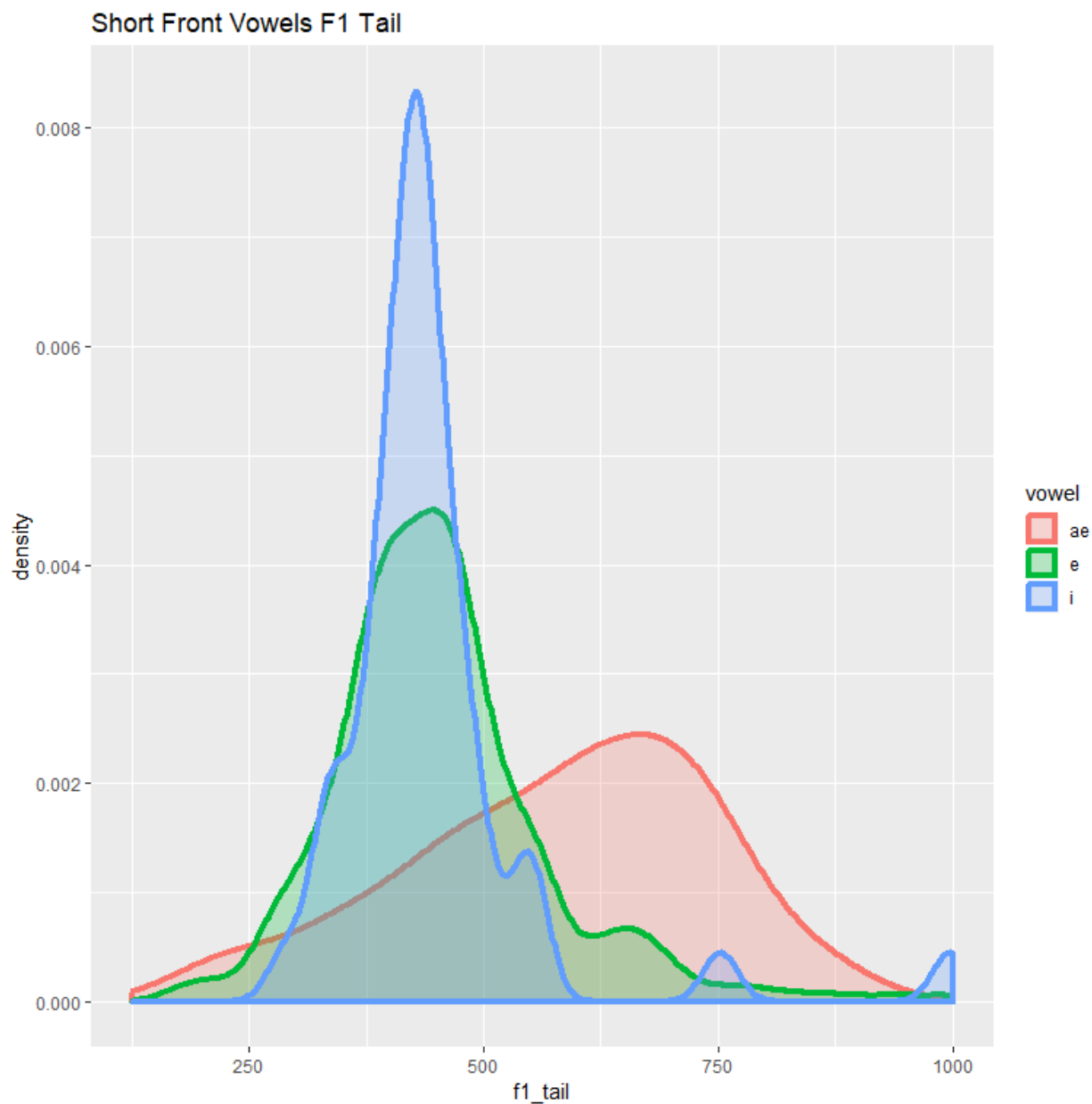


Figure 4.21: Short front vowels F1 Tail

Table 4.14 indicates there should be height variation in the short front vowels, but the reported allophony does not indicate a great deal of variation in frontness/backness.

Figures 4.22 and 4.23 look at the F2 heads and tails of these same tokens.

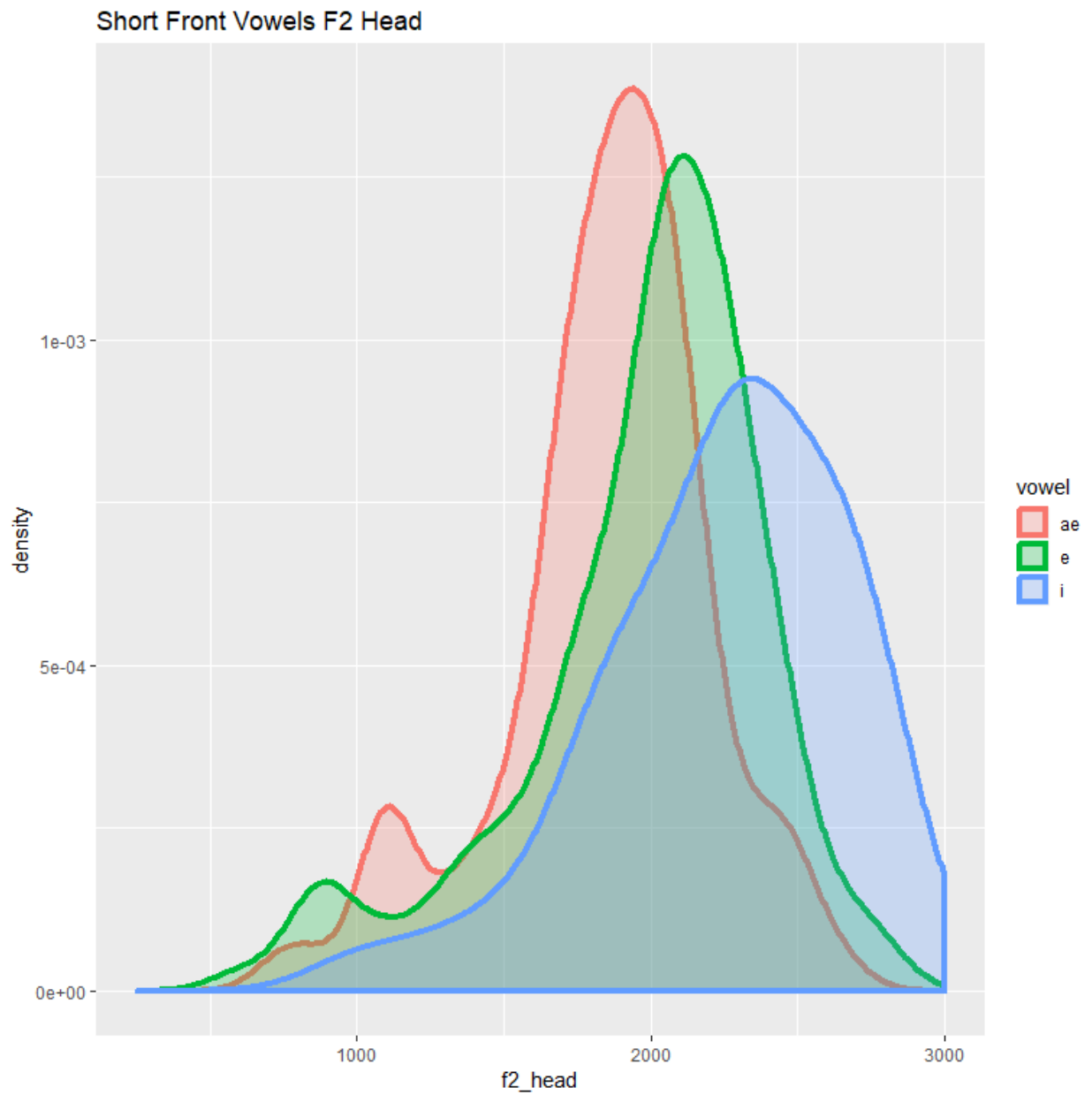


Figure 4.22: Short front vowels F2 Head

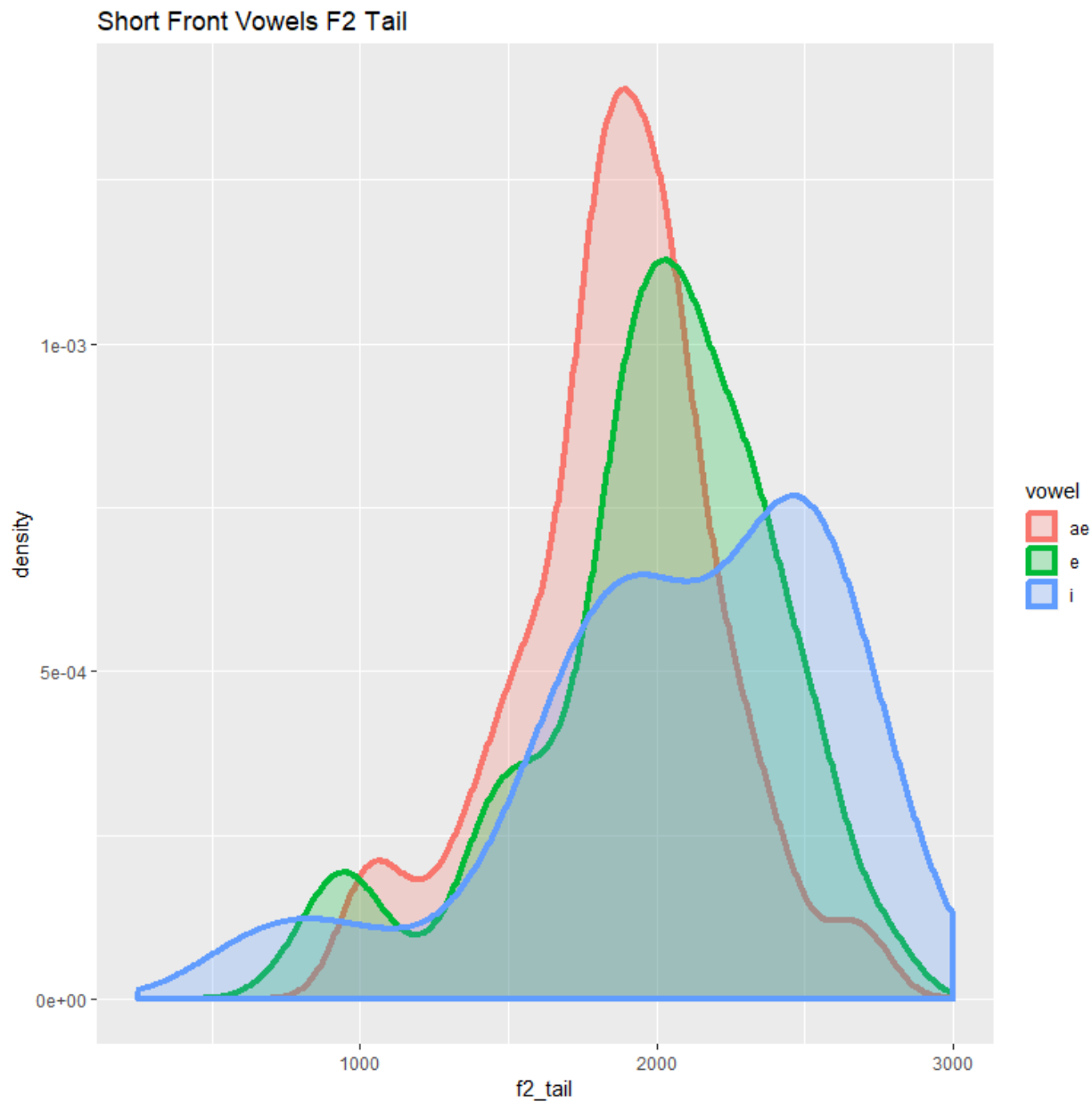


Figure 4.23: Short front vowels F2 Tail

Figures 4.22 and 4.33 show the F2 heads and tails of *ae* [æ], *e* [e], and *i* [i]. In these plots, the F2 measurements overlap a great deal, indicating that these vowels do not have much variation in frontness/backness. This is consistent with the allophones predicted in Table 4.14.

Table 4.14 shows that there has not been much reported allophony for the front long vowels. Figure 4.24 shows the predicted density pattern of three tokens that do not have any overlap in their purported allophones.

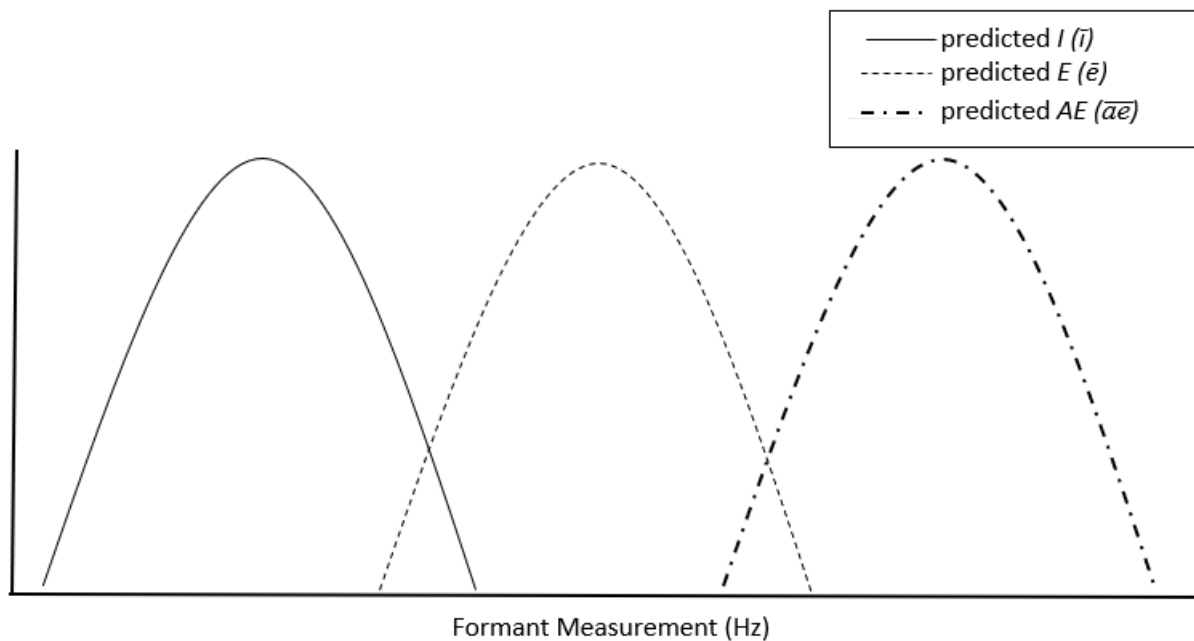


Figure 4.24: Predicted Density Pattern of Long Front Vowels as described in Table 4.14

Figures 4.25-4.28 show the long front vowels' F1 head, F1 tail, F2 head and F2 tail respectively.

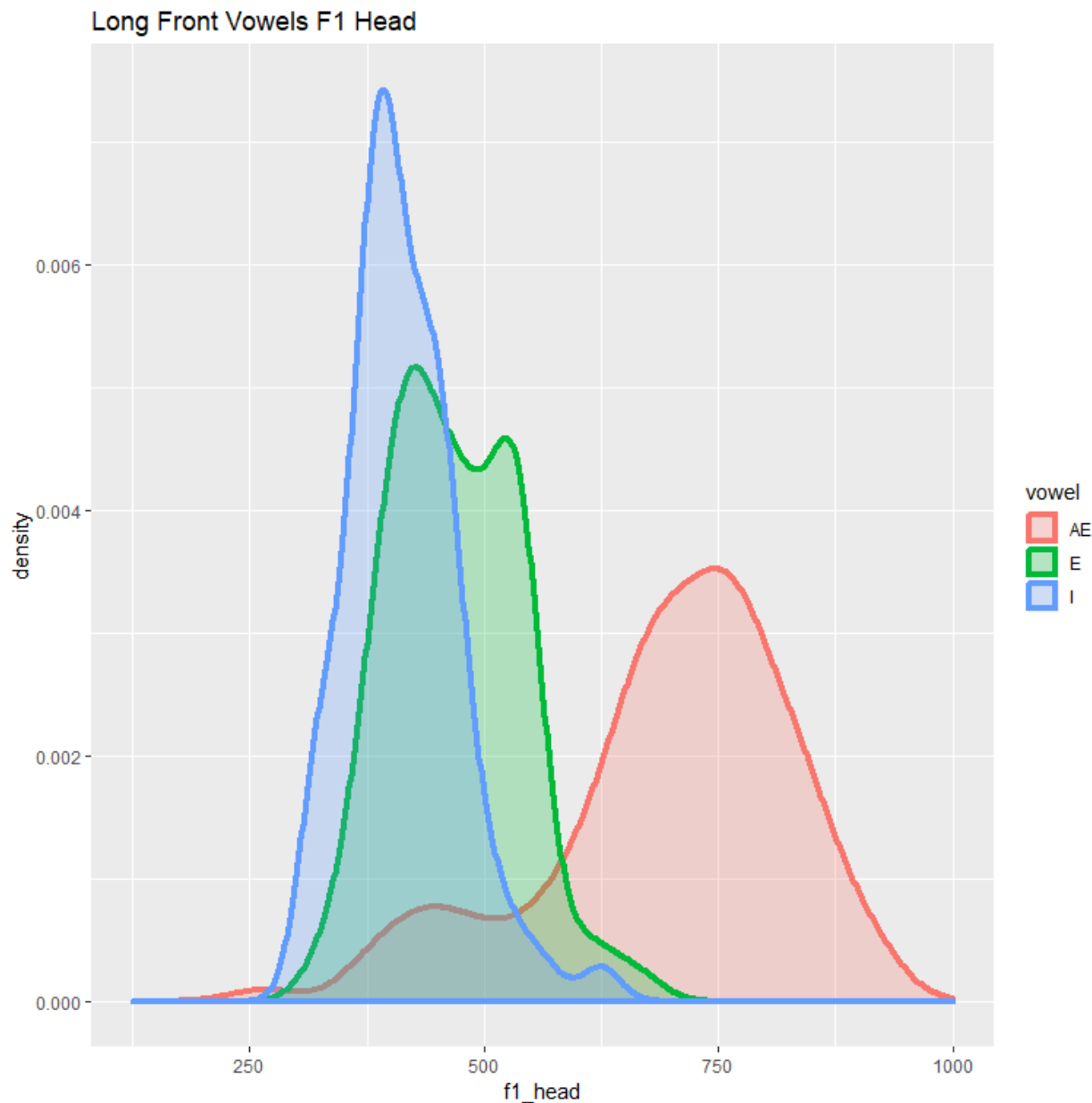


Figure 4.25: Long front vowels F1 Head

Figures 4.25 and 4.26 show the long front vowels' F1 head and tail. These two figures show that \bar{i} [i:] and \bar{e} [e:] overlap almost completely and $\bar{a\bar{e}}$ [æ:] is largely distinct from the two in height within the acoustic space. These figures look remarkably similar to Figures 4.20 and 4.21. While \bar{e} [e:] and \bar{i} [i:] are a little more distinct from each other than e [e] and i [i], they still

overlap a great deal. In fact, the long front vowels' F1 measurements look more like the pattern of the short front vowels' F1 measurements than they do the predicted lack of allophonic overlap from Table 4.14. $\bar{a}\bar{e}$ [æ:] is more distinct than ae [æ], but still has some overlap with \bar{i} [i:] and \bar{e} [e:]. This indicates not only the presence of allophones in the long front vowels, but that these allophones may mimic the allophonic patterns of the short front vowels.

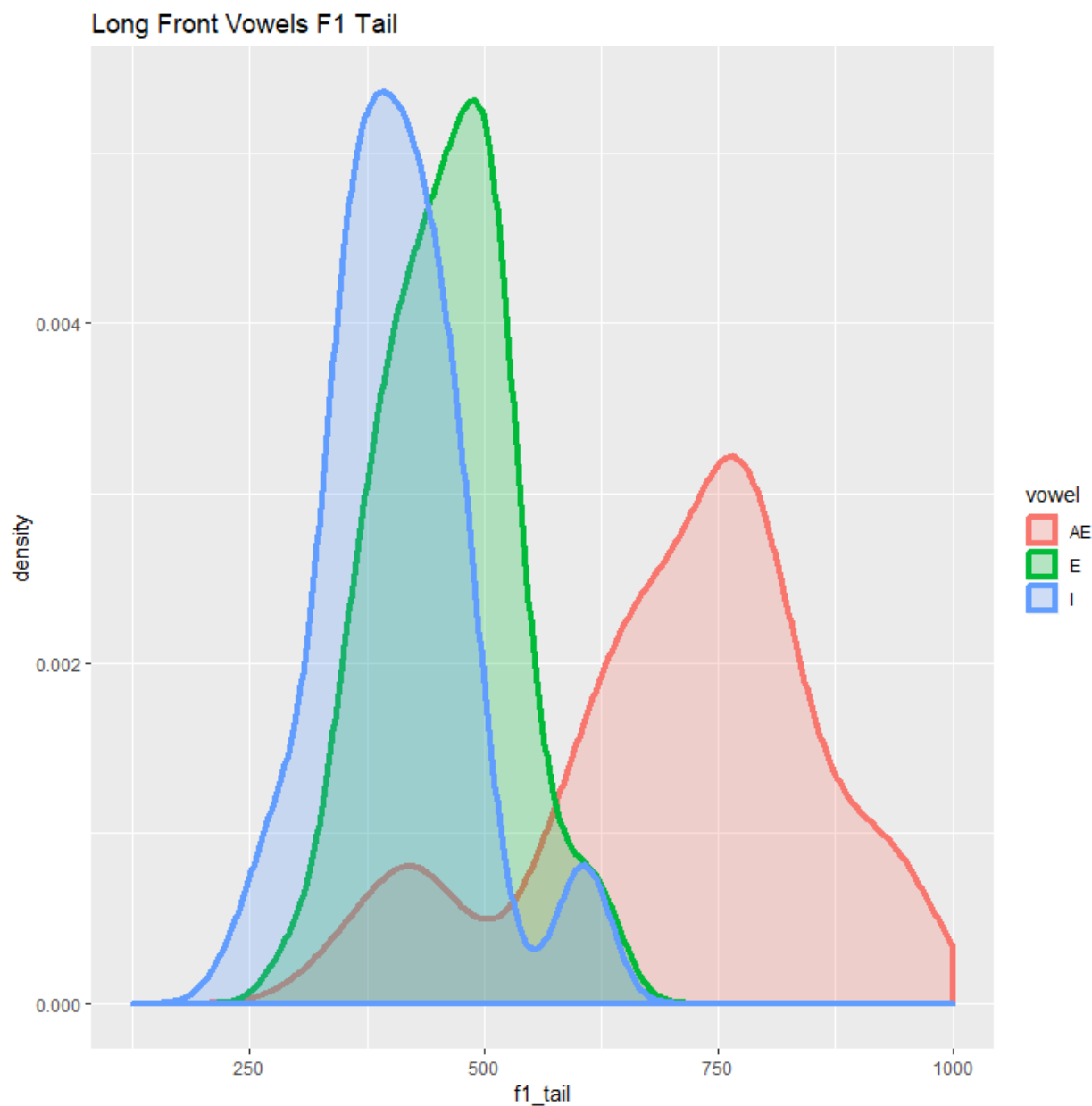


Figure 4.26: Long front vowels F1 Tail

Figures 4.25 and 4.26 indicate allophony in vowel height of the long front vowels. Figures 4.27 and 4.28 show the same tokens' F2 head and tail frequencies.

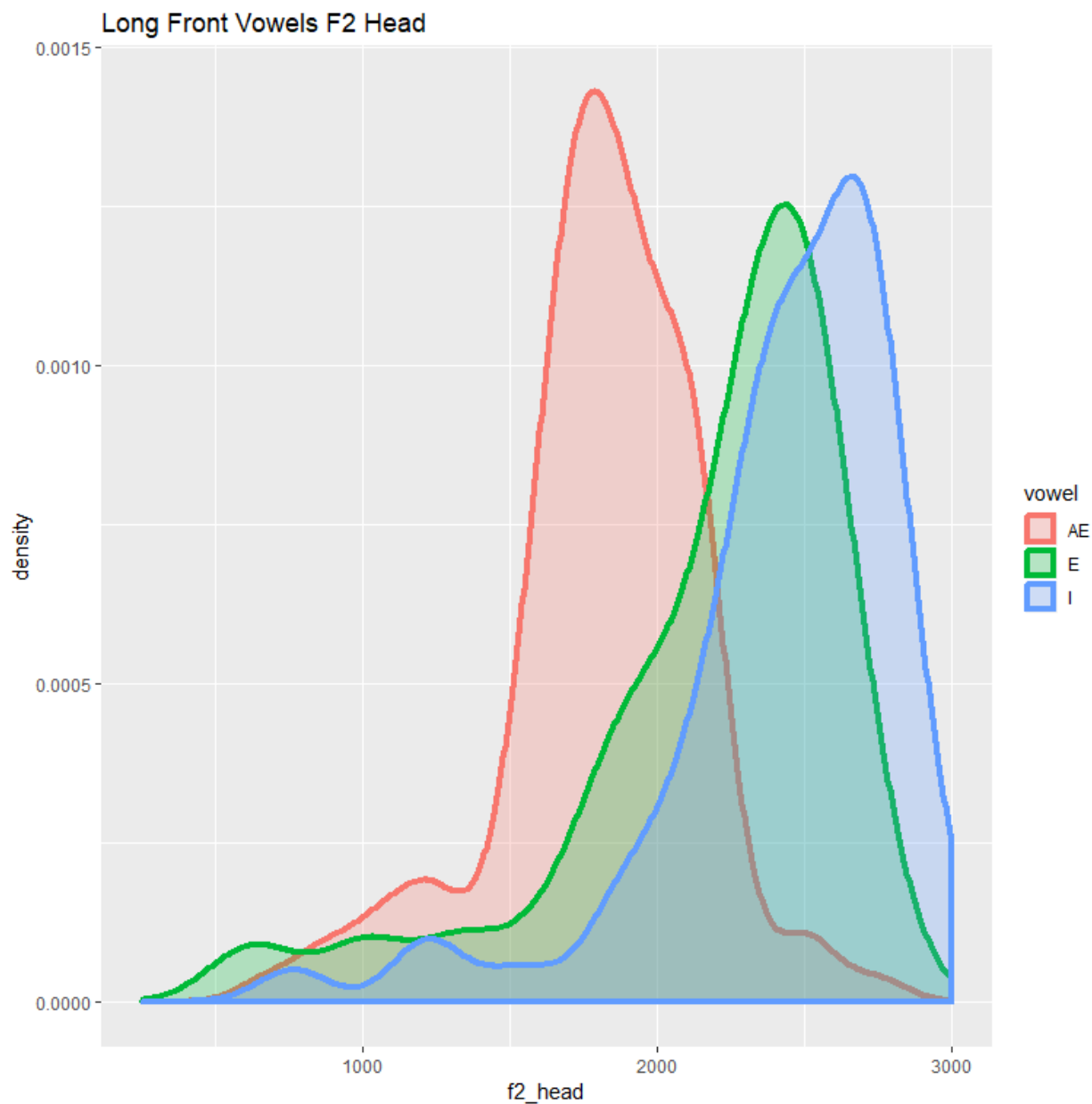


Figure 4.27: Long front vowels F2 Head

Figures 4.27 and 4.28 show the heads and tails of $\bar{a}e$ [æ:], \bar{e} [e:] and \bar{i} [i:]. As in Figures 4.25 and 4.26, \bar{e} [e:] and \bar{i} [i:] are nearly identical in frontness/backness. Once again $\bar{a}e$ [æ:] is distinct

from the two, this time with a lower average frequency, indicating $\bar{a}\bar{e}$ [æ:] is more back as a front vowel than \bar{e} [e:] and \bar{i} [i:]. This is consistent with low front vowels typologically (Ladefoged and Maddieson 1998). The F2 measurements largely reflect typological expectations of front vowels' frontness and backness, so further research is needed to determine to what degree these figures represent allophonic variation.

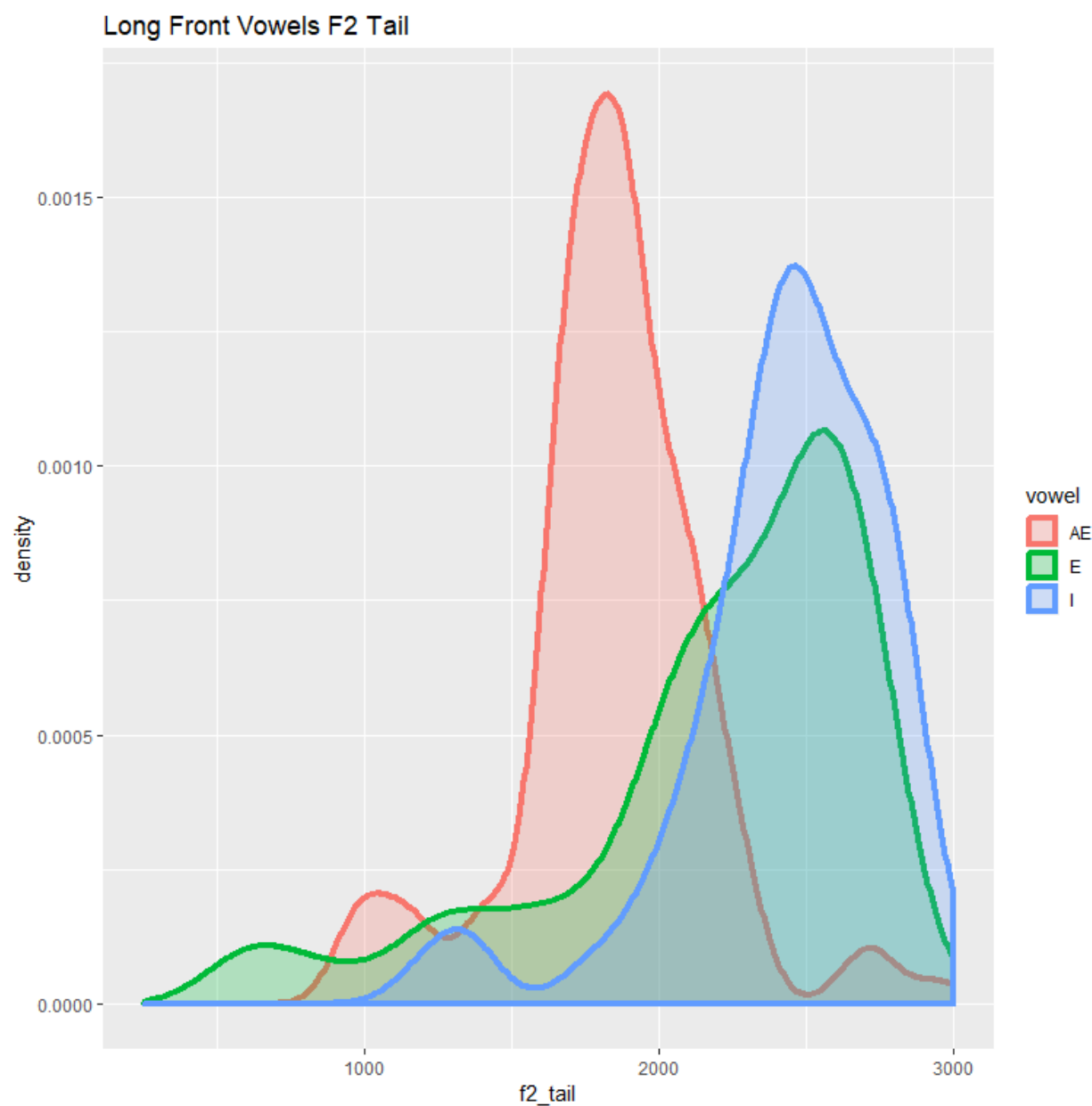


Figure 4.28: Long front vowels F2 Tail

The following series of figures examine the short and long back vowels along the same parameters as the front vowels: short, long, F1 head, F1 tail, F2 head, F2 tail.

Table 4.14 indicates more allophonic variation in the short back vowels than in the long ones, just as it predicts for the front vowels. The description of the short back vowels indicates that *u* does not have much variation ([ʊ]), though *o* [o] should overlap with *u* [u] ([o], [ʊ]) and *a* [a] (both have [ə] listed as an allophone). *a* [a] also has two allophones that are not shared with *o* [o] or *u* [u]. Figure 4.29 shows the predicted density pattern based on this description.

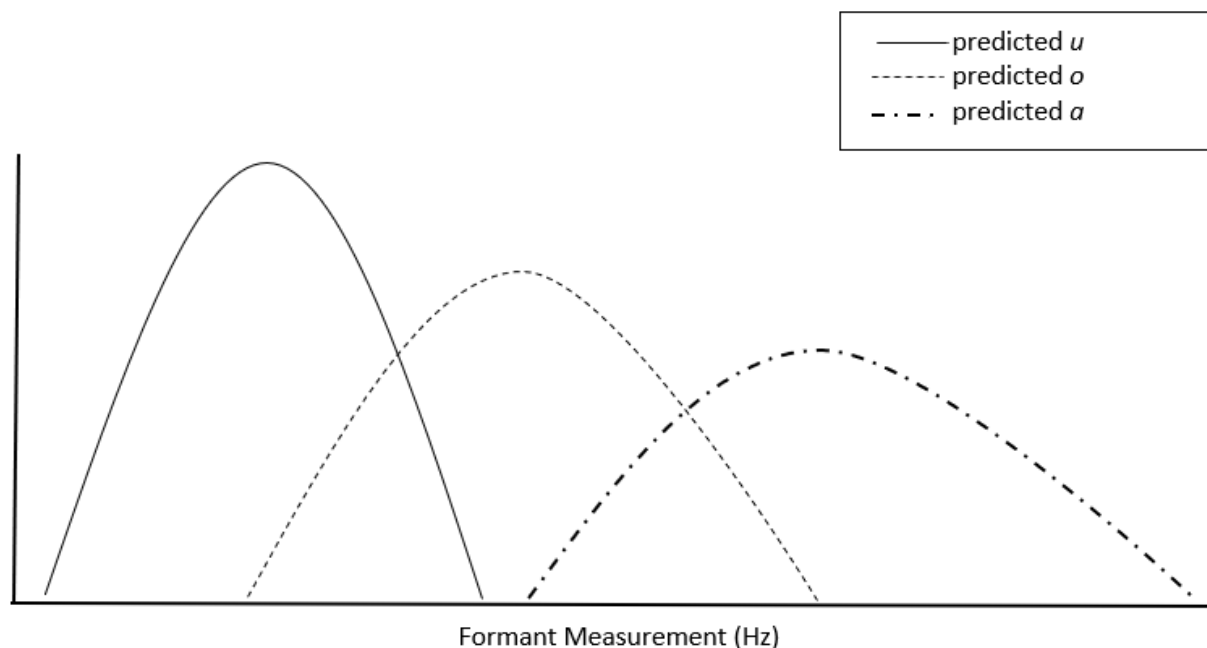


Figure 4.29: Predicted Density Pattern of Short Back Vowels as described in Table 4.14

While the literature predicts overlapping allophony with *u* [u], as discussed before the data set I used only had two tokens so I removed them since no fair generalizations can be made from only two data points. Therefore, from the description in Table 4.14, I expect *o* [o] to have a higher peak and *a* [a] to be lower and flatter, with a large range distinct from *o* [o]. Figures 4.30 and 4.31 show the F1 head and tail frequencies of the short back vowels *o* [o] and *a* [a] only.

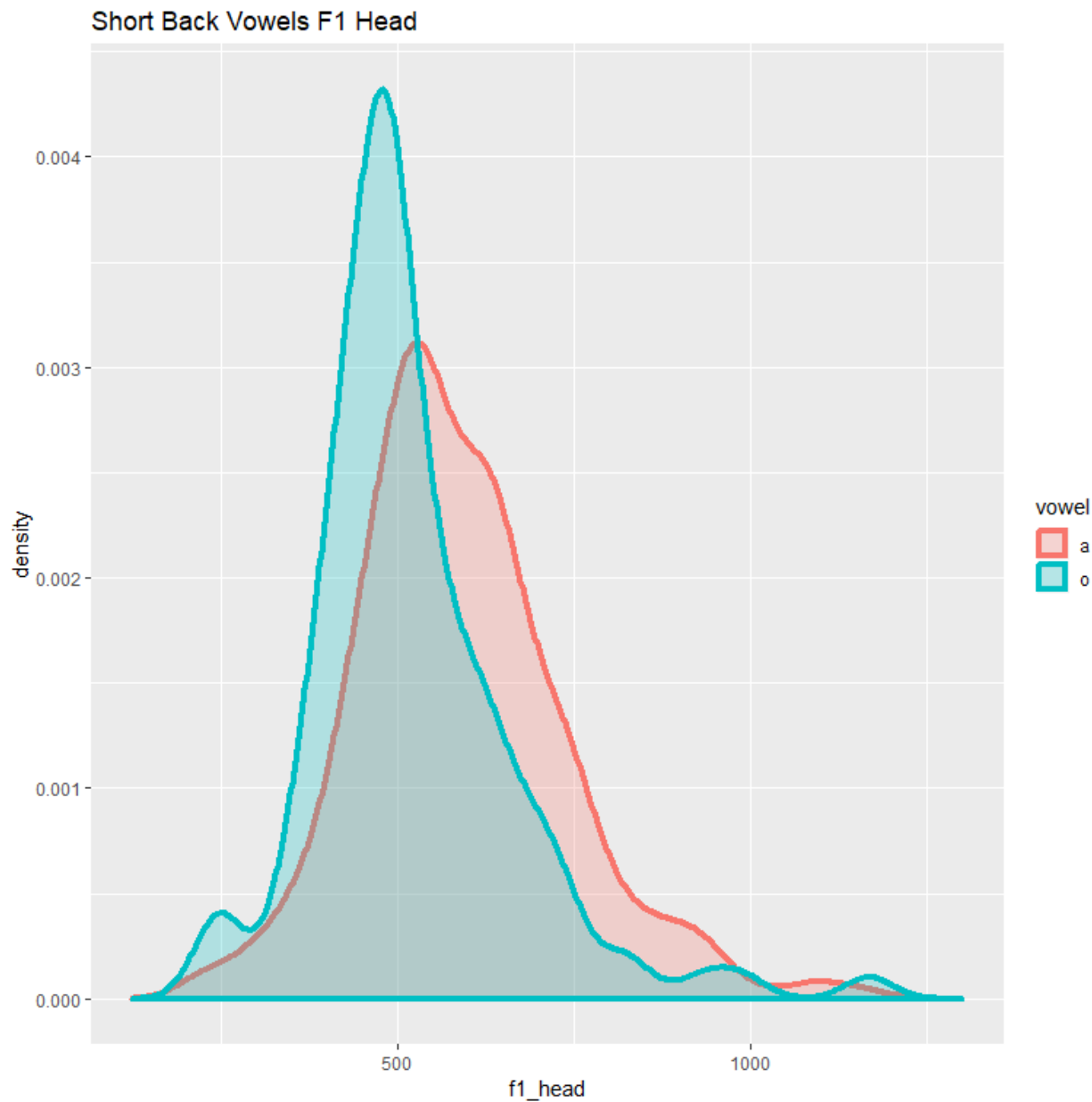


Figure 4.30: Short back vowels F1 Head

Figures 4.30 and 4.31 look very similar at the head and tail measurements of the short back vowels. However, *a* [a] and *o* [o] overlap almost entirely with very few tokens representing a distinct *a* [a] range and a distinct *o* [o] range. This is unexpected as the literature would expect a set of the *o* [o] tokens to be distinct, and which would theoretically overlap with *u* [u] with a

similar allophone. These two figures indicate a very different allophonic pattern than predicted by Table 4.14.

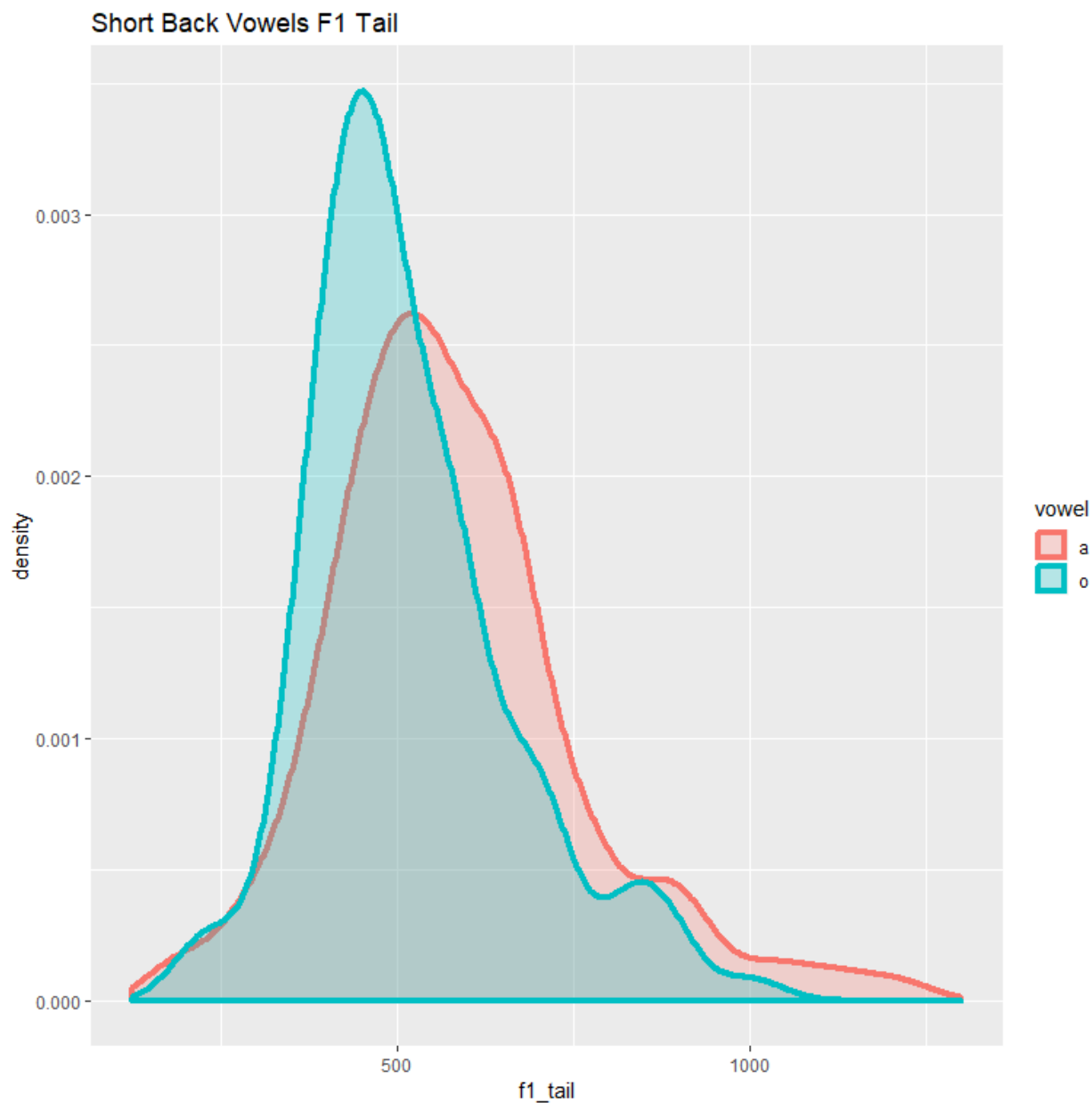


Figure 4.31: Short back vowels F1 Tail

Figures 4.30 and 4.31 indicate that there is very little height difference between the majority of the *a* [a] and *o* [o] tokens. A small set of *o* [o] tokens are higher in the acoustic space than *a* [a]

and a small set of *a* [a] tokens are lower in the acoustic space than *o* [o], but for the most part the height difference does not appear distinct.

Figures 4.32 and 4.33 show the F2 head and tail frequency measurements of the same two tokens.

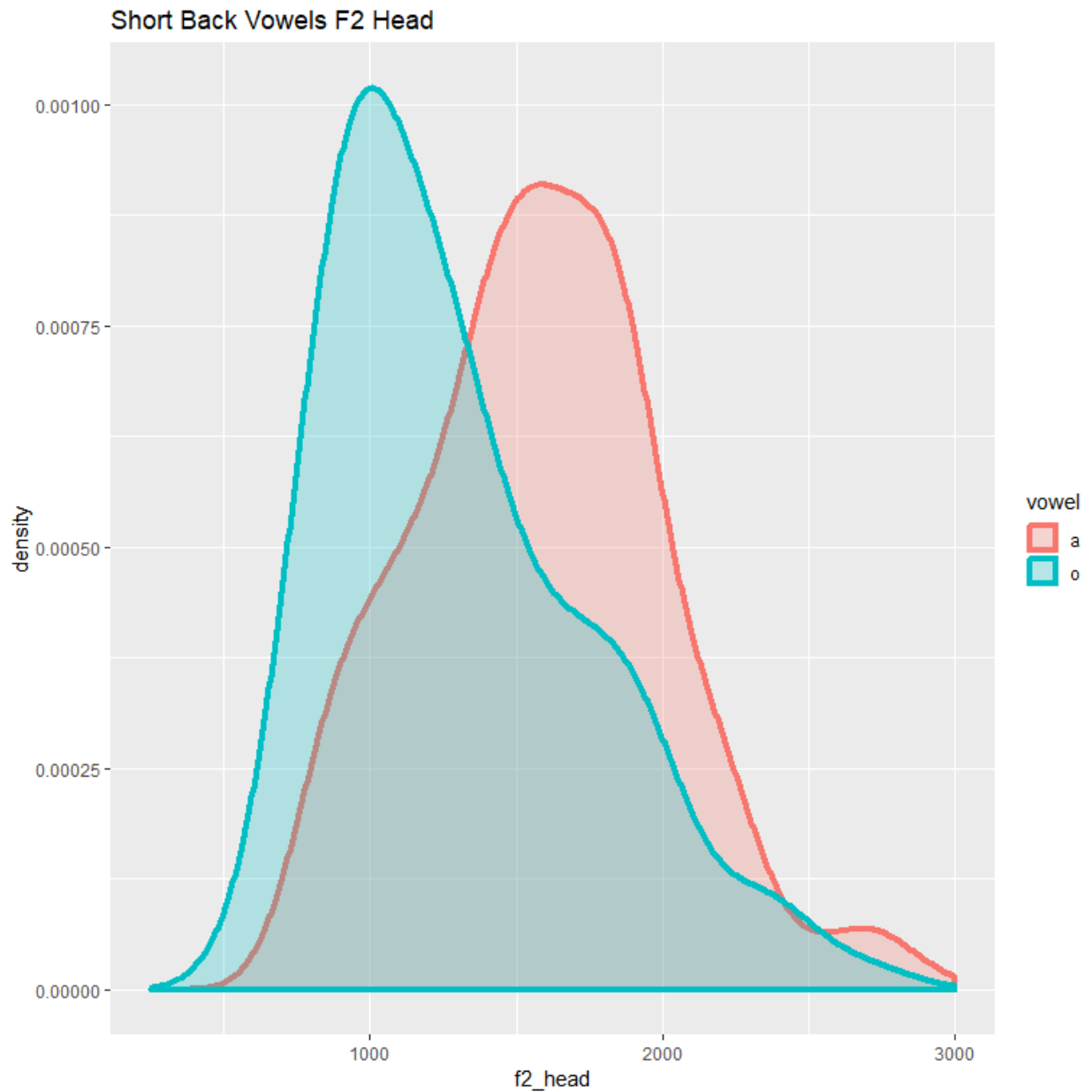


Figure 4.32: Short back vowels F2 Head

Figures 4.32 and 4.33 show a slightly different pattern between the *a* [a] and *o* [o] with a great portion of *a* [a] and *o* [o] distinct from each other, though there is still a great deal of overlap. This indicates that a portion of the *o* [o] tokens are more back in the acoustic space and a portion of the *a* [a] tokens are more front, though again most of the *a* [a] and *o* [o] tokens will realize within the same shared acoustic space.

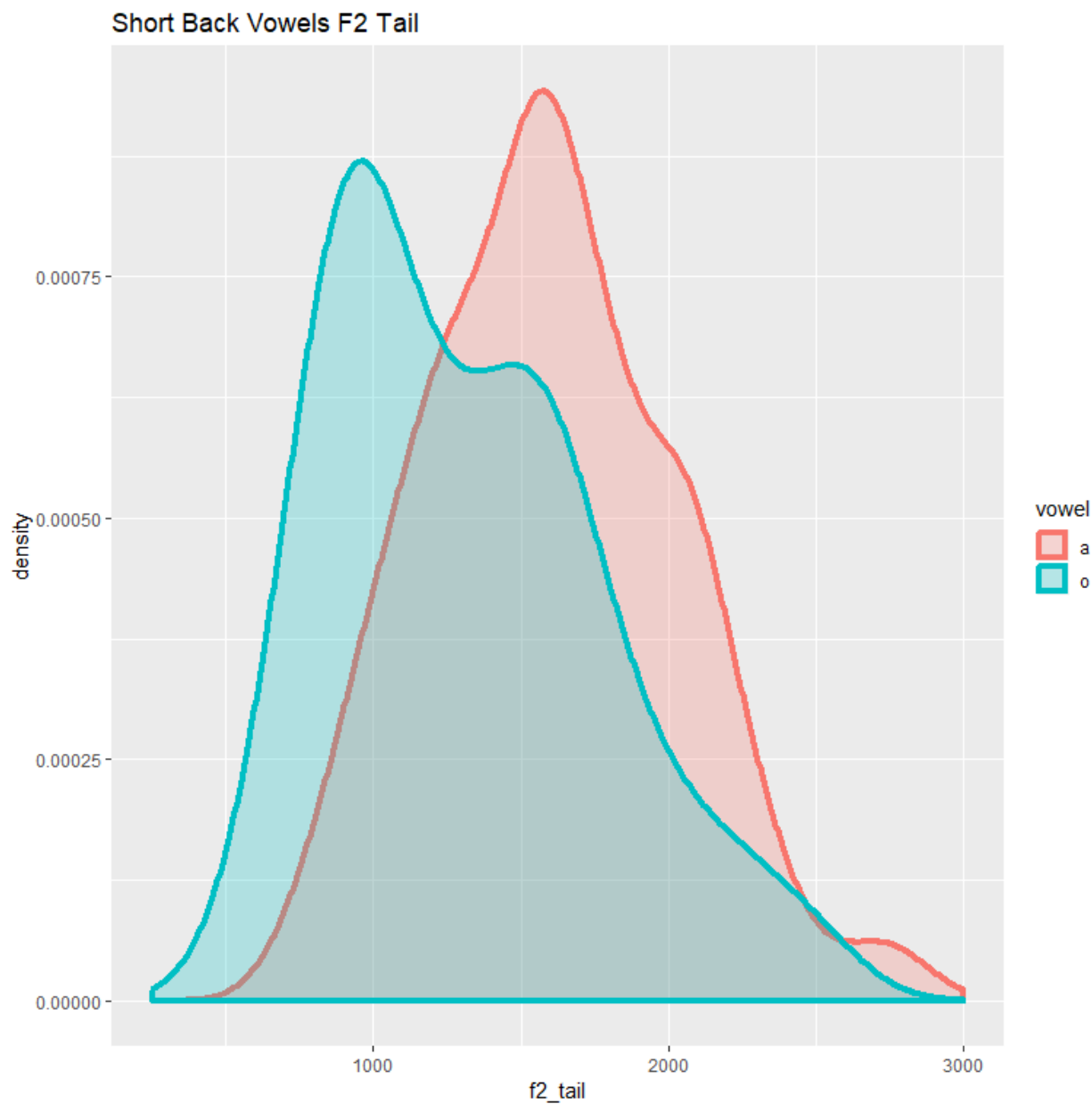


Figure 4.33: Short back vowels F2 Tail

Figures 4.30-4.33 show the short back vowels *a* [a] and *o* [o]. Figures 4.35-4.38 show the long back vowels \bar{a} [a:], \bar{o} [o:], and \bar{u} [u:].

Table 4.14 indicates a similar expectation of allophony in the long back vowels as it does for the long front vowels: almost none. According to reported descriptions of the language, the back long vowels do not have much allophony. \bar{u} /u:/ has only one realization: [u:], \bar{o} /o:/ has only one realization: [o:], and \bar{a} /a:/ should overlap partially with \bar{o} as it has two predicted realizations: [a:] and [o:]. Figure 4.34 shows the anticipated vowel density pattern based on this description.

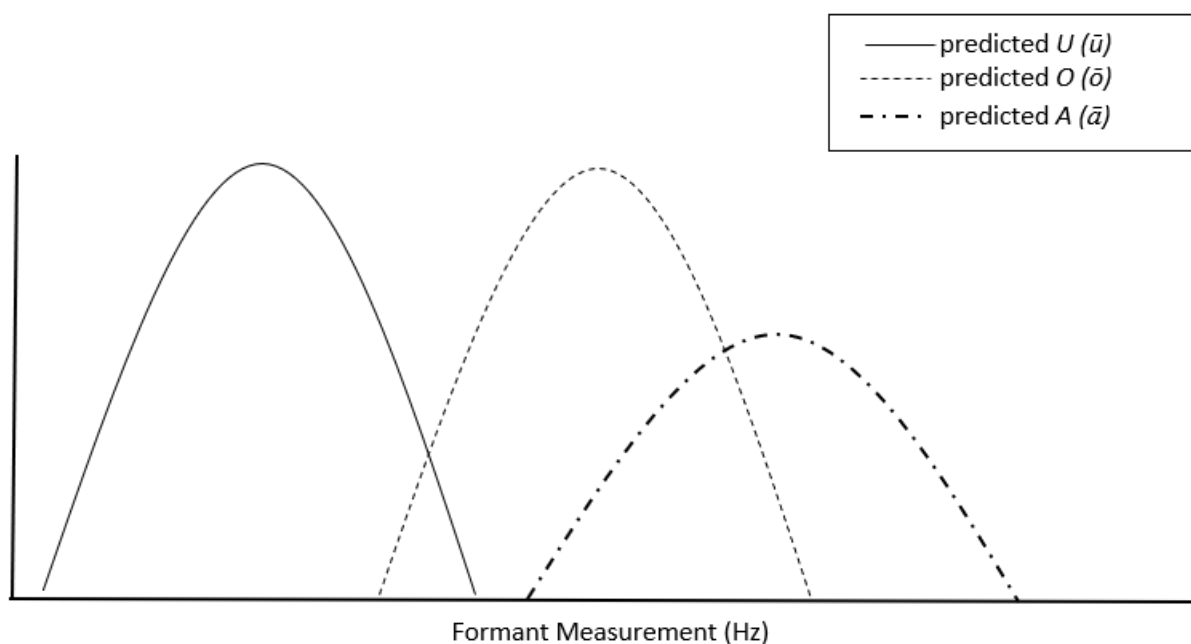


Figure 4.34: Predicted Density Pattern of Long Back Vowels as described in Table 4.14

Figures 4.35 and 4.36 show the long back vowels' F1 head and tail measurements.

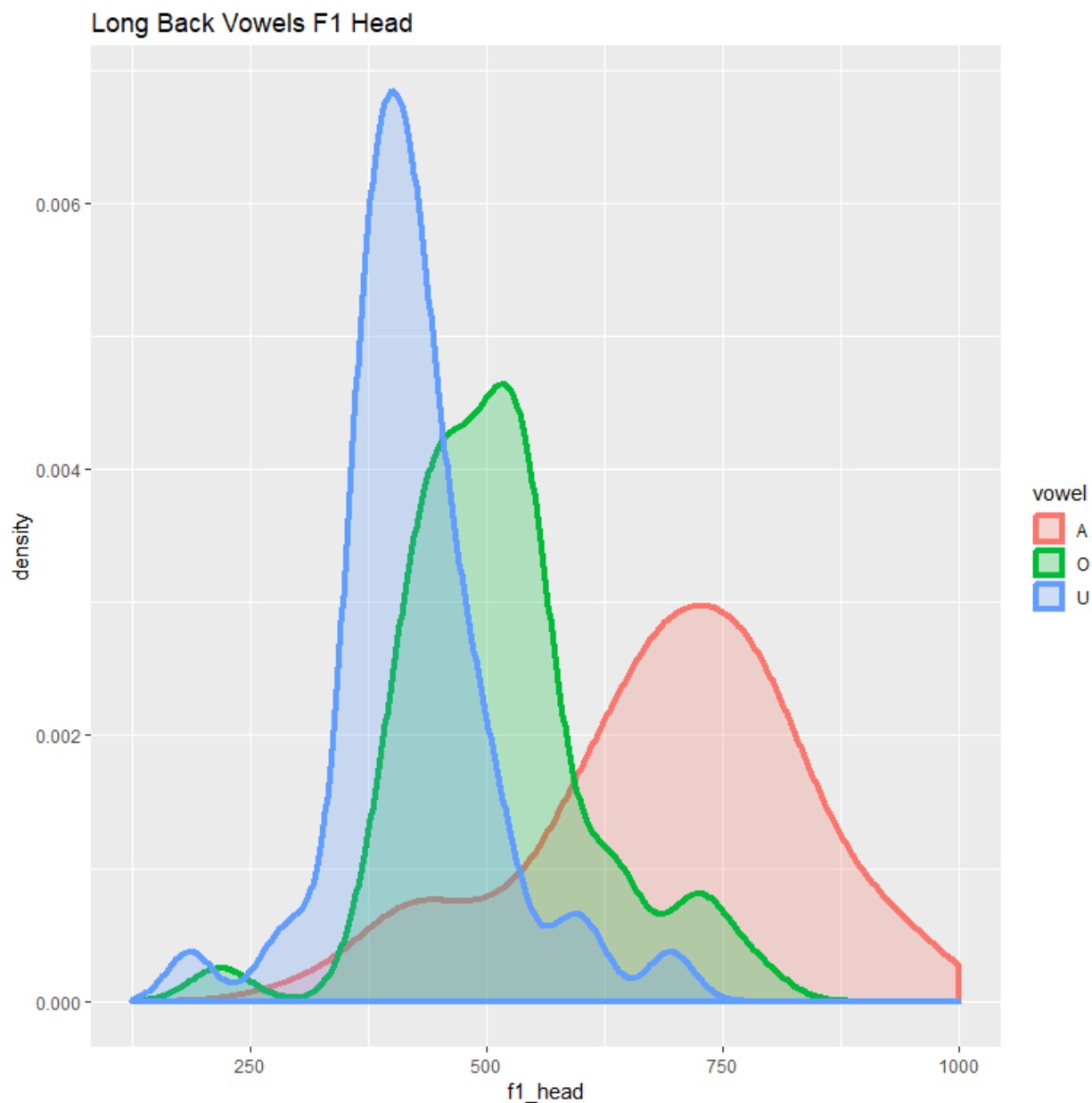


Figure 4.35: Long back vowels F1 Head

Figures 4.35 and 4.36 do not follow the predicted pattern of density overlap of tokens. \bar{u} [u:] and \bar{o} [o:] overlap a great deal and largely share the same height in the acoustic space. What is especially unexpected is that \bar{a} [a:] tokens overlap with the \bar{u} [u:] acoustic height as well as \bar{o} [o:].

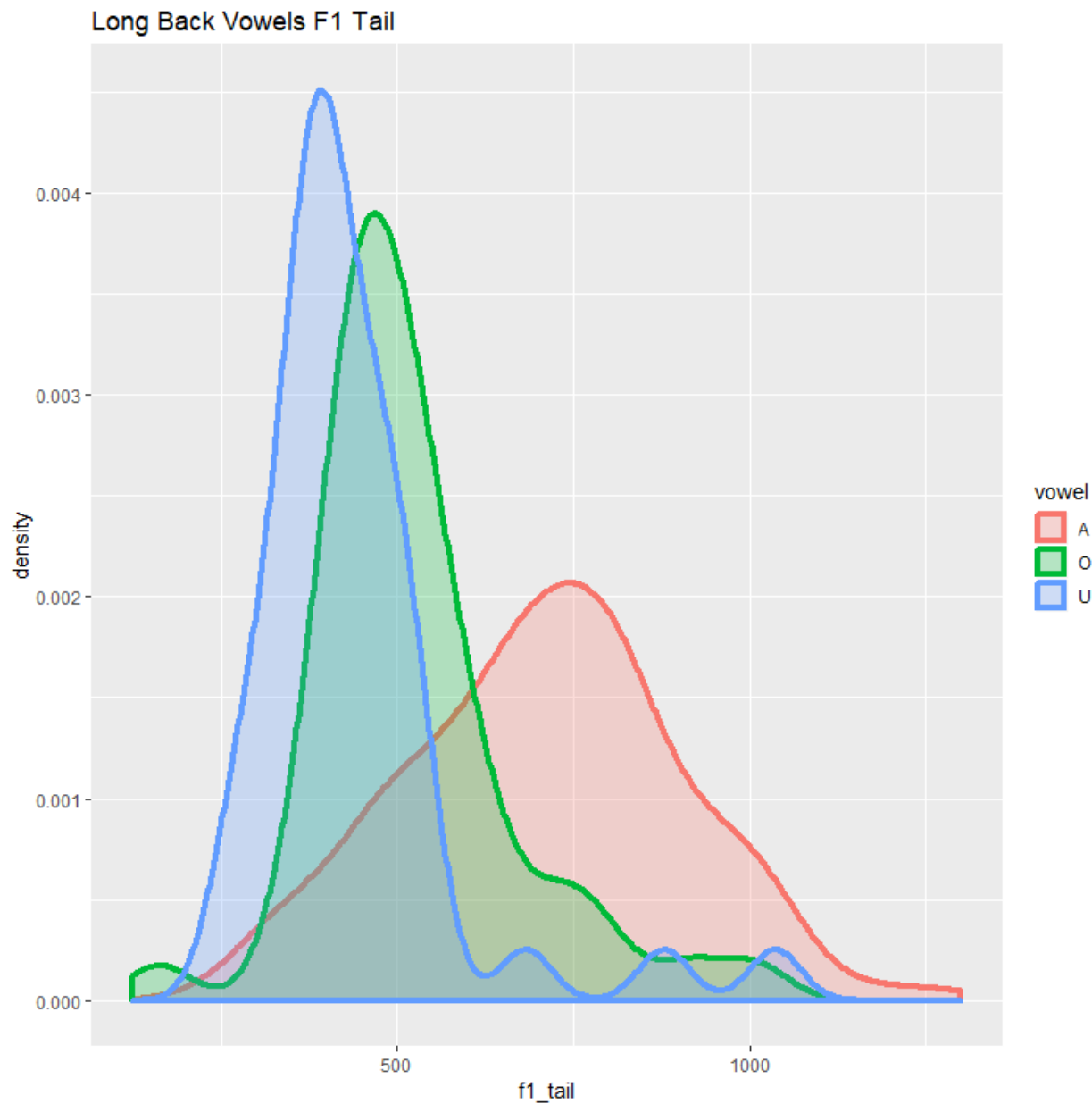


Figure 4.36: Long back vowels F1 Tail

Figures 4.35 and 4.36 show the long back vowels' F1 head and tail measurements. Figures 4.37 and 4.38 show the long back vowels' F2 head and tail measurements.

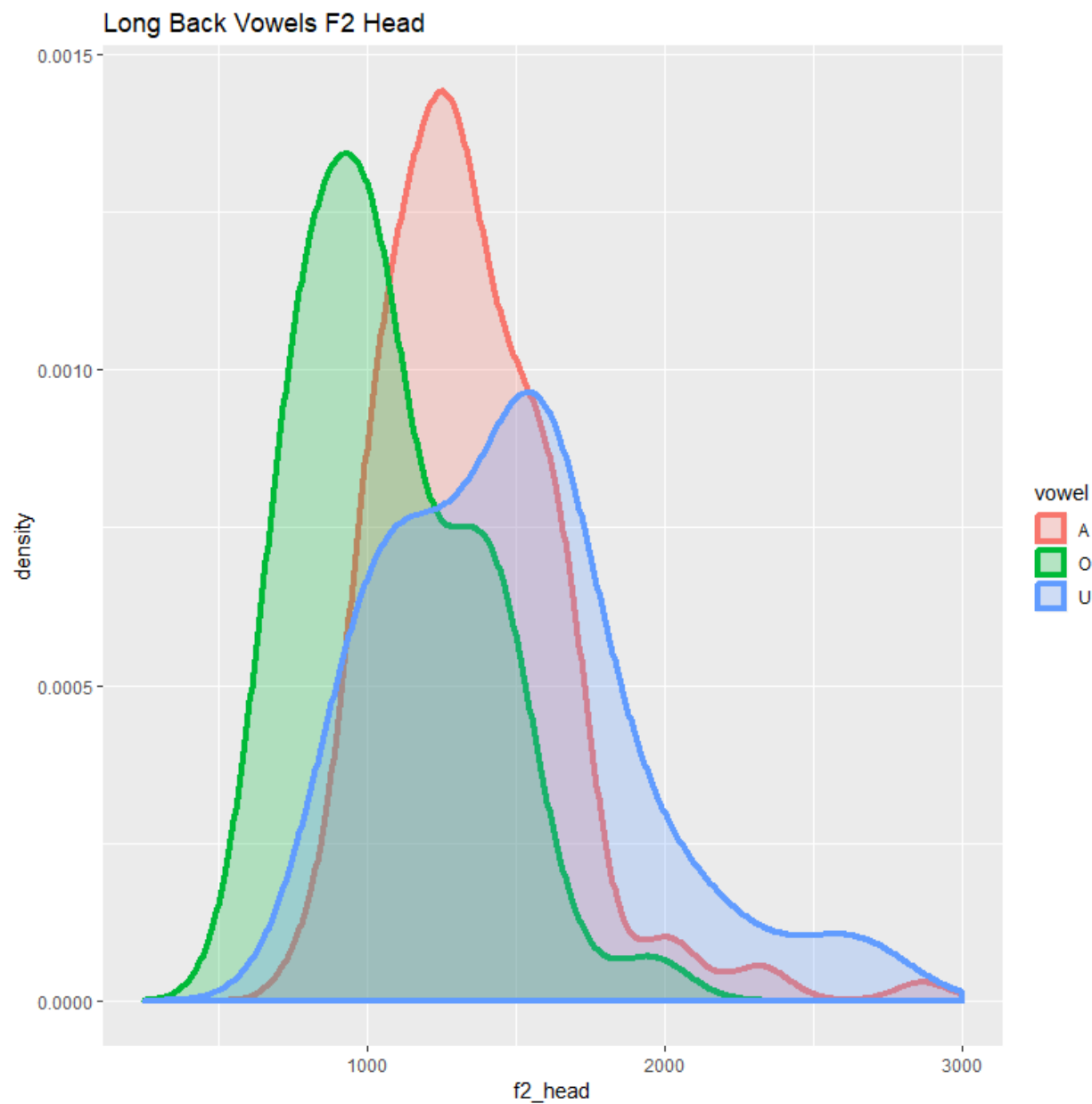


Figure 4.37: Long back vowels F2 Head

Unlike the previous head and tail figures, Figures 4.37 and 4.38 indicate some movement in the \bar{u} [u:] tokens that is not as noticeable in the other vowels examined here. The F2 measurements in these two figures are also different from the F1 patterns of the long back vowels as well. \bar{a} [a:] and \bar{o} [o:] overlap a great deal in frontness/backness, though they still have some distinct ranges

within the front/back range. \bar{u} [u:] is almost entirely within the same front/back range as both \bar{a} [a:] and \bar{o} [o:], with very few tokens in a distinct range.

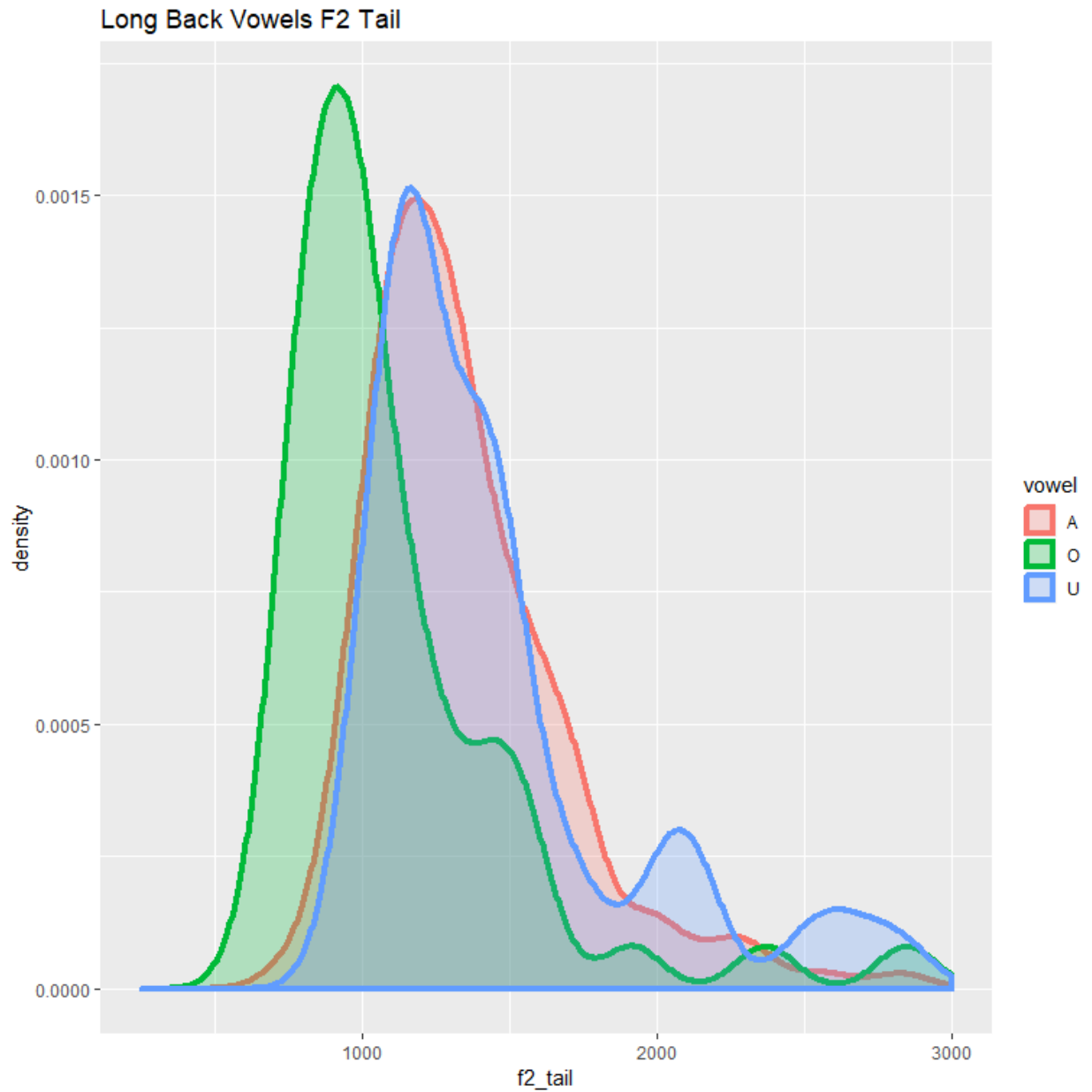


Figure 4.38: Long back vowels F2 Tail

4.3.1. Conclusions on Acoustic Space

This section has shown an acoustic look at Menominee vowels. Throughout I have shown that some vowels are consistent with expectations based on previous literature, such as long vowels being more peripheral than the short vowels. This section also identifies the first potential hallmarks of allophony in the data with distinct peaks compared to the rounded, flatter peaks. The figures presented here show that by and large, the allophonic patterns between the short and long, front and back vowel sets do not follow the predictions from the literature on vowel variation. I leave to future projects to examine these allophonic patterns in greater detail. The following section looks at the vowel density patterns for specific case studies of Menominee native speakers.

4.4. Case Studies

In this section, I take a closer look at the idiolects of three of the native speakers. As I discussed earlier, without the option to conduct detailed elicitation, the token counts for certain vowels were very inconsistent between the speakers. Additionally, five speakers are not necessarily representative of the entire Menominee-speaking community in the 2000s and 2010s. This section focuses in greater detail on three of the native speakers, chosen because I was able to identify the most tokens for these three. Table 4.15 repeats Table 4.3 above with the token counts for the three native speakers examined in closer detail in the following subsections.

		NS_2	NS_3	NS_4	Total
short vowel	i	11	15	16	42
	e	63	87	117	267
	ae	8	41	41	90
	u	0	2	0	2
	o	9	38	47	94
	a	27	121	90	238
	ya	1	6	1	8
	wa	1	15	12	28
long vowel	ī	8	25	25	58
	ē	18	31	32	81
	āē	17	37	50	104
	ū	6	25	10	41
	ō	6	9	24	39
	ā	23	41	55	19
	ia	5	19	8	32
	ua	1	17	7	25

Table 4.15: Individual Vowel Numbers by Case Study Speaker

An example of some of the differences between speakers can be seen in the following figures.

Figure 4.39 shows very different patterns of vowel production by NS_2, NS_3 and NS_4. NS_4 has a very narrow, sharp peak indicating a low degree of variation in \bar{a} [a:] produced. NS_3 has a peak within a similar frequency range as NS_4, but it is slightly wider at the base and slopes, indicating a greater range of variation, but still with the majority clustering consistent with NS_4. NS_2 presents a very different pattern of \bar{a} [a:] production. The peak is very wide and rounded, indicating little distinct clustering of \bar{a} [a:], but rather nearly equal numbers of tokens across a large frequency range. Thus NS_2 shows a greater degree of variation in \bar{a} [a:] production, followed by NS_3, and NS_4 has very little variation in \bar{a} [a:] targets.

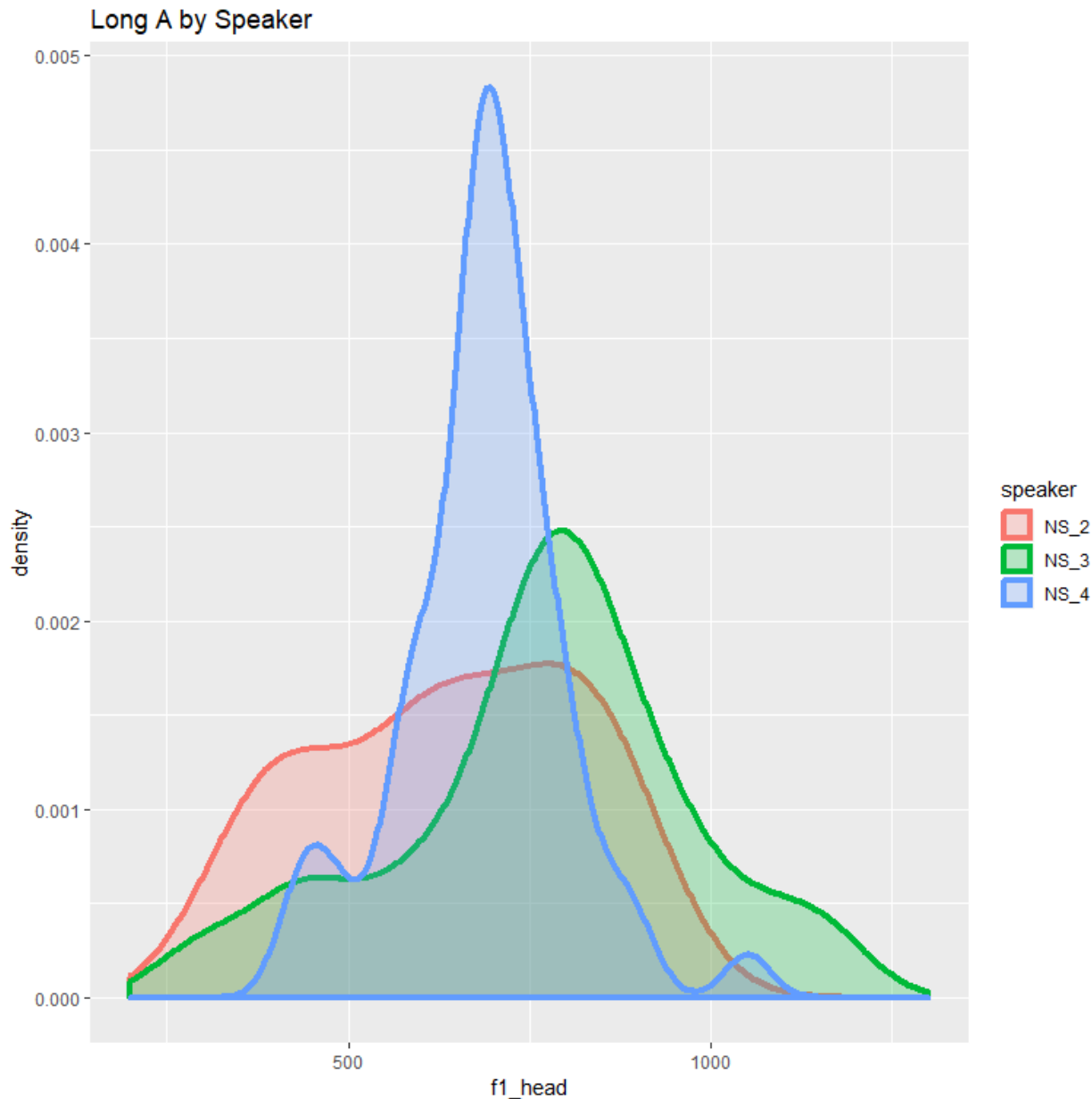


Figure 4.39: A (\bar{a}) by Speaker

Figure 4.40 shows another density plot with a great deal of variation between speakers in a pattern that looks very similar to Figure 4.39. However, this plot represents o [o], in which there is a large gap in the number of tokens between speakers. NS_2 has nine tokens represented, where NS_3 and NS_4 have 38 and 47 tokens respectively. Just as with the short u [u] discussed in the previous section, it is hard to claim that nine tokens can provide a strong enough pattern to

make a generalization. Thus, it is important to keep in mind the token counts when examining the figures in the rest of this section.

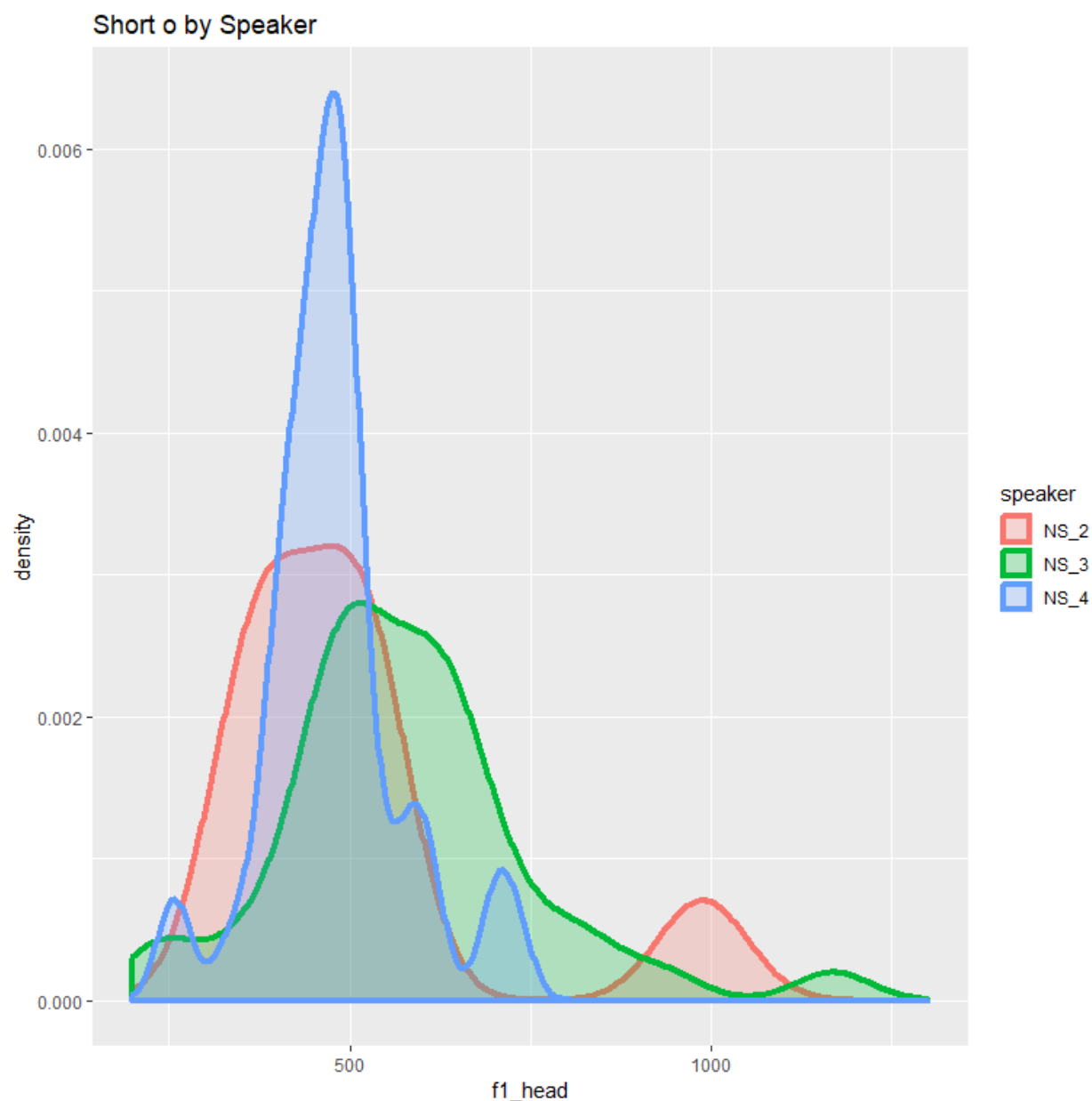


Figure 4.40: *o* by Speaker

The previous section discussed the expected density patterns of the vowel formant measurements. In the next few subsections, I look in closer detail at each of the three native speakers' vowel targets and how this compares to allophonic predictions.

4.4.1. Native Speaker 2

This section looks at the quantity and quality of NS_2 in closer detail. Table 4.16 shows the duration means and ratios between the short and long vowels for NS_2 (compare to Table 4.12 above). \bar{e} [e:] is shorter than the average combined, but \bar{ae} [æ:] is much longer.

	Mean (ms)	Ratio	Mean (ms)	
i	71.42	1:1.7	123.24	\bar{i}
e	66.58	1:1.9	125.51	\bar{e}
ae	69.75	1:2.3	163.51	\bar{ae}
u	0	0	126.61	\bar{u}
o	87.58	1:1.3	113.68	\bar{o}
a	82.51	1:2	163.27	\bar{a}

Table 4.16: Vowel Means and Ratios for NS_2

The other vowels, including o [o] and \bar{o} [o:] do not differ very much from the average for all the speakers. The discussion above shows that the vowels can still be produced in different acoustic spaces from the other speakers, even if the duration remains comparable. Figure 4.41 shows the acoustic space for NS_2's vowels.

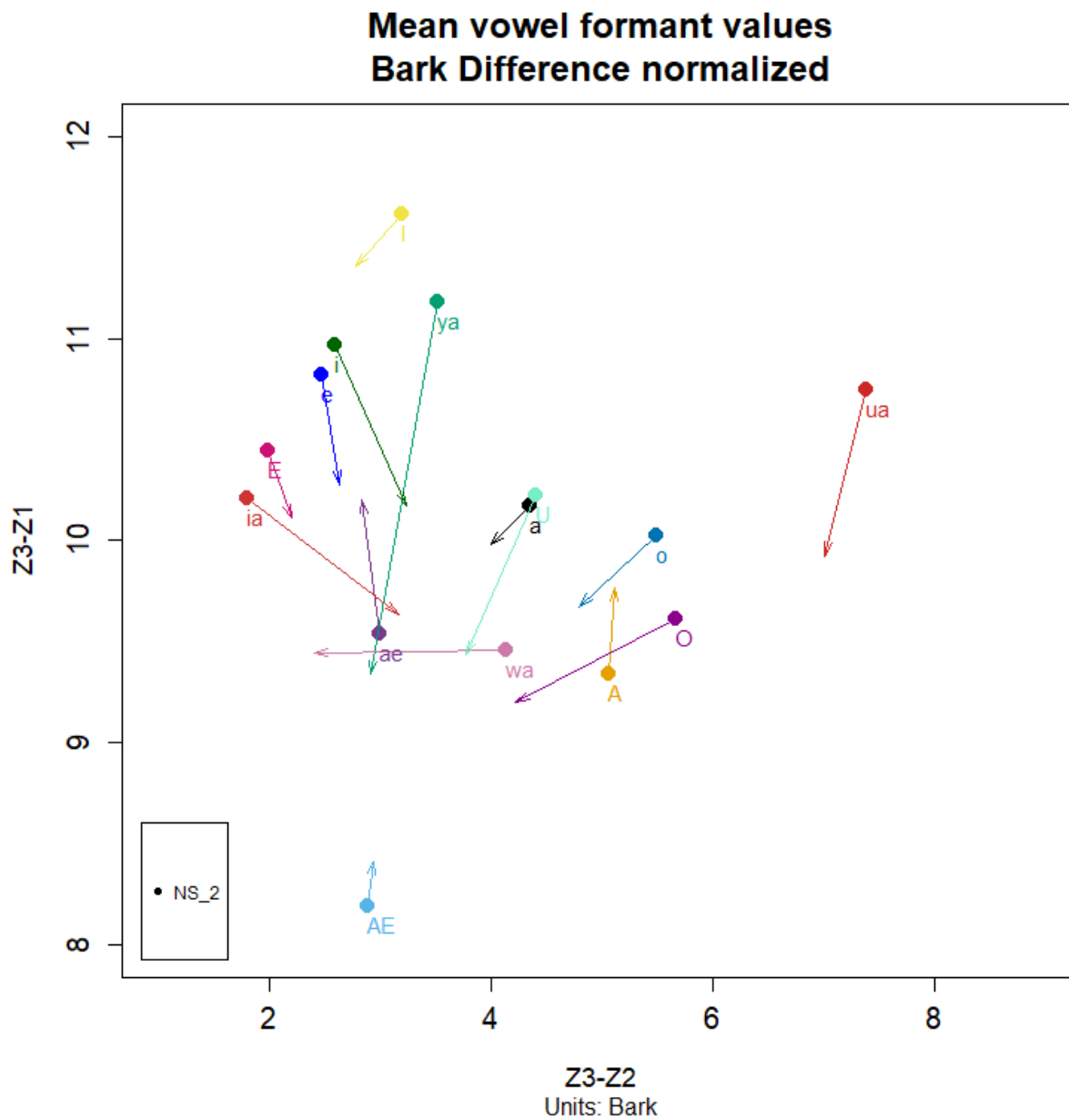


Figure 4.41: NS_2 Vowel Acoustic Quality

Comparing Figure 4.41 to Figure 4.8 above, NS_2's vowels tend to be more central and mid than the averages for all speakers. Most notably, *i* [i] and *ī* [i:] are more backed and *o* [o] and *ō* [o:] are more fronted. *ū* [u:] is much more mid and central, appearing to share nearly the same space as the most neutral *a* [a]. Unlike Figure 4.8, even the monophthongs show a great deal of head-to-tail movement. It is important to note that this speaker had the fewest number of tokens of the

three examined for the case studies, and several of these vowels represent fewer than 20 tokens (see Table 4.15 for exact numbers). These were also some of the oldest audio recordings and contained a great deal of background noise. I did not adjust the normalization of the audio files for this speaker any differently than I did for the other speakers; I chose to conduct the same procedure of noise reduction for all audio files. Therefore, further detailed analysis of the audio of this speaker may alter the results discussed here.

Figures 4.42-4.45 show the short front vowels' F1 head and tail and F2 head and tail frequency measurements.

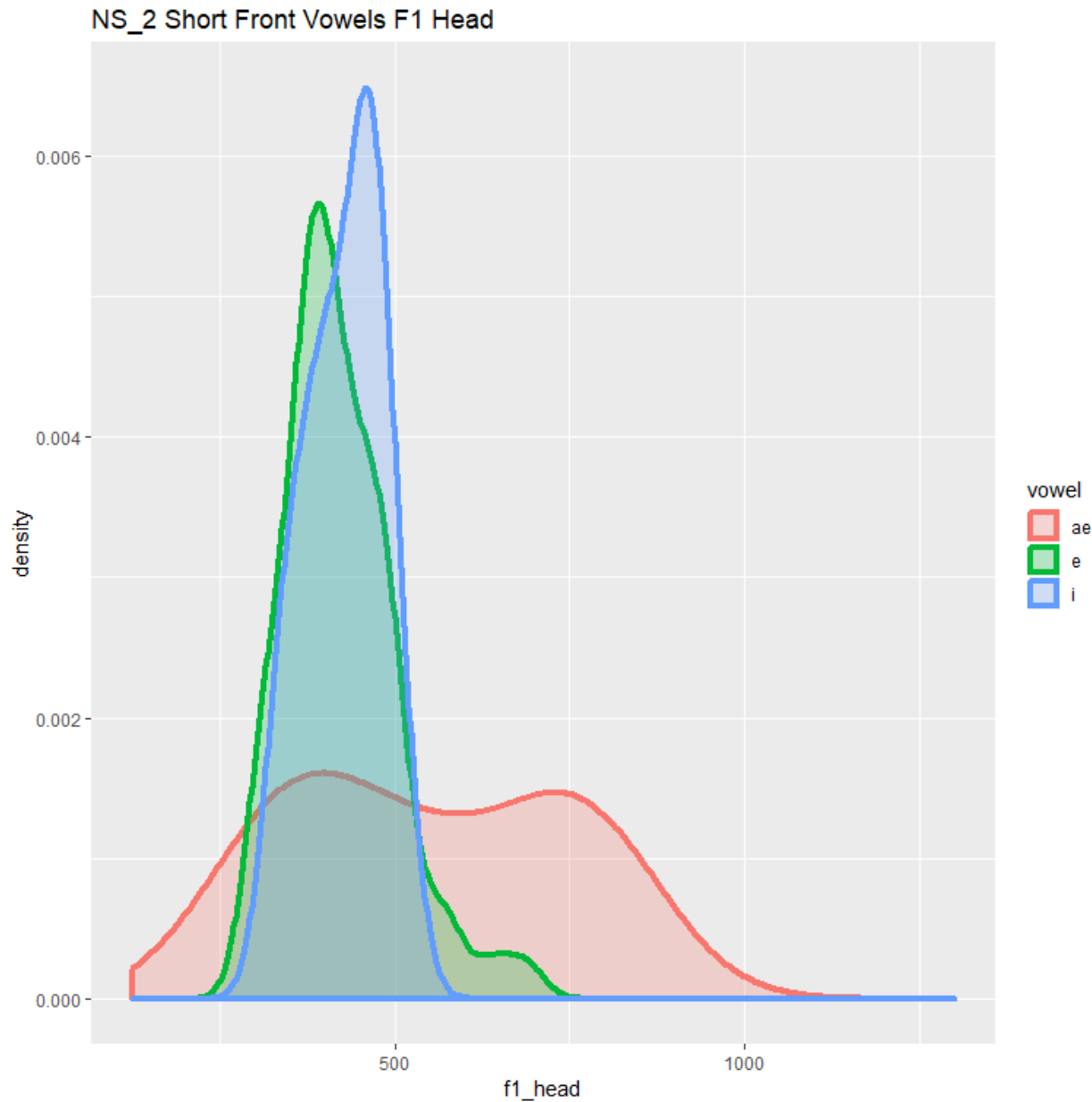


Figure 4.42: Short front vowels F1 Head for NS_2

Figure 4.42 shows near complete overlap in the produced height of *e* [e] and *i* [i] where *ae* [æ] is produced across the entire range of the two, as well as several tokens above and below *e* [e] and *i* [i] for NS_2. Figure 4.43 indicates a wider height range of *e* [e] in the tail measurements than in the heads, though *i* [i] and *ae* [æ] remain largely consistent.

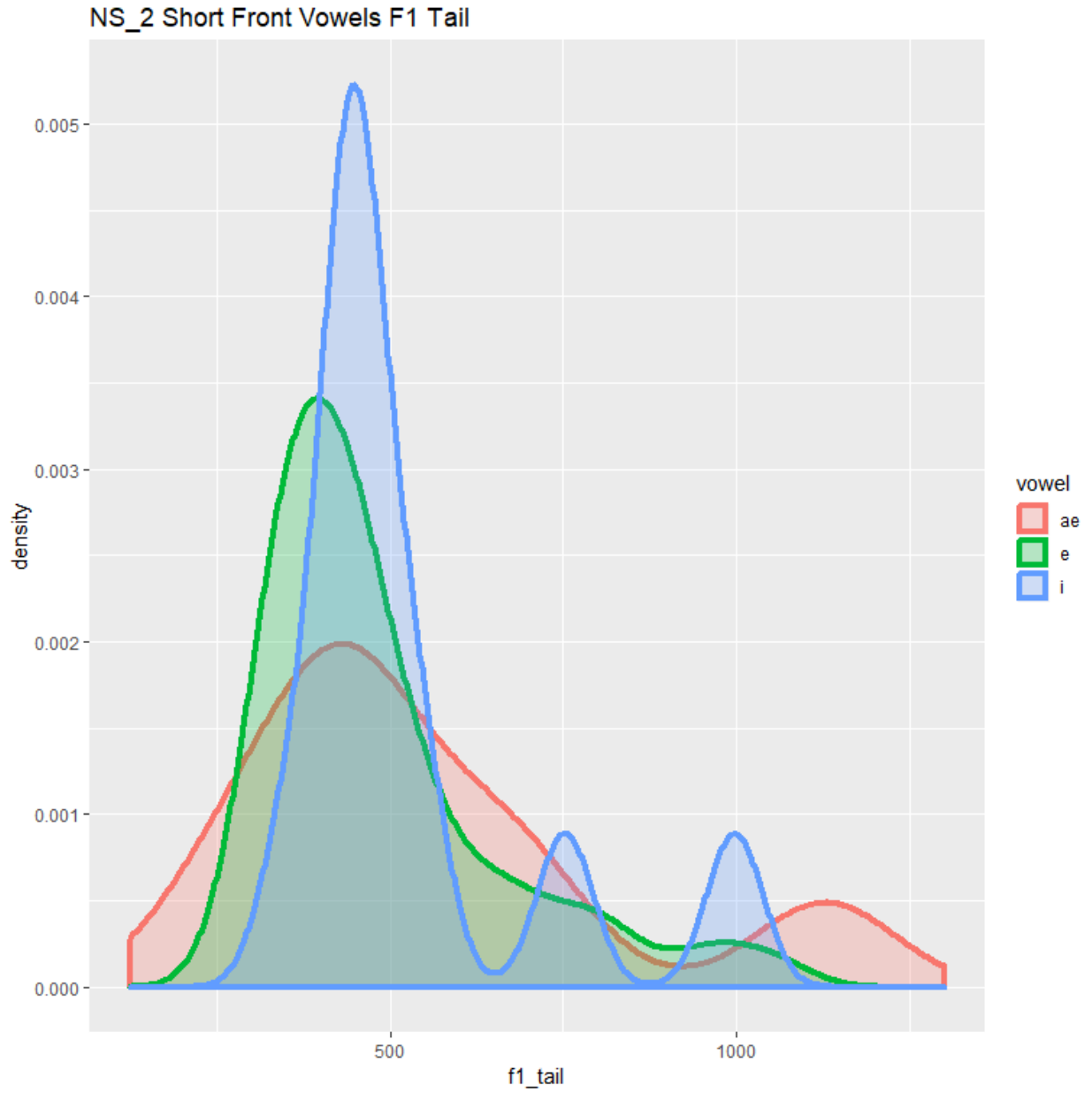


Figure 4.43: Short front vowels F1 Tail for NS_2

Figures 4.44 and 4.45 show the short front vowels' F2 head and tail measurements for NS_2.

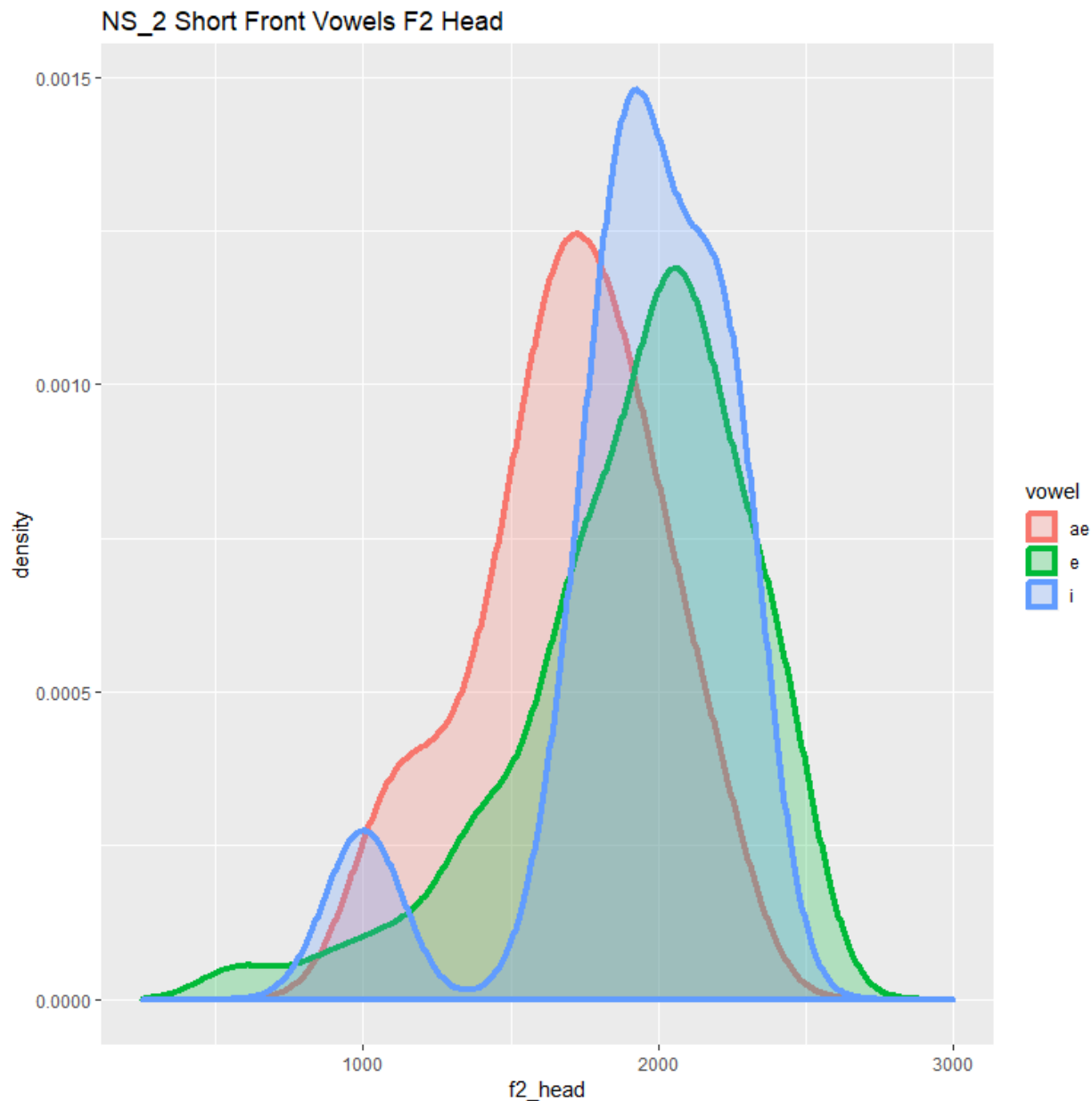


Figure 4.44: Short front vowels F2 Head for NS_2

Figures 4.44 and 4.45 indicate very little variation between the vowels regarding frontness/backness. Figures 4.42 and 4.43 are consistent with the averages for all speakers from the preceding section in that the short front vowels have some variation in height, but little variation in frontness/backness.

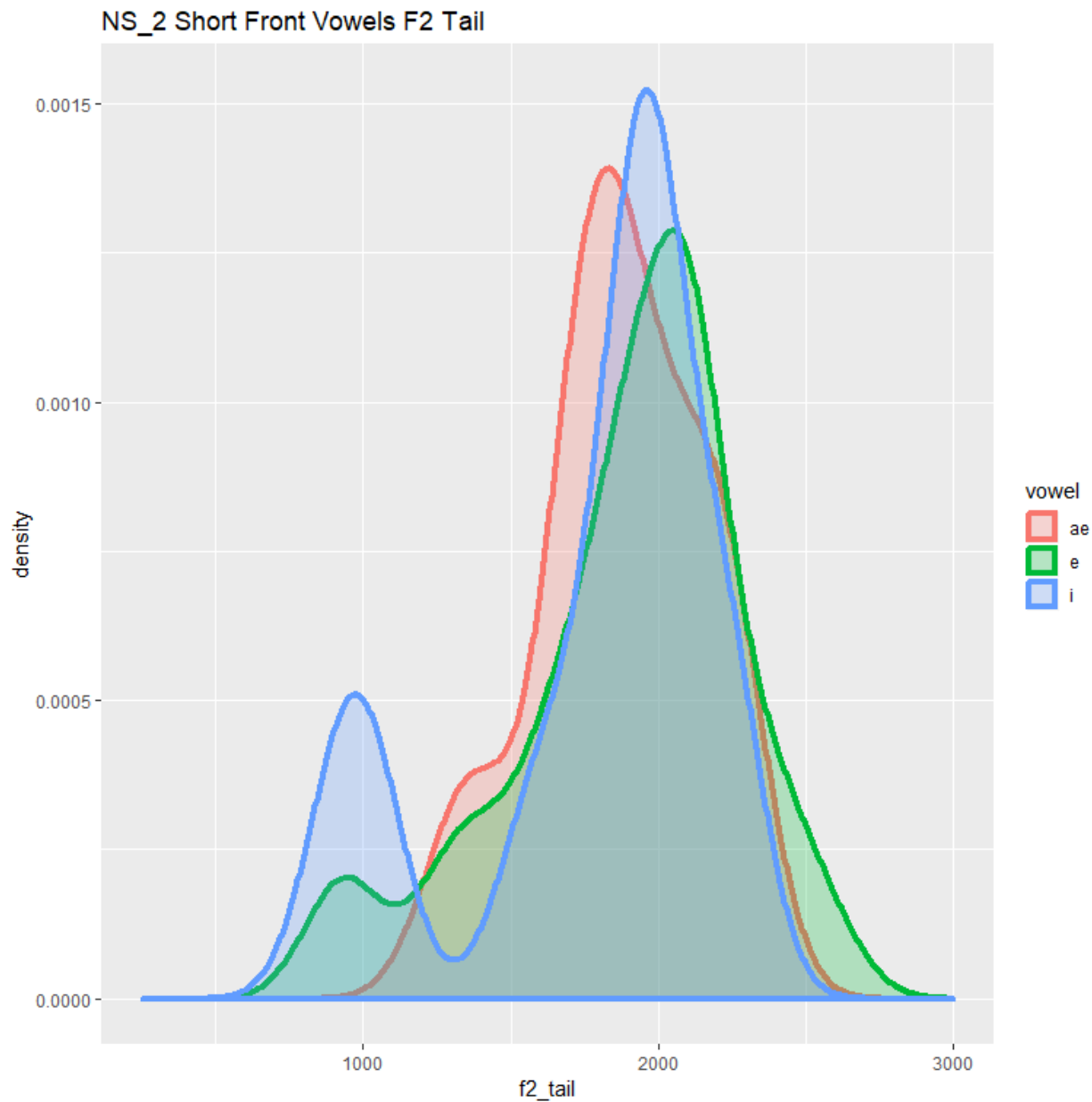


Figure 4.45: Short front vowels F2 Tail for NS_2

The token densities shown here are consistent with the short front vowels in the preceding section. The overlapping patterns of the density plots are similar to the average for all speakers, and this is mostly consistent with the predicted pattern from the descriptions of vowel variation.

Figures 4.46 and 4.47 show the long front vowels' F1 head and tail measurements and Figures 4.48 and 4.49 show the long front vowels' F2 head and tail measurements for NS_2.

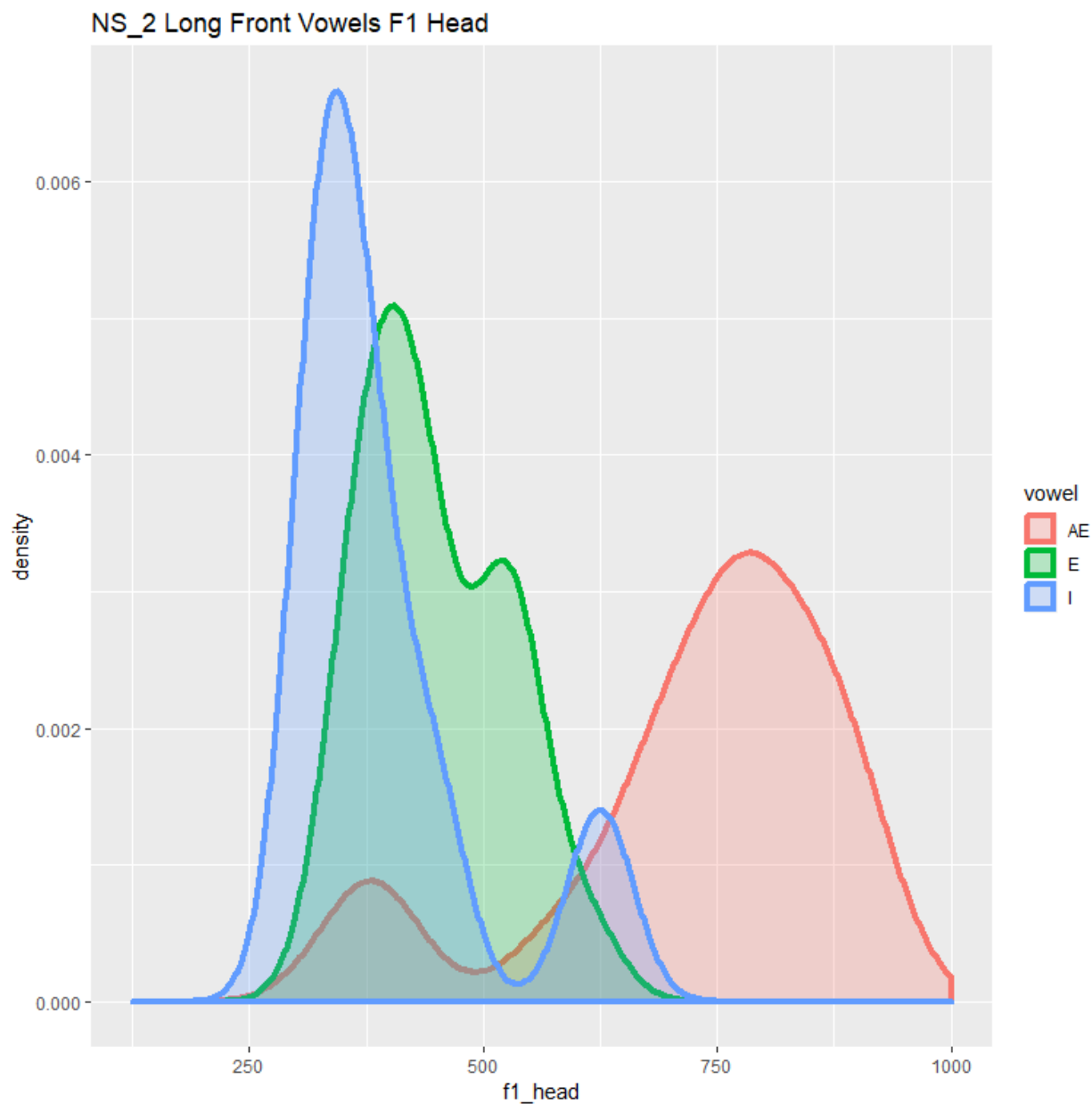


Figure 4.46: Long front vowels F1 Head for NS_2

Table 4.14 indicates that there should be little overlap in the token realizations between the long front vowels. Figures 4.46 and 4.47 indicate, just as for the short front vowels, a great deal of overlap between \bar{i} [i:] and \bar{e} [e:], though to a lesser degree than the short vowels. \bar{a} [æ] is

largely realized at a higher frequency, which means it is consistently lower in the acoustic space, though it still overlaps a small bit with \bar{e} [e:] and \bar{i} [i:].

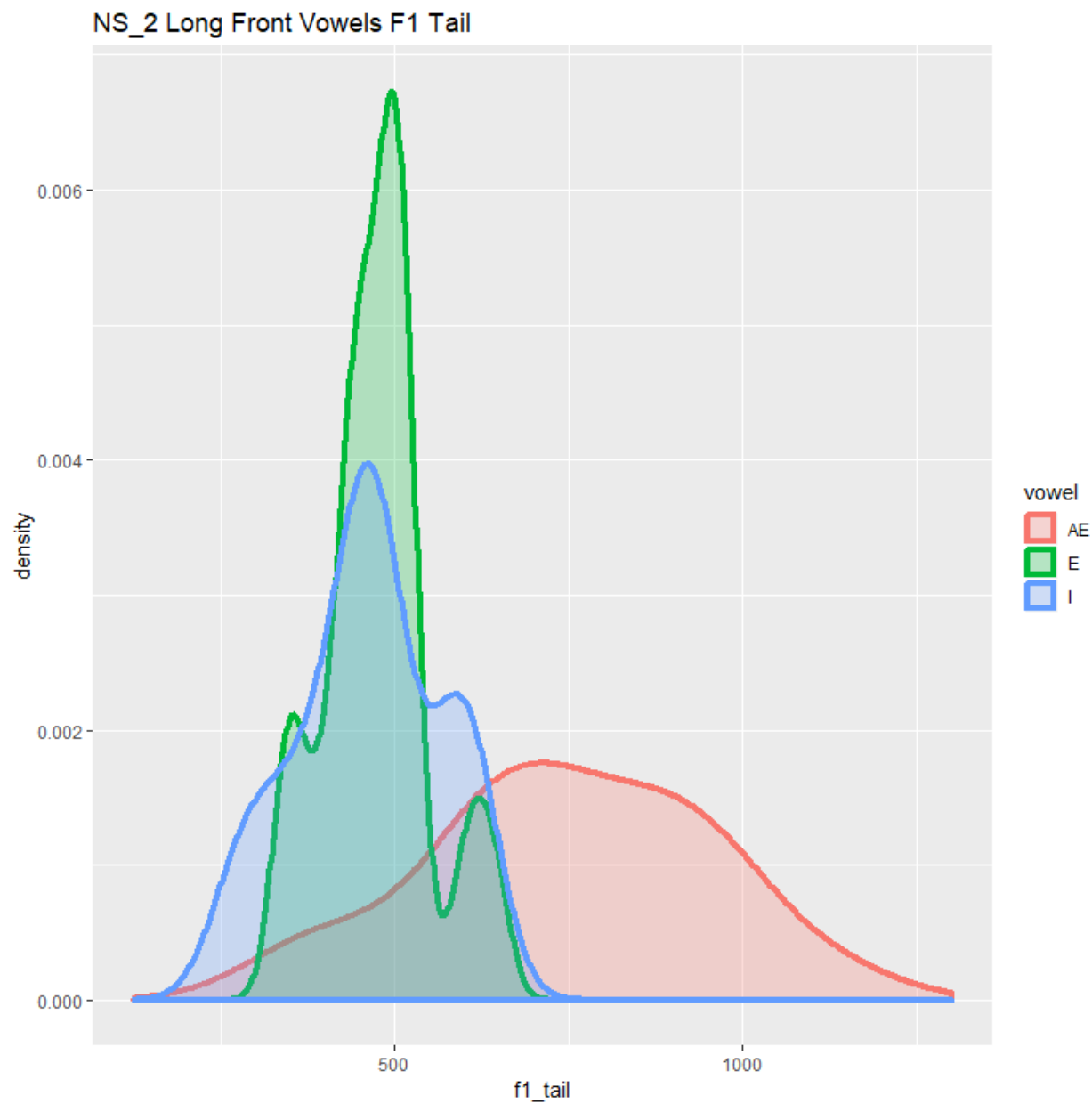


Figure 4.47: Long front vowels F1 Tail for NS_2

Figures 4.48 and 4.49 show the long front vowel F2 head and tail measurements for NS_2.

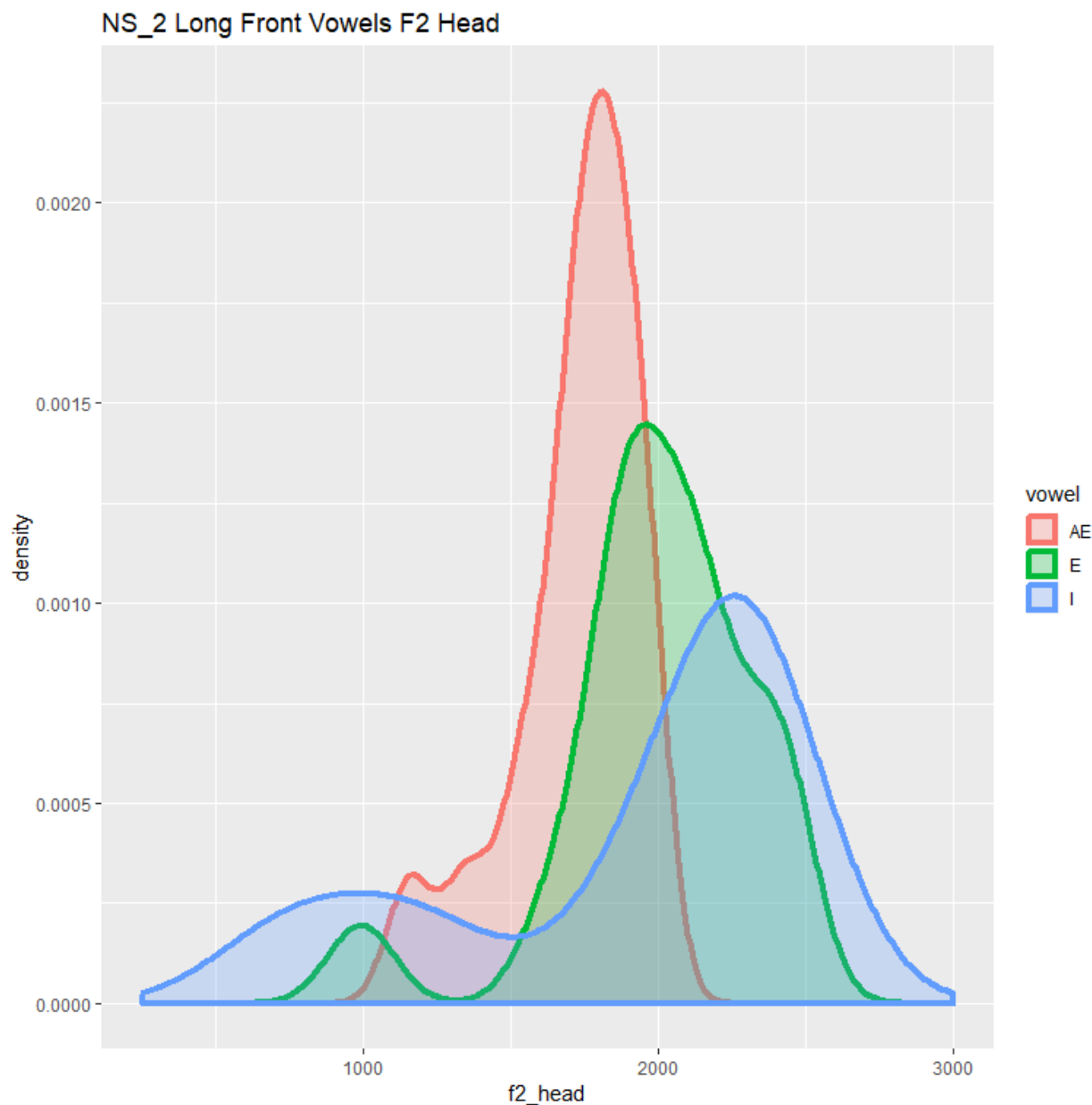


Figure 4.48: Long front vowels F2 Head for NS_2

Figures 4.48 and 4.49 indicate variation in the long front vowel frontness/backness in the acoustic space, though still with more overlap than expected. For the most part, $\bar{a}e$ [æ] is further back, which is to be expected, though \bar{i} [i:] covers the whole front/back range, with some tokens further front than \bar{e} and some further back than $\bar{a}e$ [æ:].

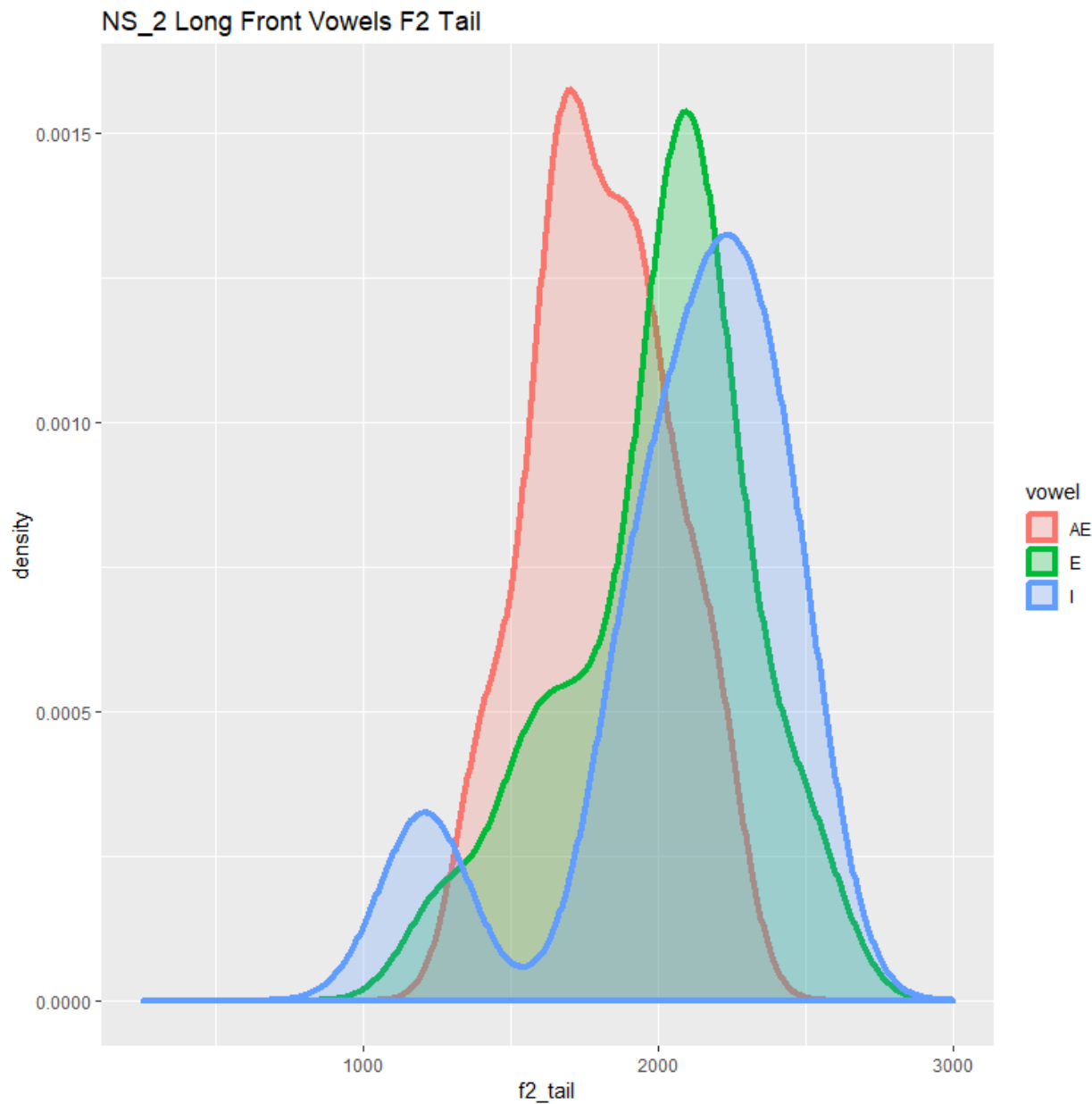


Figure 4.49: Long front vowels F2 Tail for NS_2

The F2 patterns presented here are fairly consistent with the averages for all speakers, and combined with the F1 measurements, the long front vowels indicate more variation and allophony than expected by the predictions of Table 4.14.

Figures 4.50-4.53 show the short back F1 head and tail and F2 head and tail measurements of *a* [a], and *o* [o], but as discussed earlier, not *u* [u] for NS_2.

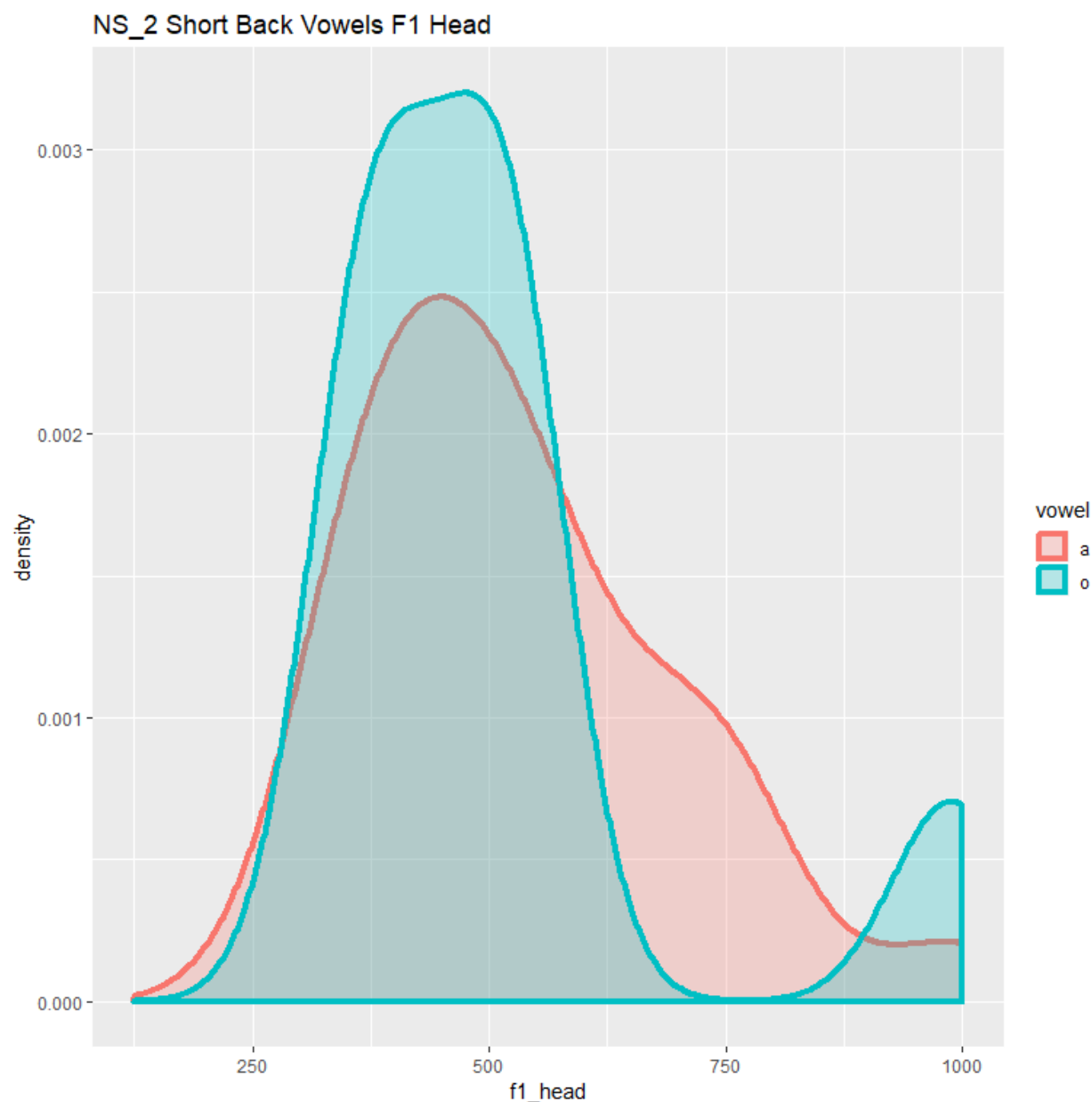


Figure 4.50: Short back vowels F1 Head for NS_2

Figures 4.50 and 4.51 show the short back vowels' F1 head and tail measurements. These two figures indicate almost complete overlap of the height of *a* and *o* in the acoustic space. This is consistent with the average for all speakers, but is completely unexpected from the predictions of

Table 4.14. Based on previous descriptions of the short back vowels, I expect *a* [a] to have a height range distinct (lower) from *o* [o], as well as some overlap in range. However, that is not the case.

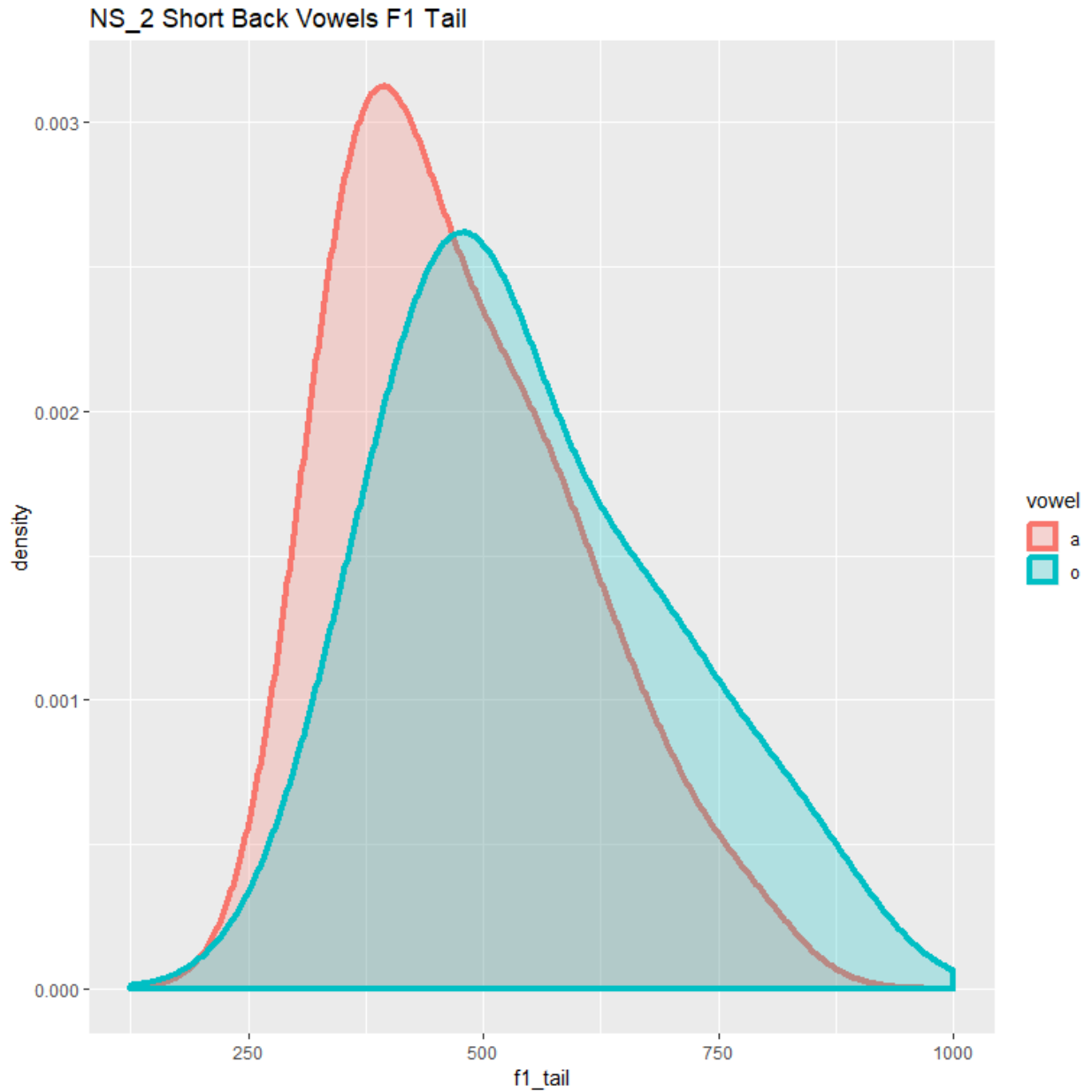


Figure 4.51: Short back vowels F1 Tail for NS_2

Figures 4.52 and 4.53 show the F2 head and tail measurements of the short back vowels for NS_2.

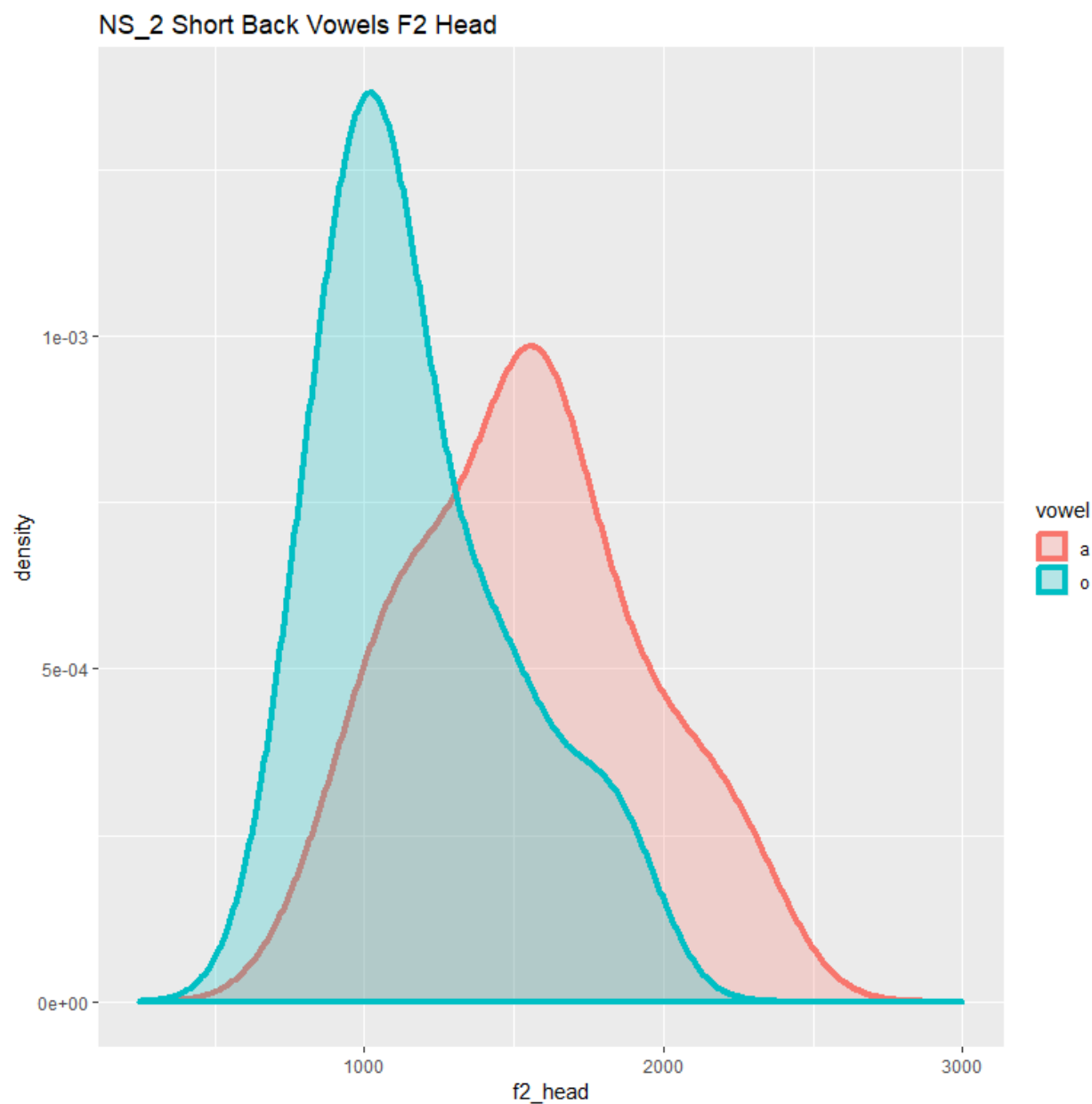


Figure 4.52: Short back vowels F2 Head for NS_2

Figures 4.52 and 4.53 show some variation in frontness/backness between *a* [a] and *o* [o]. Figure 4.52 shows that while many tokens of *a* [a] and *o* [o] are within the same range of front/back in the acoustic space, both vowels also have a unique range distinct from the other. *a* [a] has a

distinct range at a higher frequency which means those tokens are further front than the *o* [o] tokens' distinct range, which is further back.

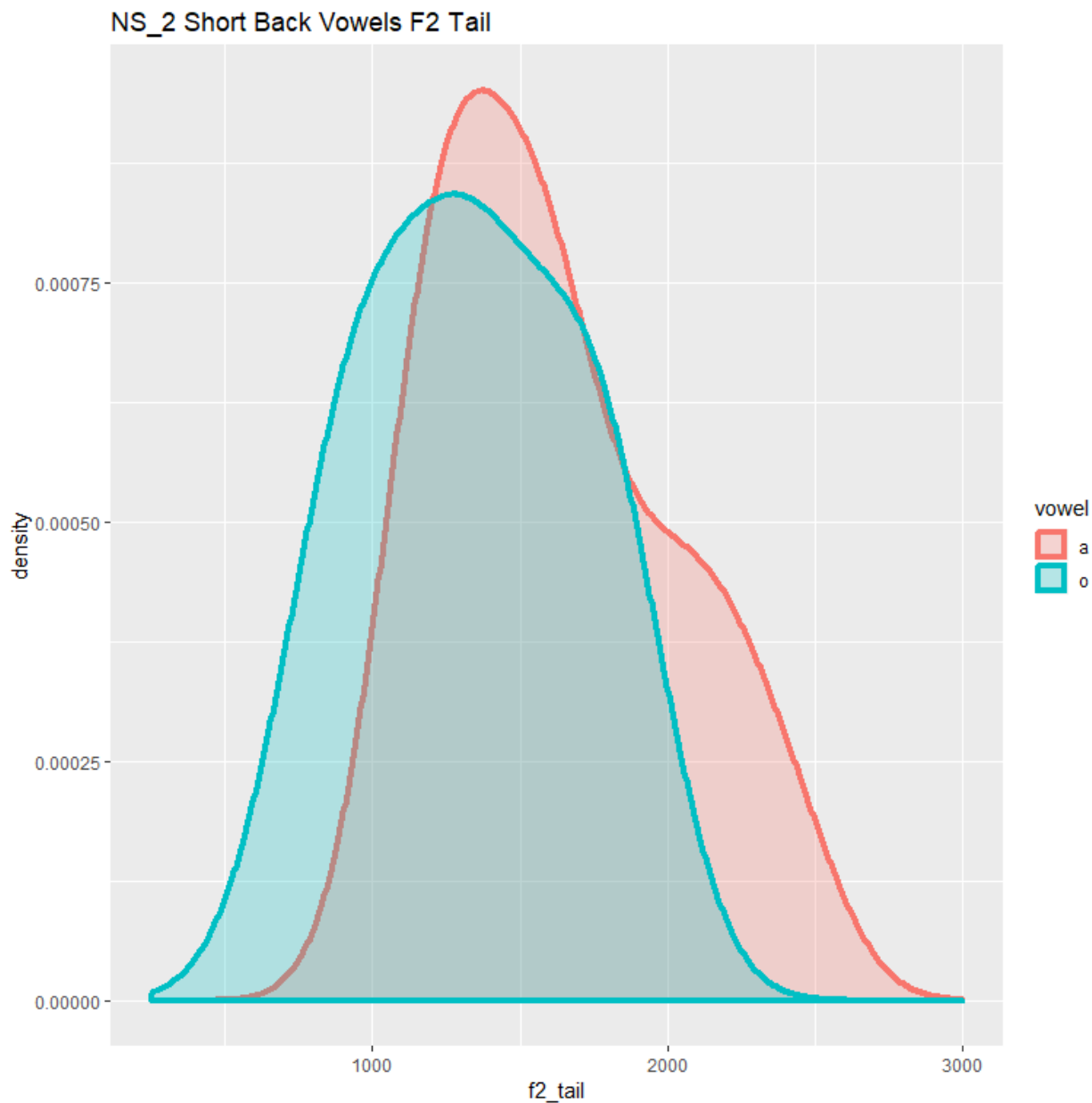


Figure 4.53: Short back vowels F2 Tail for NS_2

Figures 4.50-4.53 show the density patterns of the short back vowels for NS_2. These patterns are consistent with what I expect to see from the averages of all the speakers discussed earlier,

and as such they are completely inconsistent with the expectations of the allophonic patterns as described in the Menominee literature.

Figures 4.54-4.57 show the formant measurements for F1 head and tail and F2 head and tail of the long back vowels, \bar{a} [a:], \bar{o} [o:], and \bar{u} [u:].

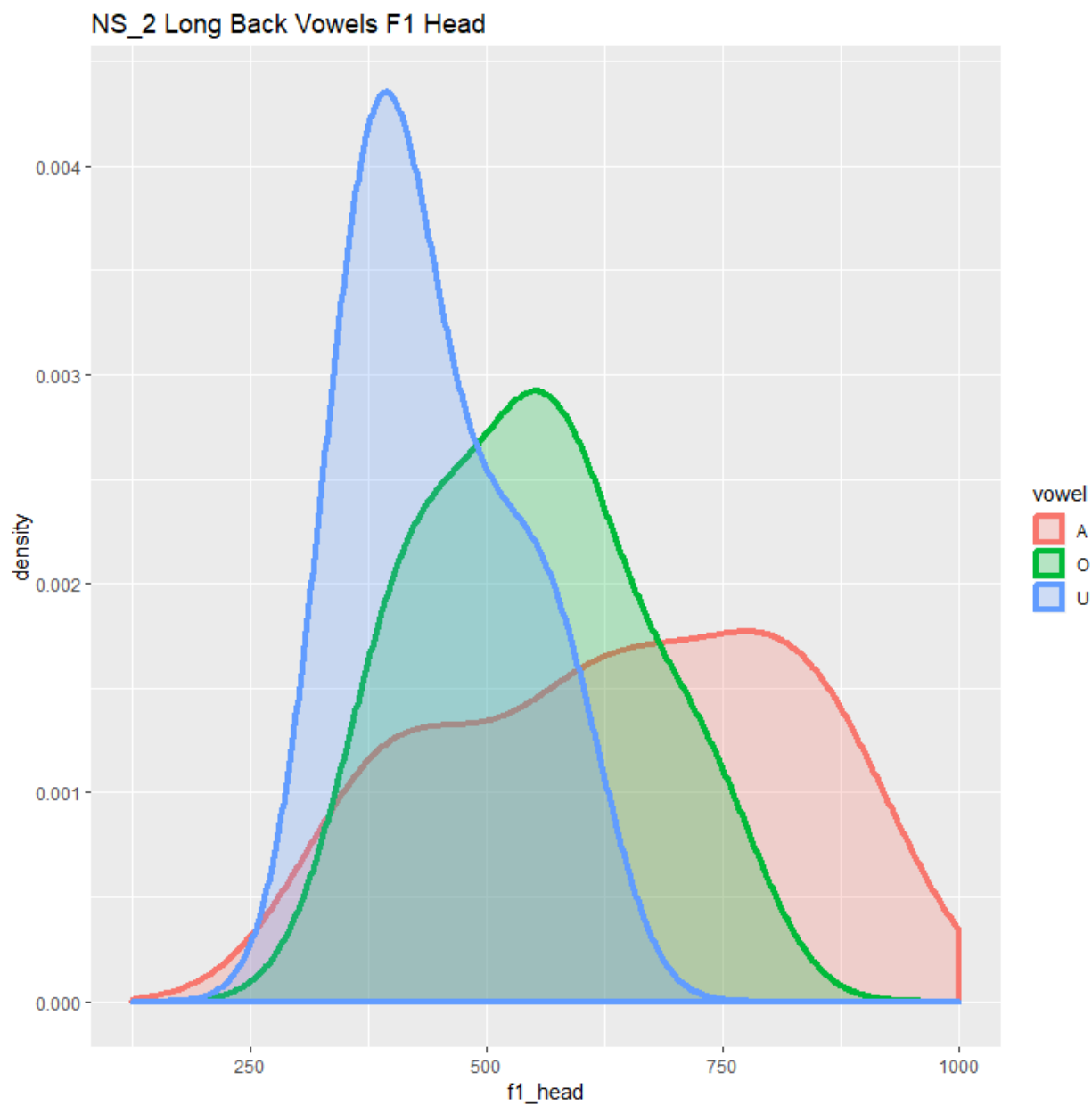


Figure 4.54: Long back vowels F1 Head for NS_2

Figures 4.54 and 4.55 show the long back vowels' F1 head and tail measurements. Just as with the long front vowels, the long back vowels show more variation than expected from the description of Table 4.14. In Figure 4.54, there is a great deal of overlap in the height of \bar{o} [o:] and \bar{u} [u:] in the acoustic space. Surprisingly, \bar{a} [a:] ranges as high as \bar{u} [u:] in some tokens, as well as maintaining a distinct range low in the acoustic space as well. \bar{o} [o:] has no range distinct from \bar{u} [u:] or \bar{a} [a:].

The F1 tail measurements of the long back vowels in Figure 4.55 show a similar pattern, though with some unusual peaks in \bar{u} and \bar{o} . This is most likely due to the low token count of those two vowels, so any measurement that differs from the rest will have an exaggerated spike.

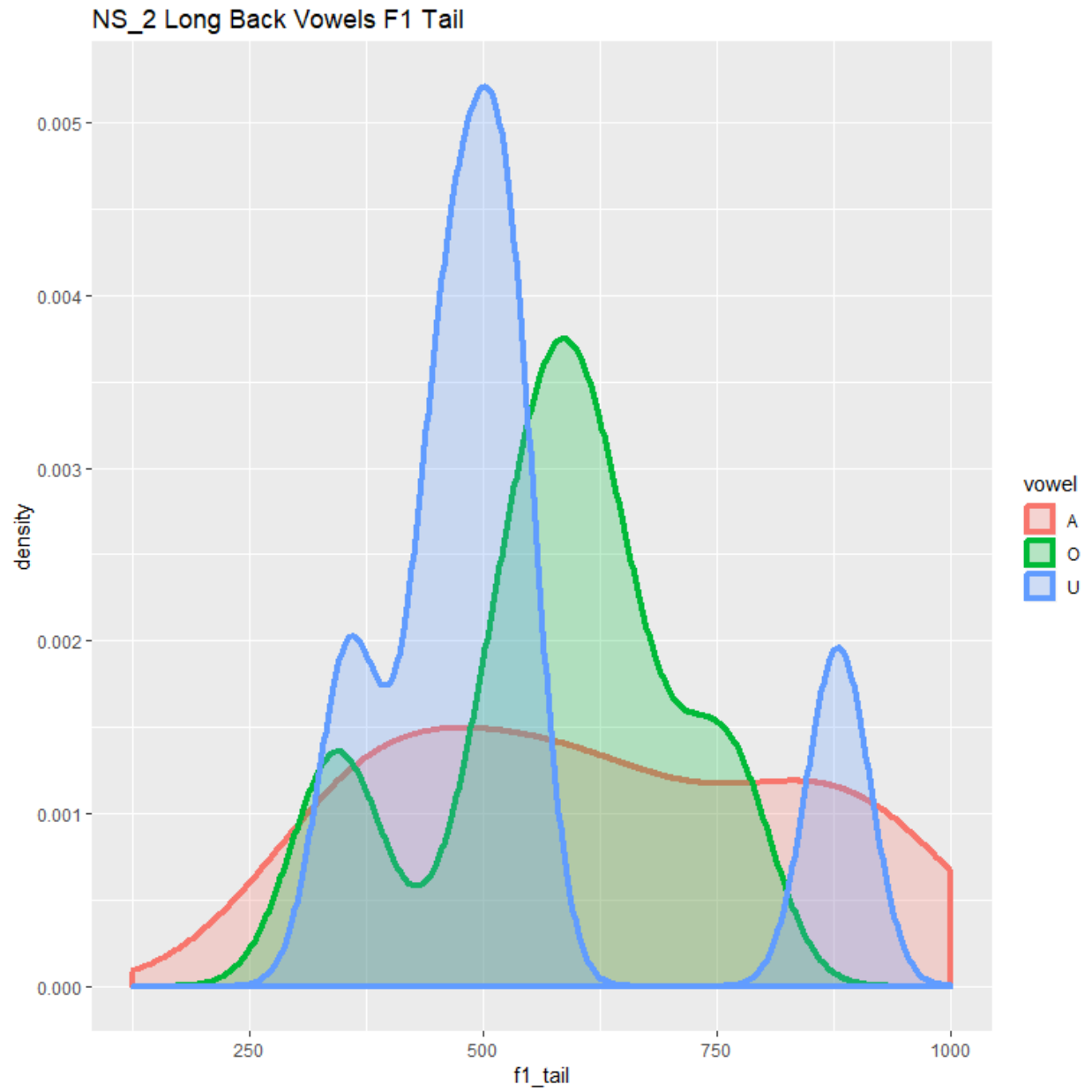


Figure 4.55: Long back vowels F1 Tail for NS_2

Figures 4.56 and 4.57 show the F2 head and tail measurements of the long back vowels for NS_2.

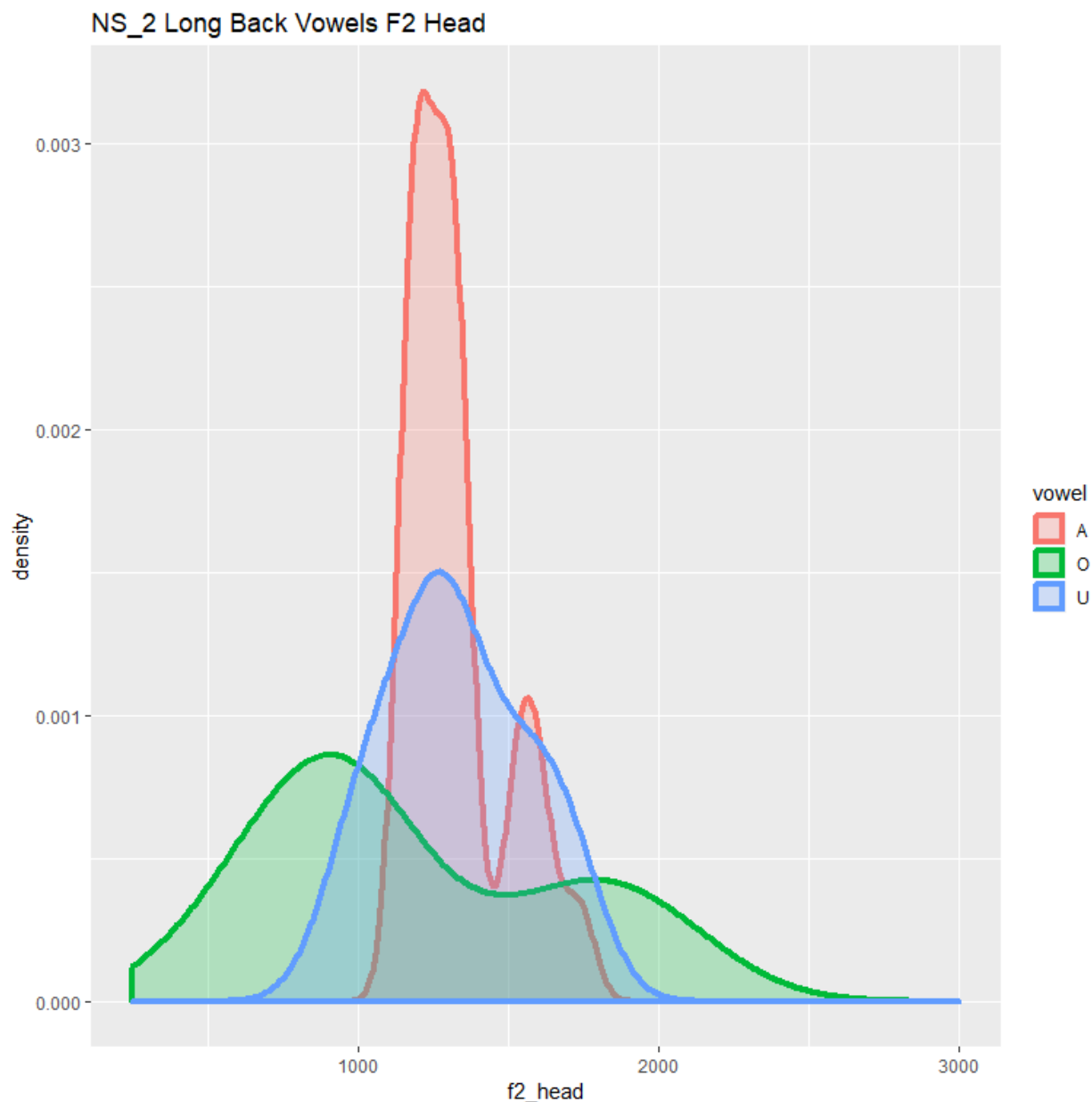


Figure 4.56: Long back vowels F2 Head for NS_2

Unlike the spikes in Figure 4.55 most likely attributed to small token counts, the spikes in Figure 4.56 for the \bar{a} [a:] tokens are more interesting because there are 23 \bar{a} [a:] tokens, as opposed to six for \bar{u} [u:]. The F2 tails indicate a similar peak. Clearly distinct spikes can also be

an indicator of predictable vowel allophony, though at this stage there are still too few tokens to say with any certainty. This would be a variable to examine in greater detail in a future project.

The density patterns in Figures 4.56 and 4.57 are unexpected based on the predictions of Table 4.14. Table 4.14 predicts that \bar{a} [a:] will partially overlap with \bar{o} [o:], but neither should overlap much with \bar{u} [u:], and should each have a distinct range as well. These figures show the for NS_2 \bar{o} [o:] is realized throughout the entire front/back range of \bar{u} [u:] and \bar{a} [a:]. \bar{a} [a:] has no distinct range independent from \bar{u} [u:] or \bar{o} [o:], and \bar{u} [u:] has no range independent from \bar{o} [o:].



Figure 4.57: Long back vowels F2 Tail for NS_2

The figures presented for the long back vowels are largely consistent with the averages for all speakers. NS_2's vowel targets are unexpected based on the predictions of allophony in Table 4.14. It is in the F2 measurements of the long back vowels that NS_2 differs most noticeably from the composite of all speakers.

4.4.2. Native Speaker 3

This section looks at the vowels of NS_3 in greater detail. Table 4.17 shows the means and ratios of the vowel durations for NS_3.

	Mean (ms)	Ratio	Mean (ms)	
i	88.75	1:1.5	132.55	\bar{i}
e	71.74	1:2.1	152.88	\bar{e}
ae	128.1	1:1.3	162.14	\bar{ae}
u	100.19	1:1.5	155.26	\bar{u}
o	82.34	1:1.7	136.0	\bar{o}
a	88.81	1:1.8	158.66	\bar{a}

Table 4.17: Vowel Means and Ratios for NS_3

NS_3 has a longer *i* [i] and *ae* [æ], and a shorter \bar{ae} [æ:] than the average, making the duration ratios slightly different. *o* [o] and \bar{o} [o:] are both longer than the average, but have a greater difference in duration than the average, resulting in a larger ratio between the two vowel lengths (1:1.7 compared to the holistic average ratio of 1:1.4).

Figure 4.58 shows the acoustic space for NS_3.

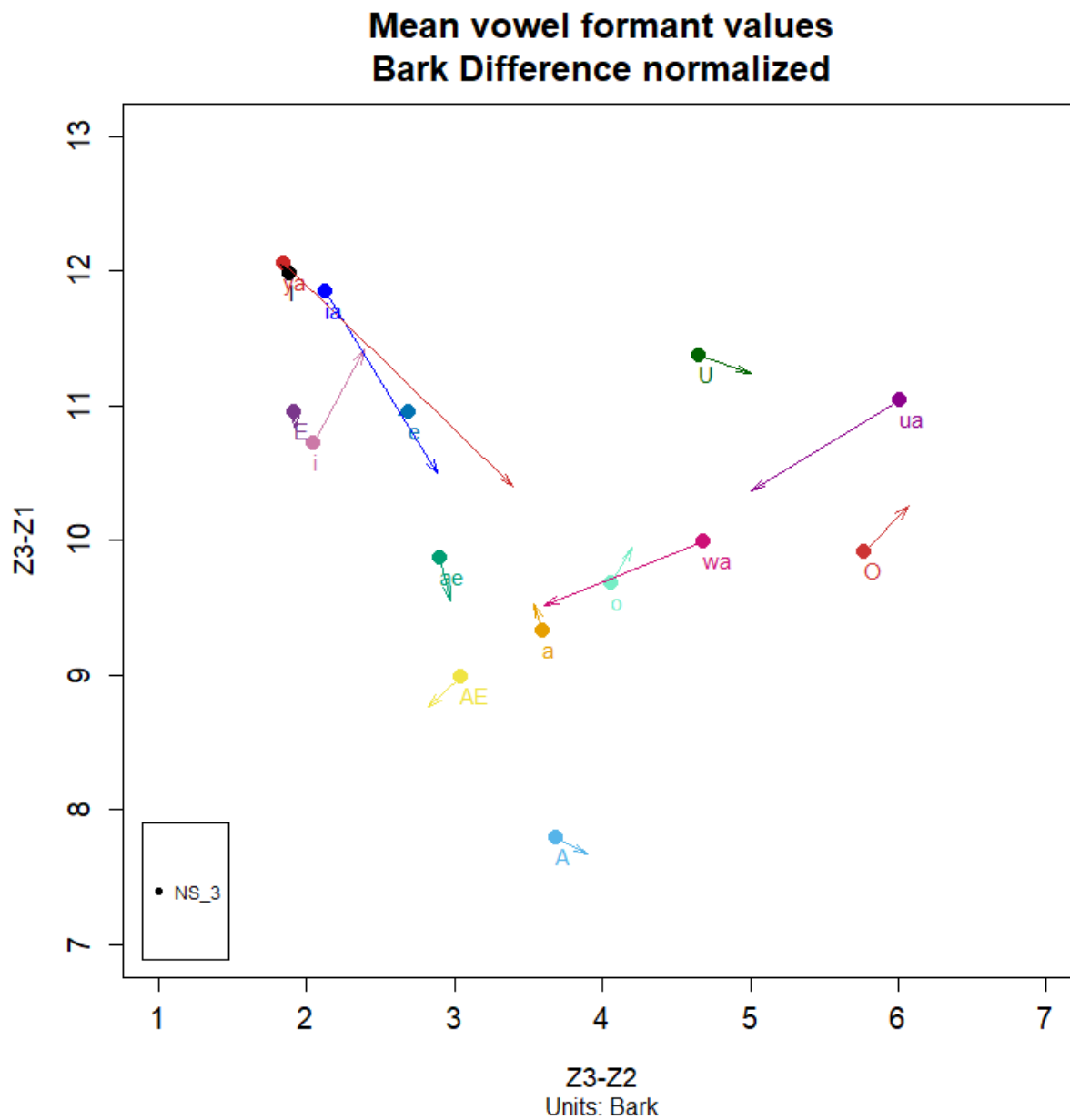


Figure 4.58: NS_3 Vowel Acoustic Quality

The acoustic space for NS_3 is very similar to the average for all the speakers. The long vowels remain peripheral, and the front vowels are in the expected acoustic space, just as seen in Figure 4.41 for NS_2 above. The back vowels are slightly different, though. While *a* [a] remains mid and central, \bar{a} [a:] is more fronted and *o* [o] is nearly in the same mid, central space. Both *o* [o] and \bar{o} [o:] are more fronted than the average of all the speakers. The following figures show the

density plots for the short, long, front, back vowels, and F1, F2, head, and tail measurements for NS_3 only.

Figures 4.59 and 4.60 show the short front F1 head and tail measurements for *ae* [æ], *e* [e], and *i* [i] for NS_3.

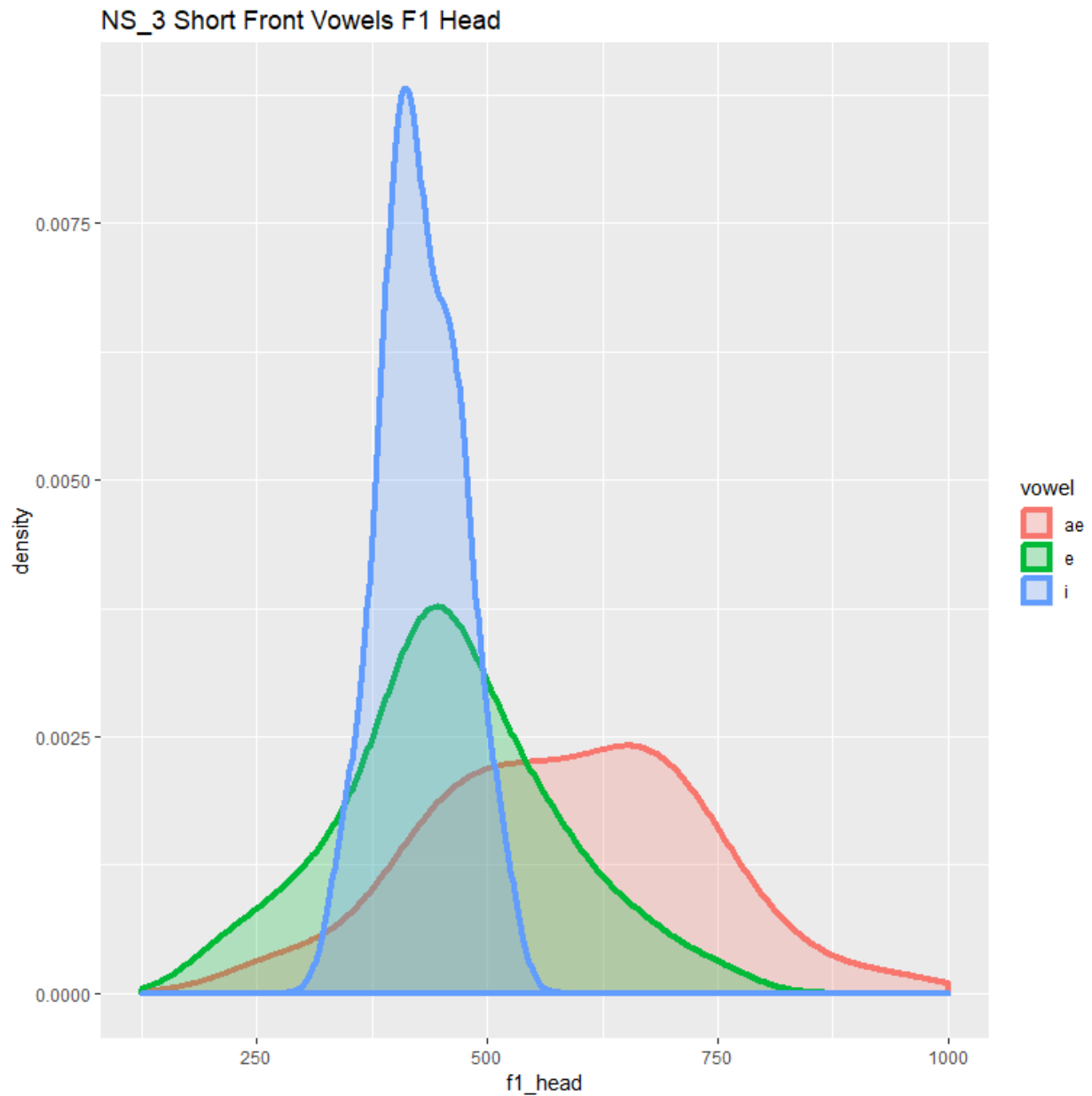


Figure 4.59: Short front vowels F1 Head for NS_3

Figures 4.59 and 4.60 show that *i* [i] has a very narrow height range it is realized in for NS_3. The high sharp peak indicates a lack of variation in the measurements and that most of the tokens cluster in the same range. *ae* [æ] and *e* [e] overlap nearly entirely, though both have a small range unique to each vowel. NS_3 differs from the average in that *e* has a range distinct from *i* [i], indicating more variation in *e* [e] realizations and in *i* [i], and *i* [i] has no unique range in vowel height. Just as with the average for all speakers, these figures do not represent the anticipated pattern identified in Table 4.14.

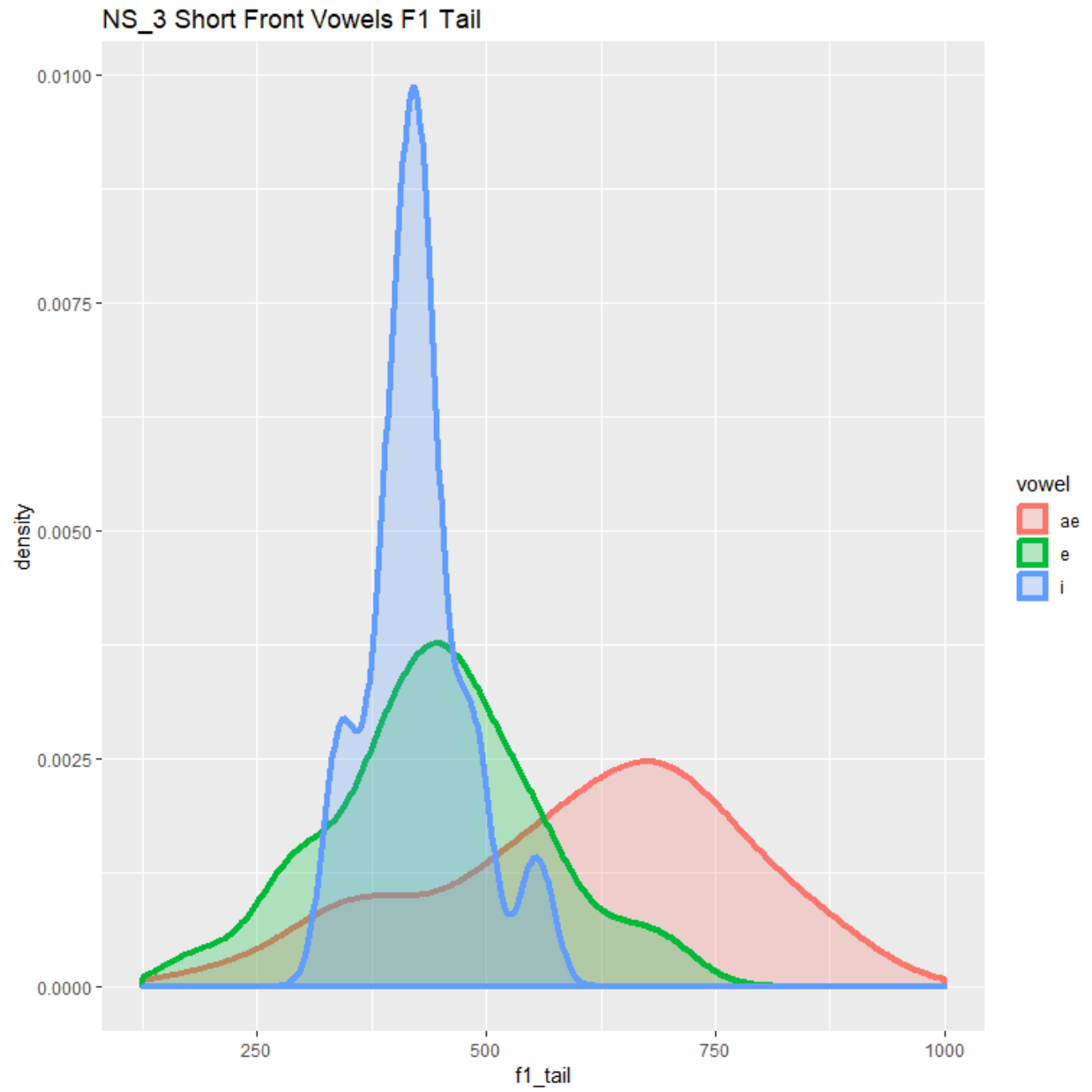


Figure 4.60: Short front vowels F1 Tail for NS_3

Figures 4.61 and 4.62 show the F2 head and tail measurements for the short front vowels for NS_3.

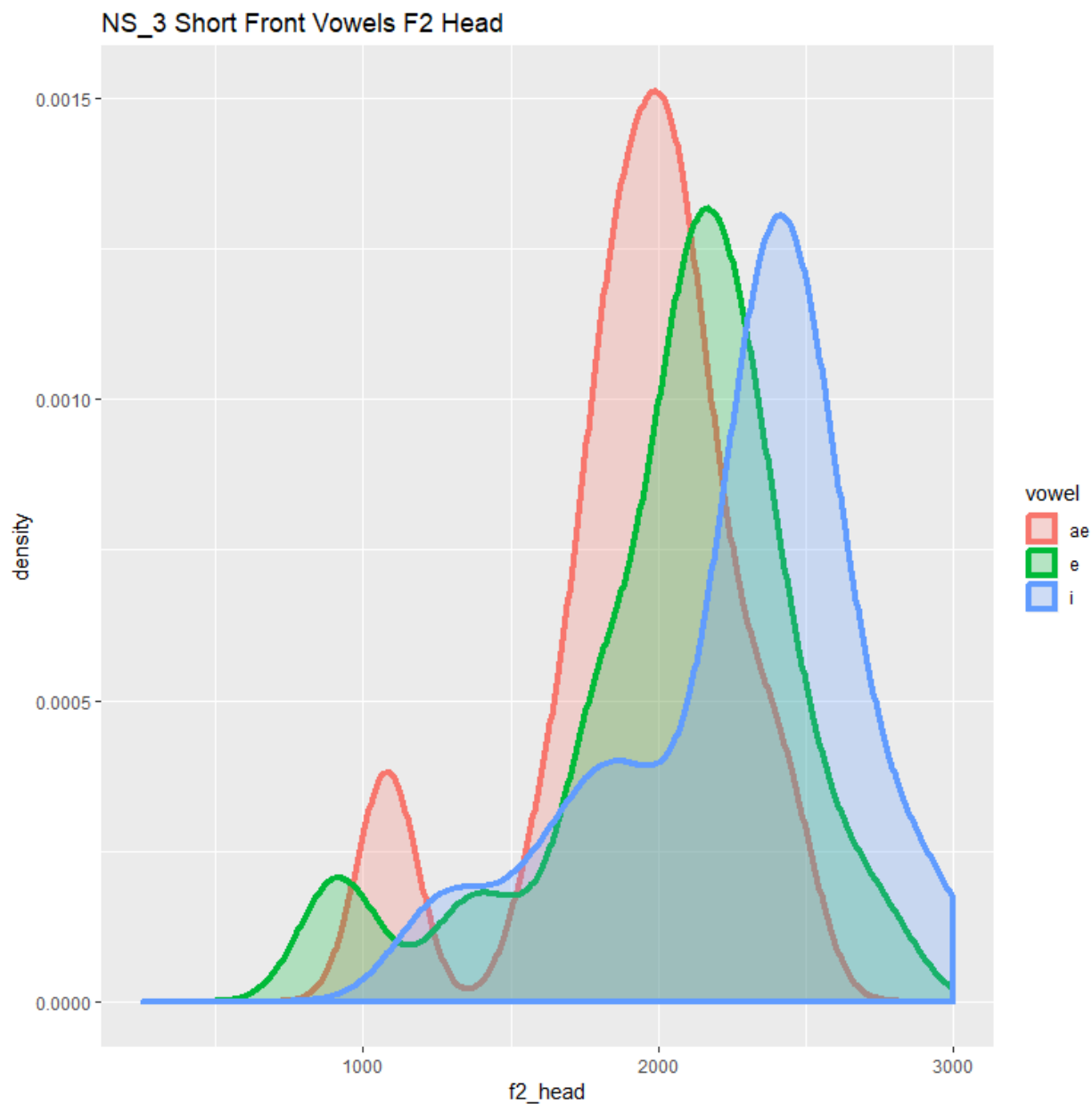


Figure 4.61: Short front vowels F2 Head for NS_3

Figures 4.61 and 4.62 indicate that there is a small difference in frontness/backness of the short front vowels, though the ranges of all three are very similar and overlap almost completely.

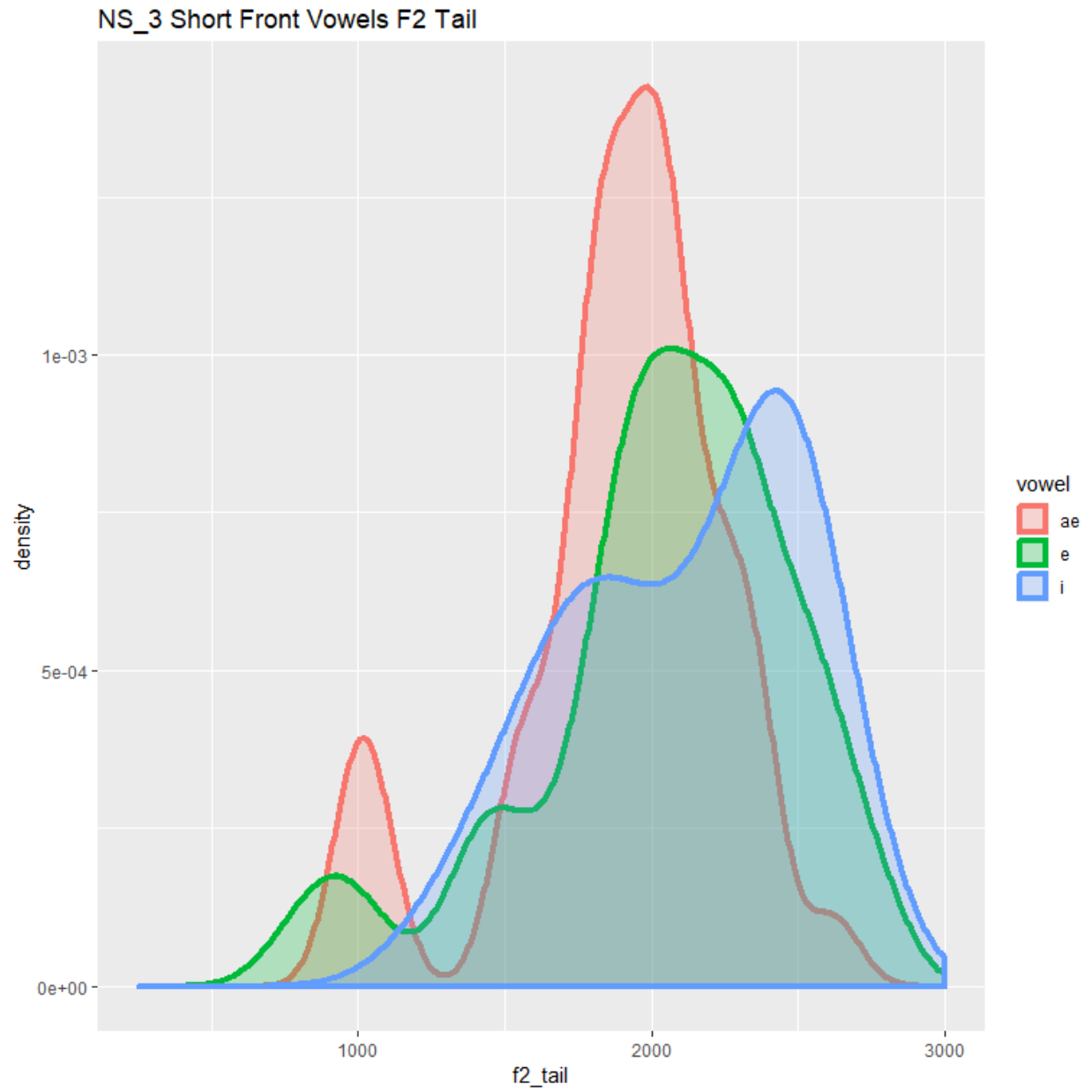


Figure 4.62: Short front vowels F2 Tail for NS_3

Figures 4.63-4.66 show the density plots of the long front vowels' F1 head and tail and F2 head and tail for NS_3.

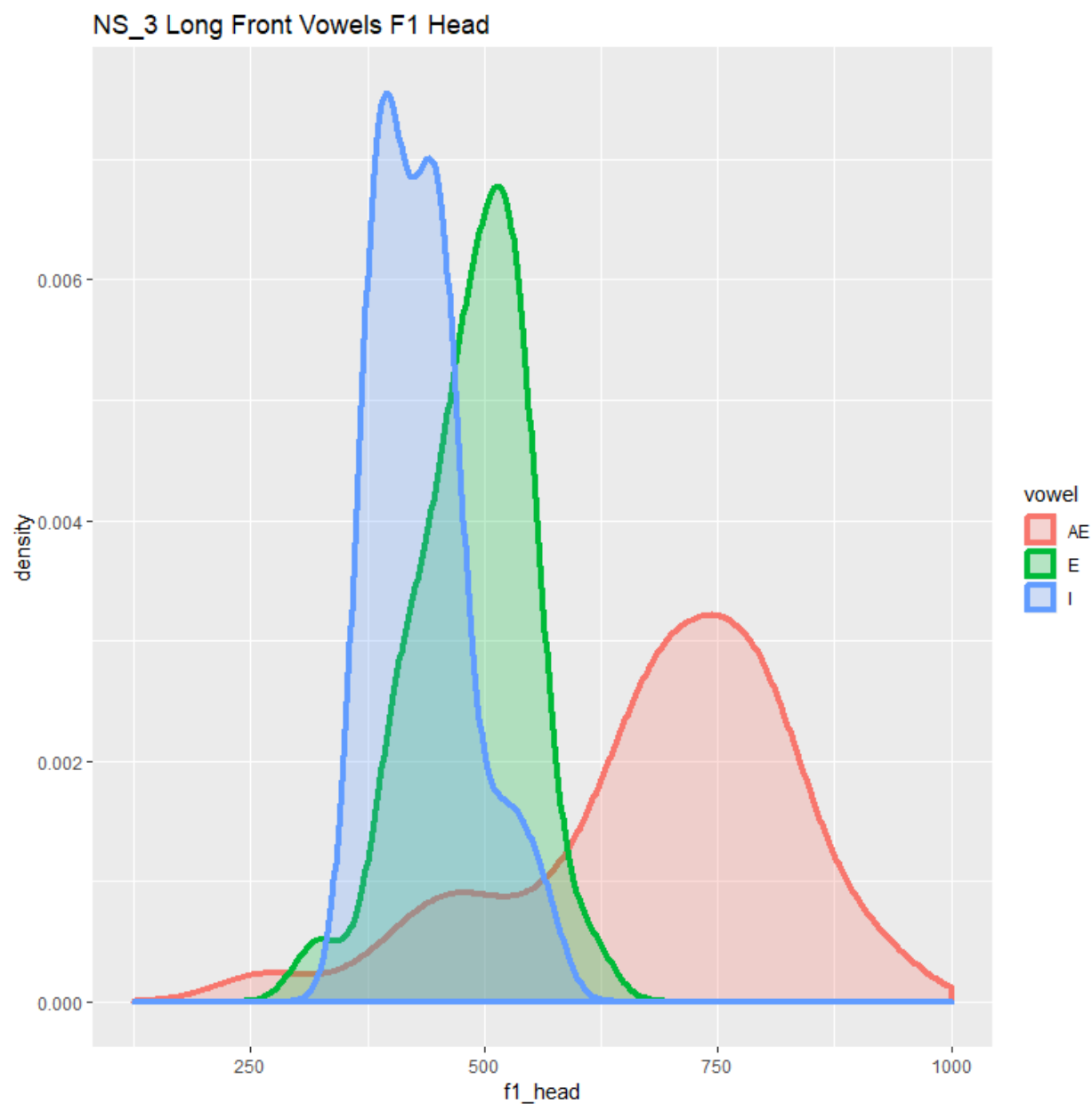


Figure 4.63: Long front vowels F1 Head for NS_3

Figures 4.63 and 4.64 show the long front vowels' F1 head and tail measurements for $\bar{a}e$ [æ:], \bar{e} [e:], and \bar{i} [i:]. These figures indicate that $\bar{a}e$ [æ:], as expected, is typically realized much lower

in the acoustic space than \bar{e} [e:] and \bar{i} [i:]. \bar{e} [e:] and \bar{i} [i:] overlap almost completely. Consistent with the average for all speakers, and inconsistent with the predictions from the literature, \bar{ae} [æ:] also ranges throughout the height range of \bar{i} [i:] and \bar{e} [e:], and even higher than the two in a rare case.

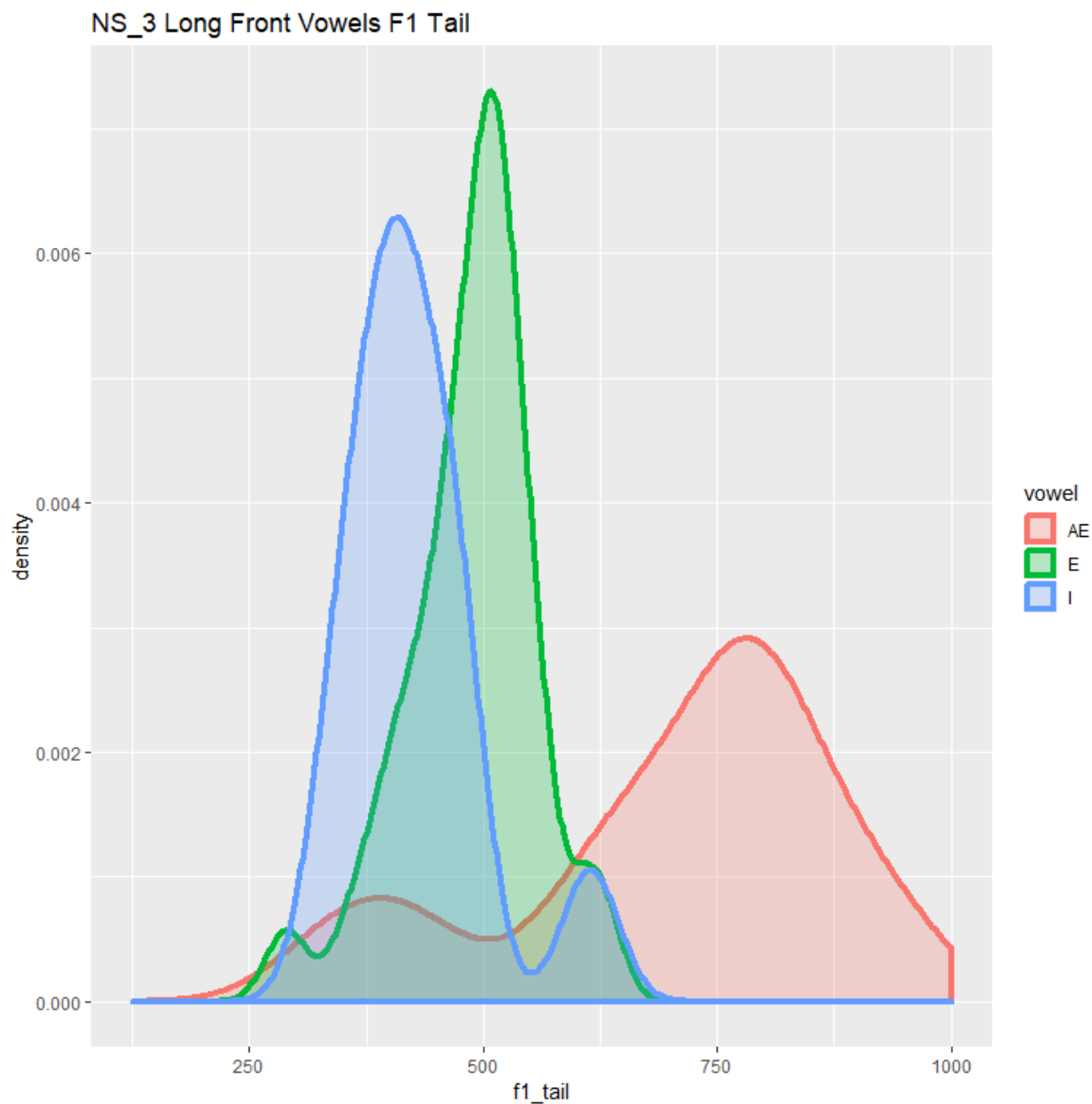


Figure 4.64: Long front vowels F1 Tail for NS_3

Figures 4.65 and 4.66 show the F2 head and tail measurements of the long front vowels for NS_3.

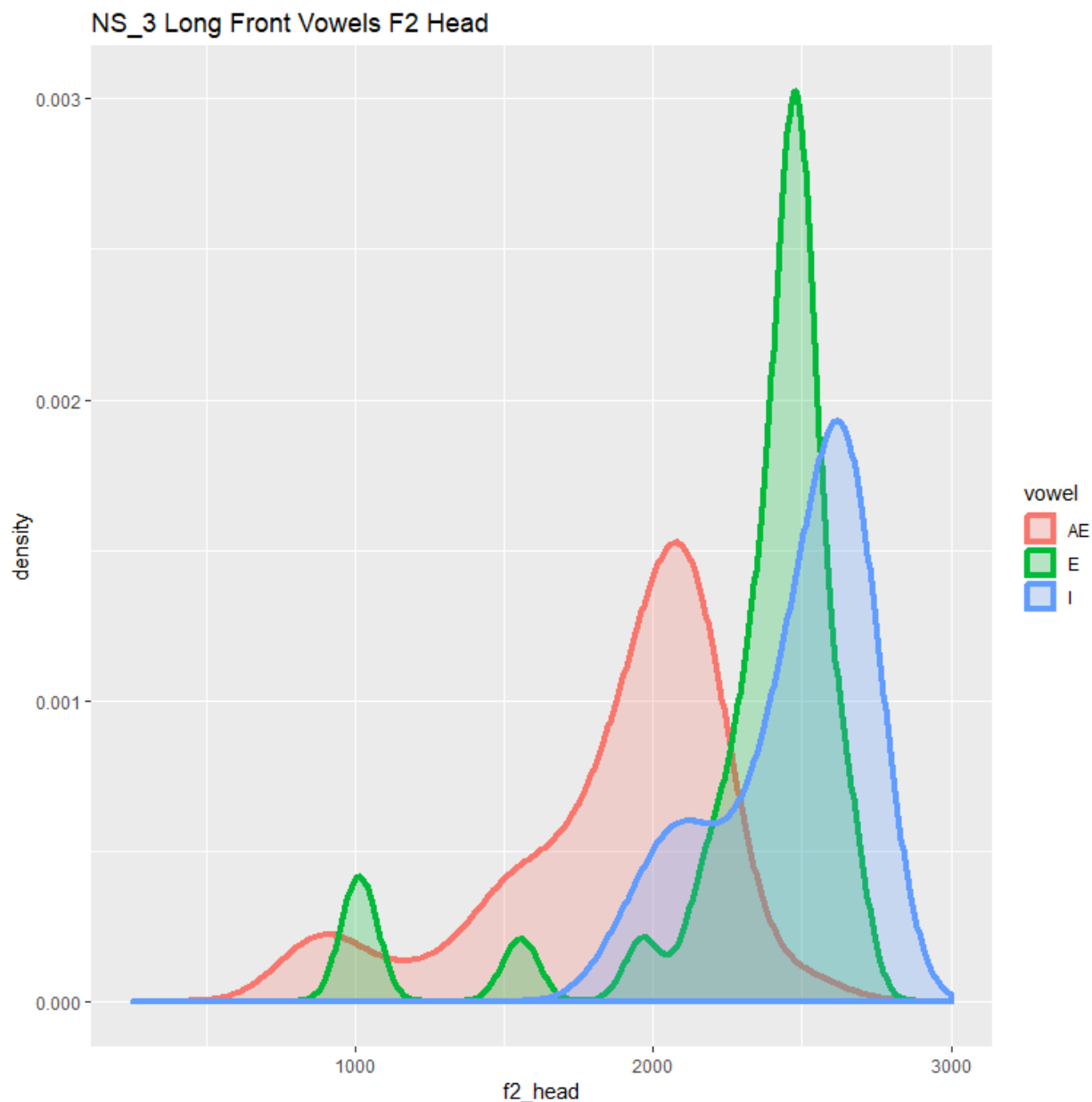


Figure 4.65: Long front vowels F2 Head for NS_3

Figures 4.65 and 4.66 show height variation for the long front vowels. The measurements in these figures indicate that $\bar{a}e$ [æ:] is further back in the acoustic space and \bar{e} [e:] and \bar{i} [i:] are in nearly the same range. This is consistent with expectation from the averages of all the speakers.

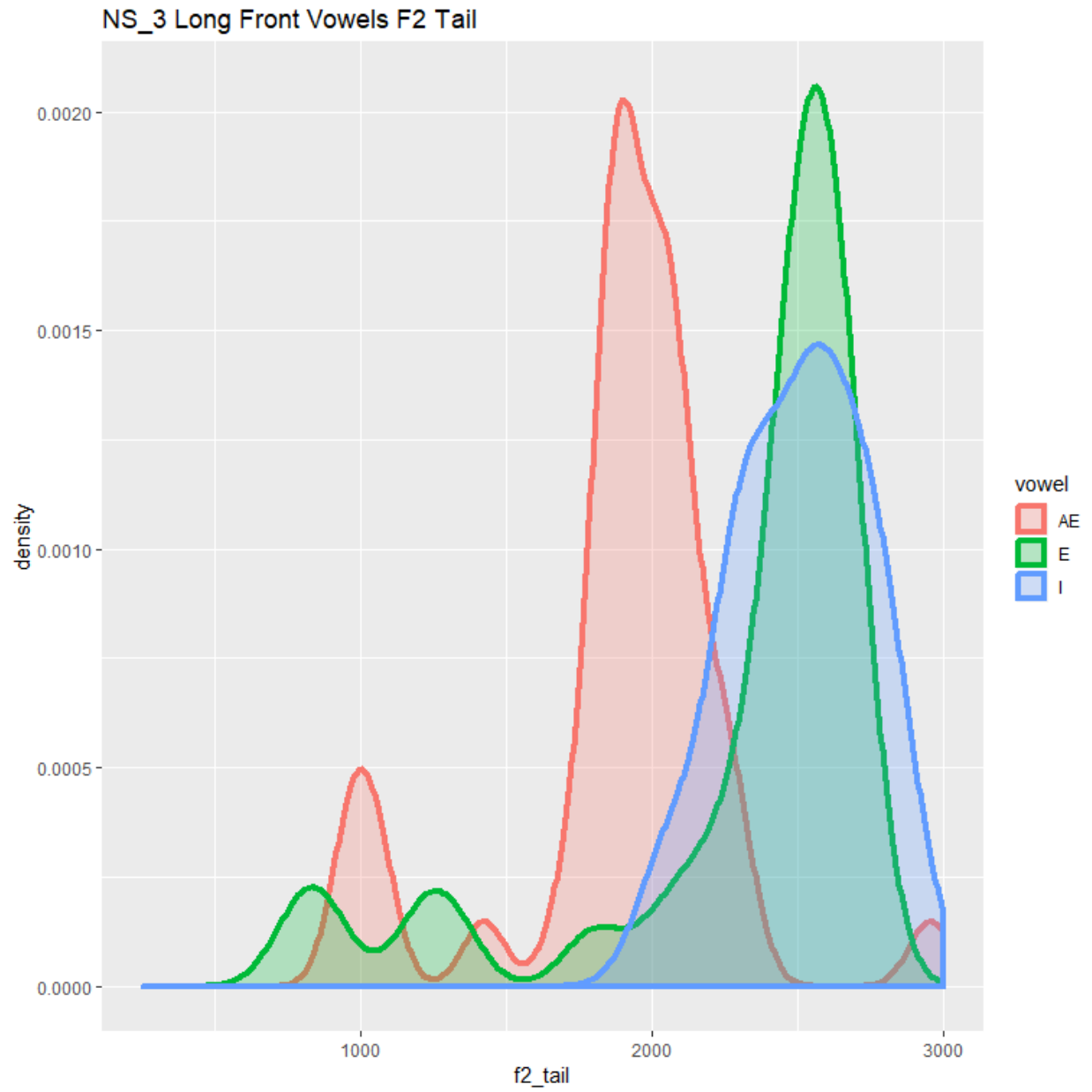


Figure 4.66: Long front vowels F2 Tail for NS_3

Figures 4.67-4.70 show the short back vowels' F1 and F2 head and tail measurements for NS_3.

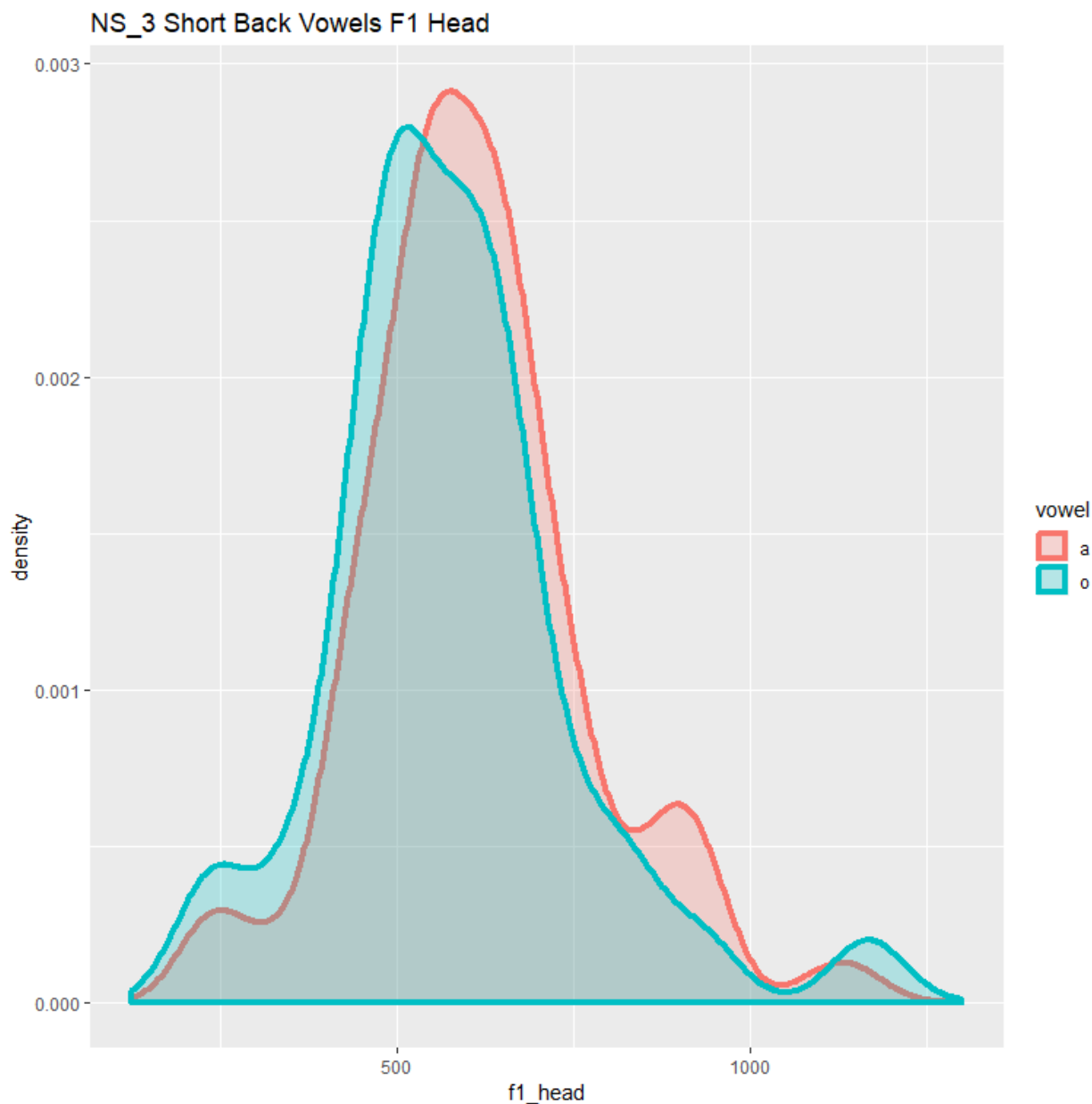


Figure 4.67: Short back vowels F1 Head for NS_3

Figures 4.67 and 4.68 show the short back vowels *a* [a], and *o* [o] F1 head and tail measurements. These figures indicate little to no height variation between the two vowels for NS_3. This is consistent with the averages from all the speakers, and again inconsistent with the expectations from Table 4.14.

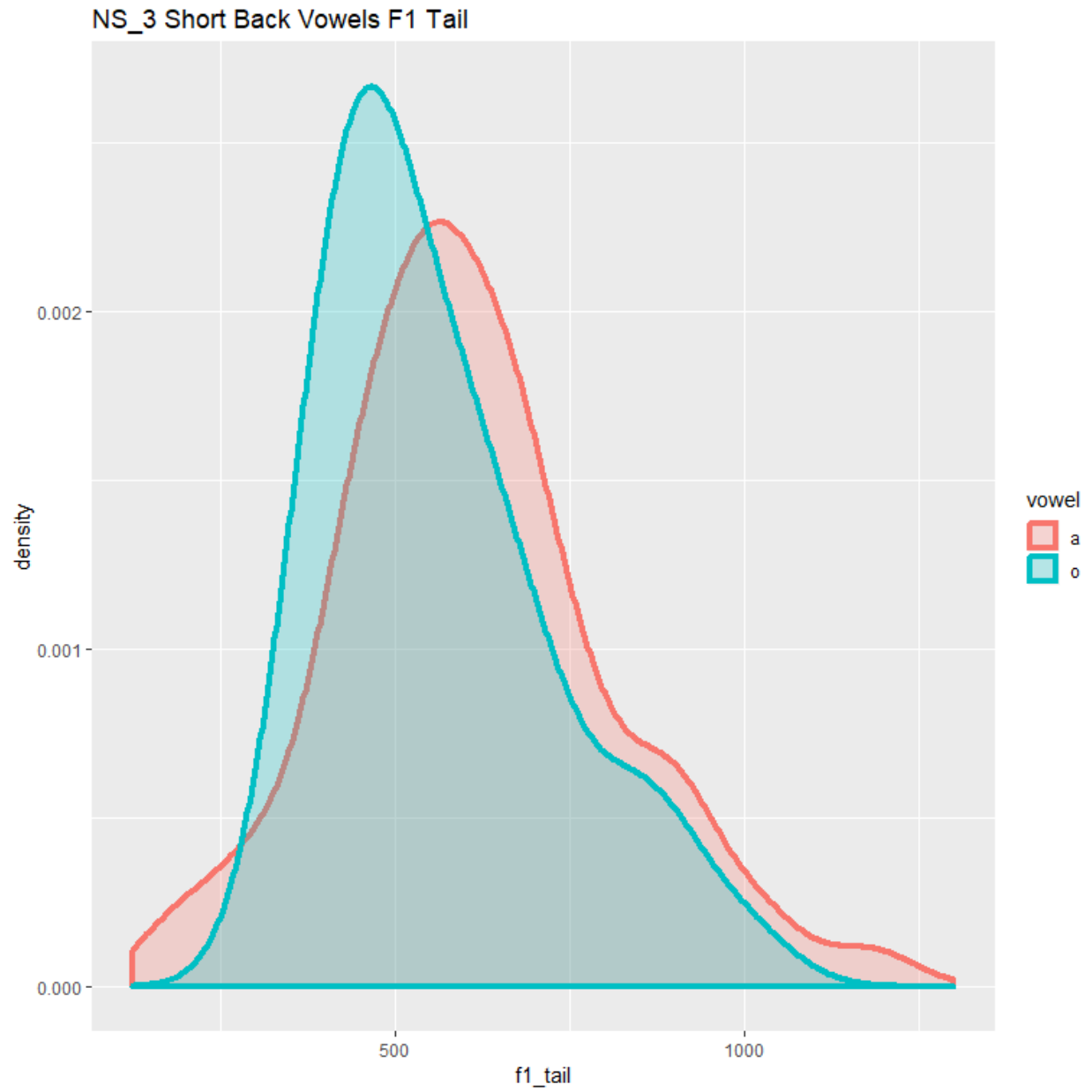


Figure 4.68: Short back vowels F1 Tail for NS_3

Figures 4.69 and 4.70 show the short back F2 head and tail measurements for NS_3.

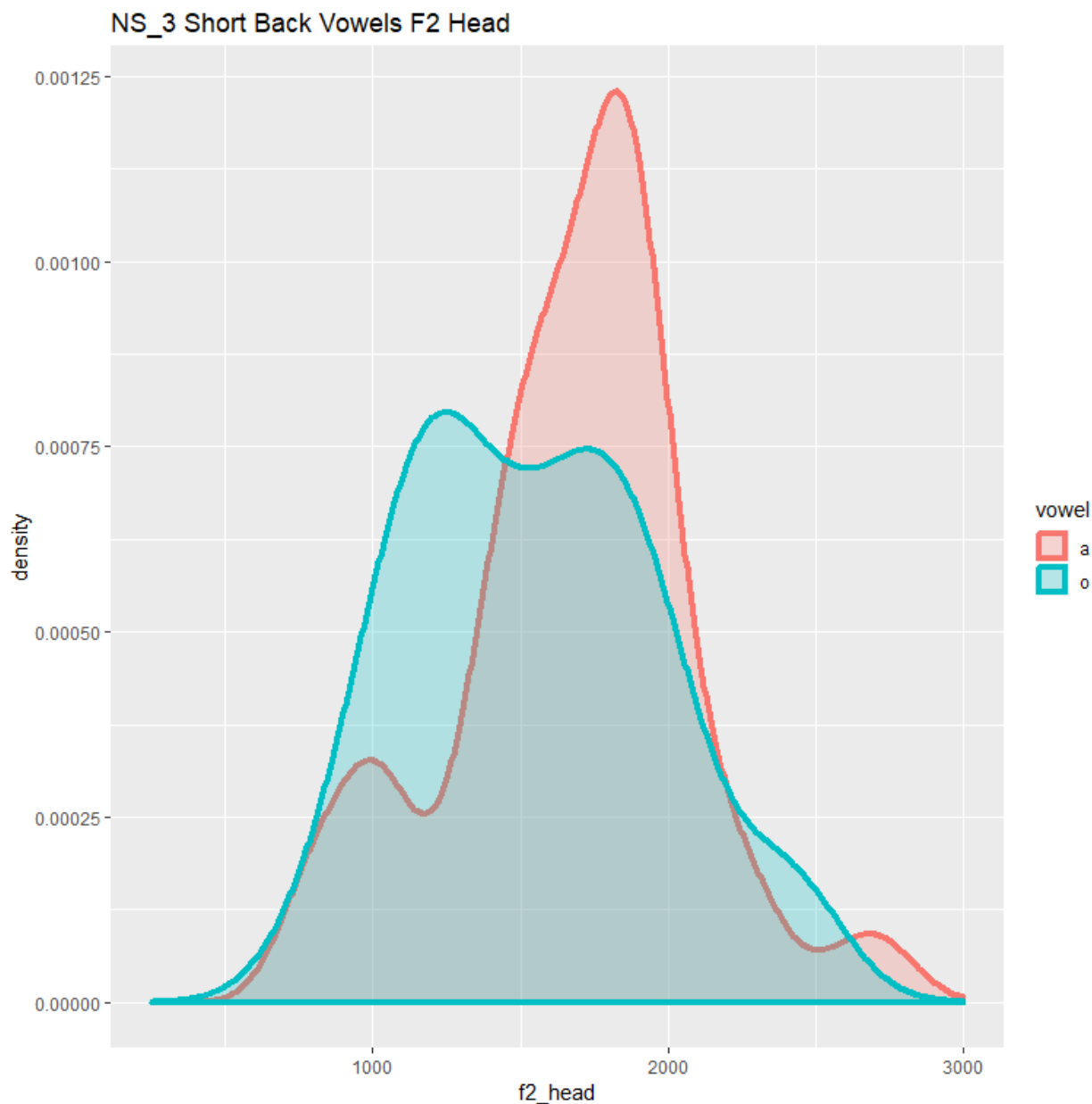


Figure 4.69: Short back vowels F2 Head for NS_3

Figures 4.69 and 4.70 show the short back vowels' F2 head and tail measurements. Just as with the F1 measurements, these figures indicate very little variation in frontness/backness for the *a* [a] and *o* [o]. The ranges seen here are closer and overlap more completely than the averages of

the short back vowels for all speakers, but the overall patterns are still consistent with all speakers.

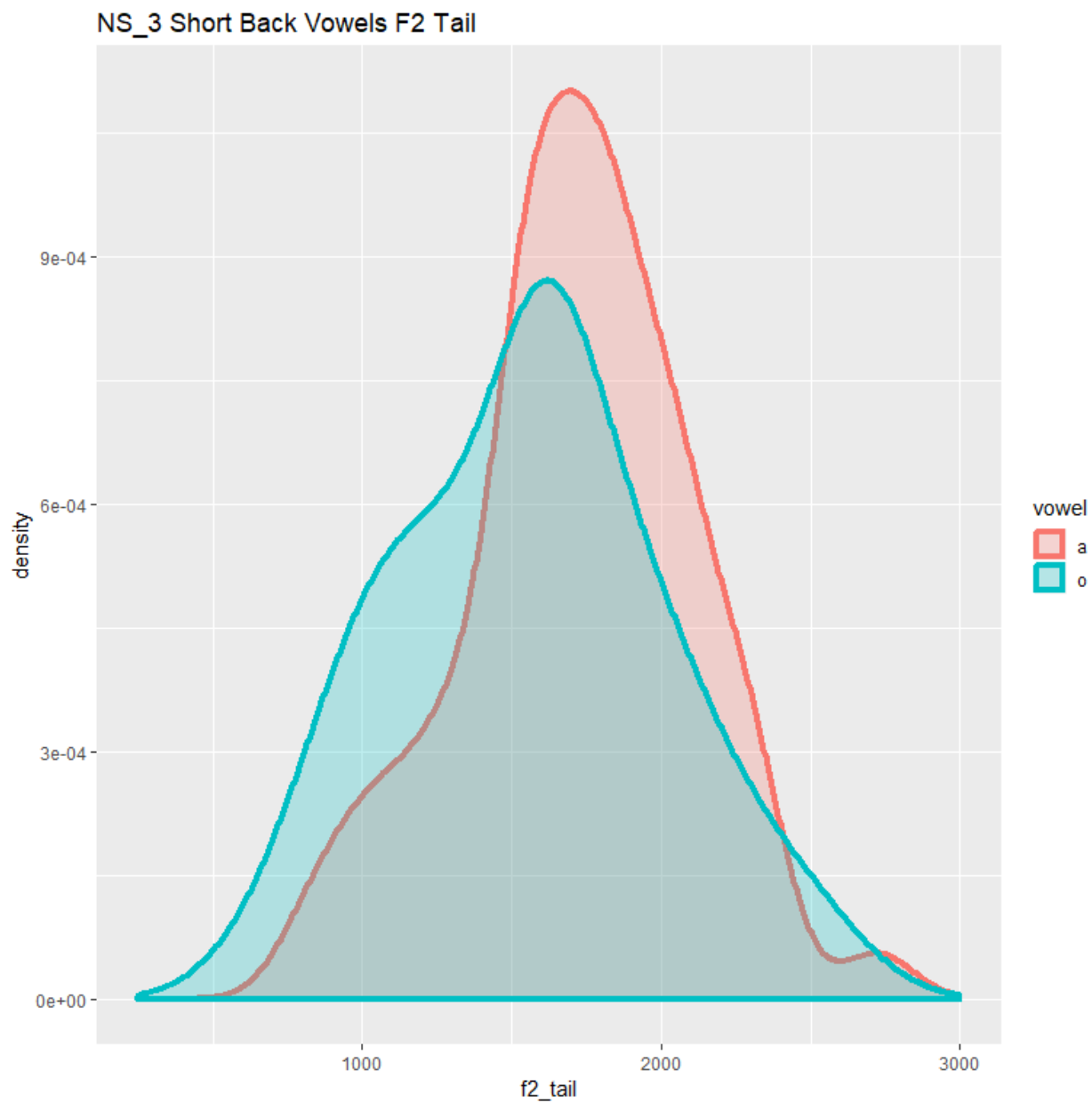


Figure 4.70: Short back vowels F2 Tail for NS_3

Figures 4.71-4.74 show the formant measurements for the long back vowels' F1 and F2 head and tail tokens for NS_3.

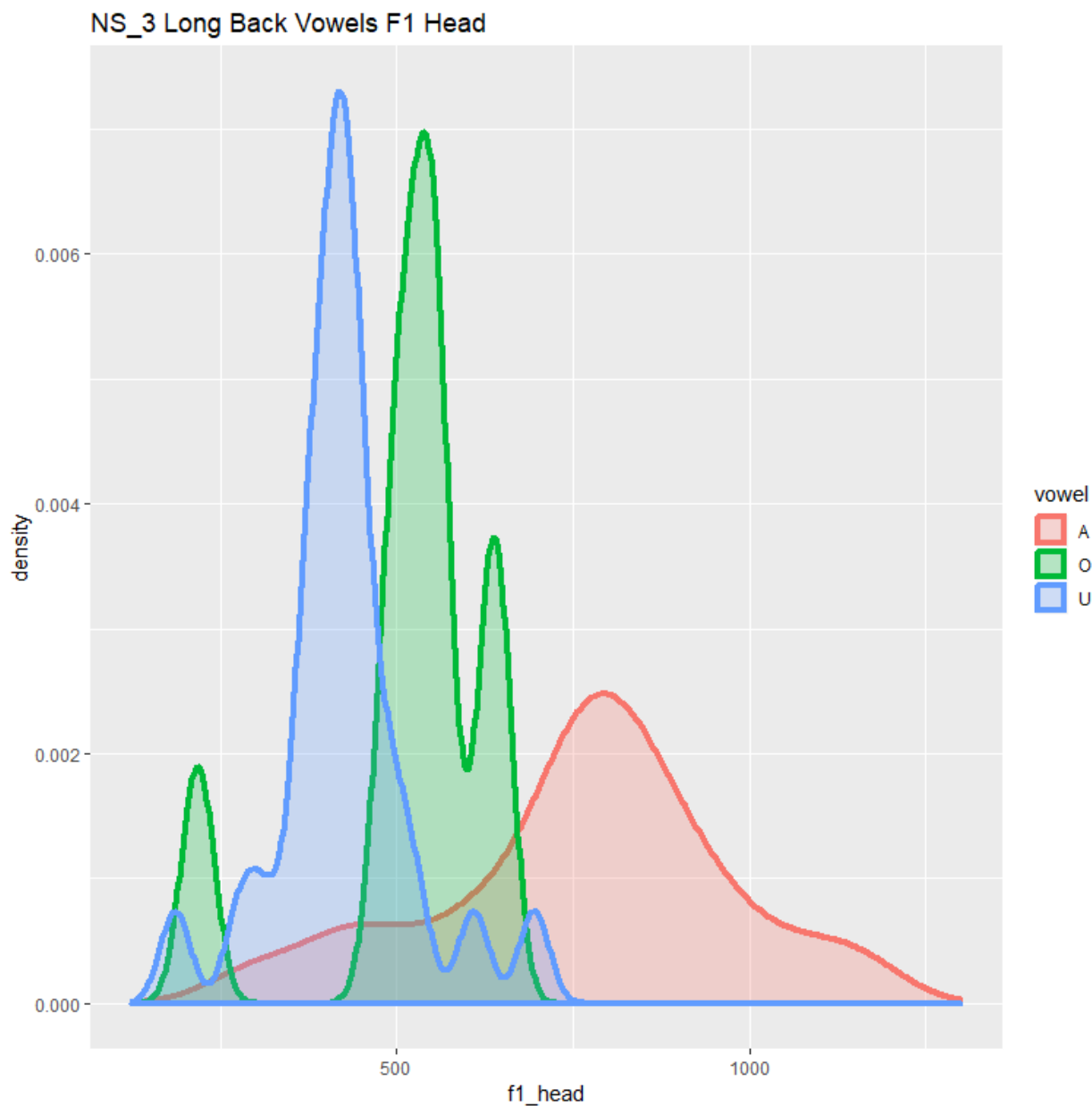


Figure 4.71: Long back vowels F1 Head for NS_3

Figures 4.71 and 4.72 show the F1 head and tail measurements of the long back vowels for NS_3. Just as the long back vowels \bar{o} [o:] and \bar{u} [u:] for NS_2 showed unusual spikes, so too do these tokens for NS_3. I can attribute the peaks for \bar{o} [o:] to the low token count: nine. But \bar{o}

[o:] has 25 tokens and \bar{a} [a:] has 41. More tokens for NS_3 may round out some of these peaks, or the pattern in \bar{o} [o:] may be the beginnings of a predictable allophonic pattern. At the moment there are still too few tokens to tell, and I leave this line of research to a future project.

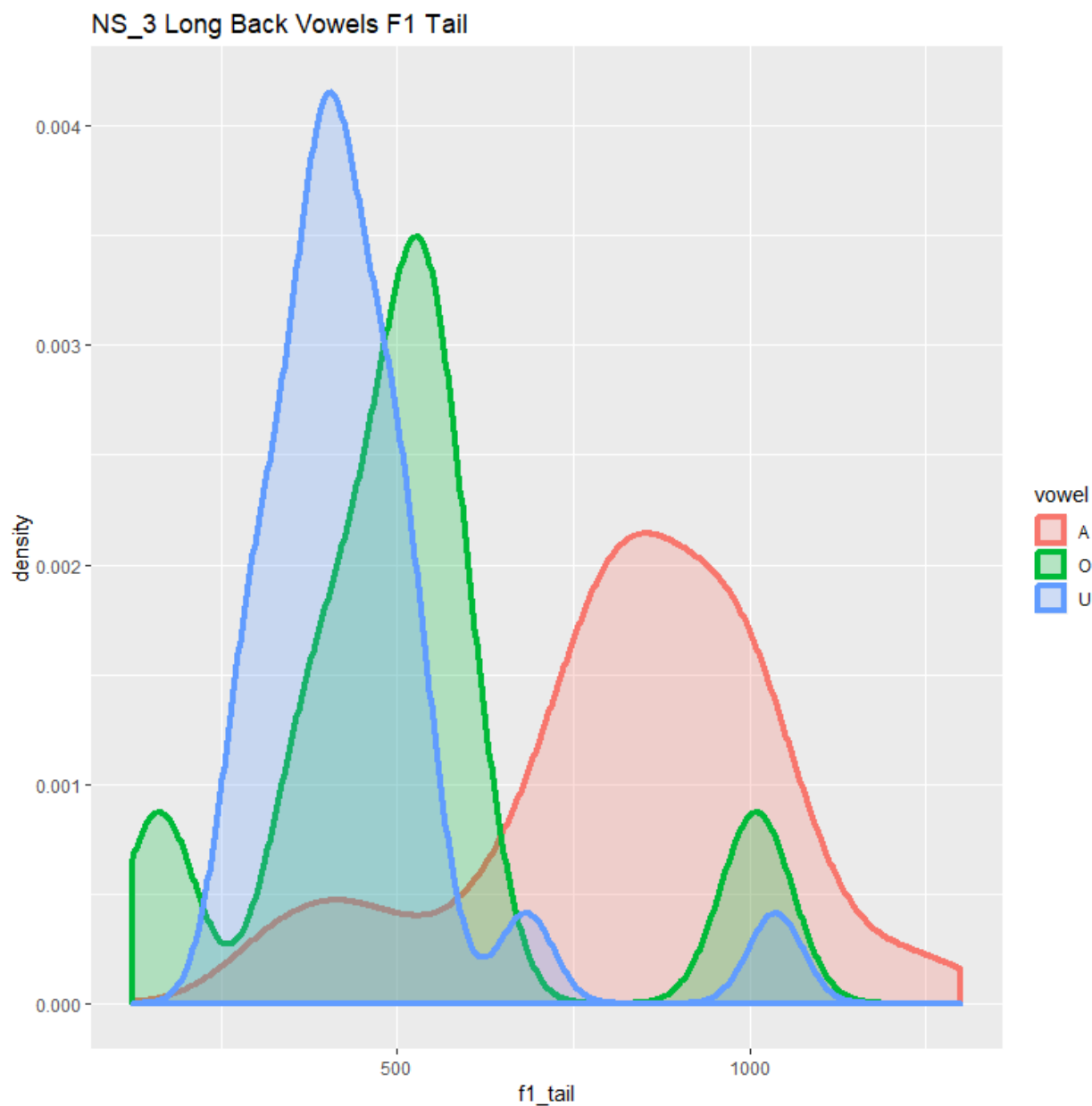


Figure 4.72: Long back vowels F1 Tail for NS_3

These figures also indicate a great deal of overlap in the height ranges of the long back vowels.

\bar{a} [a:] overlapping in height with \bar{o} [o:] is predicted from Table 4.14. However, \bar{a} [a:] and \bar{u} [u:],

and \bar{o} [o:] and \bar{u} [u:] sharing height range in the acoustic space is unpredicted from the literature, though consistent with the results of all speakers discussed above.

Figures 4.73 and 4.74 show the F2 head and tail measurements of the long back vowels.

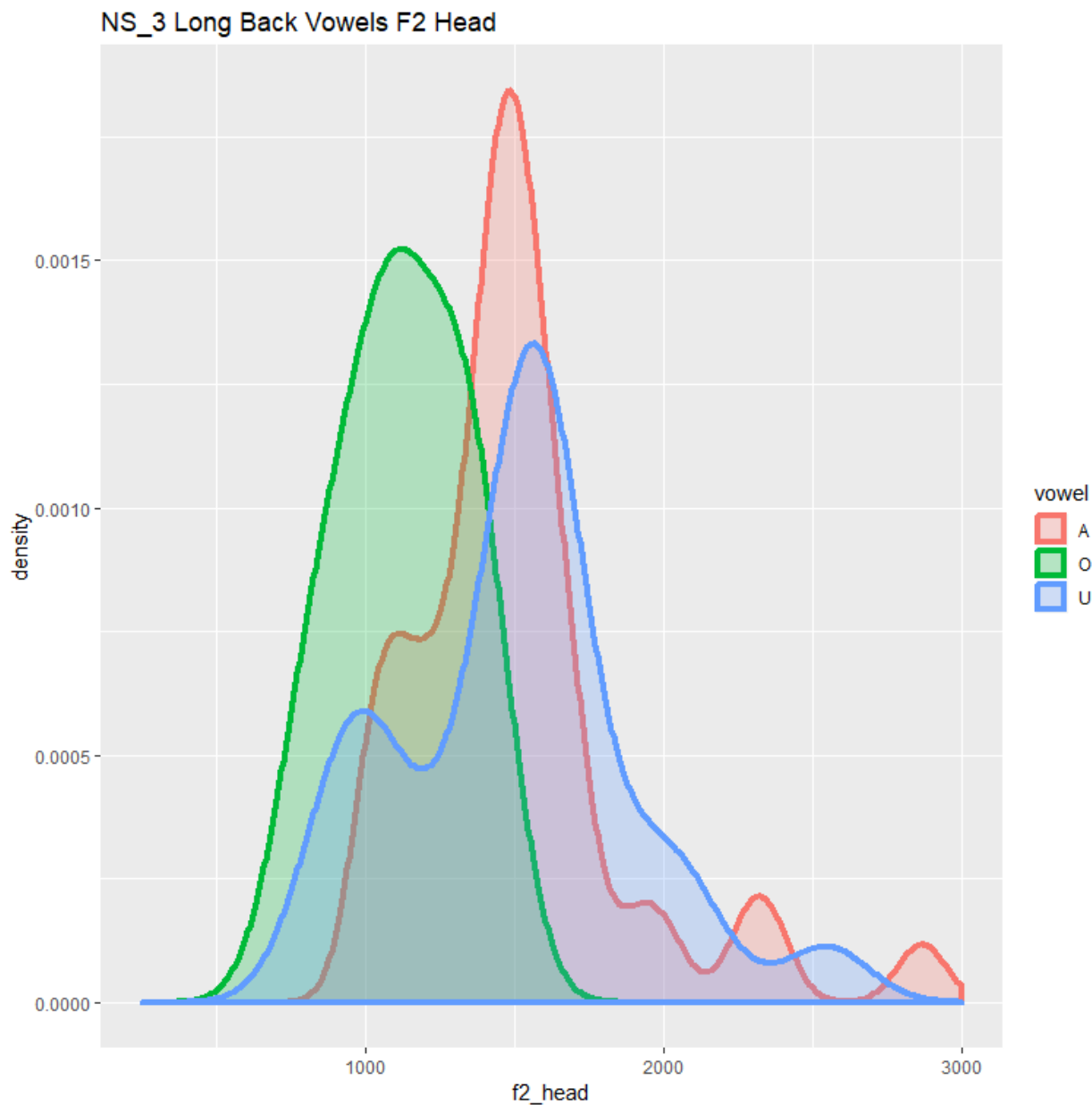


Figure 4.73: Long back vowels F2 Head for NS_3

Figures 4.73 and 4.74 do not indicate very much variation in the frontness/backness of the long back vowels. This is consistent with the averages for all speakers.

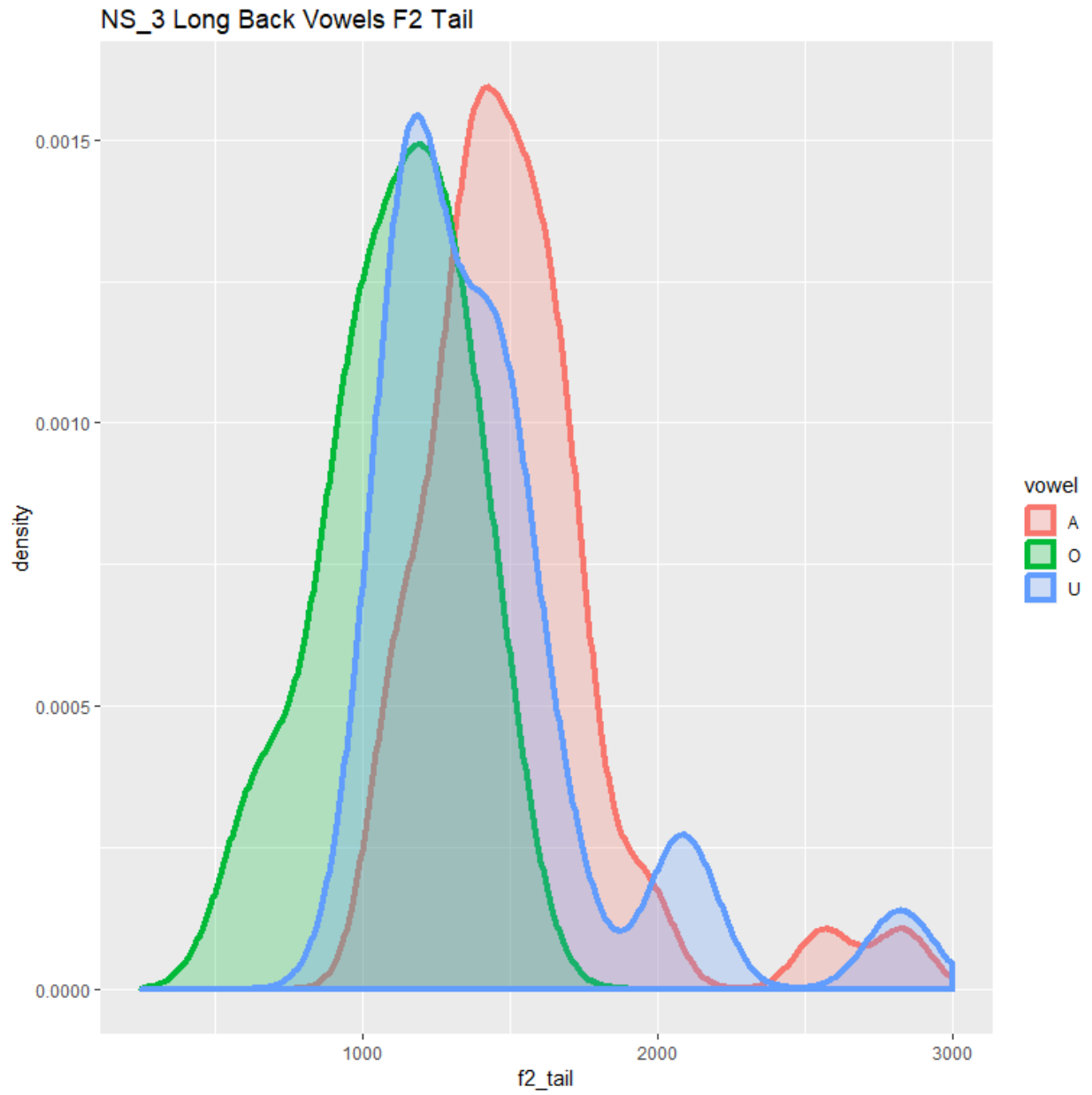


Figure 4.74: Long back vowels F2 Tail for NS_3

4.4.3. Native Speaker 4

The final case study I look at is NS_4. Table 4.17 shows the means and ratios of vowel duration for NS_4. NS_4 has a shorter *e* [e] and longer *ē* [e:] duration than the average, resulting in a greater ratio between the short and long mid front vowel (1:2.5 compared with 1:2.1 for the average of all speakers). *a* [a] and *ā* [a:] are both shorter than the average, but the difference between the two is greater, resulting in a larger ratio between the two (1:1.7 compared with 1:1.5 for all speakers).

	Mean (ms)	Ratio	Mean (ms)	
i	77.29	1:1.7	132.37	ī
e	64.1	1:2.5	158.33	ē
ae	92.29	1:1.7	155.34	āē
u	0	0	121.0	ū
o	97.67	1:1.3	128.93	ō
a	71.8	1:2	141.33	ā

Table 4.18: Vowel Means and Ratios for NS_4

Figure 4.75 shows the acoustic space for NS_4.

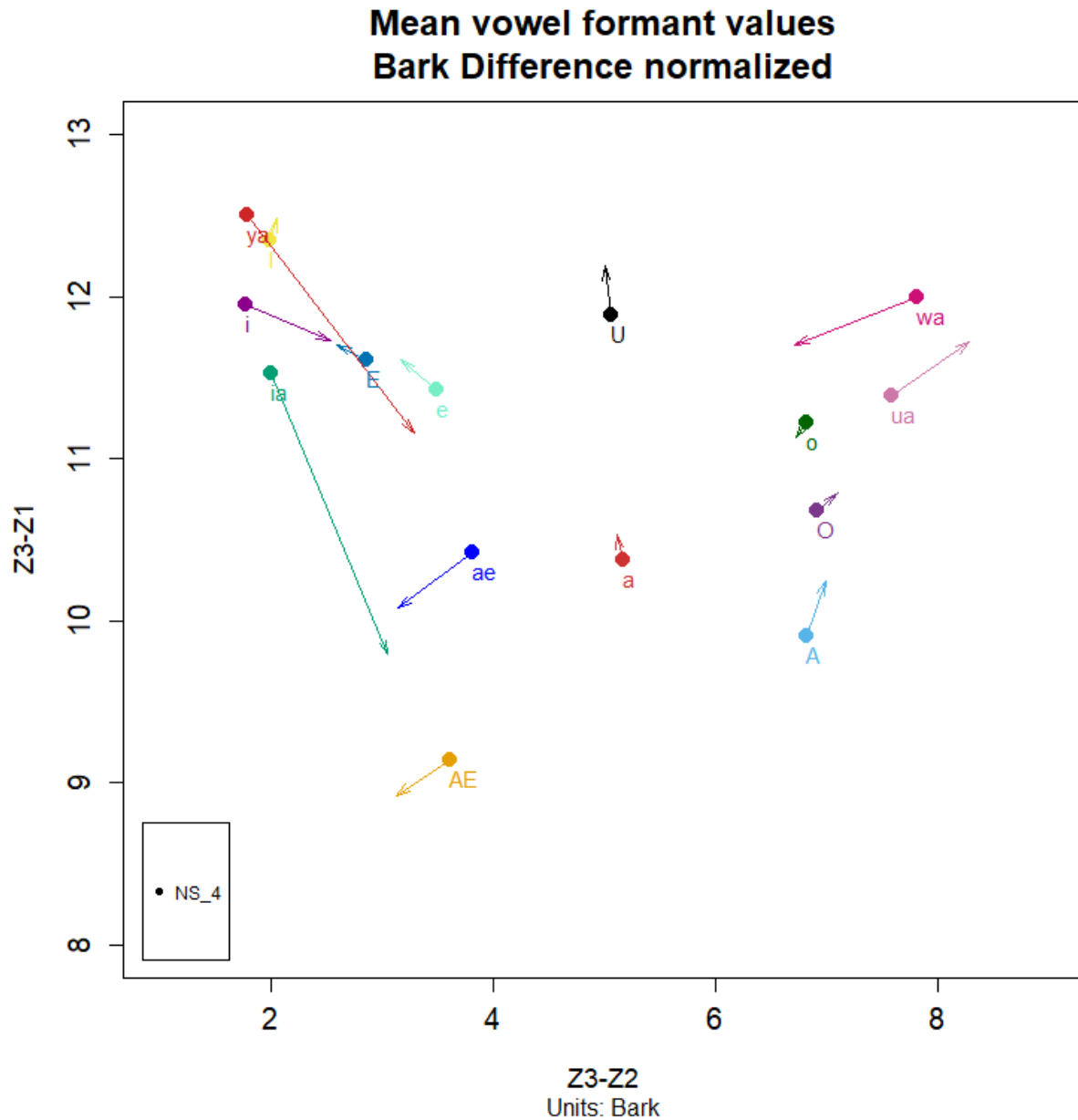


Figure 4.75: NS_4 Vowel Acoustic Quality

NS_4's front vowels are largely in the same acoustic space as the average for all speakers, except \bar{e} [e:] which is more back, but still peripheral to e [e]. While a [a] remains mid and central, \bar{a} [a:] is higher and further back within the space, sharing nearly the same space as o [o] and \bar{o} [o:]. o

[o] is also further back than the average for all speakers. The following figures show the density plots for the high, low, front, and back vowels for NS_4 only.

Figures 4.76-4.79 show the density plots of the short front F1 and F2 head and tail measurements for NS_4.

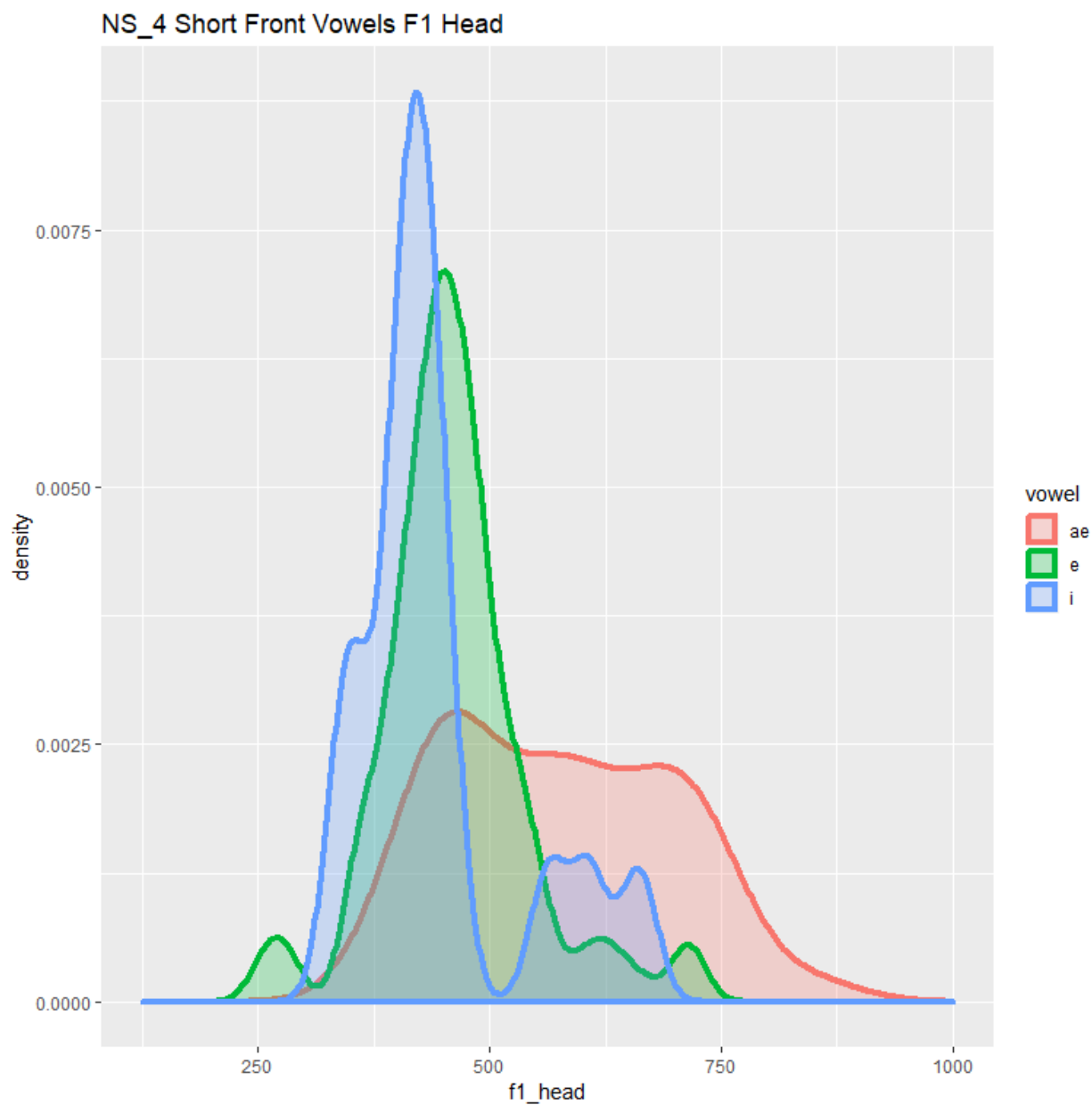


Figure 4.76: Short front vowels F1 Head for NS_4

Figures 4.76 and 4.77 show the F1 head and tail measurements of the short front vowels *ae* [æ], *e* [e], and *i* [i]. The densities of the short front vowel tokens consistently pattern with the average for all speakers, and are largely consistent with the described allophony in Table 4.14. *ae* [æ] covers the whole height range of *e* [e] and *i* [i]. *e* [e] and *i* [i] overlap in height almost entirely.

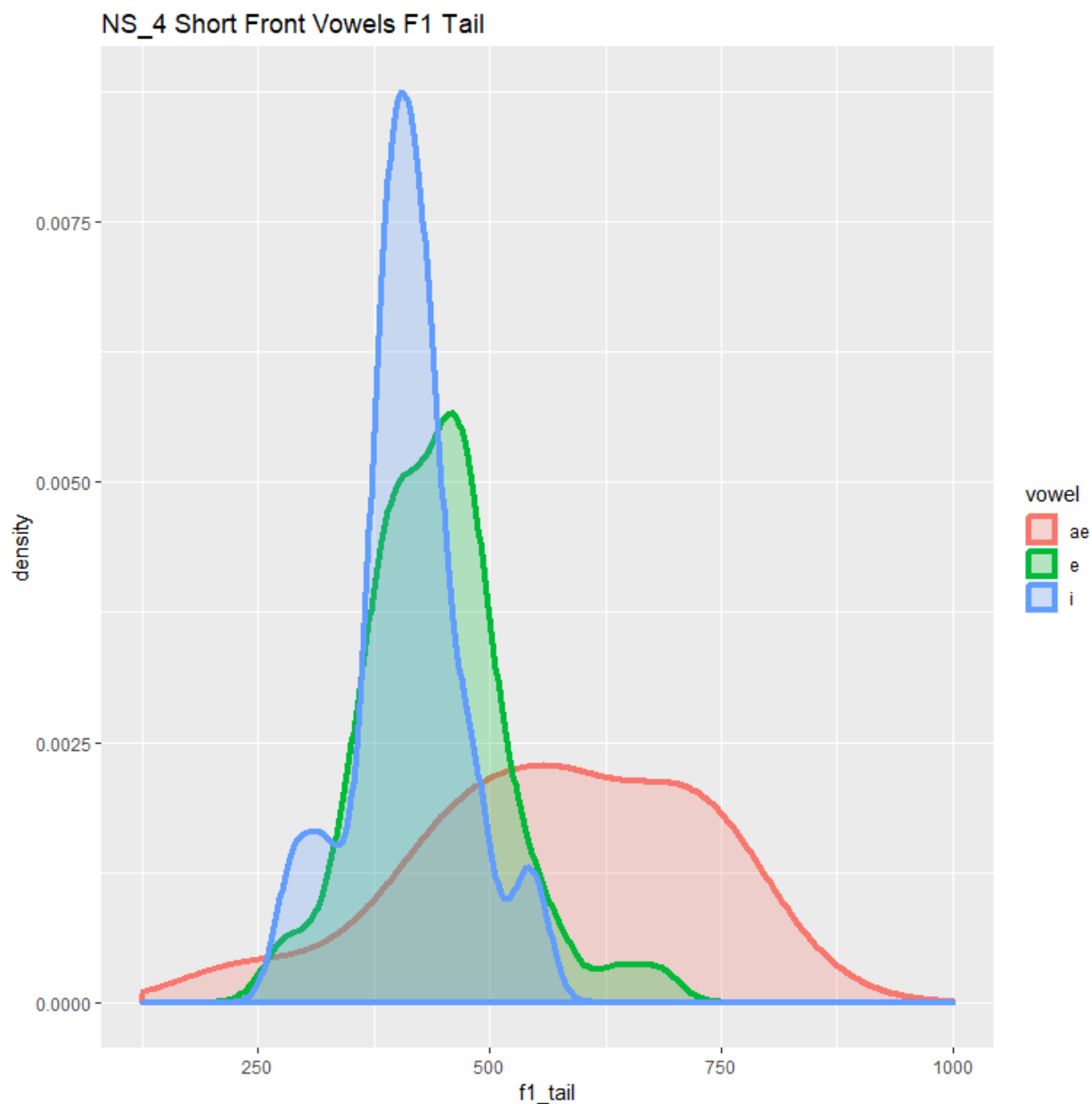


Figure 4.77: Short front vowels F1 Tail for NS_4

Figures 4.78 and 4.79 show the short front vowels' F2 head and tail measurements for NS_4.

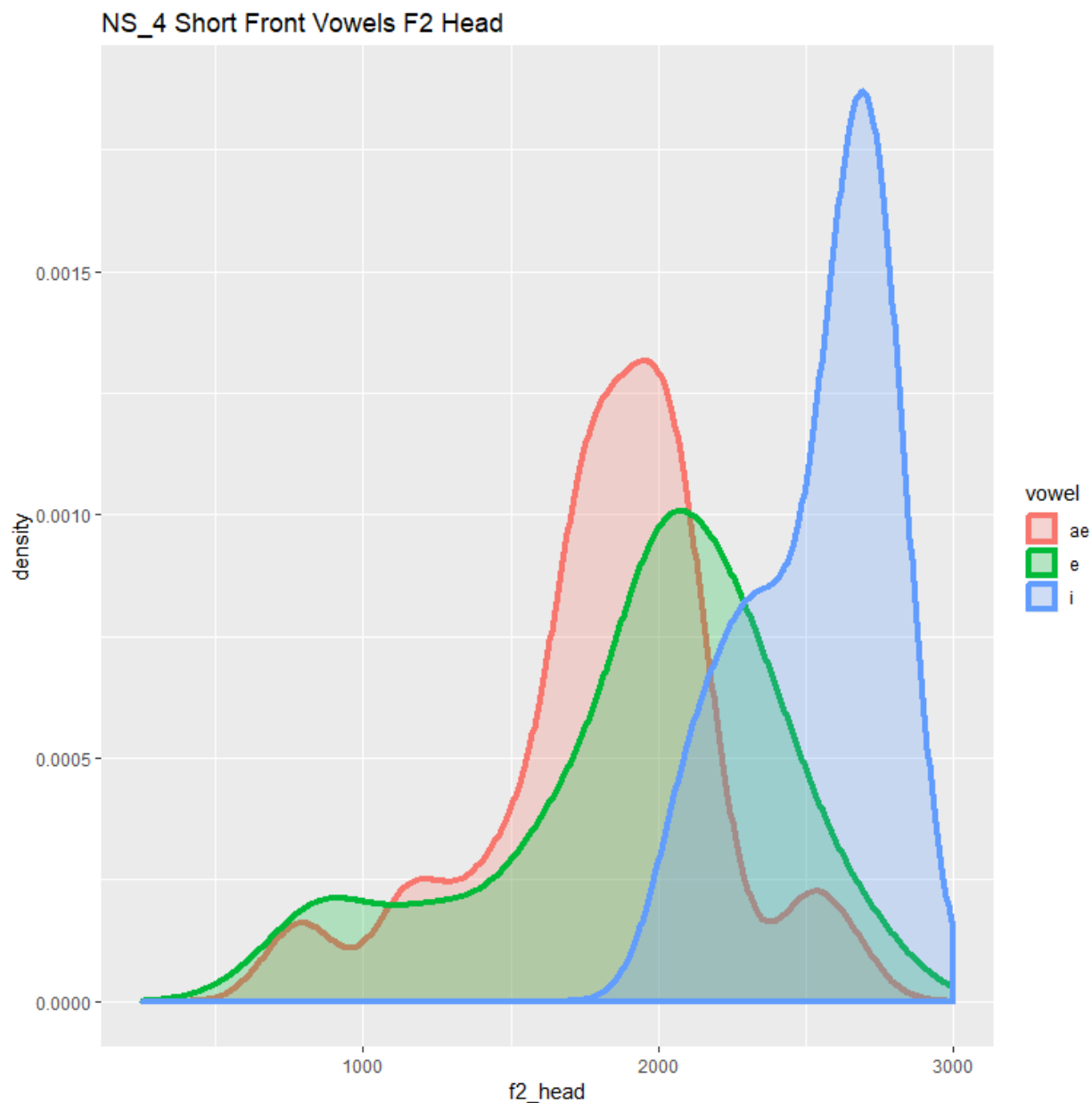


Figure 4.78: Short front vowels F2 Head for NS_4

Figures 4.78 and 4.79 show that *i* [i] is further front in the acoustic space than *e* [e] and *ae* [æ], which largely overlap and share the same frontness/backness range in the acoustic space. This is largely consistent with the average for all speakers, though for NS_4 *i* [i] is slightly more distinct from *e* [e] and *ae* [æ]. Figure 4.79 shows that a few *i* [i] tokens have some movement between

the head and tail and that the tails share more of the front/back range with *e* [e] and *æ* [æ] than the heads do.

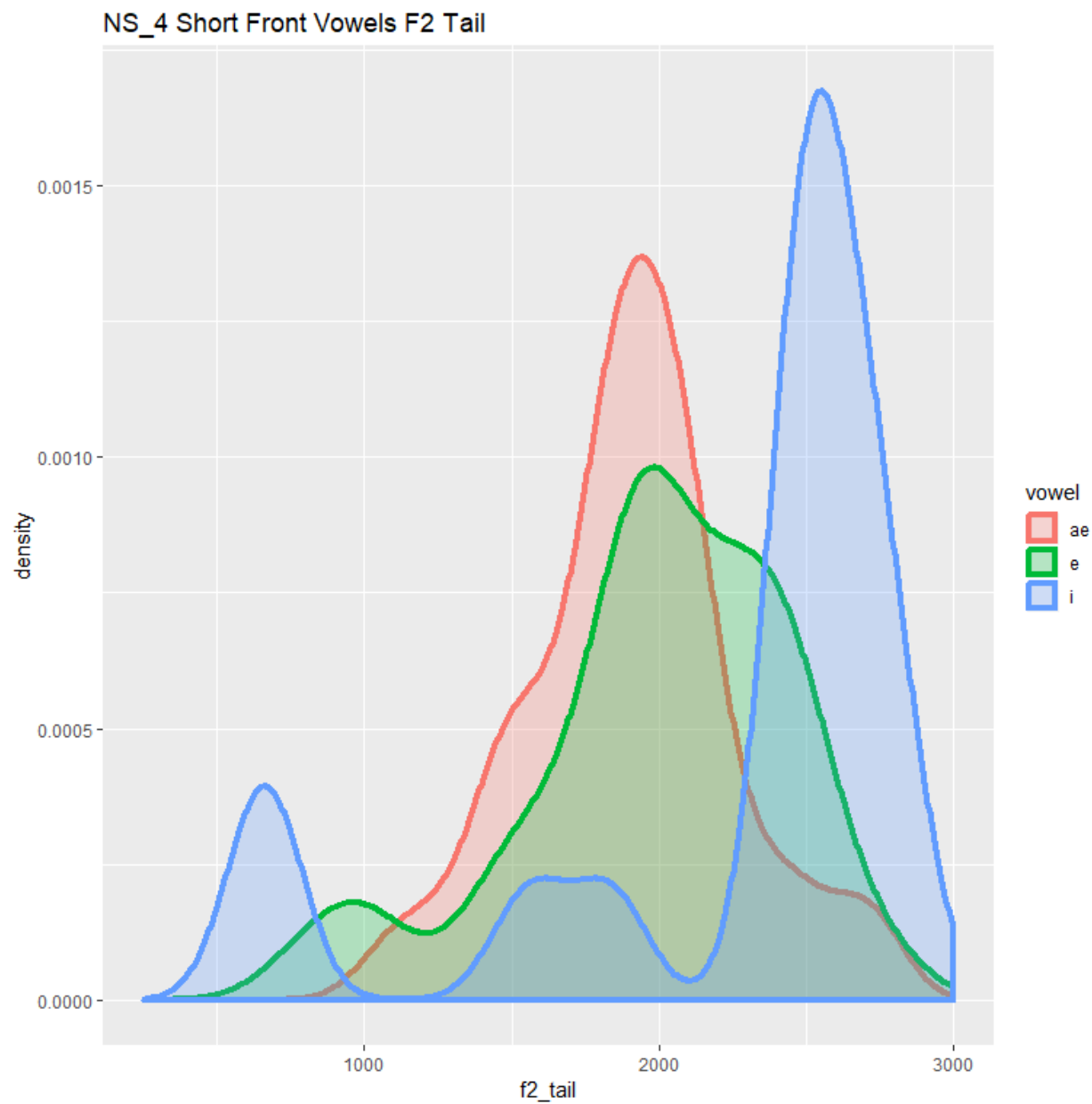


Figure 4.79: Short front vowels F2 Tail for NS_4

Figures 4.80-4.83 show the F1 and F2 head and tail measurements for the long front vowels of NS_4.

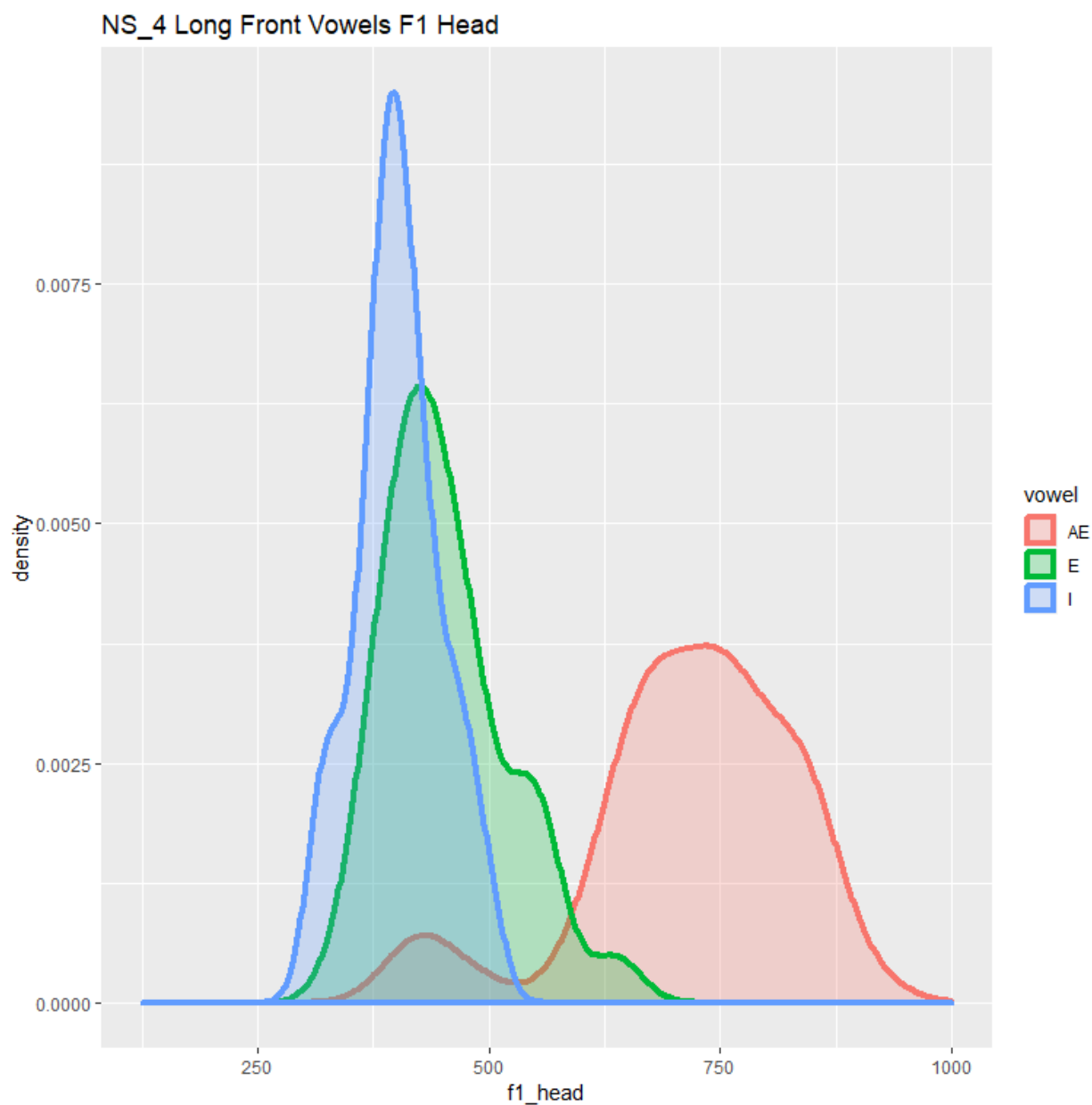


Figure 4.80: Long front vowels F1 Head for NS_4

Figures 4.80 and 4.81 show the F1 head and tail density plots of the long front vowels $\bar{a}e$ [æ:], \bar{e} [e:], and \bar{i} [i:] for NS_4. These figures show very similar patterns to the average for all speakers

discussed above. However, for NS_4 $\bar{a}\bar{e}$ [æ:] has less overlap with the acoustic height of \bar{e} [e:] and \bar{i} [i:], which overlap almost entirely.

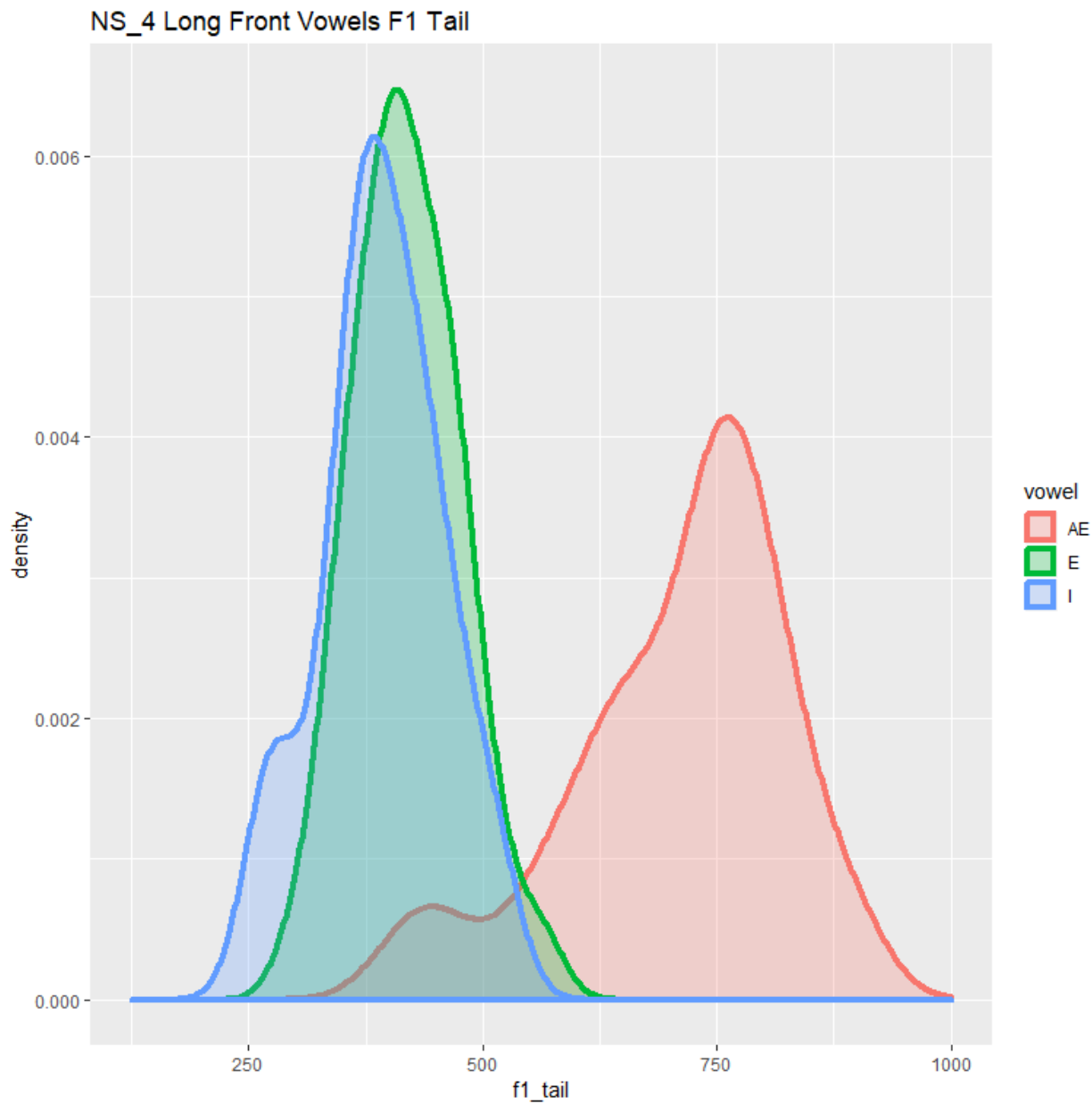


Figure 4.81: Long front vowels F1 Tail for NS_4

Figures 4.82 and 4.83 show the F2 head and tail measurements of the long front vowels for NS_4.

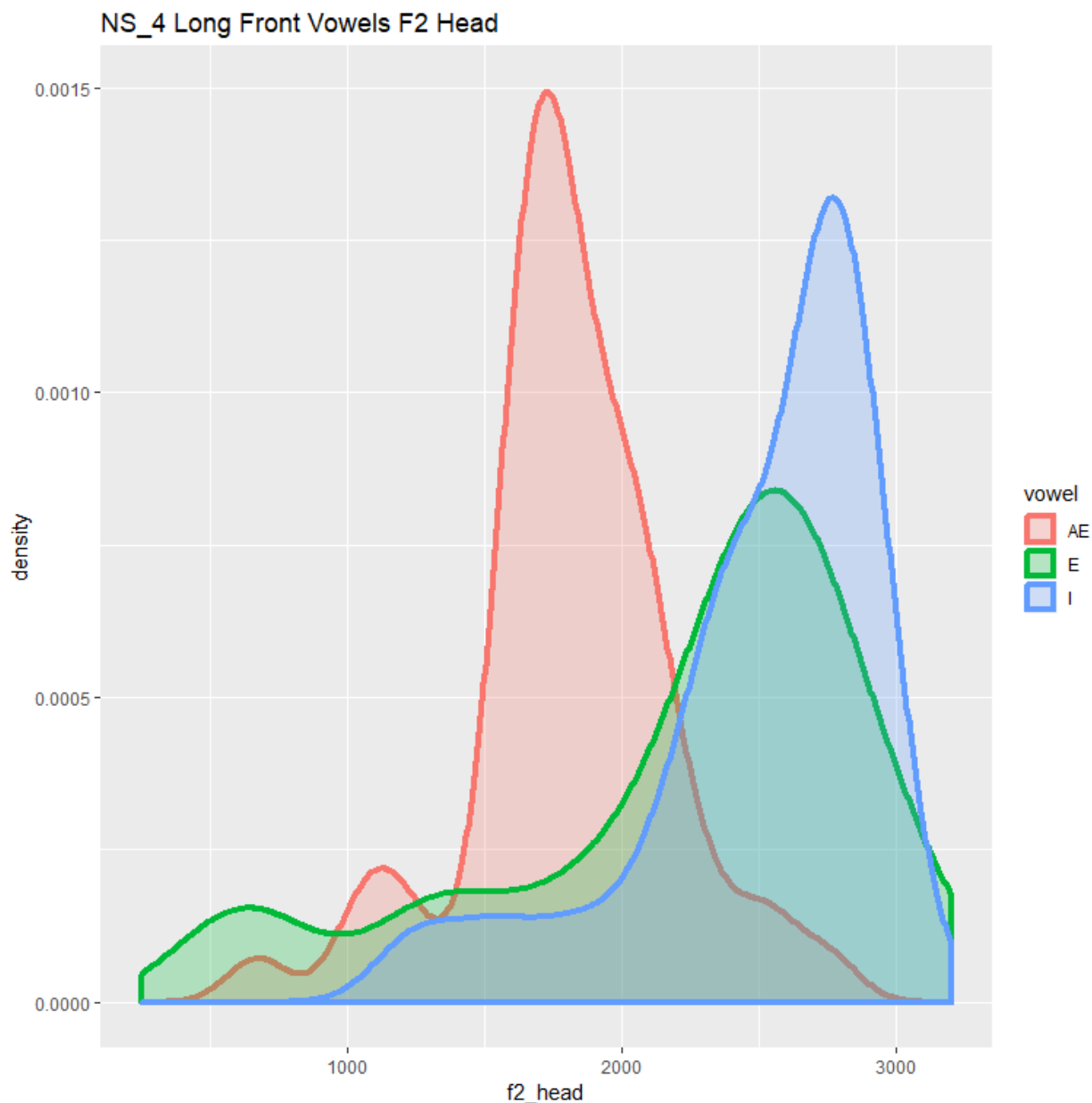


Figure 4.82: Long front vowels F2 Head for NS_4

Figures 4.82 and 4.83 show that \bar{e} [e:] and \bar{i} [i:] overlap in frontness/backness within the acoustic space while $\bar{a}\bar{e}$ [æ:] is much lower. $\bar{a}\bar{e}$ [æ:] still overlaps in the space shared by \bar{e} [e:] and \bar{i} [i:] and has no uniquely distinctive range. What sets $\bar{a}\bar{e}$ [æ:] apart from \bar{e} [e:] and \bar{i} [i:] is that the

peak is much sharper, especially in the F2 tail measurements represented in Figure 4.83. This indicates that the $\bar{a}e$ [æ:] tokens are more consistently realized within a smaller range than the \bar{e} [e:] and \bar{i} [i:] tokens.

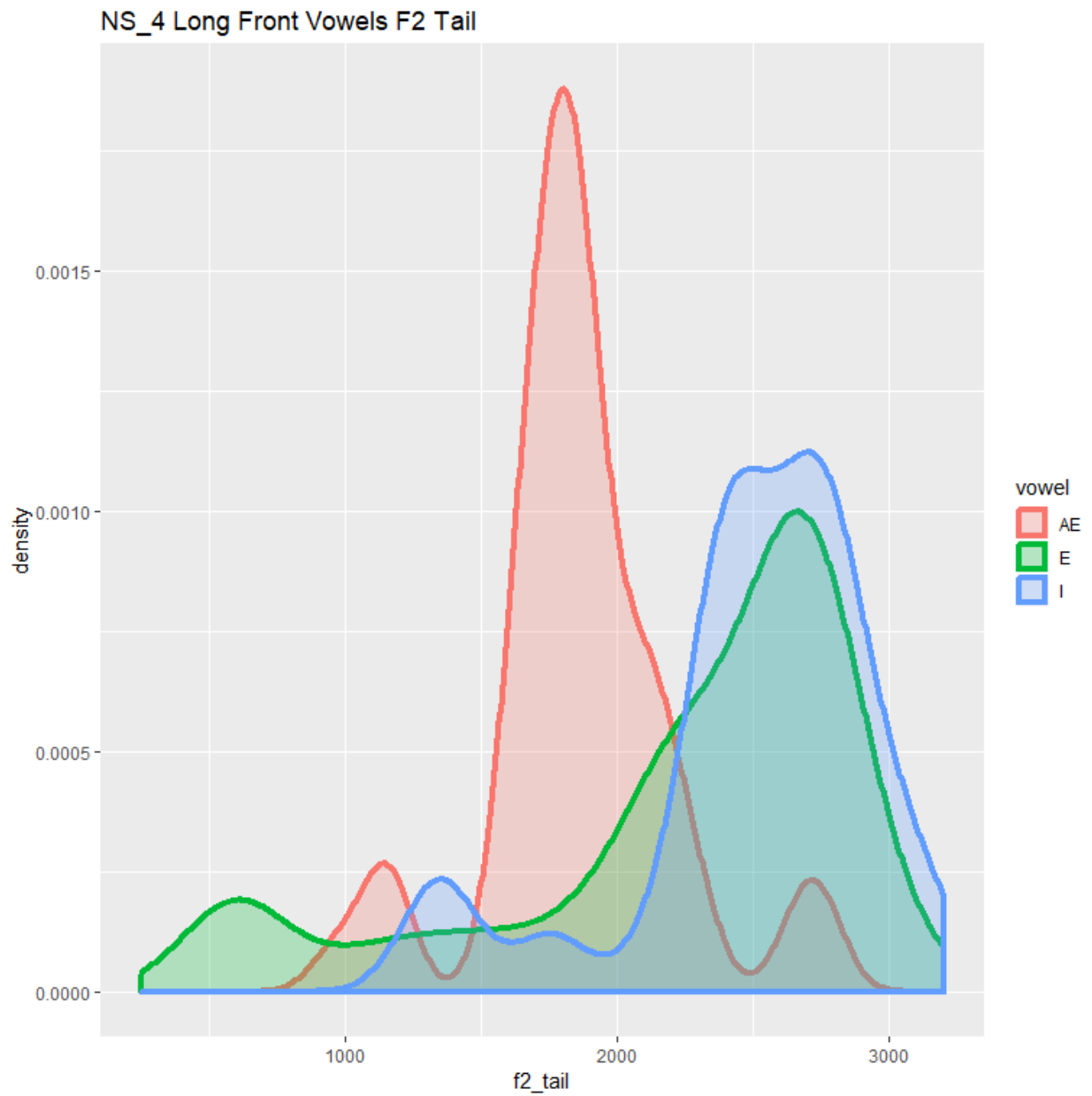


Figure 4.83: Long front vowels F2 Tail for NS_4

Figures 4.84-4.87 show the F1 and F2 head and tail measurements of the short back vowels *a* [a] and *o* [o] for NS_4.

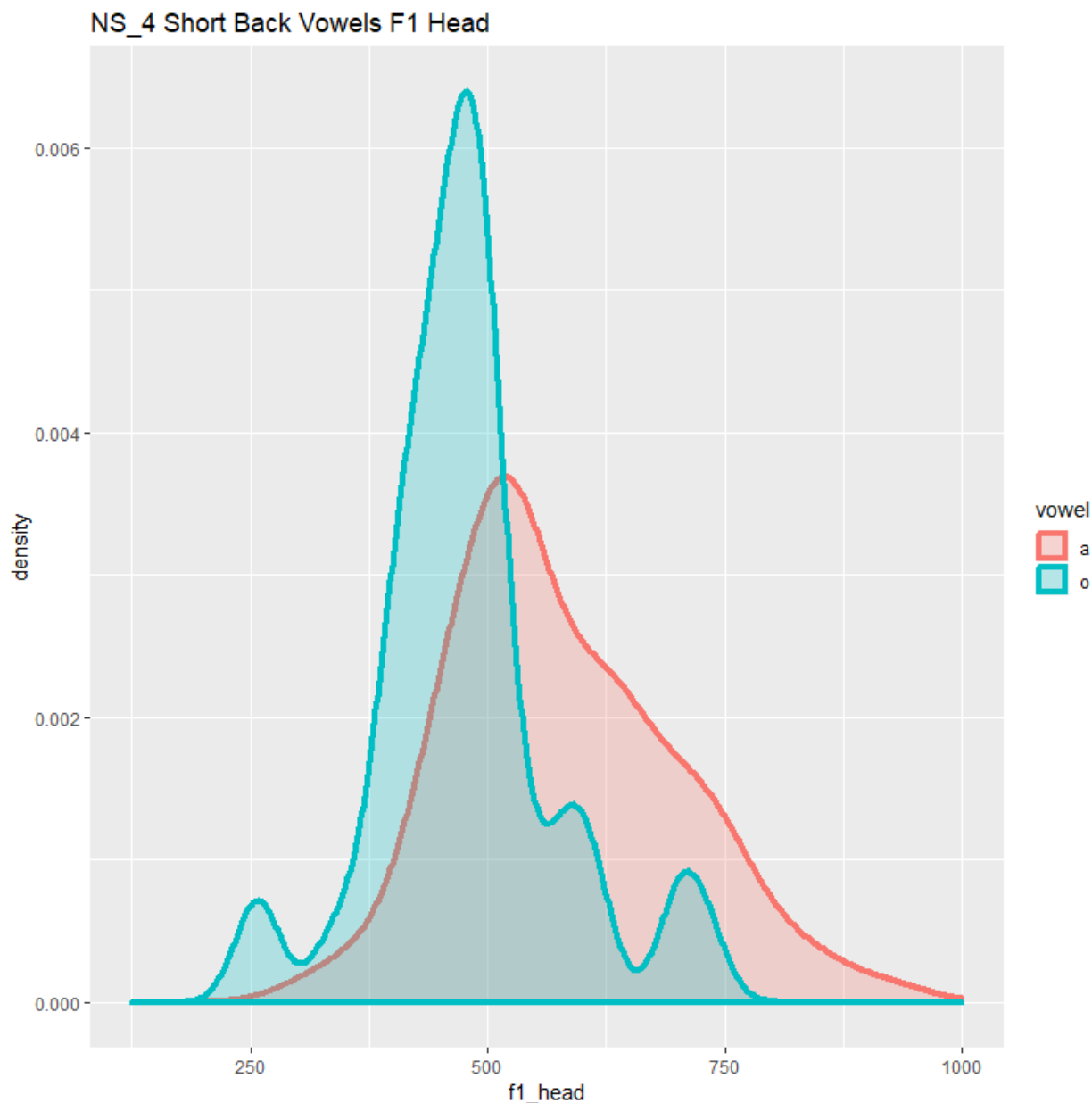


Figure 4.84: Short back vowels F1 Head for NS_4

Figures 4.84 and 4.85 show the F1 head and tail measurements of *a* [a] and *o* [o]. Consistent with the average for all speakers, the two overlap almost entirely with very few tokens

representing a distinct range unique to each vowel. This runs counter to the expectations from Table 4.14 in the same ways as discussed above.

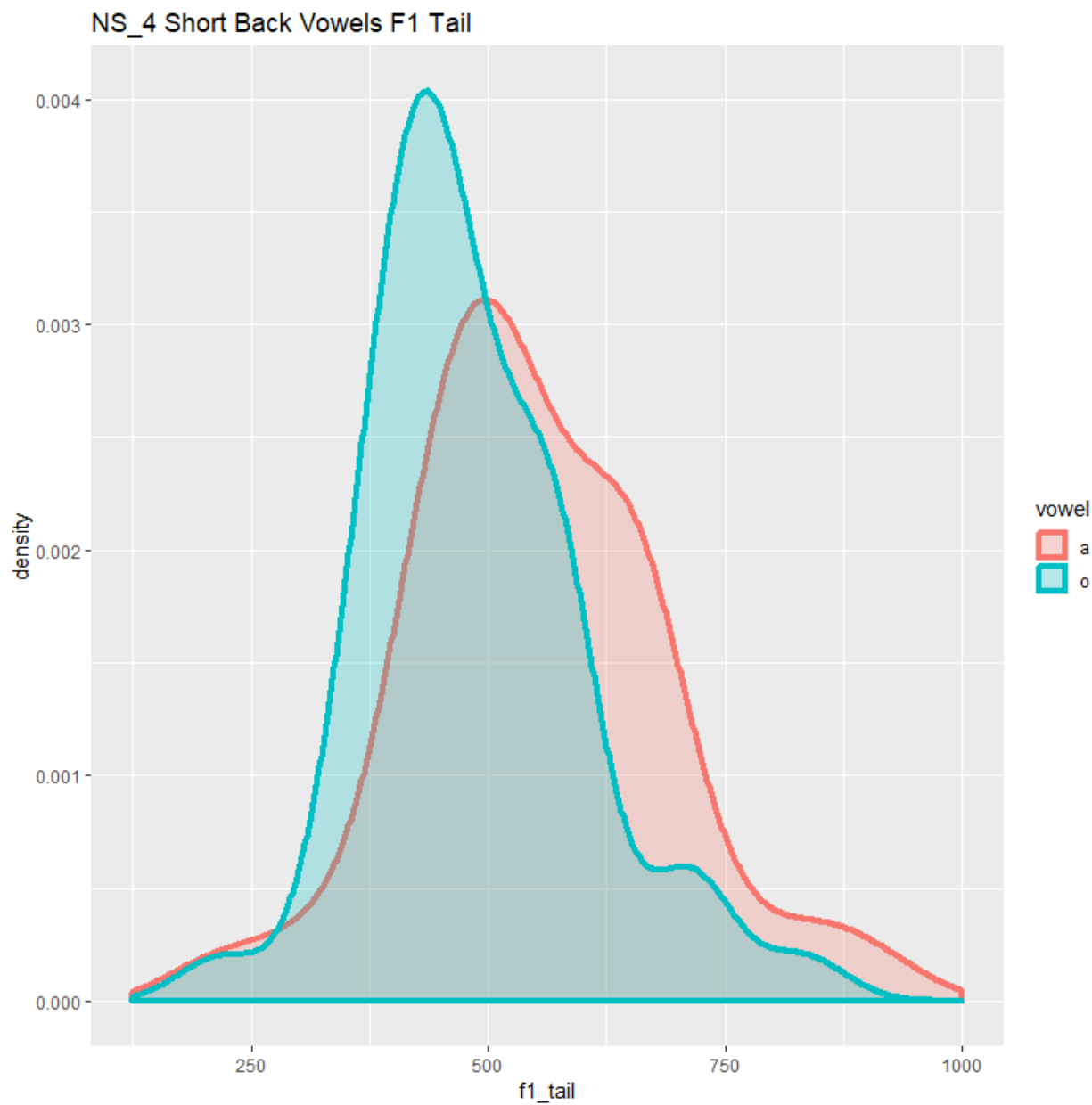


Figure 4.85: Short back vowels F1 Tail for NS_4

Figures 4.86 and 4.87 show the F2 head and tail measurements of the short back tokens for NS_4.

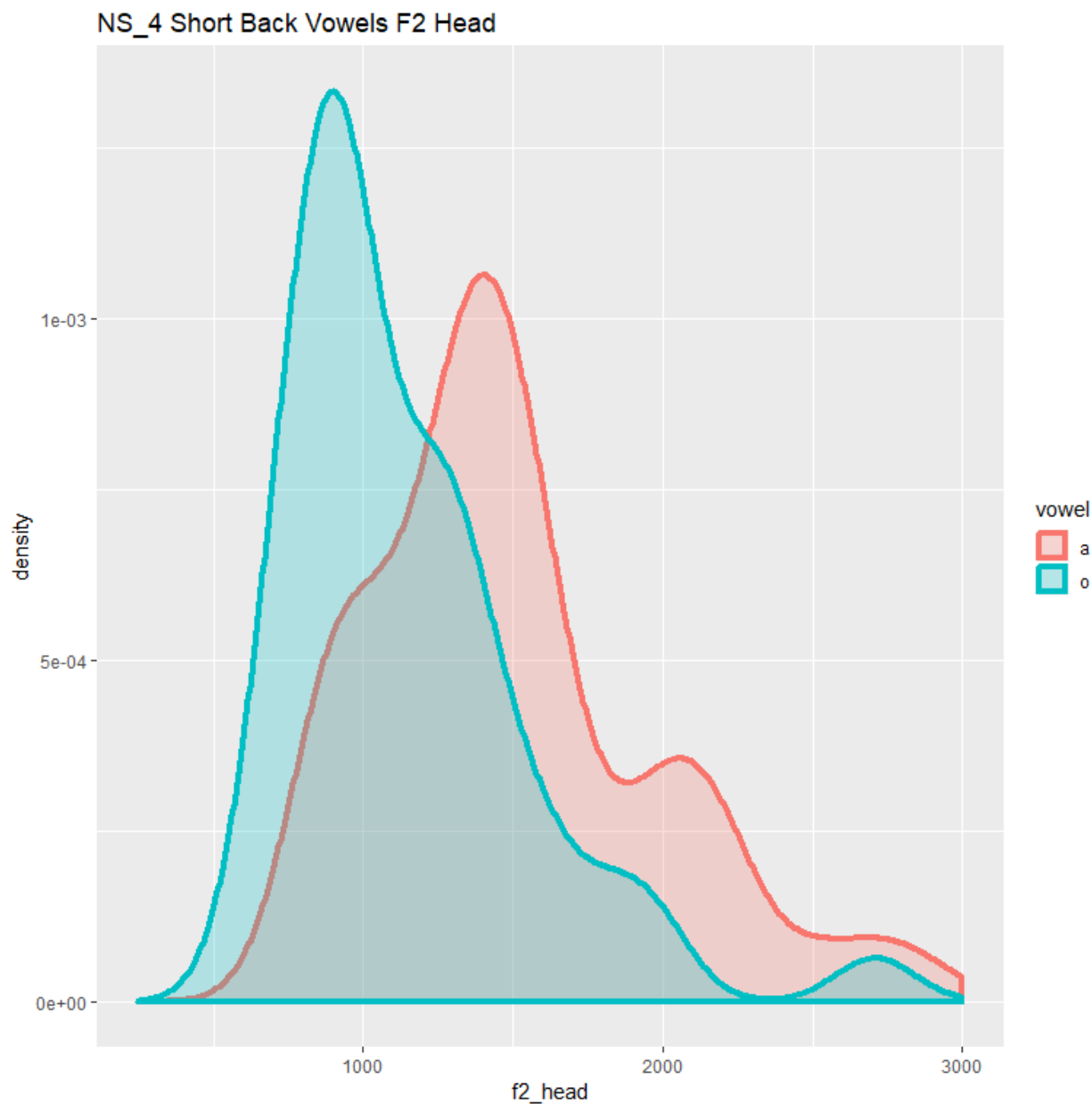


Figure 4.86: Short back vowels F2 Head for NS_4

Figures 4.86 and 4.87 show that just as with the F1 measurements, the F2 measurements indicate very little variation between the short back vowels regarding frontness/backness within the acoustic space.

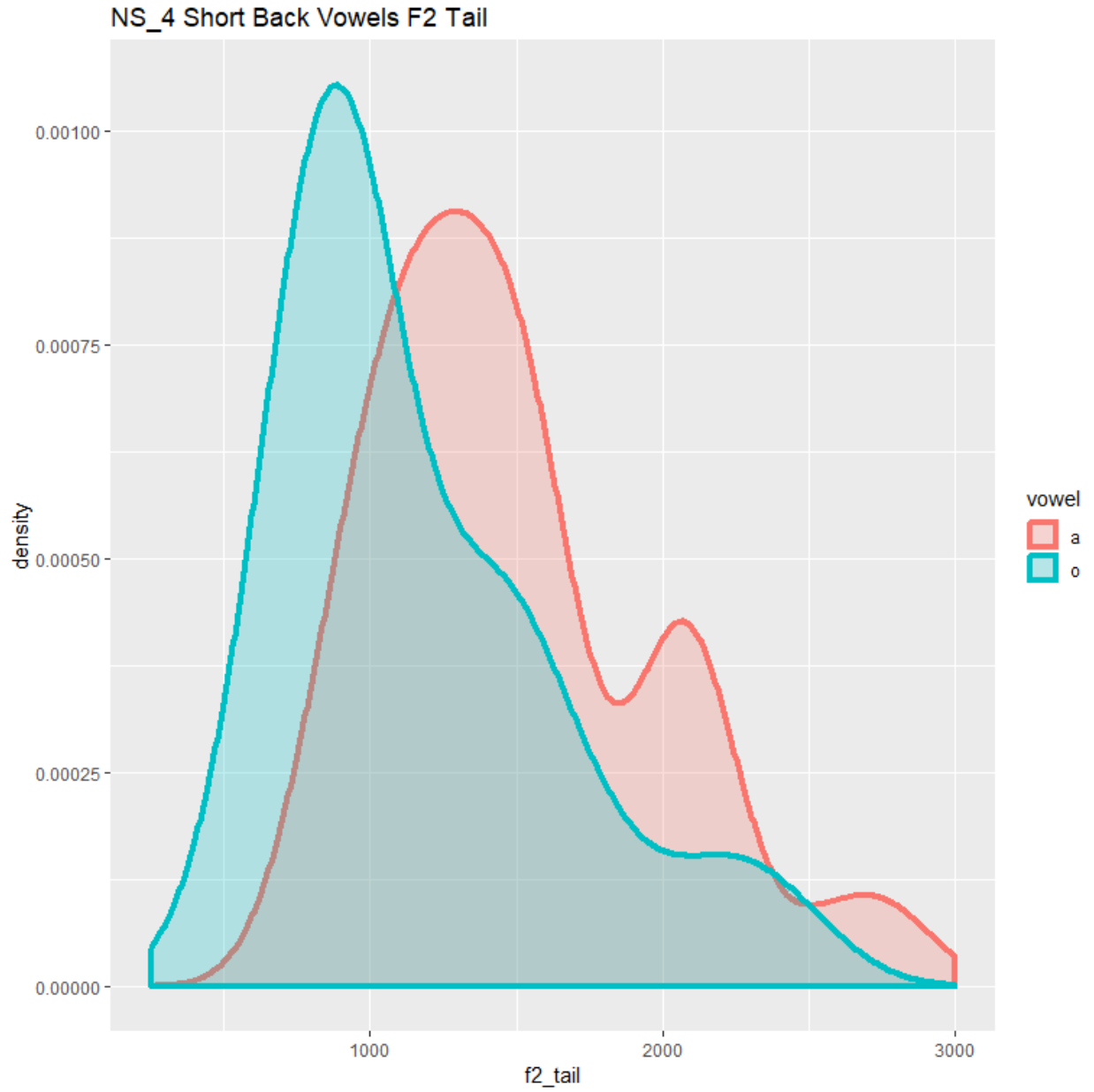


Figure 4.87: Short back vowels F2 Tail for NS_4

Figures 4.88-4.91 show the head and tail F1 and F2 measurements for the long back vowels for NS_4.

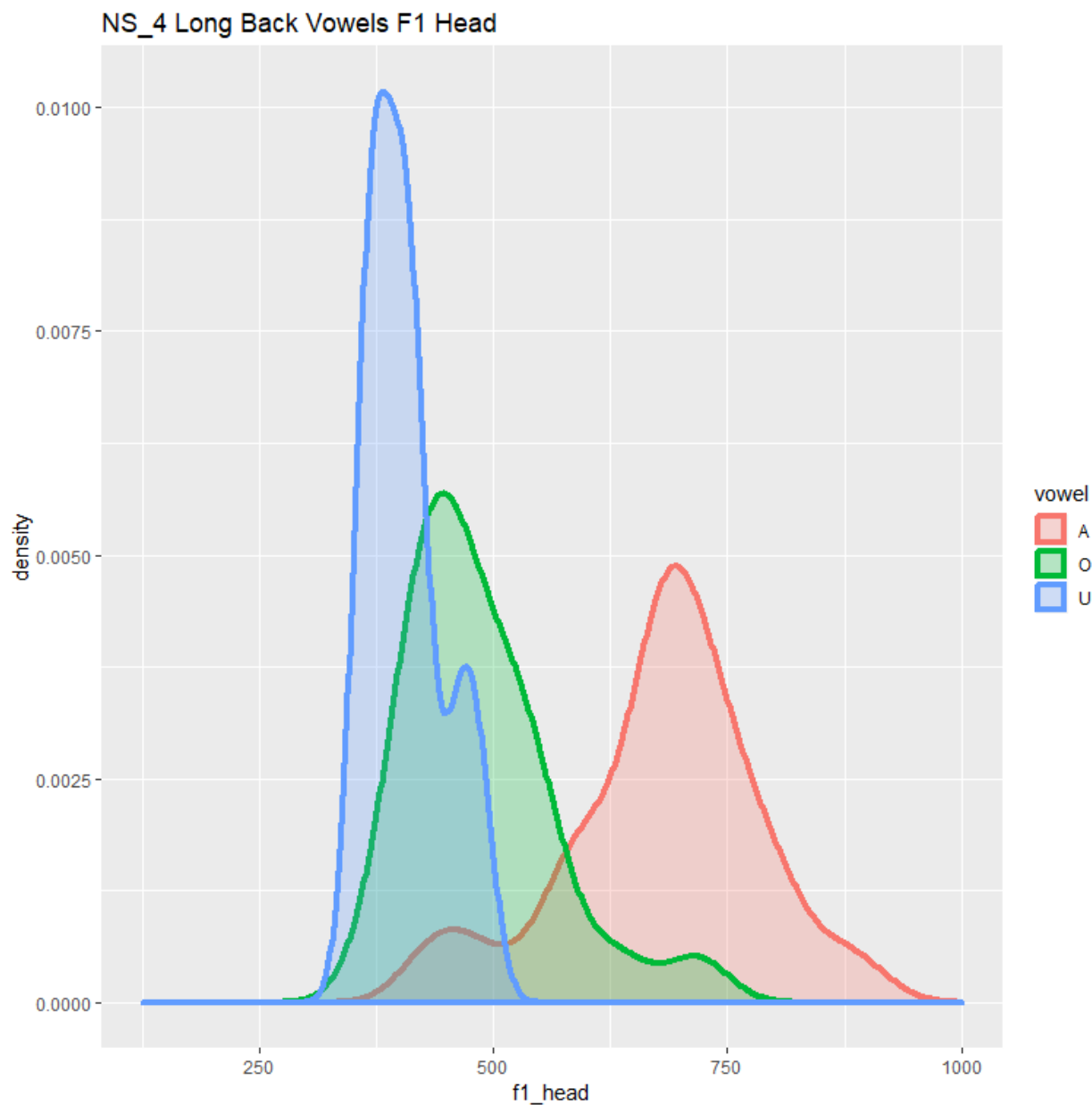


Figure 4.88: Long back vowels F1 Head for NS_4

Figures 4.88 and 4.89 show the F1 head and tail measurements of the long back vowels \bar{a} [a:], \bar{o} [o:], and \bar{u} [u:]. These figures show that \bar{u} [u:] has no distinct height range in the acoustic space.

\bar{u} [u:] shares its entire range with \bar{o} [o:] and partially with \bar{a} [a:]. This pattern is very consistent with the average for all speakers and is inconsistent with the predictions from Table 4.14.

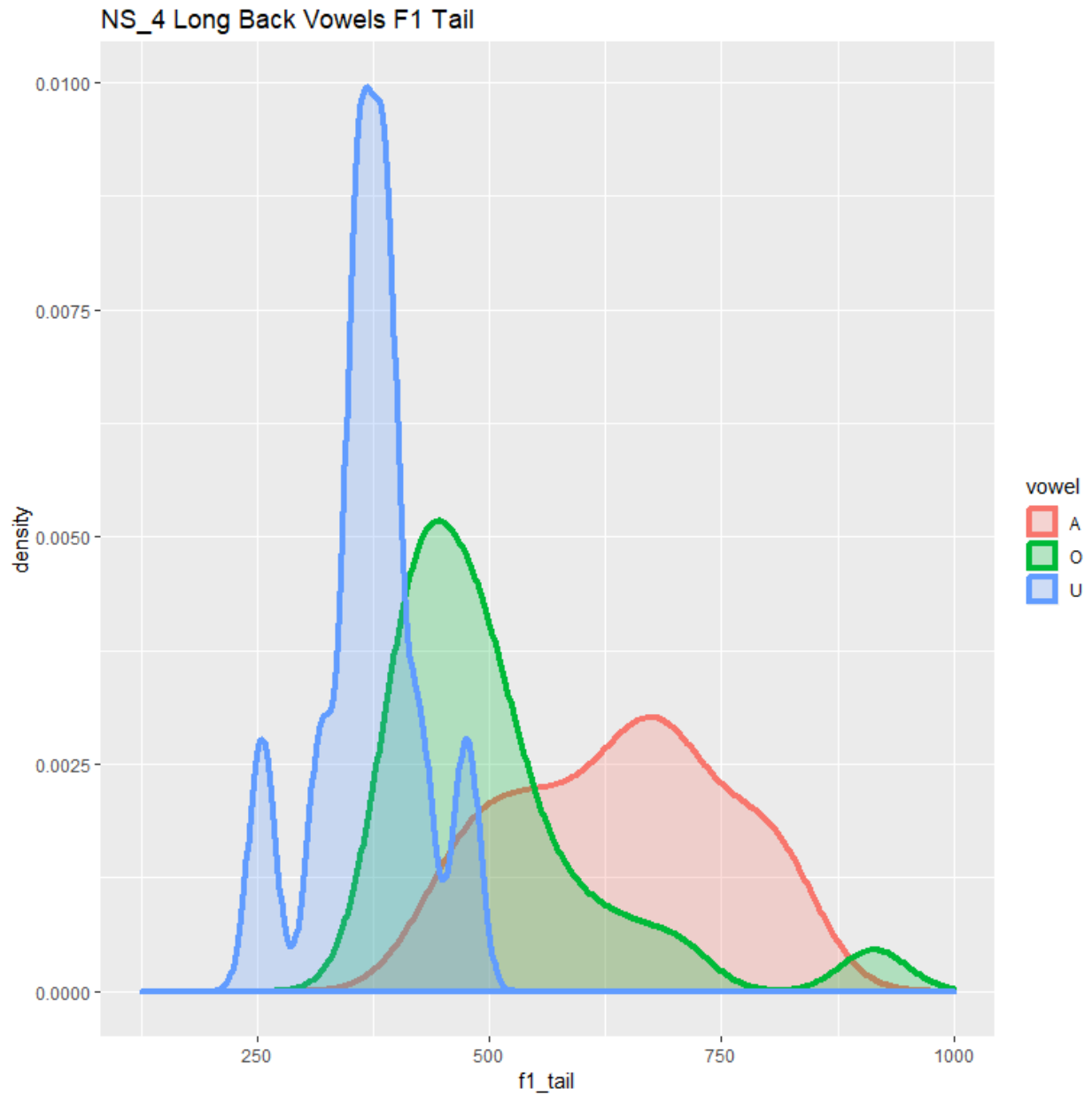


Figure 4.89: Long back vowels F1 Tail for NS_4

Figures 4.90 and 4.91 shows the F2 head and tail measurements of the long back vowels for NS_4.

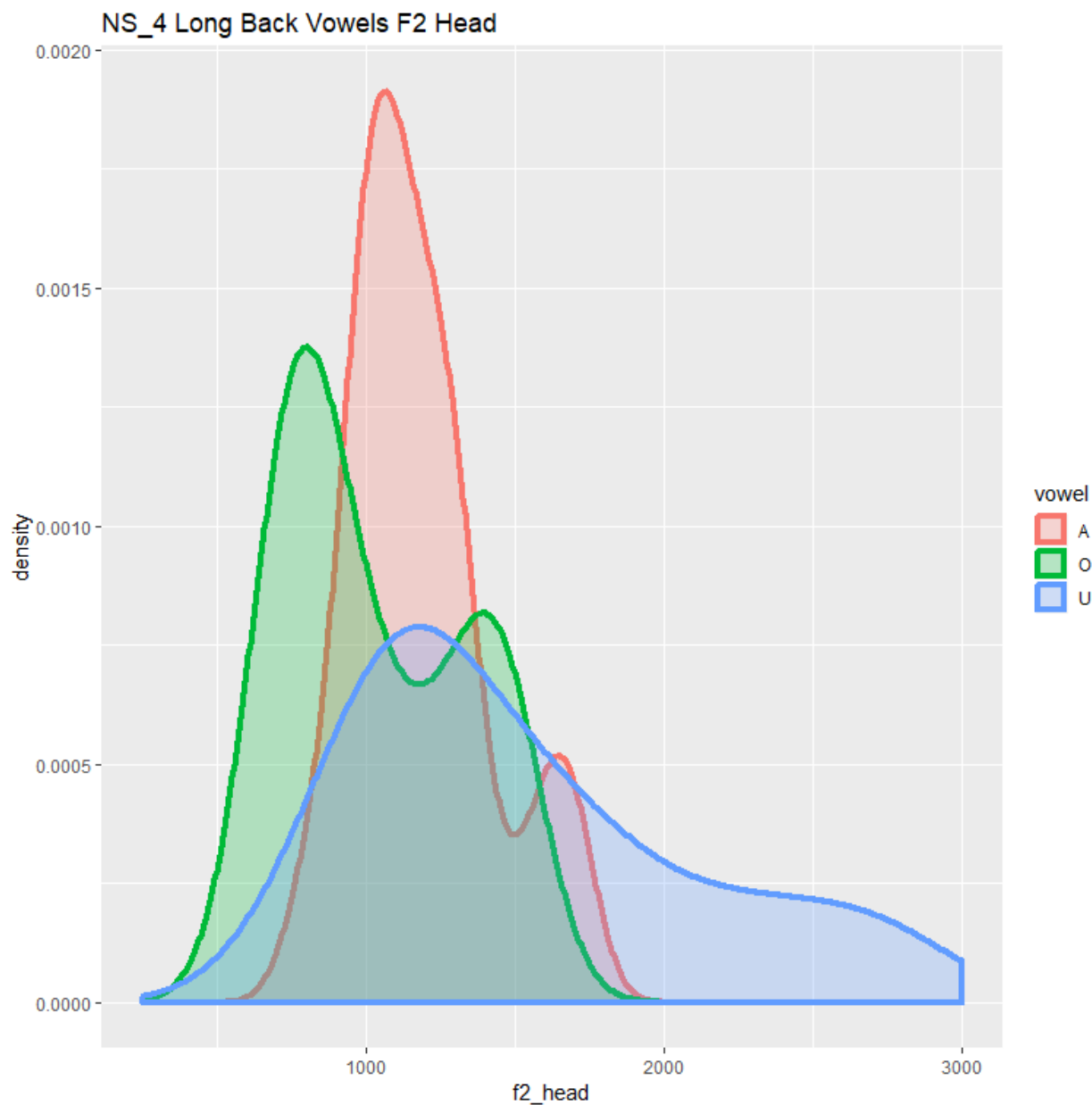


Figure 4.90: Long back vowels F2 Head for NS_4

Figures 4.90 and 4.91 are consistent with the patterns of the other speakers. Figure 4.90 shows distinct peaks forming for \bar{a} [a:] and \bar{o} [o:]. Unlike in previous examples, NS_4 has 55 and 24

tokens for \bar{a} [a:] and \bar{o} [o:] respectively. This is another signifier of a potential pattern of predictable allophony.

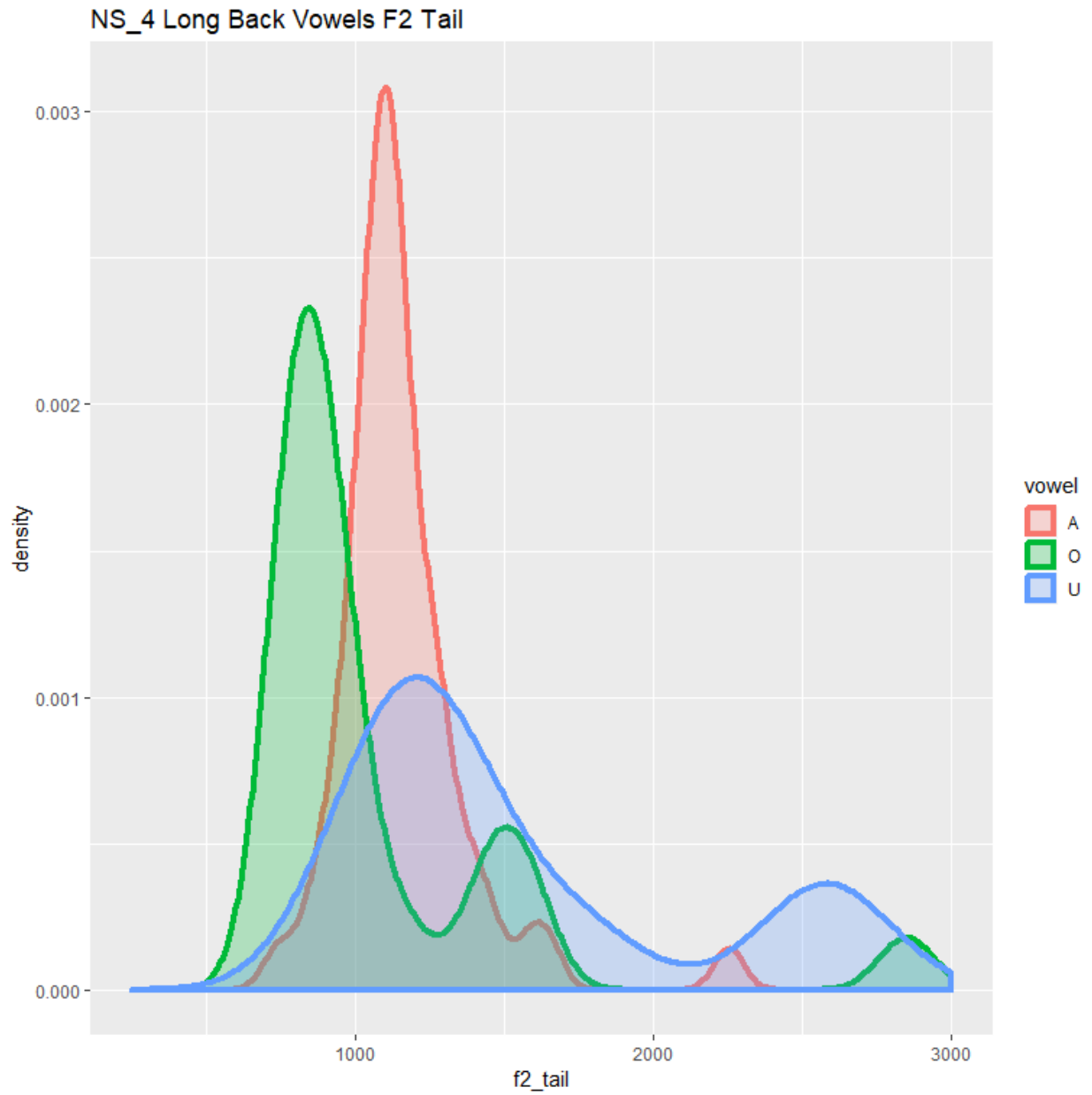


Figure 4.91: Long back vowels F2 Tail for NS_4

4.4.4. Conclusions from the Case Studies

Looking at the individual speaker variation, this section has shown some patterns in variation and production of the vowels. Each case study began with a look at the mean durations, followed by a look at the vowels that are the most different for the individual speaker from the average for all the speakers. In a few cases, the vowels that had duration differences overlapped with those that had quality differences from the average, but not all of them. This implies that duration is a different dimension than vowel quality, and that vowels can vary along quality or quantity separately. \bar{e} [e:] and $\bar{a}\bar{e}$ [æ:] have the most variable duration, but o [o] and \bar{o} [o:] have the most variation in acoustic space among the three native speakers.

Surprisingly, there is also a different pattern for the acoustic variation between the short and long vowel pair. For example, for NS_2 e [e] and $\bar{a}\bar{e}$ [æ:] are consistent with the average of the other speakers, but \bar{e} [e:] and ae [æ] are in a different acoustic space than the average. For NS_3, a [a] is consistent with the other speakers, but \bar{a} [a:] differs. For NS_4, a [a] and e [e] are consistent, and \bar{a} [a:] and \bar{e} [e:] are in a slightly different acoustic space than the other speakers.

Finally, as I pointed out throughout the analysis, some of the vowel measurements form multiple distinct peaks while others have smoother slopes. Figures 4.45, 4.47, 4.56, 4.60, and 4.61 show one side of the density plot with one or more peaks for one data set, while the other set has a smooth slope at nearly the same angle, but without the peaks. This indicates different distributions of the data, which has implications for potential allophony and variation. This is discussed in further detail in the following chapter.

4.5. Issues and Limitations with the Data Set

The measurements and analysis for this project posed several problems along the way. This section discusses what issues arose and how that may have affected the results I present in this chapter.

The first stage of this project was to take the sound files and adjust them to account for background noise and get them into a usable format to run vowel measurements on. There were several files that could not be cleaned up enough to be measurable. This resulted in the largest amount of attrition in tokens.

As a result of the low token counts for certain segments, it was difficult to make generalizations about some of them. There were very low numbers of tokens for *u* [u], *ū* [u:], *wa* [wa], *ua* [ua], and *ia* [ia]. Often there was only one token of each for a single speaker, which makes any sort of generalization impossible.

Linguistic research should take into account sociolinguistic factors that could affect the data as well as the interpretation of the data itself (Labov 2010; Thomas 2011). The results of this study only represent the speech community of the five elderly women whose speech was consulted. The generalizations discussed in this chapter are specific to the Menominee spoken by elderly women in this time period.

The duration studies I have presented here do not take into account phrase-level or word-level position of the tokens. Milligan (2005) shows that short vowels in word-final position are almost always lengthened. The position of the vowel within the word or phrase can play a large role in duration and/or stress in English (Turk & Shattuck-Hufnagel 2007). Since the majority of the tokens I analyzed came from isolated words that had already been extracted from their

elicited environment and uploaded to the database, I did not code my data for word position.

Appendix II lists the vowel tokens in their lexical environment, but not the phrase environment.

Bark normalization minimizes physiological variables when comparing data points in the hopes of having more comparable data results. Because human perception is more selective at different frequency ranges, Bark measurements normalize the frequency differences between the x- and y-axes when representing vowel height and frontness/backness. Bark normalization differs from non-normalized data by measuring the differences between formants which more accurately reflects changes in the vowel space, where a non-normalized measurement records the Hz of the formants alone. Bark normalization also accounts for the whole vowel space where a non-normalized measurement would set the vowel space around the vowels measured. This could result in a skewed vowel space since it would move depending on the tokens measured (Thomas & Kendall 2007).

Since Bark measurements depend on F3 as part of the difference in movement between formants, a major disadvantage, according to Thomas & Kendall (2007), is that F3 can often cause disruptive measurements. It is often unclear or not recognized by default Praat settings, and rhotics can cause F3 to move drastically. Since Menominee does not have rhotics, this was not a major complication to the data, but the abnormal tendencies of F3 may account for some of the extreme outliers seen in the data discussed in the previous subsections. It has been noted that nasals can have an effect on F3 movement (Lindau 1978; Ladefoged and Maddieson 1998), which is a variable that was not accounted for in the current data set.

4.6. Conclusion

This chapter has taken a quantitative and qualitative look at Menominee vowel duration and quality. Through case studies of three native speaking elders I have examined their individual vowel idiolects in more detail. This chapter also includes a closer descriptive analysis of the allophony as predicted by the acoustic data, and addresses issues and potential factors affecting the results.

The quantitative duration study confirms previous work on Menominee vowel length. Long and short monophthongs are significantly different in quantity, as are the long and short diphthongs from the long and short monophthongs. The results indicate that the short diphthong *wa* is significantly different from the long monophthongs, but *ya* is not.

This study also shows that underlying length significantly affects duration of the surface vowel. A vowel that is SS (underlyingly short, surface short), is significantly shorter than a vowel that is LS (underlyingly long, surface short). Conversely, a vowel that is SL (underlyingly short, surface long), is not significantly different in duration than one that is LL (underlyingly long, surface long).

Section 4.3 presented a first acoustic analysis of Menominee vowels. This study concludes that the acoustic realizations of both the long and short vowels are different than what is predicted by the literature on Menominee vowels. Only the short front vowels roughly overlap in the acoustic space as predicted in Bloomfield (1962) and Milligan (2005). The long front vowels have a very similar overlap pattern in the acoustic space to the short front vowels, indicating a similar pattern of variation between the two.

Sharp, distinct peaks show that the vowel measurements are clustering together in a relatively restricted range. Multiple distinct peaks indicate the measurements are clustering together in

separate, distinct groupings, with fewer measurements in the intervening ‘valley.’ This indicates a potentially predictable pattern of allophony. Rounded, flatter peaks indicate vowel measurements crossing a larger range of the acoustic space, but without a distinct pattern to the vowel production.

Future projects could round out the acoustic analysis by increasing the token counts for the vowels with these variable peaks and overlap patterns to determine if these patterns do in fact indicate an allophonic variation, or if it is just an artifact of the data.

Chapter 5: Menominee Vowel Phonology

In this chapter I propose an analysis of the underlying contrastive hierarchy for Menominee vowels based on the phonological rules discussed in Chapter 2.

I present the hierarchical structure with a description of the completions and trace this hierarchy through the vowel patterns well-documented in Menominee. In pursuit of accurately representing the features and phonologically significant vowel behavior, I propose a structural addition to the hierarchy to incorporate vowel length into the underlying analysis. A Bifurcated Ranking Model allows for a phonological discussion of all Menominee vowels, without inserting length into the feature hierarchy as part of dominance structure. With this proposal I follow Spahr in explicitly removing length from the hierarchical ranking of features. I employ a parallel linking mechanism to incorporate contrastive length into a branching hierarchy of distinctive features.

In my analysis of the underlying vowel system of Menominee, I argue that high back vowels can be derived in nearly all instances, and as a result do not occupy a node in the phonological hierarchy; there is no phonological *u* /u/ or *ū* /u/. The analysis of diphthongs and other ‘glide+vowel’ patterns indicates that the ranking of contrastive features of the short and long vowel systems of Menominee are symmetrical.

This chapter traces through the phenomena presented in Chapter 2 and discusses how the underlying hierarchy reflects each of those patterns.

5.1. Vowel Hierarchy

I follow the distinctive feature work of Dresher et al. (1994), etc. and the hierarchical representation first posited by Avery & Idsardi (2001) and further developed by Purnell and Raimy (2015). The feature geometry model I follow was given in Chapter 3 Figure 3.8 and is repeated here in Figure 5.1.

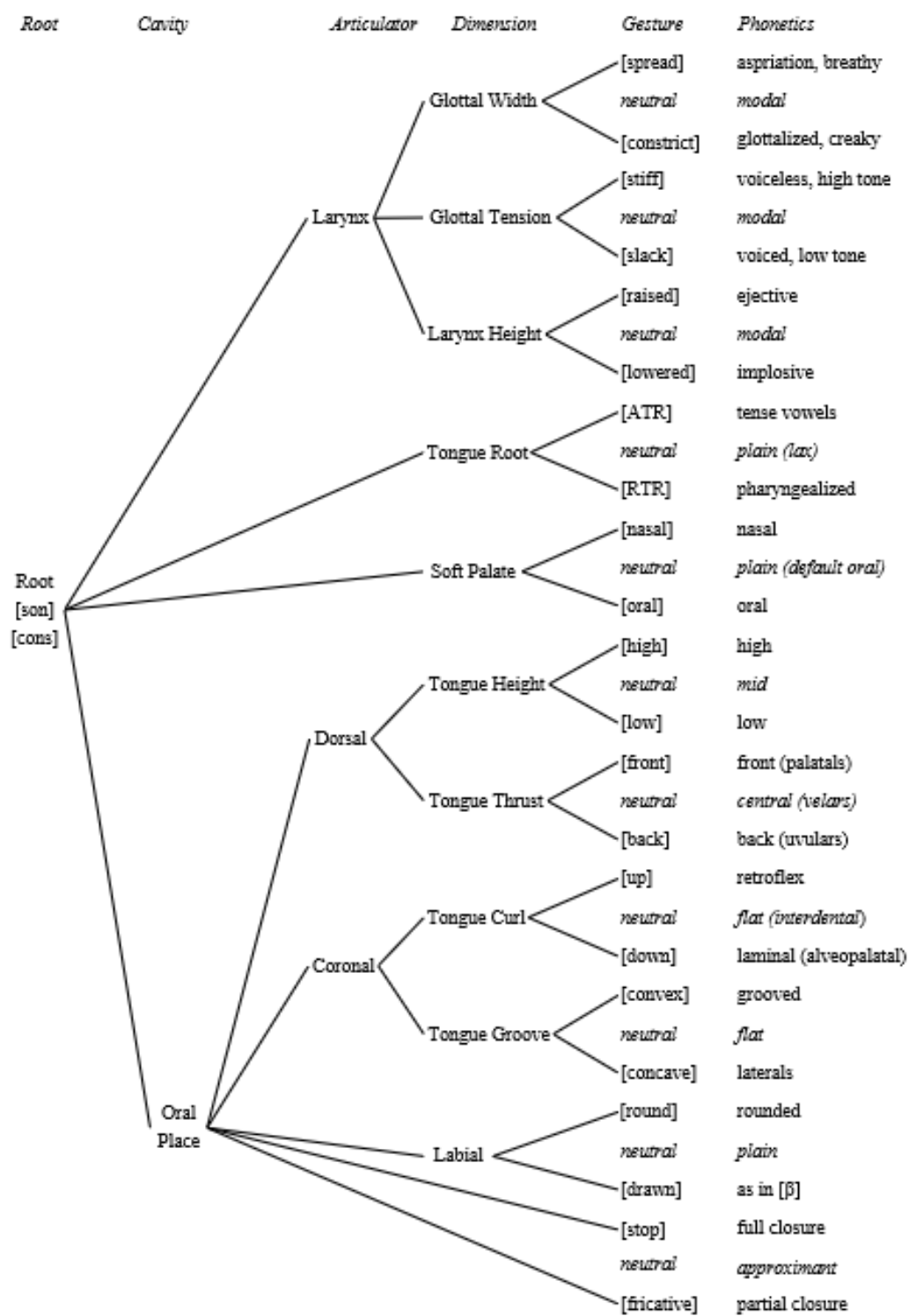


Figure 5.1: Feature Geometry (Purnell & Raimy 2015:526, modified from Avery & Idsardi 2001:66)

The segmental hierarchy in Figure 5.1 corresponds to the physical articulators and muscle groups activated during articulation within the human vocal tract. The more traditional IPA chart emphasizes the manner and place of articulation. The feature geometry presented here emphasizes the articulators and dimensions that affect the manner and place of articulation through constriction within the oral cavity. For vowels the dimension Tongue Height (TH) can be [high] or [low], or Tongue Thrust (TT) can be [front] or [back] for the DOR articulation. LAB is either [round] or [drawn]. The Tongue Root (TR) dimension is only dominated by the Root, which is either sonorant [son] or consonantal [cons] or both. TR can be either advanced [ATR] or retracted [RTR]. Only the dimensions that are required to establish a contrast in the inventory are represented in the hierarchy, following Avery & Rice (1989), Dresher et al. (1994), Avery & Idsardi (2001), Dresher (2009), Purnell & Raimy (2015), Oxford (2015), Spahr (2016), and Purnell et al. (forthcoming).

The articulators and dimensions have a hierarchical relationship where nodes higher in the tree (further left in Figure 5.1) dominate lower (further right) nodes. In the following discussion of Menominee vowels, the unmarked node will be identified by the superordinate node (following Purnell et al. (forthcoming)), which may be an articulator or cavity of the dimension in question. Though the vowel may be unmarked for that gesture, the articulator is still activated. For example, TH is immediately dominated by the DOR articulator. A split in the feature hierarchy where TH is activated for a set of segments would have the set unmarked for TH associated with a DOR node, rather than ‘null’ or \emptyset , because it is still the DOR articulator

that is playing a role in the specified and unspecified sets. This would be represented as DOR_TH to distinguish it from other underspecified DOR dimensions (Purnell et al.).¹⁶

I propose the following contrastive hierarchy for Menominee short vowels, shown in Figure 5.2. In this inventory I omit *u* [u] and *ū* [u:] from the phonology, which will be discussed in more detail in section 5.1.2 below. For each of these Figures, a) lists the ranking of the contrastive features in the hierarchy, (b) shows the branching tree model of the ranked features, and (c) lists all the specifications for each phoneme within the inventory of (b).

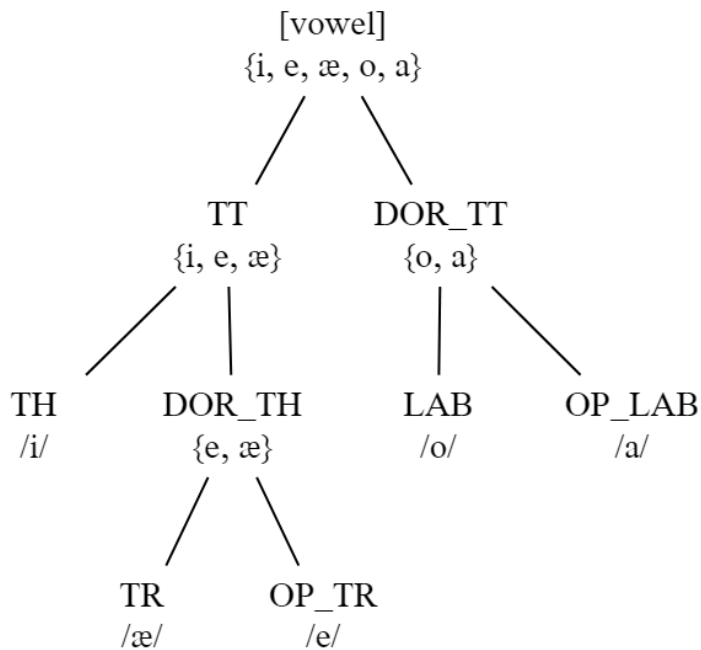
¹⁶ Avery & Rice (1991) predict a typologically expected hierarchy following Root > Air Flow > Sonority > Place, in which aperture is higher in the hierarchy. If this were the case for Menominee, (TR > TT > TH > LAB), the most un-marked vowel would be *e* /e/ and *ē* /e:/. This would also be typologically expected for the most unmarked vowel to be the one inserted in epenthesis. However, this ranking causes problems for other Menominee vowel phenomena. The hierarchy for Menominee I present here places TR lowest in the ranking. If TR were first in the ranking, subsequent rules for the glide+vowel patterns would be different between the short and long vowels. With TR at the bottom of the ranking, the rules between the short and long vowel systems are more parallel and consistent. This is discussed in further detail below in section 5.1.3.

Figure 5.2: Contrastive Hierarchy for Menominee Short Vowels

a. Feature Hierarchy:

Tongue Thrust > Labial > Tongue Height > Tongue Root

b. Contrastive Hierarchy:



c. Contrastive Segments:

/i/	/æ/	/e/	/o/	/a/
Tongue Thrust	Tongue Thrust	Tongue Thrust	Dorsal_TT	Dorsal_TT
Tongue Height	Dorsal_TH	Dorsal_TH	Labial	Oral Place_LAB
	Tongue Root	Oral Place_TR		

Figure 5.2 shows the contrastive ranking, the hierarchy within a branching tree, and shows the phonemes of this inventory and which contrastive features they are specified for. Table 5.1 provides the phonetic gestures for each short vowel.

Table 5.1: Phonetic Gestures: Menominee Short Vowels

Dimension	/i/	/æ/	/e/	/o/	/a/
Tongue Thrust	[front]	[front]	[front]	DOR_TT	DOR_TT
Labial				[round]	OP_LAB
Tongue Height	[high]	DOR_TH	DOR_TH		
Tongue Root		[RTR]	OP_TR		

In Figures 5.2 and 5.3, *a* and *ā* are the maximally unspecified vowel for the short and long systems respectively. This is consistent with Oxford (2016) but not with other analyses of Menominee vowel features, such as Milligan (2000), in which *e* /e/ is the least specified vowel. However, the phonological activity and patterns indicate *a* is the most neutral. I have chosen TR as the best representation of the patterns of Menominee vowels. Advancing or retracting the tongue root very typically correlates with a raised or lowered tongue body (van der Hulst and van de Weijer 1995). The following discussions in this chapter show why TR is more appropriate as a contrastive feature than an additional height specification.

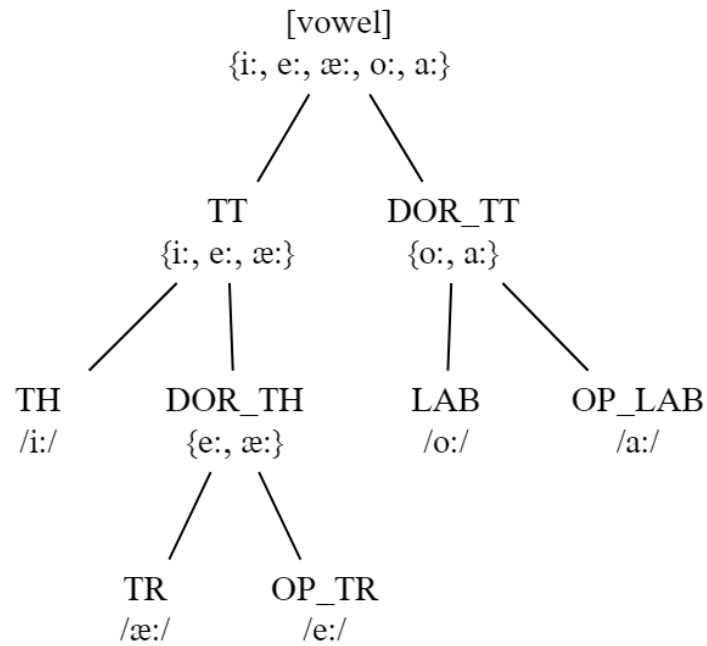
For the long vowels, I propose a feature hierarchy identical to the short vowels, which is shown in Figure 5.3.

Figure 5.3: Contrastive Hierarchy for Menominee Long Vowels

a. Feature Hierarchy:

Tongue Thrust > Labial > Tongue Height > Tongue Root

b. Contrastive Hierarchy:



c. Contrastive Segments:

/i:/	/æ:/	/e:/	/o:/	/a:/
Tongue Thrust	Tongue Thrust	Tongue Thrust	Dorsal_TT	Dorsal_TT
Tongue Height	Dorsal_TH	Dorsal_TH	Labial	Oral Place_LAB
	Tongue Root	Oral Place_TR		

Table 5.2 shows the phonetic gestures of the long vowels, as 5.1 does for the short vowels.

Table 5.2: Phonetic Gestures: Menominee Long Vowels

Dimension	/i:/	/æ:/	/e:/	/o:/	/a:/
Tongue Thrust	[front]	[front]	[front]	DOR_TT	DOR_TT
Labial				[round]	OP_LAB
Tongue Height	[high]	DOR_TH	DOR_TH		
Tongue Root		[RTR]	OP_TR		

In Menominee, the short and long vowels have identical contrastive rankings, as well as identical completions. The following discussion addresses an example of an Algonquian language with an asymmetrical short and long vowel system, Ojibwe.

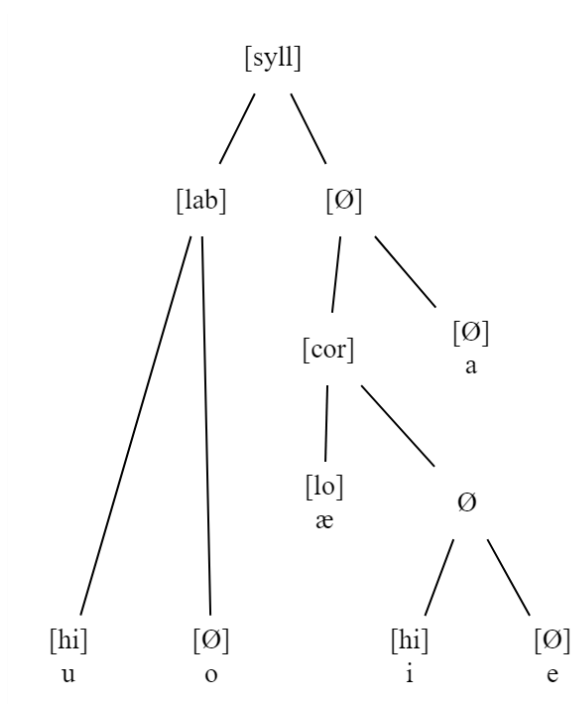
While I propose a TH and TR specification, two height specifications allow the ‘mid’ vowels *e*, *ē*, *o*, *ō* to have height distinct from both the low set *ae*, *āē*, *a*, *ā* and the high set *i*, *ī*, *u*, *ū* by being specified for neither [low] nor [high], which can be seen in the hierarchy initially proposed by Oxford (2015:330), shown in Figure 5.4.

Figure 5.4: Menominee Vowels with Two Height Contrasts (Oxford 2015:330, 2016:11)

a. Feature Hierarchy:

[labial] > [coronal] > [low] > [high]

b. Contrastive Hierarchy:



c. Contrastive Segments

/u/	/o/	/æ/	/i/	/e/	/a/
[lab]	[lab]	[Ø]	[Ø]	[Ø]	[Ø]
[hi]	[Ø]	[cor]	[cor]	[cor]	[Ø]
		[lo]	[Ø]	[Ø]	
			[hi]	[Ø]	

The hierarchies proposed in 5.2 and 5.3 differ from 5.4 in that TT completed as [front] is higher in the hierarchy than LAB (Oxford's [cor] and [lab]). Additionally, a terminal TR specification

distinguishes the lower front vowels from the TH [high] vowel, switching where *i* and *ae* terminate in the hierarchy from Oxford's approach. The discussion on the glide+vowel patterns in Menominee in section 5.1.3 show why Figures 5.2 and 5.3 fit more of the Menominee data than would be represented by Figure 5.4. Oxford employs LAB to separate the high back vowels *u*, *o* from the rest in order to place both *u*, *o*, and *i*, *e* as sister nodes to more easily address vowel harmony in Menominee. Figures 5.2 and 5.3 show that LAB is not the highest ranked contrastive feature in the hierarchy. As I argue below, there is no need to establish *o* /*o*/ and *u* /*u*/ as sister nodes as there is no phonological *u*. The inventory of Menominee vowels presented in Figures 5.2 and 5.3 do not include *u* /*u*/, and *ū* /*u:*/ as part of the phonological system. Section 5.1.2 discusses the marginal status of *u* [u] and *ū* [u:] in Menominee. This analysis organizes the Menominee vowels in different ways than Oxford, which allows the hierarchy to accommodate all the vowel alternations and rules discussed in Chapter 2 as phonetic and phonological phenomena in Menominee, which will be shown throughout the rest of this chapter.

5.1.1. Length within a Contrastive Feature Hierarchical Model

Oxford (2015) incorporates [long] representationally as a feature on the distinctive feature hierarchical trees in his discussion of Algonquian languages. He notes that while there are few arguments claiming length as a feature, it still has contrastive phonemic status in some languages, like Menominee. Though [long] is part of Oxford's featural analysis of Algonquian languages, he emphasizes that he does not intend to establish length as a feature itself, but rather solely to represent the contrastive length for the vowel inventories he is discussing (Oxford 2015). Chapter 3 showed an example of the underlying vowel system of Proto-Algonquian, incorporating [long] within the distinctive feature hierarchy. It is worth noting that Oxford

(2015) proposes a tree for Menominee vowels to address Menominee Vowel Harmony that does not make use of vowel length at all. Menominee Vowel Harmony regularly applies to long high vowels and applies to the short mid back vowel only before a glottal stop (Bloomfield 1939; 1962). I revisit this issue in further detail later in this chapter.

As described in Chapter 3, Spahr (2016) incorporates length into a distinctive feature hierarchy tree as explicitly structural. Length is linked to the rest of the hierarchy using a different linking mechanism from the features that are part of the super- and subordinate hierarchy. The feature-chain Spahr presents reflects the hierarchical order of the features from a contrastive hierarchy tree into the same ordering of features in a one-dimensional feature-chain.

I propose a Bifurcated Ranking Model of the short and long contrastively specified vowels, in which the short and long vowel systems each have their own hierarchical structure, but the two trees are linked at shared feature nodes between the two hierarchies. A language with asymmetrical short and long vowel systems will necessarily have a different number of contrastive features for the two systems. A larger inventory requires more features to contrastively specify all phonemes than the smaller inventory.

The Bifurcated Ranking Model removes length from a linearly branching framework. This allows for a short and long vowel system to be asymmetrical and potentially have different hierarchies of features between the two. It is even possible for a language to have the same short and long vowel inventory, but a different ranking of features between the two. Similar to Oxford (2015), I employ this bifurcated mechanism in order to accurately represent the phonological distinctiveness of short vs. long vowels, but following Spahr (2016), I represent length as a structural element rather than a distinctive feature. Figure 5.5 shows the Menominee short and long vowel hierarchies and how they interact with each other. Where the feature nodes are the

same between the two hierarchies, they map together and link nodes (shown with a dotted line), allowing vowel lengthening and shortening rules to operate from the short hierarchy to the long one, and vice versa.

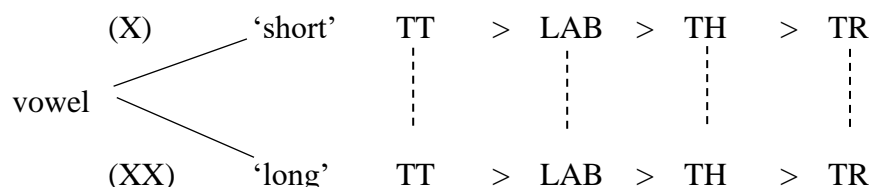


Figure 5.5: Menominee Bifurcated Ranking Model, Accounting for Length

By splitting the ranking, I am expanding the capabilities of a ranked feature system. Previous approaches have relied on a linear ranking of features, but as the following example shows, inventories of a language are often asymmetrical and require an adjustment in how a ranking can be represented.

Bifurcated Ranking also allows for the short and long hierarchy to be asymmetrical within a language. The Menominee short and long systems are almost completely parallel and thus have the same underlying hierarchy of distinctive features, but this model allows for a representation of an asymmetrical short and long system as well.

Treating the long and short systems as distinct allows for an analysis in which the short and long vowels have different hierarchies, or even non-parallel inventories. For example, the Ojibwe vowel inventory is asymmetrical between the short and long systems, /o, o:, ε:, i, i:, a, a:/ (Oxford 2015:325). Oxford (2015) compares modern inventories to the Proto-Algonquian (PA) inventory with length as a node on the distinctive feature tree. Where PA had symmetrical short and long vowel inventories, Ojibwe no longer does. As a result, Oxford analyzes [length] in

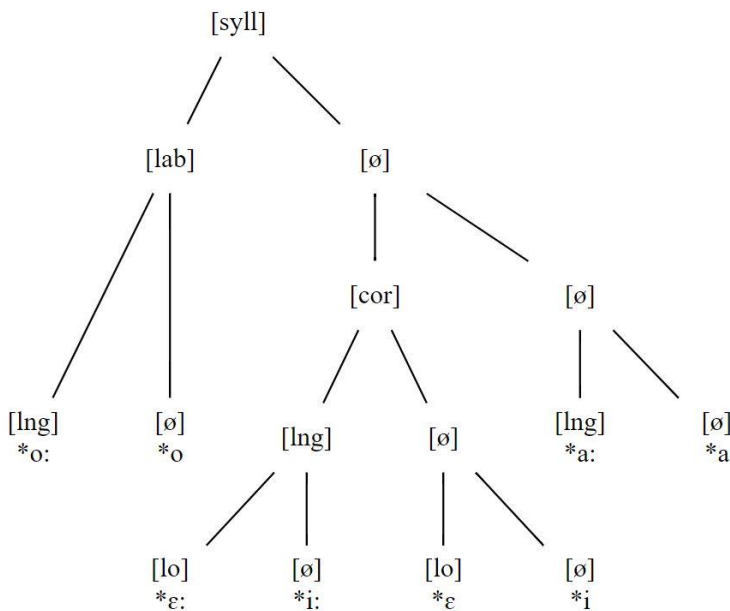
Ojibwe as higher in the feature hierarchy (affecting a larger set of vowels) than in PA. Compare the hierarchies in Figures 5.6 (PA) and 5.7 (Ojibwe).

Figure 5.6: Proto-Algonquian Hierarchy with [lng] as a Feature (Oxford 2015:323)

a. Feature Hierarchy:

[labial] > [coronal] > [long] > [low]

b. Contrastive Hierarchy:



c. Contrastive Segments:

*/o:/	*/o/	*/ε:/	*/i:/	*/ε/	*/i/	*/a:/	*/a/
[lab]	[lab]	[Ø]	[Ø]	[Ø]	[Ø]	[Ø]	[Ø]
		[cor]	[cor]	[cor]	[cor]	[Ø]	[Ø]
[lng]	[Ø]	[lng]	[lng]	[Ø]	[Ø]	[lng]	[Ø]
		[lo]	[Ø]	[lo]	[Ø]		

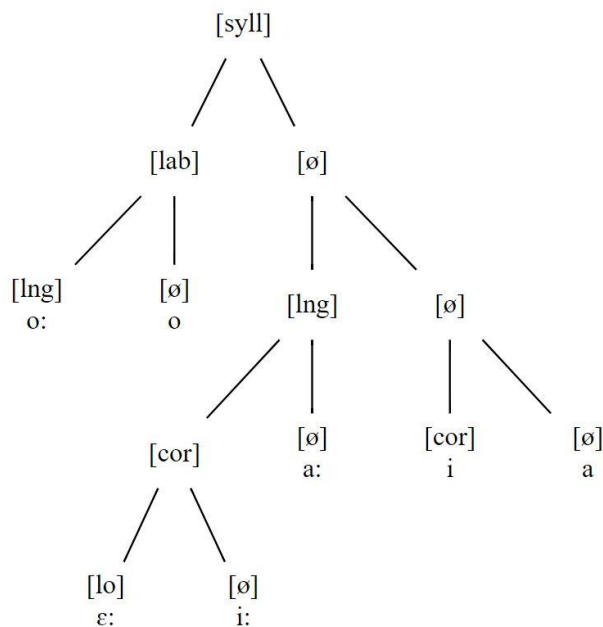
Following Oxford's Sisterhood Merger Hypothesis, in Figure 5.6 */ɛ:/ and */i:/ must be sisters because they merge in Ojibwe (Figure 5.7). Key here is that the Bifurcated Ranking Model divides the long and short vowels into separate, potentially different, feature rankings, but it does not prohibit the sister nodes required for Oxford's diachronic analysis of PA. As a result of this merger, Ojibwe now has fewer short vowels than long vowels. This means that the short and long inventories are not identical, and the larger inventory necessarily requires more distinctively specified features.

Figure 5.7: Ojibwe Hierarchy with [lng] as a Feature (Oxford 2015:325)

a. Feature Hierarchy:

[labial] > **[long]** > [coronal] > [low]

b. Contrastive Hierarchy



c. Contrastive Segments:

/o:/	/o/	/ε:/	/i:/	/a:/	/i/	/a/
[lab]	[lab]	[Ø]	[Ø]	[Ø]	[Ø]	[Ø]
[lng]	[Ø]	[lng]	[lng]	[lng]	[Ø]	[Ø]
		[cor]	[cor]	[Ø]	[cor]	[Ø]
		[lo]	[Ø]			

A Bifurcated Ranking Model of the same hierarchy for Ojibwe removes [length] from the linear ranking of features and allows the short and long system to have different features. This is demonstrated in Figure 5.8.

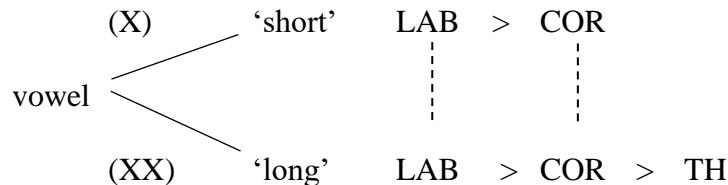


Figure 5.8: Ojibwe Bifurcated Ranking Contrastive Hierarchy (following Oxford's distinctive feature analysis (2015:325))

Since the nodes that are shared between the two hierarchies are mapped onto each other in a split model, short and long vowels remain sister nodes because they share the same parent node. This is crucial when following Oxford's Sisterhood Merger Hypothesis, which restricts structure-changing mergers to sister nodes. An analysis following the diachronic and synchronic framework proposed by Oxford (2015) is not adjusted in any other way, except that length is now removed from playing a role within the linear ranking and more clearly reflects length as a structural mechanism.

5.1.2. High Back Vowel(s)

Bever (1967) argues that all *i* [i], *ī* [i:], *u* [u], and *ū* [u:] can be derived from a raising rule and thus Menominee only has an underlying four-vowel system /a, æ, e, o/. Miner (1975; 1979) and Milligan (2000, 2005) briefly touch on the issue of deriving high back vowels, but do not pursue the topic in great detail. Miner (1979) mentions the status of the high vowels in a footnote and states that “other than in interjections and borrowings, [*ū* is] a derived vowel; *u* is, oddly enough, required for just one morpheme” (Miner 1979:22). He goes on to say that *i* [i] is synchronically derived and the only underlying phoneme is *ī* /i:/. Milligan (2005) includes a footnote on the issue, saying “although the phonemic status of /*ū*/ and /*u*/ is open to debate, I treat them as phonemes” (Milligan 2005:3).

While there is sufficient evidence to support an underlying high front vowel, both long and short, Bever is correct in his initial assessment that *u* [u] and *ū* [u:] can be derived as a result of raising of the mid back vowel *o* /o/ or *ō* /o:/, or as a result of raising and subsequent lengthening. *i* /i/ and *ī* /i:/ appear in environments where no clear derivation can be identified (such as word-initial for *ī* /i:/), supporting their status on a phonological level. In this section, I will discuss the role of *u* [u] and *ū* [u:] in the morphological inventory, a potential reanalysis, and how this affects the analysis of the underlying contrastive hierarchy.

The Menominee Database (MD), built up with morphological analyses based on Bloomfield (1962; 1975) as well as work by modern linguists, contains five morphemes with an underlying long *ū* /u:/.¹⁷ As Table 5.3 shows, each of these five morphemes only occurs in one or two lexemes, and all lexemes contain the trigger for vowel harmony that would raise an underlying *ō* /o:/ to *ū* [u:] (Milligan 2005:96). Recall from Chapter 2 that the triggers for vowel harmony are *i* /i/, *ī* /i:/, *u*, [u], *ū* [u:], *Cy* /ya, ya:/, or *Cw* /wa, wa:/.

Morpheme containing /u:/	Lex. category	Gloss	# of Lexemes the Morpheme Occurs In (analyzed)	Vowel Harmony Trigger Later in Lexeme
/kaku:-/	root	sleepy	1	✓
/-kenu:pikw/ ¹⁸	final	snake	1	✓
/ku:k-/	root	meat-bird	1	✓
/mu:cehkiw-/	root	bluejay	2	✓
/tu:kan-/	root	blackbird	1	✓

Table 5.3: Morphemes containing *ū* [u:]

¹⁷ Menominee words can be made up of three derivational morphemes: root, medial, and final. Roots and finals are typically considered obligatory and medials are optional. They form the stem to which inflection affixes. This is a vast simplification of a very complex phenomenon, but for the purposes of a phonological analysis, further detail is not needed. See the works of Bloomfield, Goddard, and Macaulay for more detail on Menominee morphology.

¹⁸ The noun meaning ‘snake’ *kenūpik* is analyzed with an underlying root /kaenw-/ ‘long’ and final /-ēpikw/ ‘string’. As shown in Table 2.6, /Cw/ + /e:/ = /Co:/, which would then become *ū* [u:] from vowel harmony.

A comprehensive search of the MD only turns up four morphemes with an underlying short *u* /u/.

Table 5.4 shows that of the four morphemes containing underlying *u* /u/, three of them occur in only one lexeme and are followed by a trigger of vowel harmony in that lexeme.

Morpheme containing /u/	Lex. category	Gloss	# of Lexemes the Morpheme Occurs In (analyzed)	Vowel Harmony Trigger Later in Lexeme
/mahkuk-/	root	yellow birch	1	✓
/nakut-/ ¹⁹	root	wedge	1	✓
/otunep-/	root	chub	1	✓
/-uw/	transitive animate (TA) final	adds a second object to the verb	24	

Table 5.4: Morphemes containing *u* [u]

I also searched the database for all morphemes containing surface *u* [u] or *ū* [u:]. All long *ū* [u:] are in the environment of vowel harmony. The only lexical items that contain short *u* [u] (as a monophthong and not as the first target of the diphthong *ua* /wa:/) are in the sequence of either *uq* [uʔ] or *uw* [uw]. Recall from Chapter 2 that *oq* /oʔ/ raises to *uq* [uʔ] in vowel harmony. There are 28 lexemes containing *uq* [uʔ] and all precede a vowel harmony trigger (*i* /i/, *ī* /i:/, *u* [u], *ū* [u:], *Cy* /ya, ya:/, or *Cw* /wa, wa:/). There are 24 lexical items analyzed as containing the final *-uw* [-uw] (and about 35 others that potentially contain it but are not yet analyzed as such), but there were no sound files to analyze. Presumably, this is the single morpheme Miner was referring to.

A Proto-Algonquian dictionary (protoalgonquian.atlas-ling.ca) contains ten reconstructions of Menominee words containing the [-uw] morpheme (as analyzed in the MD). All ten are reconstructed to */aw/ in the PA words, but that database does not break the PA words into

¹⁹ *Nakūth* ‘wedge’ is an inanimate noun. The MD contains a homophonous animate noun *nakūth* ‘sunfish’ that does not have an underlying morphological analysis. However, the trigger for vowel harmony is still present in ‘sunfish’ just as it is in ‘wedge.’

morphemes. A PA morpheme dictionary (Hewson nd.) gives two Menominee words containing a morpheme corresponding to the PA morpheme *-aw ‘transitive animate (TA) final’. Of these two words, the MD analyzes one as containing *-uw*, and the other as containing a different morpheme *-naw* ‘vision, intellect, emotion’. I am unaware of an analysis that reconstructs Menominee *u* to PA **a*.

As the two tables show, most of the morphemes that Bloomfield noted as underlyingly *u* /u/ or *ū* /u:/ can be alternatively analyzed with underlying *o* /o/ or *ō* /o:/ instead, which does not drastically change the morphological analysis of the lexical items containing these morphemes. Vowel harmony can account for all the surface *ū* [u:] that are currently analyzed as underlying *u* /u/ or *ū* /u:/. The only exception to deriving short *u* [u] is *-uw*. Bloomfield argues for the status of *u* /u/ as a phoneme because the *u* /u/ in this one morpheme triggers vowel harmony and a reanalyzed /-ow/ would not, based on how the Vowel Harmony Rule is stated (only short *o* /o/ preceding a *q* /ʔ/ gets raised). Examples of this raising can be seen in (1).

(1) *-uw* Triggering Vowel Harmony

- | | | | |
|-------------------------------|---|----------------------------|---|
| a. ak [̄] ōt-uw-aew | → | [ak [̄] ūtuwaew] | ‘he or she hangs it up for him or her’ |
| b. os [̄] ēht-uw-aew | → | [os [̄] īhtuwaew] | ‘he or she makes, gets it ready for him or her’ |

As this single morpheme is the only known morpheme to theoretically contain an underlying *u* /u/, I propose reanalyzing it as /-ow/ underlyingly, in which this particular *o* in this specific morpheme has exceptional behavior of raising a preceding *ē* /e:/ or *ō* /o:/. Other morphemes containing /ow/ do not trigger vowel harmony.

Scobbie & Stuart-Smith (2006) argue that phonological contrast can be gradient.

Phonological contrast of segments is typically determined by their predictability. Are they in complementary distribution? If so they are allophones, if not, separate phonemes (Harris 1990;

Harris 1994; Scobbie & Stuart-Smith 2006; Hall 2009; Hall & Hall 2016). However, as the Menominee case of the *-uw /-ow/* morpheme shows, this is not always a clear-cut distinction. Examples of intermediate segments are also shown in the works of Crothers (1978), Goldsmith (1995), Hualde (2005), Kager (2008), Scobbie & Stuart-Smith (2008), Ferragne et al. (2011) among others. In Menominee, *u* is predictable when derived as part of vowel harmony in almost all cases. The remaining case that is not phonetically predictable is part of the morpheme *-uw*.

Based on this discussion of the morphemes containing the high back vowels, I agree with Bever (1967) and Miner (1979) that there is no underlying \bar{u} [u:] and the phonological status of *u* /u/ is shaky at best. In the analysis presented here I take the position that a single morpheme does not support the phonological status of a phoneme, and there are no underlying high back vowels in Menominee.

In order to account for the single *u* /u/ phoneme and the presence of a derived \bar{u} [u:] in Menominee, Miner (1979) offers arguments supporting a push-chain of PA vowels splitting and lowering, resulting in the modern Menominee inventory, which he termed the ‘great Menominee vowel shift’. PA **i* split into *i* /i/, *e* /e/; **e* lowered to *ae* /æ/. Though he does not discuss it in more detail, Miner notes that a comparable splitting process in the back vowels is “incomplete” (Miner 1979:9). Even the front vowels demonstrate certain aberrant behavior that is attributed to “a residue of vowels which failed to lower” (Miner 1979:18), and which Bloomfield has treated as three vowel morphophonemes: *E*, *æ*, and \bar{a} (Bloomfield 1962).²⁰ Miner suggests that perhaps the single *u*-containing morpheme is in fact an idiosyncratic *o* /o/ which is in the early stages of a split similar to that of the *i* /i/, and *e* /e/ in the front vowels, and is moving towards an underlying status of *u*, \bar{u} that does not need to be derived.

²⁰ I do not address the vowel morphophonemes further in this project and leave the phenomenon for future research.

This reduced inventory is more consistent with the other Central Algonquian languages, few of which have a diachronic split from PA *o to a modern *o and *u. The following table summarizes the vowel inventory for several documented Algonquian languages.

Region	Language	Mid Back Vowel	High Back Vowel
Plains Algonquian	Arapaho		✓
	Atsina	✓	✓
	Cheyenne	✓	
	Blackfoot	✓	
Central Algonquian	Meskwaki	✓	
	Cree	✓	✓ (some dialects)
	Menominee	✓	✗
	Ojibwe	✓	✓ (some dialects)
	Potawatomi	✓	
	Miami	✓	
	Shawnee	✓	
Eastern Algonquian	Narragansett		✓
	Penobscot	✓	✓
	Passamaquoddy-Malecite		✓
	Micmac	✓	✓
	Munsee	✓	
	Unami	✓	✓

Table 5.5: Mid and High Back Vowels in Other Algonquian Languages

This table is divided into three of the geographic regions that Algonquian languages are often grouped into (but I do not make any further claims here about sub- or genetic groupings). Two of the four the Plains Algonquian languages have been reported to have a high back vowel. Only two of the seven Central Algonquian languages have been reported to have a high back vowel in some, but not all, dialects. Finally, at the bottom of the table, five of the six Eastern Algonquian languages surveyed have a high back vowel. This shows that it is more expected in the family for Menominee not to have an underlying *u* and *ū*, as most of the Central Algonquian languages do not have a phonological high back vowel.

5.1.3. Diphthongs (Vowel + Glide Alternations Revisited)

Bloomfield's discussion on how 'postconsonantal semivowels' pattern (or glide+V) implies that the diphthongs are a glide+vowel combination that remains clearly glide + vowel, where all other vowels merge in some way with the postconsonantal glide, and surface as a vowel alone (Bloomfield 1962:84-85). The glide+vowel combinations occur at morpheme boundaries, but they are not the only vowel effects that happen when two morphemes meet and the first ends in a vowel and the second begins in a vowel. Tables 5.6 and 5.7 repeat Tables 2.5 and 2.6 from Chapter 2 respectively to demonstrate what happens between two vowels that meet in sequence at morpheme boundaries.

Vowel #1	+ Vowel #2	Outcome		
Long vowel (\bar{V})	Long vowel (\bar{V})	Epenthetic y	$\bar{V}_1 + \bar{V}_2 = \bar{V}_1y\bar{V}_2$	Except \bar{a} ($\bar{a}+\bar{a}=\bar{a}$)
Short vowel (V)	Long vowel (\bar{V})	Long vowel	$V_1 + \bar{V}_2 = \bar{V}_2$	
Long vowel (\bar{V})	Short vowel (V)	Long vowel	$\bar{V}_1 + V_2 = \bar{V}_1$	
Short vowel (V)	Short vowel (V)	2 nd short vowel	$V_1 + V_2 = V_2$	

Table 5.6: Vowels in combination at morpheme boundaries
(from Bloomfield 1962:82-83)

This table demonstrates Menominee strategies for resolving vowel hiatus. Menominee does not allow vowel clusters as separate syllables, known as hiatus, and as such has strategies for resolving this disallowed structure at morpheme boundaries. Table 5.6 shows that two vowels in sequence can either coalesce or be separated by an epenthetic y /y/ (consonantal in this case, not as part of a diphthong). Long vowels such as \bar{e} /e:/, \bar{i} /i:/, and \bar{ae} /æ/ in a sequence will be separated by a consonantal y /y/. As discussed in Chapter 2, these patterns do not represent all vowel combinations. There are some combinations, such as $\bar{o}+\bar{o}$ (/o:/+/o:/) or $\bar{a}+\bar{a}$ (/a:/+/a:/) that do not appear to occur. Bloomfield does not address \bar{o} /o:/ in long vowel sequences with another long vowel. A search of the MD finds ten roots, one medial and seven finals that end with \bar{o} /o:/, and two medials and 27 finals that begin with \bar{o} /o:/. They occur in 83 lexical items. The finals

that begin in \bar{o} /o:/ do not come in sequence after another long vowel in any of the lexical items.²¹ Of the roots and root allomorphs that end in \bar{o} /o:/, the only vowel sequence they occur with are short vowels, and the predicted pattern of the long vowel prevailing holds true.

Similarly, though \bar{a} /a:/ occurs at the beginning or end of 275 morphemes, I was still unable to find an example of $\bar{a}+\bar{a}$ (/a:/+a:/) in sequence at morpheme boundaries, with the exception of the underlying \bar{a} /a:/ that is the second vowel in the diphthongs (of which there are dozens of examples: $Cw\bar{a}+\bar{a}$ (/Cwa:+a:)).²²

In summary, the main strategies for hiatus resolution in Menominee are as follows: when a short vowel and a long vowel meet at morpheme boundaries without an intervening consonant, the long vowel will prevail. Regardless of the quality of either vowel, length takes precedence in the surface vowel. When two short vowels are in sequence together, the second will typically prevail, regardless of the quality of either vowel (Bloomfield 1962).

A more common pattern at morpheme boundaries is for the first morpheme to end in a post-consonantal glide and for the following morpheme to begin with a vowel. Tables 5.7 and 5.8 show the patterns of coalescence between a glide and a vowel at morpheme boundaries.

²¹ Of the finals that end in \bar{o} /o:/, only two have been analyzed in lexical items. One in a transitive inanimate class 2 (TI2) verb which ends in $-\bar{a}w$ /-a:w/, and the \bar{a} /a:/ apparently takes precedence. The other lexeme is a transitive inanimate class 4 (TI4) verb. For this particular lexical item, Bloomfield (1962) explicitly states that the \bar{o} /o:/ ending is irregularly replaced by $-aw$ /-aw/.

²² There were two exceptions to this: $n\bar{a}t\bar{a}p\bar{a}e\bar{h}k\bar{o}w$ with a UR root /na:-/ and UR medial /-a:pæhk-/ but the allomorph of the root is analyzed as [na:t-]; and $k\bar{e}t\bar{a}h\bar{a}h\bar{k}w\bar{a}n\bar{a}e\bar{w}$ with a UR root /kæta:-/, UR medial /-a:hkw-/. I do not know where the h /h/ intervening between the two \bar{a} /a:/ comes from based on this analysis.

Cw	+	ae, o	→	Co		Cy	+	o	→	Co
Cw	+	e / ___w	→	Cow						
#w	+	ae / #__	→	#o						
Cw	+	e, i	→	Ci		Cy	+	e	→	Ci
Cw	+	āē, ī	→	Cī		Cy	+	āē, ī	→	Cī
Cw	+	ē	→	Cō						
						Cy	+	ae	→	Ce
						Cy	+	ē	→	Cē

Table 5.7: Glide + Vowel alternations (from Bloomfield 1962:84-85)

Table 5.7 shows what happens in vowel combinations when a glide follows a consonant and immediately precedes a vowel. Remember that this is the environment where the diphthongs appear with the low back vowel. This table shows that for all the other vowels in combination with a glide, the glide disappears, but some amount of vowel quality change usually occurs. Looking at the set of Cw+V, the resultant vowel is either *i* /i/, *ī* /i:/, *o* /o/, or *ō* /o:/ and for the set of Cy+V the resultant vowel is either *o* /o/, *i* /i/, *ī* /i:/, *e* /e/, or *ē* /e:/. This indicates that LAB, TH, and TR are key features in the contrastive ranking of Menominee vowel features.

It is very difficult to distinguish a glide from a vowel phonetically (Senturia 1998), and glides are often considered either phonetic reflexes of high vowels, or even “ultra-short” vowels (Kaye & Lowernstamm 1981; Catford 1988). Some languages have been reported to maintain a phonemic contrast between glides and vowels (Guerssel 1986: Ait Seghrouchen dialect of Berber; in Senturia 1998) where others show patterns of glide and vowel reflexes of the same phoneme (Barker 1964: Klamath; in Senturia 1998).

The diphthongs in Menominee are *wa*, *ua*, *ya*, and *ia*. Bloomfield (1962) analyzes these underlyingly as /wa, wā, ya, yā/. If we add this into the pattern presented in Table 5.7, a path to

determining the underlying feature hierarchy emerges. Table 5.8 now contains the diphthongal glide+vowel as well (repeated from Chapter 2 Table 2.6).²³

1	Cw	+	ae, o	→	Co		9	Cy	+	o	→	Co
2	#w	+	ae / #__	→	#o		10	Cy	+	ae	→	Ce
3	Cw	+	āē, ī	→	Cī		11	Cy	+	āē, ī	→	Cī
4	Cw	+	e, i	→	Ci		12	Cy	+	e	→	Ci
5	Cw	+	e / __w	→	Cow							
6	Cw	+	ē,	→	Cō		13	Cy	+	ē	→	Cē
7	Cw	+	a	→	Cwa		14	Cy	+	a	→	Cya
8	Cw	+	ā	→	Cwā		15	Cy	+	ā	→	Cyā

Table 5.8: All Glide + Vowel Alternations *or* Patterns of Hiatus Resolution

The patterns of glide+vowel in Table 5.8 indicate that on the whole, the features of the glides spread or delete the features of the nucleic vowel, with the exception of *a* /a/ and *ā* /a:/.

Remember that *w* /w/ is contrastively specified for LAB [round] and TH [high]. *y* /y/ is contrastively specified for TT [front] and TH [high].

I discuss how these features interact in more detail below, but first I turn to the underlying syllable structure of Menominee and how glides fit into this picture. Figure 5.9 shows the maximal Menominee syllable structure, including diphthongs.

²³ Bloomfield (1962:84) writes that *Cwa* /Cwa/ often merges to *o* /o/, so this appears to be an irregular pattern with *Cw* + *a*, but I attribute this to neutralization in rapid speech.

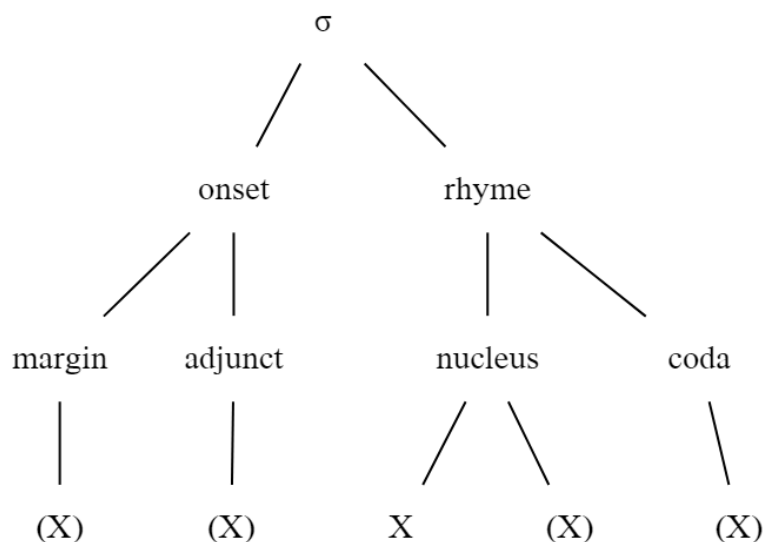


Figure 5.9: Menominee Syllable Structure-including diphthongs

In Figures 5.9 and 5.10, I follow the syllable structure presented by Cairns (1969) and Cairns & Feinstein (1982). It is important to note that though I employ their analysis of a syllable onset containing the *margin* and the *adjunct*, I make no claims about the markedness of this structure within a greater Menominee syllabic analysis. Figure 5.10 shows the same syllable structure presented in Figure 5.9 with (C), (G), and (V) representing which X-slots are consonant slots, glide slots, and which are vowel slots.²⁴ The glide slot in the onset is restricted to phonemes specified for TH, which is either *w* /w/, or *y* /y/.

²⁴ Cairns & Feinstein (1982) use C for obstruents, but for this and any other discussion in Menominee, I use it as a general marker for any consonant, including intervocalic glides which are in the margin, and in word-final position can be in the coda.

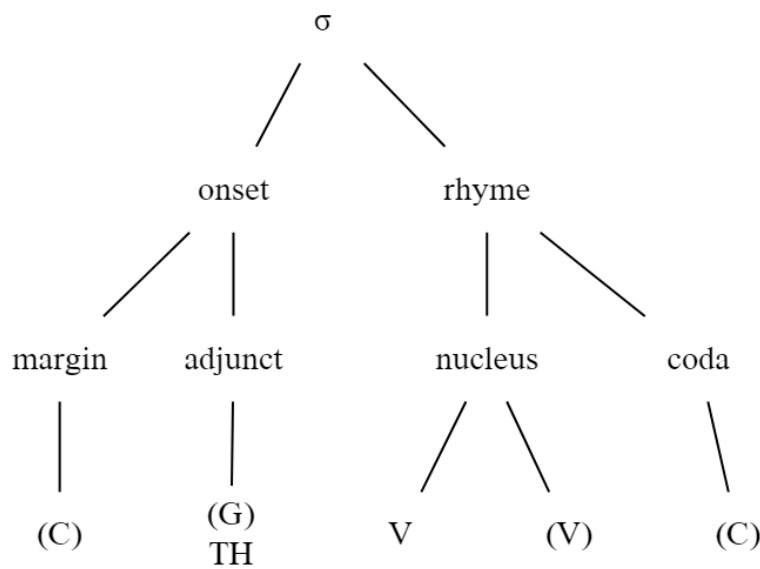


Figure 5.10: Menominee Syllable Structure with C/V Slots Marked

When a glide (G) follows a consonant (C) and precedes a vowel (V), it is restricted to the adjunct position in the onset. The adjunct is restricted to a G specified for TH. Table 5.8 shows that most of the vowels in Menominee are affected by post-consonantal G, and that the diphthongs are actually the only G+V sequences that do not, to use Bloomfield's word, merge into a different vowel. Thus, the glide must be an onglide in these sequences in order to account for the diphthongs. I identify the on-glide in the onset of the syllable because the nucleus still needs to be able to apply two X-slots to account for the underlyingly long second vowel target of the diphthong when needed. The second position, the short or long vowel, is in the nucleus, which can optionally contain one or two X-slots (following Pesetsky 1979).

Placing the glide into the adjunct position allows a straight forward analysis of Menominee C+G phenomena. If the glides as the onset of the diphthong were in the rhyme, this structure would not allow for the phonological length distinction between the short diphthongs and long diphthongs.

When a G occurs, it first tries to fill the margin or coda, depending on the overall syllable structure of the word. If the onset is occupied, the margin is obligatory (Cairns & Feinstein 1982). G in the margin occurs intervocally and G in the coda is typically word-final. If the margin is already occupied by a C, the G is forced into the adjunct position. This specialized node in the syllable structure is restricted to G specified for TH (i.e. *w* /w/ or *y* /y/).

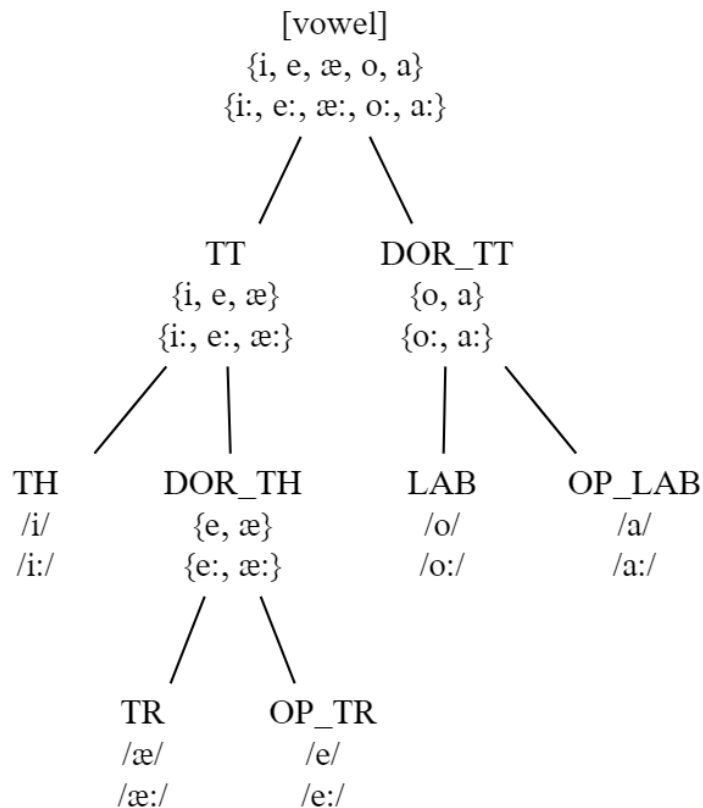
Following the hierarchy discussed above, and repeated here as Figure 5.11 and Table 5.9, we can see that placing the postconsonantal glides into the specialized margin gives insights into which distinctive features have precedence over others within the underlying vowel system of Menominee.

Figure 5.11: Short and long vowels in Menominee (repeated from Figures 5.2 and 5.3 above)

a. Feature Hierarchy:

Tongue Thrust > Labial > Tongue Height > Tongue Root

b. Contrastive Hierarchy:



c. Contrastive Segments:

/i/ /i:/	/æ/ /æ:/	/e/ /e:/	/o/ /o:/	/a/ /a:/
Tongue Thrust	Tongue Thrust	Tongue Thrust	Dorsal_TT	Dorsal_TT
Tongue Height	Dorsal_TH	Dorsal_TH	Labial	Oral Place_LAB
	Tongue Root	Oral Place_TR		

Table 5.9: Phonetic Gestures: Menominee Vowels

Dimension	/i/ /i:/	/æ/ /æ:/	/e/ /e:/	/o/ /o:/	/a/ /a:/
Tongue Thrust	[front]	[front]	[front]	DOR_TT	DOR_TT
Labial				[round]	OP_LAB
Tongue Height	[high]	DOR_TH	DOR_TH		
Tongue Root		[RTR]	OP_TR		

As discussed above, the short and long vowels are distinct rankings in the Bifurcated Ranking Model and therefore are not required to present identical contrastive feature patterns. The contrastively specified feature hierarchy of both the long and short systems is informed by the G+V combinations summarized in Table 5.8, as well as the vowel alternations discussed throughout the rest of this chapter. The glide+short vowel rules are as follows:

The patterns /Cw/ + /æ, o/ → [Co] and /#w/ + /æ / #/___ → [#o] (Lines 1 and 2 in Table 5.8) indicate that the LAB specification on the G in the adjunct spreads and deletes a TR specification in the nucleus (LAB > TR), shown in (2).

(2) /Cw/ + /æ, o/ → [Co]
 /#w/ + /æ / #/___ → [#o]

Input				Output	
[cons]	+ LAB	+ TR	→	[cons]	+LAB
C	G	V		CV	

The patterns /Cw/ + /e, i/ → [Ci] (Line 4 in Table 5.8) indicate that TH in the adjunct raises an underspecified TR phoneme, or OP_TR, in the nucleus (TH > OP_TR), shown in (3).

(3) /Cw/ + /e, i/ → [Ci]

Input					Output	
[cons]	+	TH	+	OP_TR	→	[cons] + TH
				TT		TT
C		G		V		CV

The pattern /Cy/ + /o/ → [Co] (Line 9 in Table 5.8) indicates that LAB in the nucleus will also delete TH preceding it in the adjunct (LAB > TH), shown in (4).

(4) /Cy/ + /o/ → [Co]

Input					Output	
[cons]	+	TH	+	LAB	→	[cons]+LAB
C		G		V		CV

The pattern /Cy/ + /æ/ → [Ce] (Line 10 in Table 5.8) indicates that TH in the adjunct and TR in the nucleus cancel each other out, leaving only a TT specification, which both are also specified for (TR † TH), as in (5).

(5) /Cy/ + /æ/ → [Ce]

Input					Output	
[cons]	+	TH	+	TR	→	[cons]+ TT
		TT		TT		DOR_TH
				DOR_TH		OP_TR
C		G		V		CV

The pattern /Cy/ + /e/ → [Ci] (Line 12 in Table 5.8) indicates that an underspecified TR, OP_TR phoneme in the nucleus is raised by TH in the adjunct (TH > OP_TR), as in (6).

(6) /Cy/ + /e/ → [Ci]

Input				Output	
[cons]	+ TH	+ OP_TR	→	[cons]	+ TH
		TT			TT
C	G	V			CV

Together, these patterns indicate the hierarchy presented above: TT > LAB > TH > TR for the short vowel system.

The glide+long vowel rules are as follows:

The patterns /Cw/ + /æ:, i:/ → [Ci:] (Line 3 in Table 5.8) indicates that TH in the adjunct raises TR in the nucleus (TH > TR), as in (7).

(7) /Cw/ + /æ:, i:/ → [Ci:]

Input				Output	
[cons]	+ TH	+ TR	→	[cons]	+ TH
		TT			TT
C	G	V			CV

The pattern /Cw/ + /e:/ → [Co:] (Line 6 in Table 5.8) indicates that LAB in the adjunct spreads to the underspecified TR, OP_TR in the nucleus (LAB > OP_TR), as in (8).

(8) /Cw/ + /e:/ → [Co:]

Input				Output
[cons]	LAB	+	OP_TR	→ [cons] + LAB
C	G		V	CV

The patterns /Cy/ + /æ:, i:/ → [Ci:] (Line 11 in Table 5.8) indicates that TH in the adjunct raises TR in the nucleus (TH > TR), as in (9).

(9) /Cy/ + /æ:, i:/ → [Ci:]

Input				Output
[cons]	TH	+	TR TT	→ [cons] + TH TT
C	G		V	CV

The pattern /Cy/ + /e:/ → [Ce:] (Line 13) in Table 5.8) indicates that TH raising in the adjunct is blocked by a lack of TR specification, OP_TR, or rather perhaps it cannot find any structure to affect, and only TT remains (TH † OP_TR), shown in (10).

(10) /Cy/ + /e:/ → [Ce:]

Input				Output
[cons]	TH TT	+	OP_TR TT	→ [cons] + TT DOR_TH OP_TR
C	G		V	CV

Together, these patterns indicate the hierarchy presented above: TT > LAB > TH > TR for the long vowel system.

The pattern $Cw + e /_w \rightarrow Cow$ (Line 5 in Table 5.8) indicates that LAB both before and after spreads the LAB feature to an underspecified TR phoneme, OP_TR (though oddly enough, not the maximally underspecified phoneme, $a /a/$ and $\bar{a} /a:/$). This is shown in (11).

(11) $Cw + e /_w \rightarrow Cow$

Input				Output			
[cons]	LAB	+	OP_TR	+	LAB	→	[cons] + LAB + LAB
	TH						
C	G		V		C		CVC

Finally, the diphthongs, or rather the patterns $/Cw/ + /a/ \rightarrow [Cwa]$; $/Cw/ + /a:/ \rightarrow [Cwa:]$; $/Cy/ + /a/ \rightarrow [Cya]$; and $/Cy/ + /a:/ \rightarrow [Cya:]$ (Lines 7, 8, 14, and 15 in Table 5.8) indicate that the maximally underspecified vowel, $a /a/$ and $\bar{a} /a:/$, similar to Line 13 above, has too little structure to be affected by the G in the adjunct. As a result, the G remains in position and forms a vowel in combination with the underspecified vowel: $ia, ua, ya, wa /ya:, wa:, ya, wa/$. This is shown in (12).

- (12) /Cw/ + /a/ → [Cwa]
 /Cw/ + /a:/ → [Cwa:]
 /Cy/ + /a/ → [Cya]
 /Cy/ + /a:/ → [Cya:]

Input				Output		
[cons]	LAB	+	OP_LAB	→	[cons]	LAB + OP_LAB
	TH		OP_TT			TH OP_TT
C	G		V			CGV
[cons]	TT	+	OP_TT	→	[cons]	TT + OP_LAB
	TH		OP_LAB			TH OP_TT
C	G		V			CGV

The glide+vowel patterns discussed here show that LAB dominates TH, which dominates TR. TH and TR occasionally cancel each other out ((5) and (10), leaving TT as the only specified feature. The discussion of Menominee Vowel Harmony below shows further interactions between TR and TH.

5.2. Other Menominee Rules Supporting the Contrastive Hierarchy

In the previous section, I outlined the underlying contrastive hierarchy that best represents the phonetic effects observed in Menominee. I have shown how the ‘glide + vowel’ alternations give insights into the underlying contrastive hierarchy. In this section, I walk through other rules affecting Menominee vowels and show that they too reflect this same hierarchical ranking of contrastive features.

5.2.1. *ae* Raising Revisited

In Chapter 2 I presented the three ‘*ae* Raising Rules’, which are repeated here in (13).

(13) *ae* Raising Rules

- a. /æ/ → [e] / # ___
- b. /æ/ → [e] / # C___ unless followed by /h/ or /ʔC/
- c. /æ/ → [e] / \bar{V} C___ unless followed by /ʔ/, /h/, /w/, or /y/

The contrastive features presented above indicate that this phenomenon can also be understood as a TR Deletion Rule, shown in (14).

(14) TR Deletion Rules

- a. TR → OP_TR / #___
TT TT
- b. TR → OP_TR / # C___ unless followed by GW [spread]; or GW [constrict] + C
TT TT
- c. TR → OP_TR / \bar{V} C___ unless followed by GW; or C specified for TH
TT TT

In (14) the TR gets deleted, leaving behind only a TT specification. In the short vowel system, a TR specification gets deleted in either word initial position, or immediately following a C [cons]. When following a C [cons], but still in the position of the initial vowel of the word, this rule is blocked by Glottal Width (GW) – either [spread] (/h/), or [[constrict] (/ʔ/) + [cons]]. When TR as a nucleus follows a previous syllable with a long vowel, the deletion is blocked by [cons][son] -without a [nasal] specification (*q, h, w, y*, but not *m, n*), or rather any GW specification, or a [cons] with TH specification.

5.2.2. Vowel Epenthesis Revisited

Section 5.1.5 discussed y-epenthesis as a form of hiatus resolution, and in this instance, the y serves its consonantal role of blocking two nuclei, not in the onset as the on-glide of a diphthong (which is another strategy of hiatus resolution).

Just as Menominee does not allow two nucleic vowels in a row (which frequently occurs at morpheme boundaries and is resolved via the processes discussed in 5.1.5 above), two consonants meeting at morpheme boundaries will similarly be separated by an intervening TT underspecified for TR and TH (DOR_TH, OP_TR). This rule applies to the short system, but vowel lengthening rules can apply after epenthesis has occurred. (15) shows the rule using contrastive features.

(15) $\emptyset \rightarrow$ TT / [cons] ___ [cons]
 DOR_TH
 OP_TR

5.2.3. Menominee Vowel Harmony Revisited

Menominee Vowel Harmony as described by Bloomfield (1962) affects the short and long vowels differently; it is an asymmetrical rule within the long and short systems. (16) repeats the rule as it was presented in Chapter 2 example (13) (from Bloomfield 1962; Macaulay 2018).

(16) Vowel Harmony Rule

$\left. \begin{array}{l} /e:/ \rightarrow [i:] \\ /o:/ \rightarrow [u:] \\ /o\?/ \rightarrow [u\?] \end{array} \right\} / _ (\dots) \{[i, i:, u, u:, Cy, Cw]\} \text{ UNLESS } ae /æ/ \text{ or } \bar{a}\bar{e} /æ:/ \text{ intervenes}$

This rule raises the two long mid vowels \bar{e} /e:/, \bar{o} /o:/ to long high vowels \bar{i} [i:], \bar{u} [u:]. The only vowel in the short system to raise is the short back mid vowel o /o/, and only when it precedes a glottal stop /ʔ/. The triggering environment is when the target (\bar{e} /e:/, \bar{o} /o:/, $o\text{ʔ}$ /oʔ/) is followed anywhere else in the word by one of the following: i [i], \bar{i} [i:], u [u], \bar{u} [u:], Cy /Cy/, or Cw /Cw/. ae /æ/ or $\bar{a}\bar{e}$ /æ:/ between the target and trigger will block vowel harmony, but a /a/ or \bar{a} /a:/ does not. Cy /Cy/ and Cw /Cw/ include the diphthongs as a trigger.

Vowel Harmony can also be understood as a Raising Rule by spreading the feature TH, which can be blocked by TR. Just as with the diphthongs above, a /a/ and \bar{a} /a:/ are affected differently than the other vowels. The glide+vowel patterns discussed above did not indicate that TH has any effect on the maximally underspecified vowel, and that same behavior occurs in vowel harmony as well. (17) restates Menominee Vowel Harmony with contrastive features.

(17) Vowel Harmony TH Spreading

Input				Output	
LAB	+	TH	→	LAB	
V		V, G		TH	
				V	
TT	+	TH	→	TT	
DOR_TH				TH	
OP_TR					
V		V, G		V	

TH spreads (backwards in the word) and adds TH to LAB, or TT. The phoneme already specified for TH, /i, i:/ remains the same as it cannot raise any higher. Interestingly, TR blocks

TH, so only the phoneme that is underspecified for TR, /e, e:/ marked with OP_TR, can raise.

TR also blocks TH in (5) above.

I also suggest, following Milligan (2000:251-252) and Oxford (2015:329-331, 2016:3-4), that Menominee Vowel Harmony is not asymmetrical between the short and long vowel systems. Oxford (2016) follows Miner (1979), who claims that short vowels “undergo almost complete neutralization” (Oxford 2016:2) to [ɪ] and [ʊ] and are only distinguishable before a laryngeal phoneme. Also following Milligan (2000), Oxford suggests that Menominee Vowel Harmony applies to both the short and long vowels, but that the short vowels are indistinguishable due to the neutralization, and therefore, do not have audible harmony. This makes for a more consistent theoretical analysis of Menominee Vowel Harmony and avoids the issue of asymmetrical short and long rules for the vowel harmony (Milligan 2000; Oxford 2016).

Chapter 4 of this dissertation looked in closer detail at the acoustic realizations of the short vowels. The short vowels *i* /i/, *e* /e/, and *ae* /æ/ that Miner (1979) and Milligan (2000) discuss as typically neutralizing to [ɪ] show a great deal of overlap within the acoustic space. As discussed previously, there are not enough *u* [u] tokens to make any generalized claims, so I cannot say much about the *u* and *o* that are reported to neutralize to [ʊ] (Miner 1979; Milligan 2000).

Figure 5.12 shows the short vowels for all the speakers from the dataset presented in Chapter 4. The ellipses encompass all vowel tokens within one standard deviation of the mean, or roughly 67% of the tokens for each vowel.

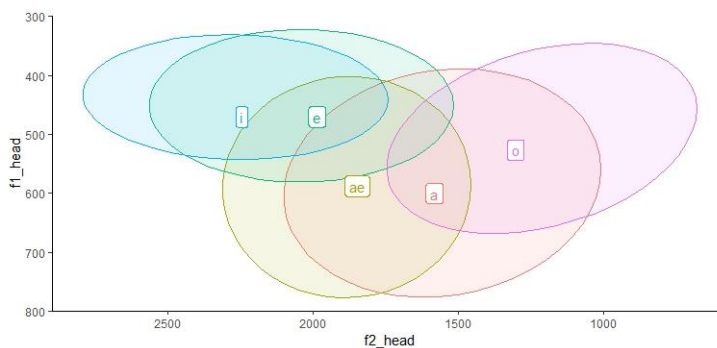


Figure 5.12: 1SD of all speakers' short vowels

As the discussion in Chapter 4 and this image show, *i* [i] and *e* [e] have a great deal of overlap in acoustic realization. In fact, for some speakers, there is almost no distinct acoustic space unique to either vowel. Chapter 4 suggests that the patterns of acoustic realization overlap between these vowels do not follow the predicted expectation from descriptions of allophony. These patterns of overlap do, however, suggest a great deal of not-yet-understood allophony.

When I coded the data and took the acoustic measurements, I did not code the short vowels if they were followed later in the word by TH without an intervening TR (the trigger for vowel harmony). I suggest that some of this overlapping, apparent free variation, in the *i* [i] and *e* [e] acoustic realizations could represent vowel harmony in the short vowels. If this is the case, it follows logically that there may be a raising pattern in the short *o* [o] as well, potentially deriving short *u* [u]. I leave this acoustic project for future research.

This analysis streamlines the Menominee Vowel Harmony Rule by removing the length asymmetry. This analysis also means that *o* /o/ in any morpheme potentially raises just as *ō* /o:/ does, and does not require a glottal stop /ʔ/ as part of the obligatory environment. Closer coding of the data and acoustic analysis of Menominee back vowels could examine this hypothesis more closely.

Figure 5.13 shows the overlap of the long vowels for comparison to the short vowels.

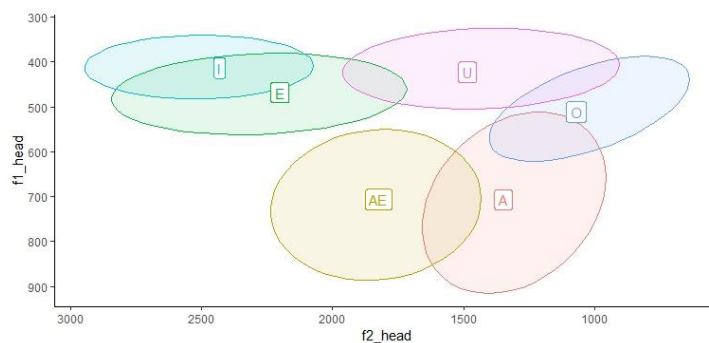


Figure 5.13: 1SD of all speakers' long vowels

This figure shows less overlap between the low and back vowels, but still a great deal of overlap between the long \bar{i} /i:/ and \bar{e} /e:/, which has not been described in the literature, just as described in Chapter 4. These two figures indicate more complexity in the allophonic patterns of Menominee vowels than the descriptive literature has indicated, and further study may illuminate more details about Menominee Vowel Harmony,

5.2.4. Palatalization and Glottal Effects Revisited

As discussed in Chapter 2, and shown through the examples in this chapter, there are a set of consonants that interact with the vowel rules, blocking, triggering, or acting as the target. In this section, I briefly review the rules as they were discussed in Chapter 2 and describe how the rule can be understood within a distinctive feature analysis.

The Palatalization and *N* morphophoneme rules are triggered by the same environment. The two rules are repeated here in (18) and (19).

(18) Palatalization rule

$$t \rightarrow c / ___ \{e, \bar{e}, y\}$$
(19) *N* morphophoneme rule
$$N \rightarrow s / ___ \{e, \bar{e}, y\}$$

Both of these rules are affected by TT. While *y* is specified for both TT and TH, it is actually the first position of the diphthongs, because the environment presented here would have *y* /*y*/ immediately following a consonant (either *N*/*s* or *t*/*c*). Therefore, the trigger for these rules is TT, but in a restricted set. *y* /*y*/ triggers the alternation with TT in the adjunct position of the syllable. *e* /*e*/ and \bar{e} /*e:*/ are specified only for TT, and are underspecified for TH and TR (DOR_TH and OP_TR). These three phonemes do not really seem to form a natural class of contrastive features, save for the presence of TT. The nucleus trigger for this alternation requires not only TT specification, but specifically requires underspecification for TH and TR. Example (18) from Chapter 2, repeated here as (20), show explicitly that *i* /*i*/ and $\bar{a}\bar{e}$ /*æ:*/ do not trigger palatalization, even though they share TT with *e* /*e*/ and \bar{e} /*e:*/.

(20) Palatalization examples

a. ahpēht- e -qtā-w	→ [ahpēh ce qtaw]	‘he, she, it (an) moves, works so fast’
b. ahpēht- y āhk-am	→ [ahpīh ci ahkam]	‘he or she deals with it to that point’
c. mamātāw-āpaht-am	→ [mamātāwāpahtam]	‘he or she looks upon it as miraculous’
d. akwāt- i kamekw	→ [akuatikamek]	‘roof’
e. naekot- ā ēs	→ [nekōtāēs]	‘all at once, suddenly’
f. awā ē tok-ēwe	→ [awā ē tokew]	‘he or she has spiritual power’

As the discussion in Chapter 2 shows, the palatalization triggers in Menominee run counter to implicational universals that have been posited for palatalization, which state that lower vowels (such as /*e*/) cannot trigger palatalization without the higher vowels (/i/) also triggering

palatalization (Chen 1973; Hall & Hamman 2006; Bateman 2007, 2011). A look at the diachrony of Menominee vowels will perhaps offer a solution to this issue. PA *i lowered to Menominee /e/ and the modern Menominee /i/ comes from PA *i coalescing with a glide (Miner 1979; Oxford 2015). PA *e split into modern Menominee /e/ and /æ/ (Bloomfield 1946; Goddard 1979; Miner 1979; Hockett 1981; Oxford 2015). Since there are two pathways to the modern Menominee /e/, Menominee has a morphophoneme *E* that does not “cause mutation” (Bloomfield 1962:81), or rather, does not palatalize a preceding *t* /t/. Palatalization in Menominee is most likely a remnant of palatalization in PA, triggered by the *i and *i: that are today *y* /y/, *i* /i/, and *ī* /i:/ (Salmons, p.c.). The *E* that does not cause palatalization corresponds to PA *e.

Raimy (p.c.) has suggested that the pattern of *t* is no different from that of *n*: there are essentially two patterns of *t* just as there are two patterns of *n*. The parallels are presented in (21).

(21) Parallels between *t* and *n*

- a. $t \rightarrow t$ / before anything but /e, e:, y/
 $t \rightarrow t$ / ___ [e, e:, y]
 $t \rightarrow c$ / ___ /e, e:, y/
- b. $n \rightarrow n$ / before anything but /e, e:, y/
 $n \rightarrow n$ / ___ /e, e:, y/
 $n \rightarrow s$ / ___ /e, e:, y/

While Bloomfield makes a diachronic case for the *N* morphophoneme, this pattern implies more parallels between the two cases than a shared triggering environment. The discussion above presents a diachronic analysis for the unexpected triggers of palatalization in Menominee, in

which it is the trigger and not the target that reflects a historical artifact. Further historical work on the morphophonemes is needed.

Additionally, several of the vowel rules discussed above are affected by *h* /h/ and *q* /ʔ/ as well. As the patterns such as (13) above have shown, laryngeal settings such as Glottal Width impact some of the vowel features. The glottal stop, GW [constrict] also blocks SSL in the first syllable of a word. A more detailed analysis of the contrastive features and feature hierarchical ranking would need to account for these uncommon patterns.

5.3. Conclusion

Menominee Vowel Harmony has been discussed at great length by previous researchers, but less attention has been paid to other vowel phenomena in the language. This chapter has addressed a variety of rules and patterns that are all representative of the same underlying contrastive phonological system.

In this chapter, I have proposed a contrastive hierarchy that represents the vowel rules and alternations observed in the Menominee language. I showed that the high back vowels can all be derived in their surface forms with the exception of a single /-ow/ morpheme that has unique raising, and thus *u* [u] and *ū* [u:] do not have phonological status in the underlying system. I also showed that the post-consonantal glides+vowels show the underlying feature hierarchy of Menominee vowels. The hierarchy I posit represents vowel length structurally, but it is still part of the phonological system, in order to show asymmetrical patterns between the short and long system.

The Bifurcated Ranking Model expands the applicability of the contrastive feature ranking and allows for asymmetrical inventories between the short and long vowel systems of a

language. This model does not contradict previous approaches to hierarchical feature rankings and contrastive specification, but rather enhances and expands upon them. By presenting this model through the lens of Algonquian languages, I show that contrastive feature models can also apply to understudied languages, and even highlight gaps in the literature on the language in question.

Chapter 6: Contributions and Conclusion

6.1. Introduction

This dissertation has presented a phonetic and phonological analysis of Menominee vowels. The duration study shows that long and short monophthongs have a statistically significant difference in duration, which is consistent with previous literature (Milligan 2000, 2005). This study also showed that the underlying length of a vowel significantly affects the surface duration for vowels that are underlyingly short and surface short and vowels that are underlyingly long and surface short. In addition to examining underlying and surface length as a variable, the duration study also looked at the durations of the short and long diphthongs. The short and long diphthongs are significantly different in duration from the short and long monophthongs, as well as each other.

The vowel quality study shows that long vowels are consistently peripheral to the short vowels. This data also indicates that not only is there a great deal of overlap in the realizations in the acoustic space among the short vowels, but that the long vowels show similar patterns. Only the acoustic space of the short front vowels showed patterns consistent with past descriptions of allophonic variation. The short back vowels, as well as the front and back long vowels all showed patterns of acoustic realization overlap that was not predicted in the literature.

The phonology chapter argues that *u* [u] and *ū* [u:] are only phonetic and not phonological in Menominee. The phonology chapter also includes a ranked feature hierarchy for the Menominee vowels, which is parallel between the long and short vowel systems. In order to fully address contrastive long and short vowels in Menominee, I have proposed a new way of structurally representing contrastive length within an underlying system. While length can be contrastive in a language, as it is in Menominee, it is not a feature (following Kenstowicz 1994). In order to incorporate contrastive length as a structural element where the other contrastive elements are

featural, I propose a Bifurcated Ranking Model of the short and long system to each other. The two systems can share nodes as far as the hierarchies of the features are parallel, but the extra split in the ranking allows for the two systems to diverge as well, if the data so indicates.

Chapter 5 shows that while the Menominee short and long systems are largely parallel, the model can be applied to an asymmetrical system as well (see discussion of Ojibwe in §5.1.1). This new model for incorporating contrastive length within a contrastive feature hierarchy allows for languages in which the short and long system diverges to a greater degree than in Menominee. The underlying hierarchy I propose for Menominee addresses the majority of observed vowel patterns in the language, while previous analyses have relied primarily on Menominee Vowel Harmony to inform the analysis (Oxford 2015, 2016). As Chapter 5 showed, the phonological vowel patterns of Menominee Vowel Harmony alone are not enough to inform the underlying ranked feature hierarchy of Menominee vowels. Other vowel phenomena must also be taken into account.

As the preceding chapters have discussed, Menominee vowels show some systematic variation. The data presented in Chapter 5 indicate that the vowel splits from Proto-Algonquian are most likely still in flux, especially the back vowels. Detailed historical analysis of the underlying systems of previous stages of Menominee, as Oxford (2015) presents for Proto-Algonquian, would aid in the understanding of the current underlying contrastive hierarchy.

The case studies examining the native speakers' vowels identified potential patterns of predictable allophonic variation of several of the vowels. While the data collected for this project was not robust enough to fully identify the allophonic patterns, the density plots of the formant measurements indicated several instances where the vowels were clustering in two

distinct areas of the acoustic space. I leave it to a future project to look at these potential patterns in closer detail.

6.2. Value to the Menominee

It is my hope that the work presented in this dissertation will be beneficial to the Menominee in many ways. The data presented and analyzed here provides insights into Menominee linguistics and supports future linguistic research on the language.

More concretely, I hope the work presented here aids the Menominee community in their language preservation and revitalization efforts. This dissertation project has supported Menominee preservation efforts by not only providing the first acoustic analysis of vowel quality of the language, but also by contributing to the repository of analyzed sound recordings for the online Menominee database. The database is used by instructors and students for language learning and contains audio recordings that allow users to hear native speakers of the language saying words and sentences in Menominee. Through the course of this project I transcribed over six hours of unanalyzed archival recordings, and I also helped conduct and analyze over six hours of current elicited recordings with the native speaker who works on the language preservation and revitalization projects, in addition to analyzing the audio already in the database. Through the course of this project I have relied heavily on the content contained within the online database. I have corrected errors, proposed updated underlying analyses of words and morphemes, added social and cultural information based on the recordings I was analyzing, and generally contributed to increasing the accuracy and usability of the database. From the archival and modern recordings, I extracted 98 lexemes that I added to the database as sound files, bringing the total number of lexemes in the database with associated audio to 1203.

6.3 Future Research and Conclusion

Menominee is an underdocumented language, and as such, the language is rife with possibilities for future research projects. The work presented in this dissertation also raised many specific questions for future work. Chapter 2 suggests a few avenues for future work on the Menominee metrical system. It seems that the glottal stop and perhaps the *h* /h/ may add weight to a syllable when in the coda, especially a short syllable. If this is the case, it appears as if this would account for glottal phenomena such as blocking ESL and affecting a variety of other consonant and vowel rules. A new, closer look at Menominee metrical structure may result in an analysis that is less typologically atypical.

As discussed briefly above, the patterns of Menominee vowel allophony are still not well understood. The data I presented in Chapters 4 and 5 show that the speakers I looked at as part of this project produced vowels that realize in ways completely unexpected from the previous literature (such as Miner 1979a; Milligan 2000, 2005; Oxford 2015). This indicates that either allophony in Menominee vowels has changed since Miner conducted his fieldwork (I am unaware of Milligan and Oxford making any independent claims about allophony that was not based on Miner's analysis), or that acoustic data indicates allophony that is and has been below the level of conscious awareness on the part of outside researchers and by-ear transcriptions. Miner's (1979a) claims about Menominee neutralization and allophony appear to be largely impressionistic and not a result of acoustic analysis or measurements. While I was not able to identify predictable patterns of vowel allophony, Chapter 4 discusses some patterns that may indicate predictable allophony in the vowels if more tokens were available. An acoustic analysis of the short vowels that are followed later in the word by a high vowel may indicate that some of the allophonic patterns that are described as being in free variation are actually participating in

the height harmony of vowel harmony. Further detailed analysis of the acoustics of Menominee vowels and their environments in the lexemes may provide a clearer picture of vowel allophony.

Duration and stress analyses of Menominee vowels would benefit from a closer analysis of the vowel or syllable position within a phrase or connected speech. A project of this sort would probably require a return to the original recordings of elicitation sessions with Menominee elders, and the MD would not be quite as useful as a resource. However, as I listed earlier, there are about 900 recordings of example sentences of varying length already in the MD. Coding for phrase position could result in different durational significance in different positions.

Finally, the contrastive hierarchical feature model, the Bifurcated Ranking Model, I proposed in Chapter 5 incorporates contrastive length (as a structural element) into a feature framework. Most contrastive hierarchical analyses have largely stayed away from addressing contrastive length save for a few (Oxford 2015; Spahr 2016), which I have discussed at length in the previous chapters. Ultimately, a hierarchical model should be adaptable to any language, and allow language-specific phonetic patterns to guide the phonological analysis. Future projects applying this model on other Algonquian languages with contrastive vowel length (such as Atsina, Meskwaki, Cree, Ojibwe, Miami-Illinois, Shawnee, Micmac, Munsee and Unami) would test and further refine the model I have proposed. Some of these languages still have a relatively large community of native speakers, which would allow for a closer examination of the linguistic phenomena through conversation and elicitation with the speakers.

Menominee has an estimated three to five remaining native speakers who are quite elderly, and as such many questions about specific linguistic patterns or less-well described allophony or neutralization remain unanswered. However, there is a growing community of fluent L2 speakers and the immersion daycare has just completed its second year of full immersion for its

students, and is gearing up for a third year. I look forward to these new speakers becoming a part of a robust and active Menominee language speaking community.

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APPENDIX I: F1 AND F2, HEAD AND TAIL MEASUREMENTS

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_1	a	578.7174	1820.125	648.2387	1609.682
NS_1	a	504.1713	2234.255	517.4078	2108.971
NS_1	a	568.282	1674.733	549.4599	1510.593
NS_1	a	639.0437	1726.614	679.7312	1554.652
NS_1	a	503.2203	1803.628	481.7393	1591.162
NS_1	a	495.8484	1127.846	514.3974	1196.648
NS_1	a	607.8192	1692.707	615.3854	1543.277
NS_1	a	628.6602	1235.87	584.2108	1518.897
NS_1	a	570.9324	1625.484	561.7514	1391.206
NS_1	a	571.556	1887.93	516.5062	1584.59
NS_1	a	647.5029	1440.345	597.0265	1490.295
NS_1	a	609.5307	1213.164	798.2861	1078.596
NS_1	a	442.8221	1808.86	473.7868	1361.114
NS_1	a	367.2279	1209.905	279.2761	1306.725
NS_1	a	400.2118	1476.964	412.9822	1684.175
NS_1	a	613.1206	1705.154	471.5493	1714.775
NS_1	a	680.235	1272.555	684.3574	1171.435
NS_1	a	486.0713	1717.066	507.1939	1421.991
NS_1	a	537.2641	1777.856	566.0528	1725.14
NS_1	a	701.7257	1782.498	755.6681	1688.708
NS_1	a	829.2665	1436.616	882.8461	1204.247
NS_1	a	625.9763	1810.06	619.9305	1818.805
NS_1	a	655.5322	1200.193	550.8299	1313.701
NS_1	a	483.587	1924.502	410.0864	1874.211
NS_1	a	760.9035	1189.179	627.5201	1236.156
NS_2	a	1312.471	2292.232	1324.787	2434.557
NS_2	a	729.8637	1602.692	614.1851	1133.421
NS_2	a	633.6049	1169.162	1119.164	2122.199
NS_2	a	389.1354	1734.644	1431.357	2368.608
NS_2	a	304.7149	1251.057	374.5777	1138.527
NS_2	a	649.7264	1548.985	372.4982	1446.447
NS_2	a	990.6489	2217.026	1229.485	2230.446
NS_2	a	404.9958	1395.423	326.9042	1326.966
NS_2	a	423.0622	1515.289	363.9775	1575.774
NS_2	a	359.7869	1627.434	358.0367	1695.901
NS_2	a	370.479	1510.903	363.4094	1575.048
NS_2	a	553.6541	1981.364	464.8467	2079.53
NS_2	a	530.0703	867.7639	576.9252	1615.14
NS_2	a	780.6267	1535.487	412.1877	1765.606
NS_2	a	447.5661	1079.446	412.8286	1213.239
NS_2	a	742.0136	1144.258	534.2898	1354.764
NS_2	a	539.5525	2155.412	517.4471	1563.083

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	a	597.8685	1383.459	682.9333	1569.03
NS_2	a	340.0748	1819.74	313.9839	1908.668
NS_2	a	481.1183	1846.155	443.4746	2085.841
NS_2	a	413.7843	1978.682	451.3234	1888.667
NS_2	a	539.9804	938.5013	568.9802	1109.363
NS_2	a	490.753	1161.68	536.4698	1282.089
NS_2	a	735.6363	1093.286	772.9559	1263.382
NS_2	a	501.7645	1609.784	654.6695	1254.074
NS_2	a	367.2543	1621.68	365.666	1503.862
NS_2	a	466.4813	1533.455	469.9816	1220.177
NS_3	a	661.7472	1444.931	745.883	1102.349
NS_3	a	534.1825	1758.871	532.2226	1398.549
NS_3	a	692.3675	1578.664	882.7679	1550.179
NS_3	a	687.521	1154.534	878.8297	1548.481
NS_3	a	649.4216	1216.323	687.0286	1235.032
NS_3	a	575.1648	1714.183	624.3471	1579.972
NS_3	a	561.9139	1989.806	564.6342	2059.38
NS_3	a	617.1801	755.227	673.4262	874.5991
NS_3	a	1360.746	1900.408	1441.875	2313.135
NS_3	a	639.1339	2108.774	595.4928	1778.948
NS_3	a	471.8293	1938.229	647.7692	1915.054
NS_3	a	569.6116	1849.966	565.9663	1735.396
NS_3	a	227.2447	1810.277	184.6504	1693.705
NS_3	a	248.0015	1514.005	793.8301	2373.018
NS_3	a	929.7562	1738.486	943.094	1784.938
NS_3	a	422.9021	996.7897	807.3063	1898.626
NS_3	a	429.0751	1387.257	641.3938	1672.76
NS_3	a	500.8943	1708.81	463.6883	1677.621
NS_3	a	482.4964	1755.351	430.7066	1870.292
NS_3	a	563.9067	885.6944	334.4176	985.7243
NS_3	a	623.0065	2560.444	502.7744	1263.053
NS_3	a	558.3799	1617.133	537.6834	1134.893
NS_3	a	538.8261	759.281	420.8019	898.2901
NS_3	a	903.1265	1518.673	293.0694	1007.588
NS_3	a	837.0774	1618.399	559.0549	1682.215
NS_3	a	460.2083	1701.584	454.1849	1757.355
NS_3	a	529.9154	1112.569	627.2314	1754.52
NS_3	a	564.5094	1815.321	564.1816	1802.333
NS_3	a	528.8432	2263.978	473.1902	2352.234
NS_3	a	734.642	898.0422	696.9226	2024.638
NS_3	a	509.9377	1582.914	485.3511	1531.723
NS_3	a	680.0208	1550.621	406.4111	1528.508
NS_3	a	940.35	1369.078	366.7975	1310.223

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	a	836.0775	1478.227	1157.679	1929.569
NS_3	a	665.8173	1916.046	712.3611	1654.685
NS_3	a	540.3911	1652.207	487.1736	1812.296
NS_3	a	677.8959	1973.21	713.8741	2055.396
NS_3	a	656.7453	1843.207	687.395	1567.482
NS_3	a	428.9868	1830.504	799.167	1894.125
NS_3	a	539.0913	1729.036	508.8903	1630.52
NS_3	a	753.199	1585.632	1047.16	1663.668
NS_3	a	529.7813	1852.168	414.5004	2091.752
NS_3	a	758.5144	2716.362	742.5411	2309.783
NS_3	a	553.0288	771.0302	508.3274	784.3491
NS_3	a	600.5588	1859.508	533.2349	1874.204
NS_3	a	402.2857	1473.925	194.5405	1489.676
NS_3	a	575.4249	1594.256	443.0326	1564.9
NS_3	a	318.4538	1309.301	506.7376	1245.575
NS_3	a	910.7684	1928.749	900.811	1881.912
NS_3	a	702.6023	1868.981	853.7541	1762.011
NS_3	a	395.7599	1015.342	587.3459	1520.656
NS_3	a	584.2783	1327.717	811.539	2250.243
NS_3	a	651.6129	1590.204	684.403	1488.219
NS_3	a	521.8323	1421.337	483.6721	1444.242
NS_3	a	609.2851	870.2374	631.2811	1808.002
NS_3	a	699.5444	1974.198	668.6321	2015.664
NS_3	a	509.2498	1537.366	433.558	1555.501
NS_3	a	442.841	949.0636	428.6293	1384.798
NS_3	a	663.9748	1770.582	594.0583	1790.345
NS_3	a	480.7098	1911.84	887.3308	1502.307
NS_3	a	614.5629	1732.312	571.4509	2098.324
NS_3	a	570.5133	1928.122	388.6749	1633.467
NS_3	a	643.9963	1918.61	750.2695	1496.731
NS_3	a	561.8592	814.7062	766.5156	1386.523
NS_3	a	437.1752	2041.396	427.4632	2176.668
NS_3	a	657.2134	1481.937	629.7583	1541.686
NS_3	a	914.271	1543.527	899.6145	1539.819
NS_3	a	551.9321	1026.649	528.2851	996.2544
NS_3	a	216.9723	1462.399	172.908	2069.561
NS_3	a	512.3155	2010.817	539.1225	2022.583
NS_3	a	871.9323	1705.558	890.2016	1707.368
NS_3	a	491.1826	1785.267	456.2743	1597.515
NS_3	a	686.013	1784.943	615.82	1925.06
NS_3	a	491.1318	1433.206	334.2441	1136.225
NS_3	a	1101.804	2787.714	970.4399	2321.633
NS_3	a	958.4894	2363.283	1525.639	2026.614

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	a	519.3299	1003.91	555.9457	1027.256
NS_3	a	493.4853	1389.807	268.9189	1569.104
NS_3	a	449.1345	1744.196	539.3252	1623.762
NS_3	a	630.5403	1612.287	606.1252	1626.502
NS_3	a	591.067	2006.419	674.1503	1914.138
NS_3	a	702.7602	1714.226	710.0403	1559.34
NS_3	a	623.9538	1021.338	682.7674	1103.944
NS_3	a	588.454	1086.198	660.5757	1276.903
NS_3	a	668.06	1591.359	608.3507	1546.68
NS_3	a	524.1146	1880.718	549.9424	1994.594
NS_3	a	533.9164	1896.856	474.0887	1986.873
NS_3	a	654.4513	2046.714	452.7156	2122.185
NS_3	a	752.3558	1692.822	932.149	1803.909
NS_3	a	701.9957	2092.485	606.0148	2128.356
NS_3	a	895.1528	1845.948	1035.372	1899.387
NS_3	a	628.2559	1940.657	556.9649	2085.877
NS_3	a	618.4658	1400.258	901.6971	1792.616
NS_3	a	804.9845	2086.195	631.1243	2242.82
NS_3	a	555.3647	1024.18	473.7102	834.9928
NS_3	a	865.9377	1813.757	760.4587	2203.74
NS_3	a	445.3343	1799.567	596.515	1757.465
NS_3	a	458.302	1832.325	467.4619	1947.352
NS_3	a	765.2424	1515.83	644.433	1748.942
NS_3	a	729.5902	1571.736	683.5578	1542.652
NS_3	a	695.1674	2304.276	385.5317	2235.399
NS_3	a	525.4318	1720.095	546.8145	1640.437
NS_3	a	617.6428	1827.734	564.7101	1695.215
NS_3	a	603.3127	1715.541	534.6846	1714.875
NS_3	a	633.919	1870.148	646.9574	2120.525
NS_3	a	565.4781	2273.429	554.9704	2260.929
NS_3	a	1572.103	2657.637	1205.803	2753.617
NS_3	a	766.1591	1895.372	571.5872	1962.084
NS_3	a	646.3287	2169.499	412.3984	2080.93
NS_3	a	609.0949	1873.504	575.801	1984.785
NS_3	a	277.2429	1962.334	274.9069	1812.739
NS_3	a	720.0761	2174.827	757.698	1861.565
NS_3	a	608.7172	1341.519	655.6689	1356.121
NS_3	a	562.8192	1414.059	668.3623	1343.507
NS_3	a	1157.304	1897.219	777.6236	1817.483
NS_3	a	1558.554	2138.558	1012.698	2295.277
NS_3	a	461.7007	1572.81	486.2214	1763.542
NS_3	a	358.7466	1822.689	286.027	1803.547
NS_3	a	759.4987	1593.495	707.1525	1567.294

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	a	621.2307	1350.573	506.8121	1229.936
NS_3	a	423.1918	1901.868	1433.636	2694.98
NS_4	a	634.5302	2018.86	694.0839	2241.791
NS_4	a	717.5223	1623.72	674.1923	981.2032
NS_4	a	927.1207	1469.959	852.1086	1281.024
NS_4	a	514.8609	1125.749	460.4141	1077.026
NS_4	a	611.7993	1281.594	685.588	1128.633
NS_4	a	726.8841	1360.157	618.7535	1166.994
NS_4	a	529.5462	2733.436	490.6775	2070.647
NS_4	a	539.2569	1250.814	639.6804	1692.425
NS_4	a	587.4908	1942.727	612.2261	2107.372
NS_4	a	753.1737	2231.254	194.09	2078.137
NS_4	a	449.0588	2914.7	436.6266	2868.887
NS_4	a	733.7188	1051.111	628.3255	1125.841
NS_4	a	691.4418	1347.44	659.7171	1079.634
NS_4	a	504.9504	837.6603	505.4728	729.2063
NS_4	a	624.5234	864.2091	663.6855	1075.922
NS_4	a	638.803	892.1298	368.2299	949.1102
NS_4	a	527.9894	2726.452	498.0068	2729.688
NS_4	a	522.7375	814.3613	511.7316	2757.824
NS_4	a	505.3183	994.5864	491.9661	1029.48
NS_4	a	529.904	1389.199	523.1163	1359.308
NS_4	a	669.7899	1510.835	640.8655	1304.016
NS_4	a	796.1202	1129.677	753.9915	1202.487
NS_4	a	531.7245	1445.912	533.4204	1436.448
NS_4	a	432.3046	1492.924	413.7468	1528.816
NS_4	a	523.3245	1462.099	492.8667	1637.144
NS_4	a	625.3345	1414.112	579.8073	913.0272
NS_4	a	485.1622	1071.979	448.9169	1261.611
NS_4	a	546.532	1375.585	580.0096	1006.078
NS_4	a	497.7303	739.1091	466.291	828.9464
NS_4	a	587.4687	1198.39	595.2944	1471.376
NS_4	a	677.9051	1346.967	701.4536	1163.447
NS_4	a	489.2734	956.8201	481.3342	939.1082
NS_4	a	623.704	1596.255	526.2094	1425.697
NS_4	a	494.0737	1977.872	434.9828	2062.917
NS_4	a	766.3283	1407.284	750.4417	1376.146
NS_4	a	487.1458	2096.875	465.0591	2024.596
NS_4	a	358.483	2187.572	356.4842	2158.551
NS_4	a	532.2732	1285.733	447.1305	1287
NS_4	a	647.9842	1082.921	558.1249	1000.302
NS_4	a	422.2249	1638.509	406.7374	1635.159
NS_4	a	808.5502	1494.284	556.445	1466.39

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	a	515.1007	1292.332	514.9596	1265.363
NS_4	a	503.9162	875.4294	550.0072	829.1532
NS_4	a	641.6421	1263.509	653.9724	1336.735
NS_4	a	547.4439	1471.873	489.2122	1593.291
NS_4	a	738.1728	1698.745	672.3947	1243.258
NS_4	a	598.4777	1414.093	552.243	1350.333
NS_4	a	542.5495	1104.644	500.9554	1055.077
NS_4	a	768.4159	1634.726	559.3153	1839.812
NS_4	a	843.6681	2115.649	1063.869	2192.333
NS_4	a	506.3232	941.5577	418.6983	761.077
NS_4	a	429.6644	1503.704	455.1195	1473.835
NS_4	a	437.9492	2170.385	497.0043	2029.378
NS_4	a	599.4843	1399.142	556.3608	2053.482
NS_4	a	622.8874	1392.076	504.0194	1686.477
NS_4	a	471.0987	917.8967	412.985	1130.151
NS_4	a	860.8434	1296.922	794.1882	1283.555
NS_4	a	669.3048	2519.488	1119.461	2111.788
NS_4	a	521.6915	1379.87	569.761	1451.472
NS_4	a	533.48	1325.293	566.6133	1372.09
NS_4	a	732.3661	2209.897	545.9593	1457.548
NS_4	a	649.056	1069.637	652.2173	1057.773
NS_4	a	709.589	2454.112	438.3218	2001.751
NS_4	a	370.5743	1975.28	451.9468	2574.392
NS_4	a	450.7723	1768.691	403.077	1950.936
NS_4	a	703.4976	907.859	689.663	841.8982
NS_4	a	1073.999	1873.783	933.8323	1589.765
NS_4	a	605.6016	896.3947	619.9739	932.4376
NS_4	a	592.1745	1504.311	582.0779	1205.271
NS_4	a	442.9621	1262.082	301.4365	1249.489
NS_4	a	436.2556	1277.808	392.7322	1116.862
NS_4	a	695.9513	1342.327	845.1658	1425.425
NS_4	a	539.619	1604.977	653.3565	1683.59
NS_4	a	466.6172	1846.99	439.9527	1513.327
NS_4	a	618.2456	912.8401	623.099	1409.595
NS_4	a	522.8424	1029.852	494.1113	913.023
NS_4	a	557.7103	1519.328	887.2884	2166.495
NS_4	a	470.0735	1191.316	457.5311	1509.359
NS_4	a	472.1398	850.4941	449.2838	978.1007
NS_4	a	618.6337	2023.067	704.8547	1965.051
NS_4	a	466.6416	2053.181	291.3383	2112.648
NS_4	a	463.1229	2218.848	540.5833	2514.752
NS_4	a	528.3857	1592.322	515.0627	1572.201
NS_4	a	311.3533	1647.609	231.1466	1657.248

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	a	666.6465	1346.203	638.8714	1163.65
NS_4	a	551.0566	1530.593	633.4292	1509.006
NS_4	a	547.4439	1471.873	489.2122	1593.291
NS_4	a	738.1728	1698.745	672.3947	1243.258
NS_4	a	496.5643	1186.053	481.1047	1214.906
NS_4	a	551.0566	1530.593	633.4292	1509.006
NS_5	a	632.8889	1619.943	736.0725	1697.201
NS_5	a	535.0011	1312.294	401.8737	1318.823
NS_5	a	469.7602	1756.677	388.9224	1799.581
NS_5	a	498.828	1412.85	623.2401	1477.445
NS_5	a	514.0023	1273.041	507.4471	1294.824
NS_5	a	815.5534	2127.931	340.041	1002.367
NS_5	a	301.9848	1583.127	487.9945	2010.772
NS_5	a	561.8039	1132.71	539.7363	1270.889
NS_5	a	484.6939	782.432	464.224	697.5364
NS_5	a	487.0017	1356.553	510.5815	1610.239
NS_5	a	418.0457	2275.025	535.9194	1716.704
NS_5	a	633.5475	1079.913	648.059	1005.061
NS_5	a	787.4944	1628.808	641.3232	1436.179
NS_5	a	563.7406	1172.383	722.2431	1408.086
NS_5	a	732.7963	1819.529	602.0266	1814.955
NS_5	a	499.2951	1757.259	605.4753	1692.405
NS_5	a	441.6575	957.3007	393.3819	929.3751
NS_1	A	778.7716	2030.386	855.0592	1305.741
NS_1	A	970.2846	1313.174	832.3679	1744.938
NS_1	A	729.4978	1301.998	752.2322	1380.581
NS_1	A	1077.418	1429.959	904.6309	1260.787
NS_1	A	936.4238	1327.715	1040.367	1320.707
NS_1	A	616.9673	1659.183	586.2066	1757.189
NS_1	A	663.6361	1727.948	652.0331	1756.999
NS_1	A	592.9574	1436.513	751.9907	1247.172
NS_1	A	801.8846	1336.747	732.7362	1314.218
NS_1	A	815.7124	1622.844	771.1583	1583.363
NS_1	A	749.3747	1394.157	942.305	1735.441
NS_1	A	681.9682	1602.31	666.6272	1505.204
NS_1	A	657.1392	1479.998	703.7916	1267.364
NS_1	A	766.0816	1487.074	681.0792	1269.827
NS_2	A	691.8578	1294.814	809.8509	1292.027
NS_2	A	647.4039	1160.265	690.6926	1169.187
NS_2	A	506.4644	1289.29	317.3491	1412.493
NS_2	A	849.9177	1170.935	977.1574	2050.697
NS_2	A	777.0006	1175.473	543.8763	1204.182
NS_2	A	419.3882	1174.111	334.2947	961.6812

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	A	407.0658	1325.003	394.4946	1267.064
NS_2	A	844.7058	1366.045	1032.522	1983.942
NS_2	A	899.0553	1583.254	457.2166	1767.234
NS_2	A	473.7964	1203.115	387.1491	960.191
NS_2	A	384.0642	1311.021	863.8188	1986.487
NS_2	A	769.5543	1214.115	932.9652	1300.155
NS_2	A	603.6555	1231.441	907.3595	1328.566
NS_2	A	610.1073	1304.865	630.6971	1277.503
NS_2	A	895.5059	1524.226	889.7419	1232.868
NS_2	A	806.033	1202.017	590.0864	1102.367
NS_2	A	751.3064	1733.058	797.7916	1507.875
NS_2	A	353.2804	1263.163	342.4964	1397.86
NS_2	A	657.8353	1537.982	590.0445	1499.932
NS_2	A	367.8837	1323.696	454.0309	1440.12
NS_2	A	825.7973	1331.178	717.2863	1526.01
NS_2	A	571.8667	1613.551	578.816	1636.6
NS_2	A	616.8551	1186.919	460.2678	1112.27
NS_3	A	736.564	1042.78	993.0924	1522.191
NS_3	A	279.9437	1040.334	302.688	1118.483
NS_3	A	419.0342	2868.519	452.5005	2832.269
NS_3	A	916.0839	1564.739	964.7236	1693.609
NS_3	A	542.9092	1400.784	585.0291	1617.982
NS_3	A	819.3443	1467.198	822.8462	1384.613
NS_3	A	639.9093	1474.044	686.5831	1214.896
NS_3	A	1082.775	1676.532	1270.596	1557.039
NS_3	A	839.2323	1902.963	1174.975	1631.689
NS_3	A	817.8188	1486.419	798.6334	1366.971
NS_3	A	754.911	1270.023	667.2149	1520.806
NS_3	A	770.9583	1434.348	1006.197	1709.512
NS_3	A	615.6904	1042.558	754.1334	1072.495
NS_3	A	771.18	1662.432	984.9011	1454.007
NS_3	A	740.9654	1734.108	778.8876	1544.724
NS_3	A	1161.265	1438.748	1078.872	1376.282
NS_3	A	989.8349	1431.266	765.8202	1360.558
NS_3	A	664.9621	1114.652	832.0009	1142.665
NS_3	A	713.5492	1202.978	936.1402	1432.534
NS_3	A	1057.662	1566.937	990.0792	1327.097
NS_3	A	849.9892	1366.68	886.8378	1339.859
NS_3	A	815.0021	1242.916	1021.803	1726.411
NS_3	A	799.6988	1346.256	796.5412	1487.301
NS_3	A	862.9744	1630.396	659.9336	1632.307
NS_3	A	709.9765	1480.886	797.8089	1299.922
NS_3	A	425.3769	1576.924	493.5208	1736.399

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	A	979.1384	1497.891	917.04	1277.153
NS_3	A	857.0037	1317.857	866.6785	1306.413
NS_3	A	508.0274	1520.178	863.3867	1565.661
NS_3	A	329.5458	2356.425	359.3314	2567.256
NS_3	A	902.0198	1670.736	908.0044	1416.756
NS_3	A	445.3625	2002.777	398.3448	1910.244
NS_3	A	944.3937	1546.939	995.4525	1447.453
NS_3	A	790.2609	1553.48	872.331	1697.169
NS_3	A	730.4505	1125.708	751.3435	1118.622
NS_3	A	745.2034	1524.848	825.7174	1577.204
NS_3	A	595.7362	1007.521	756.1125	1132.375
NS_3	A	853.7134	1425.93	944.2592	1446.025
NS_3	A	1159.848	2285.566	1064.611	1984.885
NS_3	A	922.2886	1393.298	991.0291	1615.041
NS_3	A	788.6505	1177.849	850.1249	1341.979
NS_4	A	586.6499	1248.699	627.3439	1200.206
NS_4	A	715.1707	1251.184	447.6156	1075.654
NS_4	A	736.8828	998.6879	707.3165	1023.392
NS_4	A	806.6472	1359.556	803.2968	1192.383
NS_4	A	656.8834	1301.044	569.5759	1382.741
NS_4	A	660.1659	1190.259	667.0981	1251.406
NS_4	A	613.38	1223.765	480.4041	1091.177
NS_4	A	505.8437	1538.36	584.1104	740.9975
NS_4	A	681.1004	1091.927	784.261	1271.688
NS_4	A	598.3952	1159.971	562.3441	1056.288
NS_4	A	737.3478	1007.244	475.1817	1105.471
NS_4	A	710.3624	1006.386	516.1433	929.7847
NS_4	A	754.3839	1300.566	808.6579	1183.407
NS_4	A	687.5432	1197.874	691.8466	1136.978
NS_4	A	660.2958	1002.737	487.4802	1120.294
NS_4	A	671.4733	1280.834	602.6803	1126.18
NS_4	A	677.9193	1077.474	597.6812	1004.636
NS_4	A	759.4251	1089.757	801.835	1164.068
NS_4	A	664.8457	1047.596	497.9359	1042.146
NS_4	A	805.9288	1643.805	841.2426	2253.851
NS_4	A	600.7249	819.9508	482.8929	922.6583
NS_4	A	697.7365	1710.265	647.4172	1351.362
NS_4	A	439.3413	964.8473	486.8378	1047.459
NS_4	A	624.2499	1125.699	549.1454	1110.864
NS_4	A	874.2771	1356.018	656.692	1241.472
NS_4	A	772.9292	968.9825	699.8711	1091.914
NS_4	A	565.0683	964.655	693.4759	1148.24
NS_4	A	808.7688	1141.649	435.0518	968.5362

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	A	854.1919	1307.16	723.2428	1149.681
NS_4	A	722.0776	1333.649	535.7659	1164.114
NS_4	A	687.0777	1631.881	554.1951	1582.124
NS_4	A	691.8923	1095.093	701.0731	1102.894
NS_4	A	778.1282	993.2079	628.17	842.8769
NS_4	A	760.5677	1269.535	780.1279	1271.095
NS_4	A	645.2654	1016.261	638.3371	1001.769
NS_4	A	1050.849	1688.601	1036.023	1648.61
NS_4	A	689.9366	1144.434	633.2696	1087.657
NS_4	A	457.5269	1149.745	442.483	969.961
NS_4	A	702.4225	957.397	697.6308	1069.758
NS_4	A	676.5633	834.0519	705.9895	1466.84
NS_4	A	601.3271	969.1692	661.68	1004.162
NS_4	A	724.1891	805.498	763.4218	884.4247
NS_4	A	422.3128	986.2796	507.7077	1057.917
NS_4	A	728.0205	1207.438	642.8823	1110.323
NS_4	A	477.3019	1037.502	548.6376	1057.533
NS_4	A	688.6627	1638.494	820.8709	1285.719
NS_4	A	903.5083	1682.377	559.7814	1254.754
NS_4	A	700.3285	1098.174	710.977	1002.391
NS_4	A	736.8133	1097.3	812.4196	1193.66
NS_4	A	742.9126	1505.087	809.6242	1309.066
NS_4	A	657.6949	947.672	739.0537	1135.583
NS_4	A	798.2819	1219.916	664.5275	1132.882
NS_4	A	575.4836	1078.972	780.4249	1111.993
NS_4	A	556.7731	1046.329	656.1477	1053.872
NS_4	A	695.8776	1305.02	708.9996	1413.017
NS_5	A	790.5966	1693.5	861.3753	2308.655
NS_5	A	553.3516	1266.648	248.331	1226.009
NS_5	A	768.3964	1393.408	736.8716	1334.008
NS_5	A	719.8558	2057.979	791.148	2178.822
NS_5	A	800.3317	1148.912	814.019	1178.319
NS_5	A	664.8843	1130.997	732.0518	1175.184
NS_5	A	719.3564	1017.429	769.2321	1012.269
NS_5	A	789.0373	1173.174	721.6413	1221.55
NS_5	A	516.5286	1240.75	324.9621	1106.859
NS_5	A	399.4913	1564.575	511.7477	2333.536
NS_5	A	627.6957	1672.884	599.3578	937.3726
NS_5	A	532.3686	1297.576	350.4386	949.2479
NS_5	A	622.6222	1459.293	765.06	1263.284
NS_1	ae	657.9606	2082.861	635.8932	1984.139
NS_1	ae	683.6833	1598.523	690.9057	1657.035
NS_1	ae	599.9553	1690.455	645.0424	1748.655

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_1	ae	472.1317	2401.247	559.4793	1595.04
NS_1	ae	595.0449	2096.387	640.2448	1772.051
NS_1	ae	628.035	1460.218	624.2572	1448.666
NS_1	ae	611.0406	1741.897	626.208	1746.985
NS_1	ae	728.8393	1857.114	734.7774	1887.238
NS_2	ae	565.9915	1415.645	467.7411	1355.637
NS_2	ae	327.8924	1606.084	705.6331	2014.967
NS_2	ae	504.6775	1711.622	423.2164	1833.452
NS_2	ae	766.1097	1928.299	456.6231	1885.828
NS_2	ae	765.0918	1112.633	610.8473	1725.856
NS_2	ae	759.9785	1891.254	1129.22	2185.845
NS_2	ae	346.1049	1679.239	347.6813	1736.083
NS_2	ae	365.1706	2157.65	250.2997	2240.202
NS_3	ae	444.3478	2209.292	388.9156	2215.483
NS_3	ae	636.1797	1864.204	702.7425	1809.939
NS_3	ae	529.326	2492.772	650.6814	2306.254
NS_3	ae	500.4248	1797.135	850.4994	1660.801
NS_3	ae	556.3214	1579.376	582.3983	1567.929
NS_3	ae	655.3865	2210.928	710.7181	2006.411
NS_3	ae	1063.865	1885.186	1120.927	1770.709
NS_3	ae	687.7888	2082.699	719.9624	1986.917
NS_3	ae	728.0641	2046.656	828.4249	2055.493
NS_3	ae	726.5572	1870.179	717.3207	2005.786
NS_3	ae	792.3729	1960.106	872.9716	1815.838
NS_3	ae	934.6201	1625.617	1095.817	1530.989
NS_3	ae	824.4344	1101.291	882.8665	1080.747
NS_3	ae	264.8692	2431.903	214.3002	1864.017
NS_3	ae	493.1928	1053.957	536.0011	1016.98
NS_3	ae	587.0825	1996.003	661.4802	2081.16
NS_3	ae	467.9987	1990.815	550.8658	1881.889
NS_3	ae	466.3884	2117.993	344.6165	2146.909
NS_3	ae	561.0177	1096.054	475.5557	998.081
NS_3	ae	580.7276	2170.561	609.1285	2260.442
NS_3	ae	683.3333	2231.806	679.6336	2239.999
NS_3	ae	696.2263	2330.202	601.4193	2336.077
NS_3	ae	694.1526	1804.783	717.769	1830.127
NS_3	ae	438.7141	1069.4	344.0849	979.7677
NS_3	ae	505.4009	2013.242	490.4602	1979.171
NS_3	ae	529.1024	2135.244	512.194	2092.396
NS_3	ae	630.9213	2104.459	756.0333	2034.316
NS_3	ae	431.4073	1867.211	513.3156	1953.298
NS_3	ae	713.07	2041.528	547.6772	1807.513
NS_3	ae	708.4653	1829.116	724.6842	1853.996

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	ae	502.8084	2052.202	644.3489	2621.397
NS_3	ae	602.6661	1755.174	619.2981	1808.857
NS_3	ae	627.3911	1911.259	636.026	2060.307
NS_3	ae	426.8001	1850.118	317.1074	1962.369
NS_3	ae	575.8441	1677.57	639.7218	1534.733
NS_3	ae	293.9782	1751.409	372.36	1694.2
NS_3	ae	671.4714	2009.405	740.7315	1839.618
NS_3	ae	664.9757	2400.437	786.3442	2382.153
NS_3	ae	776.4793	2330.209	783.2983	2367.74
NS_3	ae	376.3375	2031.889	371.9426	2127.118
NS_3	ae	409.9703	1949.78	677.827	2002.266
NS_4	ae	742.8874	2061.877	786.8343	1393.58
NS_4	ae	741.528	2510.094	719.3495	2326.228
NS_4	ae	409.2077	2103.707	329.4182	2175.923
NS_4	ae	530.7642	1909.688	364.2484	1819.179
NS_4	ae	592.7805	2044.239	590.6904	2214.409
NS_4	ae	575.3743	1711.805	581.3515	1759.339
NS_4	ae	675.6987	2170.835	712.9031	2105.691
NS_4	ae	745.2883	2123.235	771.4834	2156.395
NS_4	ae	476.9038	737.4621	527.6748	1088.076
NS_4	ae	596.751	1703.59	587.9963	1709.899
NS_4	ae	611.4049	1836.122	569.5708	1845.71
NS_4	ae	533.0205	1987.551	515.3685	2046.492
NS_4	ae	398.457	2652.237	448.6247	2491.634
NS_4	ae	566.8724	1938.129	606.0947	1822.584
NS_4	ae	689.1683	2016.972	715.9318	2028.739
NS_4	ae	590.8507	1130.113	598.6586	1414.538
NS_4	ae	446.2005	2240.88	474.7402	1956.88
NS_4	ae	623.1293	1999.72	656.6777	1973.773
NS_4	ae	445.8816	1739.682	431.4391	1644.823
NS_4	ae	680.8566	2012.16	700.2071	1989.921
NS_4	ae	728.6532	1837.874	842.7408	1859.445
NS_4	ae	556.3478	1905.385	725.8845	1904.296
NS_4	ae	1071.463	1490.682	1223.915	1714.811
NS_4	ae	397.6853	2076.174	235.3253	2683.879
NS_4	ae	499.8807	1990.192	482.5713	2082.262
NS_4	ae	455.0897	1379.117	559.7673	2731.39
NS_4	ae	466.2371	1269.454	463.3254	1501.483
NS_4	ae	470.5293	842.6323	613.9032	1495.479
NS_4	ae	674.5172	1706.651	686.2642	1530.548
NS_4	ae	728.6209	1712.879	735.7101	1888.542
NS_4	ae	717.1622	1731.511	764.7817	1858.941
NS_4	ae	683.1192	1728.421	526.414	1785.944

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	ae	450.6202	1775.126	442.19	2056.257
NS_4	ae	443.6684	2502.933	463.432	2436.034
NS_4	ae	457.6569	1519.575	596.5299	2057.475
NS_4	ae	466.5647	1827.464	419.9078	1920.283
NS_4	ae	559.2903	2082.915	513.7562	2109.913
NS_4	ae	849.4844	1141.294	1006.011	1221.634
NS_4	ae	448.1164	1571.818	214.737	1560.224
NS_4	ae	691.0076	1860.838	730.0145	1926.303
NS_4	ae	603.5823	1895.43	700.2416	1946.086
NS_5	ae	641.0905	1812.828	512.3405	1813.578
NS_5	ae	700.5904	1919.999	665.0245	1920.356
NS_5	ae	682.0949	1918.247	741.614	1585.011
NS_5	ae	486.9617	1919.712	445.4906	1356.156
NS_5	ae	397.266	1684.658	197.1068	1301.973
NS_5	ae	331.0948	1323.76	273.2446	1165.277
NS_1	AE	480.7083	1817.153	575.9031	1727.896
NS_1	AE	765.0741	1826.96	941.0478	1537.537
NS_1	AE	528.0119	1941.214	395.8429	1807.622
NS_1	AE	711.5483	1877.606	971.2229	1712.241
NS_1	AE	733.3565	1628.62	676.4062	1248.946
NS_1	AE	712.3102	1827.322	695.7219	1707.597
NS_1	AE	567.8136	1655.967	849.365	1655.372
NS_2	AE	743.8994	1869.981	672.578	1694.019
NS_2	AE	903.5306	1509.835	877.3688	2147.388
NS_2	AE	795.1302	1727.113	609.1103	1632.691
NS_2	AE	798.366	1959.356	786.6373	2099.804
NS_2	AE	858.9218	1657.515	931.5155	1956.919
NS_2	AE	380.1916	1784.93	941.4202	1910.088
NS_2	AE	779.1655	1581.688	1121.921	2211.174
NS_2	AE	684.4728	1846.35	619.7307	1944.832
NS_2	AE	873.3824	1729.802	408.5536	1644.217
NS_2	AE	772.0697	1969.383	708.6717	1891.011
NS_2	AE	891.0082	1859.68	653.8188	1674.308
NS_2	AE	697.7121	1347.383	779.1607	1780.272
NS_2	AE	578.9144	1704.881	608.734	1672.325
NS_2	AE	378.9767	1156.055	379.2673	1413.68
NS_2	AE	824.0902	1779.597	958.7671	1903.882
NS_2	AE	738.2362	1829.478	777.6528	1423.944
NS_2	AE	657.8183	1942.748	945.556	1698.239
NS_3	AE	1112.859	2170.653	1066.206	2071.724
NS_3	AE	522.8436	1984.506	753.9868	1912.232
NS_3	AE	474.9453	2015.877	322.6864	1910.077
NS_3	AE	757.7028	998.069	602.7667	1028.765

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	AE	793.7405	2055.751	799.0071	1879.555
NS_3	AE	679.4401	2080.703	788.9651	2241.92
NS_3	AE	645.6288	1466.102	687.0228	1699.664
NS_3	AE	789.305	1991.551	669.6255	2037.008
NS_3	AE	733.3722	1896.995	741.333	2122.492
NS_3	AE	694.2309	1797.654	698.4092	2020.571
NS_3	AE	777.2311	1631.469	909.5554	1849.172
NS_3	AE	825.5956	2496.672	769.9556	1888.974
NS_3	AE	763.8448	3069.082	676.7207	2955.419
NS_3	AE	680.7639	1488.182	782.5904	1064.287
NS_3	AE	705.6381	2131.945	678.4966	2033.165
NS_3	AE	724.6206	2093.238	820.7886	1867.634
NS_3	AE	773.575	1831.039	826.564	1828.044
NS_3	AE	388.9869	2111.278	939.3744	2320.903
NS_3	AE	820.5278	1509.514	817.6386	1423.96
NS_3	AE	264.1467	870.1261	362.7343	964.9394
NS_3	AE	649.1929	1920.035	787.3723	1909.39
NS_3	AE	560.5982	844.1696	853.8257	1865.66
NS_3	AE	452.3453	1951.576	448.7372	1989.498
NS_3	AE	613.7322	1242.434	425.5952	959.0852
NS_3	AE	598.4656	1954.435	415.6958	1887.979
NS_3	AE	694.6239	2124.796	784.6776	2025.547
NS_3	AE	834.138	2148.065	623.0535	2227.771
NS_3	AE	453.8803	1602.259	600.6928	1913.589
NS_3	AE	771.204	1742.73	773.7876	1777.94
NS_3	AE	664.7446	2111.942	608.0203	2134.33
NS_3	AE	901.9091	2176.553	762.2002	2234.242
NS_3	AE	927.4064	2142.232	902.5848	1913.205
NS_3	AE	1128.029	2042.032	961.2043	2017.11
NS_3	AE	827.1195	1789.579	881.3925	1819.868
NS_3	AE	720.1815	2179.521	765.6641	2091.669
NS_3	AE	684.2027	2162.72	811.2637	2067.323
NS_3	AE	791.7957	2180.349	350.8557	2092.06
NS_4	AE	426.2909	1906.879	446.701	1958.335
NS_4	AE	859.1818	2317.54	644.6255	2126.625
NS_4	AE	851.3134	2122.65	800.9494	2048.223
NS_4	AE	727.4413	1822.03	641.6097	1853.468
NS_4	AE	786.0053	1635.196	592.0761	967.776
NS_4	AE	661.781	2754.456	689.3926	2763.252
NS_4	AE	913.8856	1842.237	677.1459	1859.74
NS_4	AE	767.448	1701.02	816.6484	1802.366
NS_4	AE	815.7069	2177.742	622.7278	2245.929
NS_4	AE	650.3953	1730.686	757.8937	1769.824

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	AE	487.8208	1087.79	673.4161	1603.951
NS_4	AE	725.5205	1695.887	779.5137	1634.294
NS_4	AE	751.9037	1725.118	745.5034	1825.138
NS_4	AE	684.7506	1842.952	749.5001	1791.209
NS_4	AE	626.0975	2032.49	669.7138	2035.076
NS_4	AE	754.5165	1633.95	796.6304	1838.738
NS_4	AE	837.3208	1525.071	722.6981	1883.065
NS_4	AE	669.1265	1167.701	774.9469	1123.338
NS_4	AE	739.4023	1576.838	621.5785	1855.972
NS_4	AE	650.8992	1690.348	628.6837	1803.849
NS_4	AE	758.0873	1563.167	558.1162	1767.803
NS_4	AE	755.1906	1258.947	736.1791	1756.463
NS_4	AE	846.1428	1655.593	889.4014	1687.166
NS_4	AE	597.9818	1860.12	743.7064	1945.687
NS_4	AE	686.728	1783.807	666.3743	1706.668
NS_4	AE	646.3652	1949.374	486.6928	1788.09
NS_4	AE	689.3168	2074.444	750.4299	1885.164
NS_4	AE	673.5902	1947.726	412.9948	1671.203
NS_4	AE	851.6969	2017.044	573.5972	1167.826
NS_4	AE	641.0509	1030.448	757.621	1709.253
NS_4	AE	751.4856	1596.387	744.9778	1607.19
NS_4	AE	846.1428	1655.593	889.4014	1687.166
NS_4	AE	703.6378	1907.269	748.2397	2126.131
NS_4	AE	1026.445	1741.514	716.8833	1737.871
NS_4	AE	751.4856	1596.387	744.9778	1607.19
NS_4	AE	721.7074	2016.67	819.0728	1863.43
NS_4	AE	668.4493	1727.629	774.9307	1927.45
NS_4	AE	845.8768	1822.614	815.6903	2109.815
NS_4	AE	788.5868	1753.384	828.4373	1757.679
NS_4	AE	682.2555	2491.342	779.8194	2656.328
NS_4	AE	414.6376	2558.447	435.4578	2722.255
NS_4	AE	805.3552	2074.188	1206.373	2080.183
NS_4	AE	821.9785	1710.654	888.1597	1893.393
NS_4	AE	691.2481	1737.124	828.7737	1945.697
NS_4	AE	774.2087	2275.857	555.8475	2311.572
NS_4	AE	611.9096	1941.026	755.6054	1813.441
NS_4	AE	776.9657	2134.651	748.2047	2220.96
NS_4	AE	718.1603	2097.447	784.9359	2163.855
NS_4	AE	829.6247	1711.24	829.4187	1742.046
NS_4	AE	431.6448	674.1788	646.1858	1163.247
NS_5	AE	622.9581	1713.32	727.6148	1743.503
NS_5	AE	593.5233	1903.495	556.1431	2068.475
NS_5	AE	685.7447	2085.931	677.2264	1705.506

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_5	AE	631.2493	1711.767	728.2774	1696.559
NS_5	AE	765.0763	1751.088	795.7028	1676.681
NS_5	AE	740.1871	1733.477	682.4783	1868.298
NS_5	AE	565.0328	2226.831	723.1776	1765.158
NS_5	AE	515.556	2115.592	477.2137	1631.052
NS_5	AE	436.7906	1908.519	428.9686	1887.339
NS_5	AE	636.0972	1827.359	655.776	1728.654
NS_5	AE	752.7463	1264.012	659.7307	1387.847
NS_1	e	364.2047	2189.296	269.3521	2174.653
NS_1	e	446.1508	2518.624	385.7735	1535.016
NS_1	e	601.1109	1536.694	523.7979	1488.101
NS_1	e	571.9035	1654.468	400.8021	1483.567
NS_1	e	662.4772	2125.846	586.2205	2114.415
NS_1	e	501.4466	2301.4	540.9107	2342.799
NS_1	e	474.719	1531.693	449.8812	1513.751
NS_1	e	401.6629	1919.885	376.5688	1883.643
NS_1	e	349.4556	1819.765	638.0042	2043.175
NS_1	e	567.2581	2226.54	621.0647	2105.362
NS_1	e	539.8514	1831.517	504.7943	1762.564
NS_1	e	722.9526	1793.935	668.7429	1880.43
NS_1	e	466.0903	2190.414	446.3972	2154.033
NS_1	e	785.6084	1757.527	669.0249	1407.527
NS_1	e	470.0507	2047.929	437.2733	2531.599
NS_1	e	256.3526	1776.533	208.5051	1885.372
NS_1	e	393.9281	2192.662	398.6457	2043.878
NS_1	e	1132.361	2289.823	884.5488	2331.816
NS_1	e	1002.425	2158.092	421.1841	1737.711
NS_1	e	359.6457	2098.75	766.6116	2041.287
NS_1	e	514.1968	2006.36	462.5235	882.7925
NS_1	e	343.2893	1531.449	368.9508	1852.615
NS_1	e	332.7683	2122.73	227.8443	1994.907
NS_1	e	269.9145	1902.753	371.1895	2047.395
NS_1	e	639.0258	1931.435	464.4094	1849.346
NS_2	e	384.2567	867.9145	371.0397	980.0994
NS_2	e	460.7689	1965.03	1536.023	2621.416
NS_2	e	470.6343	1776.61	708.3392	2004.956
NS_2	e	304.8559	2051.277	778.7072	1871.596
NS_2	e	400.8219	1405.164	342.4795	873.5789
NS_2	e	373.9709	2016.792	439.3638	1889.091
NS_2	e	306.5299	1338.199	660.3269	2093.624
NS_2	e	476.994	574.6301	545.2343	1869.023
NS_2	e	430.9995	2067.845	460.2833	1214.21
NS_2	e	329.8689	1625.493	326.9346	897.7176

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	e	301.8402	1954.284	344.1063	1448.329
NS_2	e	340.5995	1655.082	992.4336	2169.398
NS_2	e	383.8166	1967.584	500.7184	1594.516
NS_2	e	366.9849	1797.401	472.3176	1771.733
NS_2	e	366.156	1815.883	370.6592	1738.881
NS_2	e	397.0005	2048.629	667.823	2085.404
NS_2	e	463.4893	2440.232	313.5543	2089.867
NS_2	e	408.2689	2383.809	413.1983	2123.365
NS_2	e	378.5242	2155.753	484.3496	2038.051
NS_2	e	447.1702	2165.748	841.0662	2508.466
NS_2	e	541.1952	2145.884	432.5445	1885.69
NS_2	e	509.647	2088.419	563.7866	2084.773
NS_2	e	426.3097	2162.459	938.4746	1883.948
NS_2	e	480.0871	1903.351	1060.258	2276.452
NS_2	e	572.1928	1768.776	488.1261	1775.377
NS_2	e	391.9	1050.4	556.7402	1980.452
NS_2	e	500.7333	2144.241	611.744	1845.76
NS_2	e	462.5528	2003.047	480.2447	2149.918
NS_2	e	445.93	2245.673	450.1839	2187.422
NS_2	e	482.2089	2040.585	462.481	2177.207
NS_2	e	362.0285	2004.441	369.5564	1353.587
NS_2	e	398.6975	2335.876	375.4177	2174.998
NS_2	e	401.1494	2038.715	357.5483	2080.365
NS_2	e	687.1464	1633.337	739.3786	1617.895
NS_2	e	462.8412	1663.367	276.3432	1882.636
NS_2	e	427.7762	2174.041	396.0961	2114.039
NS_2	e	637.5514	1432.253	635.0604	1710.808
NS_2	e	382.497	1159.779	373.6681	977.4252
NS_2	e	395.9796	1730.863	416.6376	1636.752
NS_2	e	420.9139	1346.659	429.0899	1366.216
NS_2	e	380.7186	1729.777	361.7017	1719.434
NS_2	e	453.9394	1742.702	806.9252	2033.68
NS_2	e	498.4839	2061.457	559.6496	2088.796
NS_2	e	575.7492	1967.502	543.8732	1925.927
NS_2	e	321.9283	2436.178	321.9465	1380.845
NS_2	e	415.0056	2196.478	340.4917	2123.426
NS_2	e	350.5609	2359.95	414.8029	2428.526
NS_2	e	410.0541	2402.392	440.6167	2332.916
NS_2	e	323.5959	1944.892	311.7848	2383.448
NS_2	e	347.1187	2343.552	446.1728	2328.781
NS_2	e	303.9411	2046.652	316.4819	2131.066
NS_2	e	376.6398	2248.112	376.1972	2059.671
NS_2	e	370.2003	2236.064	402.7139	2305.719

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	e	379.607	1563.842	371.5807	1562.91
NS_2	e	439.6687	1749.013	393.9644	1631.583
NS_2	e	487.9888	1822.401	414.2113	1962.859
NS_2	e	503.0626	2316.902	519.1003	1891.144
NS_2	e	499.4821	1880.529	484.8061	2018.457
NS_2	e	417.5397	2109.159	450.4405	2026.662
NS_2	e	345.0751	1428.927	332.759	1896.384
NS_2	e	427.2357	2442.759	306.7233	1259.745
NS_2	e	382.9367	2475.606	392.6958	2498.393
NS_3	e	653.9996	2367.549	653.0318	2467.305
NS_3	e	576.9916	1740.381	542.1157	1923.462
NS_3	e	188.8171	2056.893	174.8741	1834.723
NS_3	e	586.8806	2283.714	562.6883	2273.155
NS_3	e	513.2091	2485.238	438.7479	2535.51
NS_3	e	675.7632	2042.369	513.0617	2048.216
NS_3	e	404.8476	2826.369	318.6639	2767.999
NS_3	e	436.1582	2126.18	290.645	2139.914
NS_3	e	452.3513	2357.468	472.1057	2352.812
NS_3	e	463.8006	2258.932	459.4229	2298.52
NS_3	e	695.861	1513.396	710.4034	1358.498
NS_3	e	436.6909	2066.148	446.8954	2291.134
NS_3	e	415.4628	2574.758	453.7331	2629.361
NS_3	e	532.5916	2003.977	469.2354	2165.768
NS_3	e	438.5396	2464.515	478.4084	2562.531
NS_3	e	474.1883	2457.336	474.2348	2408.379
NS_3	e	493.0888	2226.948	386.5344	2590.543
NS_3	e	422.073	1958.691	379.1656	1884.259
NS_3	e	553.3421	2049.371	564.3784	2070.613
NS_3	e	464.0643	891.9717	504.8191	888.7451
NS_3	e	733.9712	2016.526	701.2891	2017.178
NS_3	e	442.1005	2218.159	438.888	2104.624
NS_3	e	435.9878	3237.196	402.5337	3005.356
NS_3	e	515.3566	1431.809	463.2852	1396.481
NS_3	e	493.2959	1304.886	517.5978	1069.299
NS_3	e	478.1111	2453.567	438.2575	2243.072
NS_3	e	468.4474	1807.068	420.6865	1819.373
NS_3	e	587.3231	2131.552	542.0887	2178.077
NS_3	e	510.1008	2617.048	489.5419	2570.874
NS_3	e	547.9938	2213.409	495.1085	1887.849
NS_3	e	446.9801	2373.896	423.5917	2391.377
NS_3	e	560.3254	2063.058	550.8283	2118.728
NS_3	e	500.8969	2096.202	483.8371	2111.893
NS_3	e	471.4892	1778.207	440.2665	1867.347

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	e	316.3595	839.3607	269.0199	853.7633
NS_3	e	365.0098	2766.121	462.0382	2683.162
NS_3	e	605.2173	2196.807	621.3927	2274.106
NS_3	e	499.8589	2267.929	439.7574	2006.892
NS_3	e	344.9839	1359.276	285.4686	1455.219
NS_3	e	293.3118	887.1144	267.8088	761.0569
NS_3	e	269.3211	955.702	371.8838	952.9416
NS_3	e	560.7972	2169.782	497.369	2128.442
NS_3	e	490.1502	2337.796	456.9274	2353.086
NS_3	e	368.5625	2306.916	376.2171	2284.122
NS_3	e	431.31	2151.136	418.5902	1910.788
NS_3	e	508.2891	2275.962	562.8582	2263.603
NS_3	e	428.3356	1885.605	402.6456	1877.693
NS_3	e	590.4101	2095.429	422.054	1895.495
NS_3	e	214.6123	924.9318	180.2812	1519.116
NS_3	e	460.7362	2199.261	433.0164	2516.84
NS_3	e	619.4037	1899.84	621.4472	1927.727
NS_3	e	544.6204	2023.241	538.0323	1968.622
NS_3	e	409.9676	1748.455	683.1192	1997.547
NS_3	e	284.5716	1059.642	321.804	986.9907
NS_3	e	1642.451	2265.416	1322.402	2259.918
NS_3	e	542.5659	2383.559	275.4852	2561.475
NS_3	e	366.2063	2252.702	348.1589	2178.554
NS_3	e	400.8661	2181.601	325.2946	2132.844
NS_3	e	381.8087	2235.846	418.4546	2360.52
NS_3	e	508.8414	2312.564	525.1693	1988.165
NS_3	e	419.2255	2648.327	1758.757	3043.138
NS_3	e	427.7093	2030.293	412.9704	1965.332
NS_3	e	664.4809	1324.971	664.3031	1398.583
NS_3	e	405.1036	2332.04	369.1469	2296.3
NS_3	e	321.0291	2730.57	394.6962	2777.274
NS_3	e	1704.315	2120.56	1747.259	2732.587
NS_3	e	644.9541	2023.827	492.5539	1830.237
NS_3	e	612.9686	2163.468	593.1608	2107.713
NS_3	e	269.5912	1841.341	263.852	1757.094
NS_3	e	760.482	1734.343	502.9362	1614.849
NS_3	e	243.181	2089.68	211.7868	2009.183
NS_3	e	451.9084	2245.914	387.8454	2341.363
NS_3	e	431.5604	2148.325	466.158	2262.216
NS_3	e	327.0386	1806.05	366.3593	2029.81
NS_3	e	224.008	2241.125	553.6794	2312.948
NS_3	e	341.4972	2048.256	584.1564	2308.992
NS_3	e	311.2028	1559.196	396.6621	1450.617

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	e	452.6135	1857.366	556.0887	2027.726
NS_3	e	373.6957	1804.89	423.2597	2537.128
NS_3	e	375.1173	2031.018	315.3671	1494.971
NS_3	e	392.1065	2163.259	382.1934	2112.943
NS_3	e	384.8812	1864.546	368.2319	1715.322
NS_3	e	452.6347	2552.624	465.4521	2497.138
NS_3	e	1079.753	2447.643	1135.194	2510.727
NS_3	e	398.9504	2084.769	295.5196	1915.329
NS_3	e	533.2861	1759.101	509.6734	1864.824
NS_3	e	465.3209	2407.728	309.0414	1647.991
NS_4	e	444.6398	1954.966	451.1367	1964.521
NS_4	e	465.5996	1999.022	392.9741	2212.071
NS_4	e	410.8252	2393.557	391.9503	2502.426
NS_4	e	530.6566	1876.724	449.4682	1893.338
NS_4	e	520.4953	2218.469	497.4989	2107.412
NS_4	e	444.9892	2373.715	374.5814	2418.944
NS_4	e	448.5308	2285.719	418.6705	2292.752
NS_4	e	552.0884	2047.583	539.8651	2017.521
NS_4	e	417.3944	2056.401	350.9029	2177.416
NS_4	e	360.3189	2269.515	376.7391	2485.367
NS_4	e	355.7915	2550.594	344.2677	2561.404
NS_4	e	424.0204	2043.635	430.5264	2584.49
NS_4	e	457.9791	2023.275	425.457	2321.457
NS_4	e	452.9218	2290.585	472.6506	1753.104
NS_4	e	497.3009	2697.844	459.5365	2611.011
NS_4	e	385.4418	1392.566	439.5717	1686.271
NS_4	e	516.0369	2213.297	480.5124	2178.423
NS_4	e	447.6617	2431.737	429.9128	2306.992
NS_4	e	541.1231	3137.003	457.8798	3066.616
NS_4	e	489.3064	2409.106	462.8298	2476.516
NS_4	e	485.417	2081.028	447.8376	2131.624
NS_4	e	534.4752	1400.738	495.8376	1855.237
NS_4	e	465.0603	2717.955	407.5472	3221.98
NS_4	e	282.3953	1948.258	519.374	2065.877
NS_4	e	448.7499	1962.838	405.17	2312.333
NS_4	e	515.3972	2479.597	481.8006	2615.221
NS_4	e	415.6963	2723.005	393.4974	2774.329
NS_4	e	424.0343	2387.444	408.2233	2447.693
NS_4	e	476.6641	1623.694	469.8469	1587.552
NS_4	e	436.6676	2527.237	413.3557	2727.519
NS_4	e	458.7765	1942.862	437.8411	1919.152
NS_4	e	468.4134	1701.41	422.7134	1771.66
NS_4	e	381.8725	2104.581	368.2451	2480.994

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	e	475.3385	2190.429	472.6454	2197.064
NS_4	e	255.2902	1732.066	292.2898	1914.229
NS_4	e	431.5845	2060.225	429.3546	2049.613
NS_4	e	449.3311	2259.649	421.9755	2215.835
NS_4	e	472.0672	2582.54	490.1373	2410.284
NS_4	e	403.3646	2281.293	367.7781	2496.648
NS_4	e	431.3035	886.4445	493.0766	890.8021
NS_4	e	404.195	782.4422	384.3872	793.8646
NS_4	e	371.7234	602.3399	386.4132	727.0977
NS_4	e	484.192	2159.633	467.8904	1995.804
NS_4	e	457.5386	2473.467	478.1329	2350.048
NS_4	e	546.2363	1929.399	464.1774	1887.015
NS_4	e	711.6464	2011.756	686.4908	2056.507
NS_4	e	279.4972	1853.011	283.2853	2218.864
NS_4	e	357.5276	2139.476	264.7516	2351.779
NS_4	e	359.4681	2164.108	395.5048	2328.567
NS_4	e	394.3854	2316.297	389.5513	2458.177
NS_4	e	454.4612	2208.005	490.9057	1931.298
NS_4	e	483.2855	861.1424	506.2594	900.9485
NS_4	e	637.0963	2008.693	551.4162	2014.85
NS_4	e	482.3509	3201.099	417.3339	3249.906
NS_4	e	475.4502	962.2644	579.5062	1411.749
NS_4	e	427.7488	2183.806	370.2648	2069.327
NS_4	e	514.4241	1683.446	437.8744	1684.297
NS_4	e	429.8118	1080.465	355.0532	1198.998
NS_4	e	428.8717	2114.673	437.0152	2181.332
NS_4	e	1084.436	2051.297	1012.904	1733.703
NS_4	e	711.4206	2126.655	472.4641	1964.536
NS_4	e	629.362	1865.259	566.4596	1763.727
NS_4	e	420.0282	2144.361	421.9905	2487.479
NS_4	e	400.2658	2532.66	383.6665	2572.393
NS_4	e	551.207	1643.142	451.8807	1433.222
NS_4	e	550.6821	1720.861	396.0692	1617.689
NS_4	e	468.8265	2370.384	438.2651	2357.432
NS_4	e	606.785	988.6012	636.5972	1023.887
NS_4	e	576.418	1744.936	637.0728	1870.827
NS_4	e	413.7129	1916.935	403.8491	2243.784
NS_4	e	412.5888	2410.736	406.956	2455.894
NS_4	e	454.9282	2691.691	534.9056	2359.958
NS_4	e	441.2664	1832.138	398.1637	1874.305
NS_4	e	507.1421	1898.95	583.9532	1938.186
NS_4	e	448.7142	1238.248	347.4031	1828.727
NS_4	e	489.4905	1139.021	501.5793	1384.271

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	e	492.5142	1954.032	519.1793	1923.436
NS_4	e	422.4288	1648.355	279.8291	1732.986
NS_4	e	485.1912	1675.937	456.5379	2830.689
NS_4	e	463.1198	855.6281	374.1712	2057.75
NS_4	e	438.6917	1997.929	419.5871	2014.403
NS_4	e	479.2207	2854.764	534.2417	2321.415
NS_4	e	461.6492	2065.297	442.1013	2146.579
NS_4	e	719.7202	2267.28	516.8417	1913.36
NS_4	e	444.9895	881.645	471.5085	1527.926
NS_4	e	521.4817	1918.442	504.8391	1999.382
NS_4	e	398.396	2256.285	388.9664	1902.782
NS_4	e	437.1341	2029.298	408.5132	1882.475
NS_4	e	608.0514	1946.134	475.2515	1919.227
NS_4	e	359.9779	2229.582	459.89	2193.65
NS_4	e	519.3697	1905.806	490.0436	1883.46
NS_4	e	480.5439	2331.729	471.8168	2340.287
NS_4	e	479.1475	1946.739	455.1047	1945.135
NS_4	e	446.4422	2306.93	446.8451	1045.733
NS_4	e	414.876	2111.766	369.9234	2033.899
NS_4	e	483.8913	2067.222	470.8341	2021.762
NS_4	e	262.2887	1921.032	334.5304	1868.158
NS_4	e	354.913	1757.998	315.1147	1728.3
NS_4	e	428.6237	2315.209	379.4127	2193.788
NS_4	e	392.0584	2064.335	334.7811	1984.343
NS_4	e	1108.049	2042.384	680.2279	1977.242
NS_4	e	448.0968	1280.622	471.6799	2136.832
NS_4	e	662.8638	1138.723	551.8919	987.1084
NS_4	e	450.9673	2417.74	465.2662	2408.808
NS_4	e	478.6775	2267.77	447.6665	2303.732
NS_4	e	402.8028	791.2905	344.5841	914.7567
NS_4	e	445.4797	1800.536	494.3639	2468.203
NS_4	e	385.8893	1455.843	383.7649	1426.918
NS_4	e	484.8416	2533.874	509.1744	2379.953
NS_4	e	380.4533	1278.798	385.3008	1536.786
NS_4	e	523.4441	739.4925	527.1277	1074.961
NS_4	e	407.976	1568.416	398.8541	1971.558
NS_4	e	497.2371	1571.027	473.0441	1505.706
NS_4	e	448.7142	1238.248	347.4031	1828.727
NS_4	e	430.7707	2136.187	411.6297	2279.021
NS_4	e	455.0476	1515.478	447.2047	1588.736
NS_4	e	497.2371	1571.027	473.0441	1505.706
NS_5	e	475.8696	1746.144	467.7237	1603.82
NS_5	e	469.8457	2383.912	461.8255	2806.782

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_5	e	417.7176	1962.036	444.0065	1993.637
NS_5	e	427.6721	2199.319	405.6355	2354.747
NS_5	e	429.0496	2011.245	422.0139	1802.115
NS_5	e	391.0727	2165.421	419.609	2139.321
NS_5	e	646.404	2075.804	649.892	2275.578
NS_5	e	413.247	1412.577	411.6462	1507.499
NS_5	e	441.9016	2223.596	332.7719	2325.092
NS_5	e	408.6073	2085.855	352.3066	1128.81
NS_5	e	451.6303	2443.203	554.0527	1621.353
NS_5	e	380.4123	2329.816	389.3868	2433.664
NS_5	e	476.5404	2061.637	528.3174	2245.2
NS_5	e	506.289	2308.259	404.0914	2570.671
NS_5	e	501.919	1896.808	431.7496	1926.981
NS_5	e	552.832	2001.683	573.4044	2151.771
NS_5	e	481.0754	2006.07	484.5534	2055.629
NS_5	e	376.2917	2240.074	341.4344	2019.773
NS_5	e	414.6267	2222.368	284.364	2172.853
NS_5	e	580.9279	2217.352	410.0472	2218.905
NS_5	e	510.5872	1977.04	494.0382	2161.71
NS_5	e	401.6829	2232.025	383.8185	2229.161
NS_5	e	473.5568	1478.523	313.8578	988.4455
NS_5	e	515.5253	2054.348	512.0916	2033.087
NS_5	e	403.6922	2244.68	462.3585	2276.545
NS_5	e	412.5868	2123.264	459.4675	2316.427
NS_5	e	366.7843	2241.528	364.4823	2095.24
NS_5	e	452.9404	2100.93	436.8626	1888.738
NS_5	e	342.8783	2376.011	399.3535	2330.657
NS_5	e	358.9876	2201.814	343.6192	2168.306
NS_5	e	476.8662	2056.114	492.6611	2026.054
NS_1	E	407.9657	2348.116	387.9475	2106.574
NS_1	E	541.3813	2143.598	521.5828	2453.981
NS_1	E	406.6515	2388.708	379.1159	1537.738
NS_1	E	462.8147	1689.536	430.7402	1950.115
NS_1	E	538.632	2140.138	477.3097	2482.728
NS_1	E	509.3162	2326.061	492.3743	2246.54
NS_1	E	402.9387	2459.556	435.3474	2524.667
NS_1	E	427.0037	1856.039	448.2762	2160.506
NS_1	E	670.5387	2253.739	603.7291	2444.123
NS_1	E	542.2012	1955.916	514.2261	1969.163
NS_1	E	421.054	2344.031	399.1794	2337.062
NS_1	E	486.261	2530.001	493.8714	1286.6
NS_2	E	346.0411	1899.418	1371.335	2271.831
NS_2	E	366.27	2273.635	502.7695	1708.652

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	E	433.0033	992.9393	491.007	1543.732
NS_2	E	523.5516	2071.542	447.8952	1932.049
NS_2	E	382.939	2428.902	504.7725	2024.772
NS_2	E	459.5932	1769.716	519.8847	2095.468
NS_2	E	387.7413	2088.792	481.6243	1791.437
NS_2	E	431.6968	2098.871	638.7269	2010.742
NS_2	E	530.051	2394.529	513.7851	2417.697
NS_2	E	373.8276	1867.361	350.9949	2116.22
NS_2	E	534.8552	1960.682	426.1693	2180.886
NS_2	E	521.7087	1634.628	441.9345	1266.679
NS_2	E	380.3476	1844.468	445.2091	1565.254
NS_2	E	431.389	1923.516	397.4217	2040.397
NS_2	E	526.5242	2187.997	466.5894	2124.818
NS_2	E	428.4577	2426.474	499.1742	2534.317
NS_2	E	607.1434	2146.222	603.4567	2221.684
NS_2	E	411.6842	1940.649	347.2595	2081.722
NS_3	E	401.7348	2332.784	289.8743	2266.083
NS_3	E	414.9914	2451.131	399.7963	2537.182
NS_3	E	548.3251	2481.675	559.4037	2487.744
NS_3	E	531.6936	2365.317	390.4105	1312.384
NS_3	E	506.6291	2142.413	504.8136	1801.743
NS_3	E	516.2082	2531.233	513.9956	2628.563
NS_3	E	475.3686	1964.651	469.5315	2161.398
NS_3	E	512.9155	2679.851	509.2899	2679.729
NS_3	E	529.858	2463.093	423.1346	2447.483
NS_3	E	514.6541	2324.562	502.7809	2444.911
NS_3	E	450.2667	2456.757	466.233	2498.928
NS_3	E	457.4412	2444.31	485.2144	2353.128
NS_3	E	560.8116	2643.628	518.8829	2562.154
NS_3	E	482.3625	1554.148	626.7366	1205.788
NS_3	E	410.1282	2217.832	491.5111	2529.494
NS_3	E	610.6882	2502.935	500.7143	2616.408
NS_3	E	469.8324	2368.903	498.1189	2736.466
NS_3	E	322.3081	2595.35	527.7995	2628.997
NS_3	E	430.3844	1010.194	438.0661	878.5153
NS_3	E	440.5991	2446.207	421.5074	2042.935
NS_3	E	552.8898	2507.802	521.1835	2667.701
NS_3	E	500.6473	2484.983	473.4022	2528.134
NS_3	E	535.2813	2451.784	555.9648	2687.205
NS_3	E	526.1941	2472.161	456.2974	2500.421
NS_3	E	533.3067	2475.844	607.6251	2547.653
NS_3	E	481.4767	2610.969	552.9655	2605.736
NS_3	E	492.1998	2518.171	525.7452	2491.191

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	E	461.3661	2508.862	512.6303	2616.403
NS_3	E	490.8042	2235.917	540.0669	2346.208
NS_3	E	393.5975	1012.779	359.188	787.6718
NS_3	E	534.2718	2321.652	456.2394	2591.485
NS_4	E	458.8817	3047.579	398.3966	2684.917
NS_4	E	436.179	1335.945	463.6738	1587.87
NS_4	E	488.8861	2432.457	445.7291	2558.577
NS_4	E	417.6287	3007.269	398.2317	3054.073
NS_4	E	479.5746	2561.857	399.3841	2244.661
NS_4	E	395.4523	2612.851	336.5331	2784.226
NS_4	E	404.0223	1792.95	429.3987	1841.291
NS_4	E	431.8439	2811.913	419.3241	2727.83
NS_4	E	543.8584	2330.903	404.7368	2708.363
NS_4	E	486.3359	2254.014	478.1923	2155.023
NS_4	E	547.6918	2222.31	435.6183	2639.737
NS_4	E	545.4711	2599.825	464.9824	2743.005
NS_4	E	374.9032	1312.277	411.0576	2181.487
NS_4	E	467.7343	2260.996	371.1651	2651.758
NS_4	E	388.1035	2776.056	376.1601	2239.42
NS_4	E	344.89	615.5309	345.1774	576.7025
NS_4	E	371.5923	585.2581	304.8512	619.1592
NS_4	E	424.6695	2610.603	423.6282	2536.445
NS_4	E	570.4898	1779.342	559.8572	2018.263
NS_4	E	439.5259	2617.556	476.3503	2630.731
NS_4	E	407.3695	2670.139	386.9153	2724.634
NS_4	E	422.1609	684.4724	381.6817	1087.361
NS_4	E	447.404	2637.421	509.4942	2362.262
NS_4	E	417.5291	2486.812	363.6601	2560.772
NS_4	E	434.8178	2649.229	458.2014	2748.291
NS_4	E	446.8883	2649.964	453.619	2739.424
NS_4	E	493.6601	3022.267	406.4446	2749.943
NS_4	E	396.6977	2503.526	351.4281	2681.382
NS_4	E	638.4469	2399.931	507.7909	2285.31
NS_4	E	472.3513	1332.666	469.745	1347.003
NS_4	E	540.1289	2215.404	421.6495	2217.245
NS_4	E	380.4542	1958.912	355.9134	608.5549
NS_5	E	461.5834	2285.752	464.587	2318.546
NS_5	E	477.1397	2305.896	507.751	2397.753
NS_5	E	530.3787	2010.632	561.4817	2013.627
NS_1	i	452.2788	1464.447	450.6759	1747.057
NS_1	i	300.0343	1817.108	330.0331	1804.786
NS_2	i	391.1389	1893.007	547.7345	918.0334
NS_2	i	465.7664	2229.89	997.7749	2223.382

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_2	i	442.2344	1710.043	752.6324	1956.676
NS_2	i	463.5243	1860.135	434.3329	1986.633
NS_2	i	454.5282	1967.03	420.3574	1577.242
NS_2	i	478.6662	1872.233	454.1953	1906.757
NS_2	i	341.7358	1971.995	456.5958	1759.879
NS_2	i	392.5878	1000.934	353.0215	1028.413
NS_2	i	346.8839	2261.649	471.143	2223.359
NS_2	i	408.9405	2225.627	509.3563	1975.11
NS_2	i	503.5508	2140.622	426.8379	1975.824
NS_3	i	386.6215	2677.337	417.573	2504.841
NS_3	i	1006.374	2405.879	337.4664	1736.253
NS_3	i	349.6583	2287.6	345.162	2424.206
NS_3	i	453.2293	2498.326	451.9358	2551.829
NS_3	i	406.7982	1275.932	386.7391	1898.78
NS_3	i	406.6128	1915.702	400.9664	1360.617
NS_3	i	422.0719	2431.862	390.079	1590.719
NS_3	i	509.1789	1834.692	554.6364	1889.394
NS_3	i	414.182	2379.649	434.9666	2385.931
NS_3	i	467.7298	2351.305	491.9426	2072.292
NS_3	i	389.2628	1622.162	423.8609	1706.424
NS_3	i	1476.117	2913.145	419.5008	2362.233
NS_3	i	456.8937	2562.756	479.9644	2571.277
NS_3	i	474.2562	2210.64	425.3203	2206.041
NS_3	i	426.8695	2445.208	424.2819	2480.73
NS_4	i	363.4083	2636.25	384.2223	2606.768
NS_4	i	426.0042	2696.849	409.0419	2479.844
NS_4	i	563.3138	2128.477	433.7285	2464.713
NS_4	i	427.1688	2308.826	405.2919	1560.664
NS_4	i	455.9504	2765.743	399.2789	2792.427
NS_4	i	660.7953	2533.579	487.7455	652.782
NS_4	i	338.1642	2809.83	288.3625	2808.155
NS_4	i	396.4477	2734.798	385.0875	2550.17
NS_4	i	430.8577	2304.709	427.0582	668.2141
NS_4	i	607.236	2343.866	543.4963	2461.483
NS_4	i	407.0154	2095.869	441.5464	2450.445
NS_4	i	410.1445	2673.836	373.032	1834.241
NS_4	i	398.9164	2704.801	399.7952	2696.188
NS_4	i	428.7108	2686.891	468.2385	2549.246
NS_4	i	447.3178	2502.283	428.604	2553.044
NS_4	i	347.0305	2705.408	325.2468	2674.869
NS_5	i	488.3417	2376.774	464.0777	2451.676
NS_5	i	475.7553	2147.13	435.2278	1962.846
NS_5	i	576.761	2191.235	436.1333	2159.071

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_1	I	455.0765	2425.219	454.7929	2181.609
NS_1	I	370.5369	2795.431	334.5161	2728.27
NS_1	I	428.6256	2766.052	409.7305	2843.308
NS_2	I	318.8506	2239.211	285.3724	2257.517
NS_2	I	395.1245	763.6136	491.1926	1899.04
NS_2	I	324.9647	1903.179	603.6039	2182.184
NS_2	I	357.429	2295.078	591.937	1971.767
NS_2	I	361.6553	2212.624	465.4949	2172.831
NS_2	I	329.2397	1193.003	361.9639	1207.775
NS_2	I	448.0386	2330.118	464.0559	2424.811
NS_2	I	624.9324	2367.231	427.5127	2433.508
NS_3	I	562.9837	2659.252	327.34	2723.658
NS_3	I	435.4683	2598.546	430.0809	2690.535
NS_3	I	482.3209	2659.144	483.4644	2837.396
NS_3	I	458.2886	2188.664	481.1812	2761.456
NS_3	I	457.2714	2013.078	418.532	2330.75
NS_3	I	452.4488	2279.562	464.0427	2364.207
NS_3	I	393.8463	2595.389	397.9806	2587.238
NS_3	I	516.0166	1898.737	617.488	2051.842
NS_3	I	450.4626	2668.775	611.2714	2249.367
NS_3	I	429.7821	2718.098	467.1673	2461.365
NS_3	I	382.7391	2715.392	347.4402	2297.975
NS_3	I	391.9845	2571.14	419.8765	2767.861
NS_3	I	398.5789	2700.772	396.0978	2737.072
NS_3	I	389.1019	2629.032	463.6059	2058.643
NS_3	I	408.5731	3016.697	368.7021	2875.695
NS_3	I	392.6065	2416.592	397.3864	2632.911
NS_3	I	439.3209	2432.54	400.2245	2554.582
NS_3	I	532.3861	2080.885	378.3725	2339.064
NS_3	I	387.1021	2098.643	455.9154	2253.757
NS_3	I	367.6068	2547.851	343.5543	2310.868
NS_3	I	448.7345	2679.258	427.718	2460.612
NS_3	I	392.5218	2368.825	374.6632	2542.022
NS_3	I	373.252	2498.565	360.5606	2568.463
NS_3	I	465.214	2463.758	407.7376	2498.523
NS_3	I	434.7919	2609.655	437.2524	2580.726
NS_4	I	442.7433	2696.571	479.3225	2786.267
NS_4	I	325.8954	2704.507	331.9373	2764.868
NS_4	I	382.7562	2792.037	387.9667	2875.107
NS_4	I	331.6863	1540.909	283.1274	1758.257
NS_4	I	395.7682	2192.393	373.7639	2395.139
NS_4	I	421.1459	2736.427	441.1585	2650.383
NS_4	I	498.883	2806.717	519.4152	2941.97

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	I	391.7166	2869.443	373.6109	2180.361
NS_4	I	463.4987	2892.369	494.9213	3038.459
NS_4	I	365.6416	2997.289	357.236	3145.203
NS_4	I	359.1122	2875.86	262.242	2456.674
NS_4	I	409.7059	1253.918	411.3452	1363.002
NS_4	I	464.3829	1826.323	446.0026	1335.372
NS_4	I	422.4956	2363.767	462.7065	2398.074
NS_4	I	368.5026	2511.659	358.4201	2529.299
NS_4	I	427.747	2770.945	424.129	2696.271
NS_4	I	377.4027	2694.25	361.7363	2633.894
NS_4	I	432.458	2736.477	423.6208	2768.552
NS_4	I	395.5866	2451.82	373.5298	2748.478
NS_4	I	395.5249	2368.462	399.8214	2382.14
NS_4	I	477.9625	2374.218	335.3214	2376.568
NS_4	I	390.952	2692.884	398.8898	2800.727
NS_4	I	314.2873	2420.533	278.1208	2413.491
NS_4	I	404.4834	2104.359	435.8216	2578.074
NS_4	I	400.4359	2867.344	384.9665	2350.423
NS_5	I	395.4009	2526.493	360.9976	2472.549
NS_5	I	492.1842	2343.757	361.1659	2423.755
NS_5	I	471.0709	2705.403	422.2896	2494.144
NS_5	I	424.975	2608.784	331.0962	2584.558
NS_5	I	325.1298	2470.144	234.1673	2475.759
NS_5	I	352.6721	2453.798	342.4825	2473.398
NS_5	I	373.9723	2258.712	302.5999	2091.649
NS_2	ia	392.2925	2103.565	535.1938	1721.85
NS_2	ia	497.9173	1829.452	1084.633	1988.238
NS_2	ia	701.4895	1949.605	607.1098	1582.389
NS_2	ia	336.4808	1766.492	356.4822	1637.69
NS_2	ia	320.1556	2068.651	354.7417	1578.908
NS_3	ia	431.7001	2404.017	684.5925	2089.171
NS_3	ia	680.2817	2100.46	624.1811	1932.621
NS_3	ia	321.921	2199.933	321.8963	2319.948
NS_3	ia	450.3997	2150.461	643.5532	1771.378
NS_3	ia	451.5359	2292.667	576.1896	1981.136
NS_3	ia	392.2787	2229.935	561.703	1634.85
NS_3	ia	459.2522	2186.483	574.6389	1905.33
NS_3	ia	460.6855	2398.653	515.2452	1971.471
NS_3	ia	428.8641	2399.187	498.5671	1755.043
NS_3	ia	372.8599	2461.239	543.4444	2195.226
NS_3	ia	423.7147	2434.888	565.9256	1587.219
NS_3	ia	362.1425	2590.145	557.2347	1554.999
NS_3	ia	429.6609	2483.002	536.898	2215.239

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	ia	392.2642	2602.032	531.7411	2459.174
NS_3	ia	387.6843	2411.206	376.983	2268.215
NS_3	ia	435.5884	2072.371	523.0346	1599.682
NS_3	ia	431.0647	2652.552	501.1288	1829.383
NS_3	ia	404.1951	2383.586	525.0492	2002.304
NS_3	ia	403.1603	1673.947	497.1078	2113.805
NS_4	ia	411.0705	2103.905	582.5279	1729.704
NS_4	ia	377.568	2557.094	669.6381	1951.366
NS_4	ia	429.9395	1512.616	720.0958	1727.482
NS_4	ia	408.0202	2523.082	533.5794	1077.343
NS_4	ia	363.9521	2504.06	484.1983	1901.465
NS_4	ia	414.2971	2566.802	505.6055	1947.302
NS_4	ia	426.6903	1829.677	449.7006	1987.168
NS_4	ia	421.7007	2128.751	524.1988	1893.246
NS_5	ia	675.9285	2010.987	667.843	2207.897
NS_1	o	487.8305	832.4461	493.4954	726.5336
NS_1	o	562.1969	975.8932	713.5923	977.2573
NS_1	o	1312.306	2300.285	301.3033	1229.024
NS_1	o	553.0817	1259.933	612.322	1241.995
NS_1	o	560.8294	1593.196	581.8692	1458.63
NS_1	o	559.6514	1229.145	562.4133	1008.899
NS_1	o	431.0049	1029.755	469.644	1435.838
NS_1	o	498.9229	1005.151	511.5207	1031.365
NS_1	o	484.164	974.7294	489.4766	1173.923
NS_2	o	988.3909	1823.483	825.6848	1640.861
NS_2	o	414.0485	899.82	466.6702	1003.872
NS_2	o	369.6643	1145.293	682.1714	1849.761
NS_2	o	486.9355	1519.158	661.2067	1755.651
NS_2	o	502.1282	1349.096	493.0926	1397.108
NS_2	o	538.2627	983.1243	494.5048	972.4595
NS_2	o	528.6791	792.4838	540.1465	800.1246
NS_2	o	347.8505	1049.428	363.6108	1255.987
NS_2	o	383.3888	1066.42	408.5988	1326.247
NS_3	o	474.3418	807.6751	356.1067	678.2782
NS_3	o	563.3497	1008.538	549.8685	1021.782
NS_3	o	623.4025	1155.988	689.6098	979.0157
NS_3	o	631.7452	1710.39	523.7477	1715.86
NS_3	o	627.305	1489.761	595.1521	1586.097
NS_3	o	239.9774	1830.435	482.8752	1547.717
NS_3	o	834.7498	1875.575	887.9914	1679.032
NS_3	o	654.3889	2404.161	599.4936	2558.477
NS_3	o	1168.015	2445.339	808.3477	2026.059
NS_3	o	615.7292	1877.397	610.3433	1999.57

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	o	494.1166	941.7376	502.6559	883.0455
NS_3	o	237.5976	1436	686.1359	1638.075
NS_3	o	657.2127	1227.375	629.4488	1488.854
NS_3	o	498.898	1159.779	342.7218	1273.784
NS_3	o	550.3718	2033.946	1003.817	2220.181
NS_3	o	811.5683	1245.319	838.3845	1602.885
NS_3	o	931.9346	2020.666	421.8187	1531.911
NS_3	o	512.3704	1328.677	419.9542	2400.587
NS_3	o	487.2367	963.1652	487.9988	939.3794
NS_3	o	753.7273	1104.18	667.9437	1138.761
NS_3	o	616.7223	1375.874	570.6745	1179.942
NS_3	o	462.3925	1129.444	472.5589	1178.364
NS_3	o	716.531	1743.716	737.4714	1774.591
NS_3	o	375.5237	1636.104	445.5279	1265.306
NS_3	o	486.074	1522.255	485.3699	1512.097
NS_3	o	346.1121	2347.63	446.198	2243.442
NS_3	o	676.8782	1167.06	889.73	1680.341
NS_3	o	619.579	1461.65	457.1283	1638.88
NS_3	o	684.9397	2020.104	386.5786	1551.863
NS_3	o	591.3088	1200.489	701.1894	1690.986
NS_3	o	438.2108	1956.048	425.4142	2008.632
NS_3	o	434.6223	1922.265	490.5562	2015.963
NS_3	o	530.2731	1668.354	568.8431	1573.243
NS_3	o	487.7147	1708.89	395.8294	1918.423
NS_3	o	460.1962	1692.731	466.047	1848.876
NS_3	o	568.5481	1189.609	572.335	1149.809
NS_3	o	520.5259	1360.827	392.7524	1293.842
NS_3	o	556.4471	1745.623	401.3831	898.8114
NS_4	o	700.0222	1288.505	560.9164	973.8026
NS_4	o	446.7266	1326.824	438.3643	1456.51
NS_4	o	589.8129	1165.03	604.6247	1136.475
NS_4	o	475.7137	918.4427	424.76	841.7344
NS_4	o	583.0573	815.5266	407.8557	517.2687
NS_4	o	467.9396	1209.39	482.2572	1033.231
NS_4	o	479.6208	1391.954	397.1922	1739.102
NS_4	o	489.8229	1156.103	461.0857	968.7263
NS_4	o	404.8657	750.4942	339.9837	656.3372
NS_4	o	502.4554	895.6602	405.7552	819.8769
NS_4	o	496.0413	848.7515	463.8206	820.9428
NS_4	o	261.1102	1005.864	365.0617	725.0696
NS_4	o	461.3765	636.2396	502.4447	818.4425
NS_4	o	731.8081	2709.974	590.8382	2220.854
NS_4	o	468.4338	731.1905	462.2661	663.4201

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	o	446.4714	1523.268	391.0247	1374.158
NS_4	o	451.555	988.1512	452.1168	1537.729
NS_4	o	253.4692	959.2261	217.602	1115.857
NS_4	o	616.996	1116.507	833.7633	1448.467
NS_4	o	600.7138	834.8393	560.6913	849.3114
NS_4	o	493.057	911.8294	436.5394	930.3812
NS_4	o	508.5851	1037.697	519.7259	1100.95
NS_4	o	415.2664	902.3377	416.5717	966.861
NS_4	o	421.8108	830.5854	456.699	844.795
NS_4	o	457.0523	696.3239	553.5919	622.2731
NS_4	o	490.0709	1666.484	497.0884	1764.496
NS_4	o	421.5878	797.8238	418.6685	764.5547
NS_4	o	398.4776	1219.742	343.5614	972.1354
NS_4	o	429.2038	707.5516	405.8632	658.4471
NS_4	o	441.6236	759.696	550.8542	895.2286
NS_4	o	390.8905	1798.786	422.6971	2128.333
NS_4	o	414.1994	1579.053	410.4887	1519.117
NS_4	o	499.8979	1917.884	592.7932	1892.251
NS_4	o	366.5682	849.6231	358.5169	901.6625
NS_4	o	558.1169	1402.368	490.5997	827.6795
NS_4	o	483.4546	1268.278	465.8965	1388.145
NS_4	o	455.4938	941.8225	561.5934	1306.514
NS_4	o	498.9183	1264.981	592.8196	1568.325
NS_4	o	334.5802	958.0267	372.1199	1522.282
NS_4	o	528.068	905.1021	552.6039	899.2217
NS_4	o	482.4466	938.4638	490.2686	944.5048
NS_4	o	441.1384	1982.757	724.5349	2493.29
NS_4	o	495.6003	981.3908	419.5122	808.8759
NS_4	o	392.9159	1475.121	715.7775	2326.038
NS_4	o	476.7411	934.6458	436.7559	863.3989
NS_4	o	529.3652	1317.556	556.5597	1080.739
NS_4	o	706.042	1278.057	700.0894	1309.378
NS_5	o	446.8292	928.1323	417.3809	896.6536
NS_5	o	405.8002	1882.257	466.0371	1332.159
NS_5	o	738.5251	1445.329	876.9694	1549.333
NS_5	o	457.6848	1012.345	236.6025	1089.829
NS_5	o	506.7922	2201.11	492.4025	1772.485
NS_5	o	642.857	1079.554	635.7673	1044.347
NS_5	o	677.7805	1338.184	231.4002	782.258
NS_5	o	421.6685	1127.291	425.0671	1378.493
NS_5	o	385.899	879.1524	426.8645	925.4066
NS_5	o	440.5724	938.6268	379.1499	1078.752
NS_1	O	508.6945	1020.232	747.5814	1524.115

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_1	O	540.2308	1487.461	479.2411	1150.96
NS_1	O	519.6987	961.6076	514.1327	976.3858
NS_1	O	784.7235	1283.984	580.1463	1100.625
NS_1	O	726.3	1094.433	809.2067	1055.661
NS_2	O	397.7205	964.7081	758.2135	1917.442
NS_2	O	440.2337	623.0178	343.3696	2370.375
NS_2	O	725.7402	1961.417	517.4583	1284.103
NS_2	O	557.3296	1651.552	578.505	1094.39
NS_2	O	620.0456	1009.226	652.2081	1010.434
NS_2	O	536.9236	898.4247	591.7348	939.9409
NS_3	O	549.5102	1418.417	1009.276	1452.376
NS_3	O	562.477	1089.222	470.5032	963.2306
NS_3	O	508.5836	1341.488	425.2891	1190.779
NS_3	O	642.549	1296.429	359.9348	1182.523
NS_3	O	519.5992	896.156	542.6276	924.2066
NS_3	O	217.7587	998.5359	162.221	1043.899
NS_3	O	545.1281	1092.034	524.7859	1349.572
NS_3	O	484.6406	787.0109	531.5154	652.1694
NS_3	O	633.8115	1194.099	597.8939	1256.677
NS_4	O	567.0543	1483.098	705.8586	1596.868
NS_4	O	418.8823	1264.161	404.6968	1177.641
NS_4	O	404.116	1512.805	914.5207	2849.79
NS_4	O	402.285	742.7392	411.7161	812.1659
NS_4	O	555.8319	1094.688	453.5679	808.3722
NS_4	O	414.6609	811.4013	463.0084	788.6783
NS_4	O	439.9494	766.6266	426.2494	749.4382
NS_4	O	450.9939	659.4842	378.0646	799.1937
NS_4	O	528.883	1068.287	482.5277	860.9563
NS_4	O	460.9917	687.35	480.5775	712.8619
NS_4	O	529.8275	836.3006	460.339	951.179
NS_4	O	428.2991	768.0641	407.7004	765.1149
NS_4	O	480.757	1269.462	648.164	1424.263
NS_4	O	481.4617	1400.193	601.1256	1547.426
NS_4	O	437.5146	700.3514	539.4413	946.9164
NS_4	O	377.5212	735.4687	417.7487	829.0911
NS_4	O	508.3819	937.2889	452.3866	897.5588
NS_4	O	632.12	1450.566	493.0698	793.9718
NS_4	O	443.7351	838.7978	521.8812	1032.66
NS_4	O	717.9513	1444.903	567.5559	1465.708
NS_4	O	479.1776	843.773	513.4386	894.7223
NS_4	O	446.0839	893.1751	419.2177	875.5656
NS_4	O	498.9885	1375.008	426.7163	895.8749
NS_4	O	532.3895	1051.496	497.831	994.1605

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_5	O	457.3781	1013.201	454.2869	1007.883
NS_5	O	444.4082	777.9475	449.5145	971.1222
NS_5	O	527.7958	866.9521	511.5473	802.0247
NS_5	O	516.5588	1037.488	459.1143	818.5881
NS_5	O	465.8571	994.6304	421.7609	976.5857
NS_3	u	444.2657	2186.371	408.9409	1931.825
NS_3	u	494.3875	2240.406	328.6926	1499.62
NS_1	U	380.3307	1129.185	393.6563	1382.297
NS_2	U	360.0732	998.9362	356.3822	1118.659
NS_2	U	514.9937	1311.256	879.1151	2132.767
NS_2	U	375.1669	1157.537	516.4266	1989.767
NS_2	U	582.1468	1293.575	476.9534	1060.714
NS_2	U	439.1131	1683.213	530.1477	1433.804
NS_2	U	394.5957	1513.647	447.1001	1148.942
NS_3	U	415.4916	1414.96	310.6828	1183.301
NS_3	U	440.9576	2119.399	448.5419	1400.285
NS_3	U	395.8088	1579.666	351.5372	1381.643
NS_3	U	185.9097	1549.229	297.8539	1610.886
NS_3	U	277.5537	1938.531	264.9149	1161.179
NS_3	U	608.922	1998.137	683.0111	2063.78
NS_3	U	421.1347	1690.603	1036.909	2825.408
NS_3	U	384.5339	1571.982	388.8712	1174.789
NS_3	U	528.4047	2548.657	395.4974	1213.527
NS_3	U	371.0309	1586.821	341.2724	1201.702
NS_3	U	694.6245	1678.213	406.0152	1689.143
NS_3	U	312.678	1410.535	415.8275	2110.695
NS_3	U	401.6954	912.6757	407.9236	1237.5
NS_3	U	423.9914	1480.988	509.508	1142.047
NS_3	U	422.6318	1591.71	370.4964	1499.992
NS_3	U	372.7312	1713.422	366.1193	1508.334
NS_3	U	445.1012	854.0694	423.6749	994.9548
NS_3	U	405.7154	1575.865	411.2253	1482.773
NS_3	U	412.8285	969.6972	465.4456	1414.562
NS_3	U	436.7396	1048.912	475.7843	1058.589
NS_3	U	485.2042	1112.156	503.1845	1147.511
NS_3	U	499.5103	977.56	516.3746	1102.33
NS_3	U	445.742	1573.51	470.2276	1193.796
NS_3	U	360.9635	1274.051	289.8214	1467.205
NS_3	U	464.5561	1472.988	548.8429	1405.657
NS_4	U	400.2716	1172.869	385.2419	1367.088
NS_4	U	421.0926	1422.811	355.9655	1187.858
NS_4	U	375.2423	903.5888	385.5506	1228.633
NS_4	U	408.094	2710.355	254.4671	2647.442

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_4	U	482.2266	2262.356	425.0525	2514.326
NS_4	U	404.8131	1218.474	392.1946	1037.52
NS_4	U	366.6741	1106.922	359.2083	1192.798
NS_4	U	363.737	1633.807	359.4994	1439.002
NS_4	U	461.6167	1044.262	475.0372	985.379
NS_4	U	373.627	1821.736	317.8213	1763.879
NS_5	U	476.8986	1835.761	436.7065	1058.324
NS_1	ua	371.8966	941.8405	389.8691	1137.938
NS_1	ua	438.7904	898.2964	438.6759	1075.232
NS_1	ua	471.4912	889.22	470.7329	1032.888
NS_1	ua	383.7561	963.0945	390.8382	1138.252
NS_2	ua	402.3772	822.4157	426.8505	790.5002
NS_3	ua	452.8684	1226.288	358.5336	1385.634
NS_3	ua	464.5592	895.5731	575.119	1528.136
NS_3	ua	411.4834	913.9159	457.6284	1136.217
NS_3	ua	648.5616	2255.151	583.4774	2050.255
NS_3	ua	404.9123	916.8892	458.1764	1002.244
NS_3	ua	430.8102	927.1806	539.5953	1406.896
NS_3	ua	481.4386	1052.466	617.1926	973.1779
NS_3	ua	587.891	1279.734	689.4237	2077.937
NS_3	ua	418.1273	667.3699	522.5672	1392.517
NS_3	ua	473.3899	1472.212	496.096	1333.15
NS_3	ua	488.2351	1663.773	815.8677	1885.052
NS_3	ua	444.4801	806.7886	641.7815	1946.722
NS_3	ua	506.6181	2308.127	321.3892	1125.579
NS_3	ua	739.5142	1660.959	1315.666	1923.33
NS_3	ua	368.114	1152.135	443.0039	1232.864
NS_3	ua	499.5379	1792.174	505.9549	1114.184
NS_3	ua	412.009	923.6811	562.6211	1700.551
NS_4	ua	442.4203	860.2813	443.9035	841.1201
NS_4	ua	431.5278	777.2833	485.463	979.1812
NS_4	ua	452.636	733.7737	417.5902	842.0541
NS_4	ua	383.5649	768.885	380.7182	818.6352
NS_4	ua	447.4024	930.0088	464.518	985.2809
NS_4	ua	436.476	829.8031	396.6985	800.0962
NS_4	ua	461.7082	1999.766	431.5981	862.6198
NS_5	ua	485.5799	1022.951	556.307	1428.648
NS_5	ua	430.0243	2138.377	460.8767	1221.397
NS_1	wa	422.6961	1027.182	430.6995	1022.689
NS_2	wa	464.3767	1252.162	487.3032	1680.286
NS_3	wa	440.5955	1760.537	374.737	1764.161
NS_3	wa	479.6798	1528.859	412.7629	1620.633
NS_3	wa	790.8118	1275.183	1174.04	1867.342

speaker	vowel	f1_head	f2_head	f1_tail	f2_tail
NS_3	wa	646.4709	1470.524	742.0066	1952.88
NS_3	wa	524.0559	1596.109	528.1061	1241.38
NS_3	wa	497.1249	1619.589	347.6969	1873.332
NS_3	wa	789.806	2184.761	647.683	1537.935
NS_3	wa	687.3659	1870.351	587.3372	1715.234
NS_3	wa	653.871	2218.458	710.7487	1840.509
NS_3	wa	555.6251	996.0187	622.9696	1195.758
NS_3	wa	582.5983	1129.8	610.2249	1480.556
NS_3	wa	633.0753	1003.193	601.6884	1749.372
NS_3	wa	523.8006	1293.95	525.9348	1431.372
NS_3	wa	488.6846	1229.433	528.442	1498.028
NS_3	wa	521.1271	1323.573	533.7523	1508.651
NS_4	wa	438.0652	861.8393	595.7525	991.1533
NS_4	wa	455.958	995.6208	477.7208	1112.1
NS_4	wa	401.1196	1099.446	304.3826	1212.034
NS_4	wa	435.1173	834.6708	678.151	1231.06
NS_4	wa	412.2878	854.993	530.0566	1108.724
NS_4	wa	470.3147	1073.223	419.5308	1192.476
NS_4	wa	411.365	844.3128	424.1494	1010.465
NS_4	wa	370.8953	1189.617	451.5226	1313.938
NS_4	wa	437.237	852.9596	451.8853	1124.333
NS_4	wa	593.9034	1414.585	350.0823	1294.642
NS_4	wa	504.4723	912.8561	421.5004	1167.634
NS_4	wa	314.479	1173.191	361.1149	1281.92
NS_5	wa	493.9828	1090.928	499.4254	1626.591
NS_2	ya	562.7591	2032.705	668.988	1914.471
NS_3	ya	344.6396	2528.465	444.5437	1508.031
NS_3	ya	485.4693	2545.602	747.8835	1740.344
NS_3	ya	409.1861	2379.898	438.9059	1970.879
NS_3	ya	447.6279	2434.965	679.2086	2159.957
NS_3	ya	447.402	2481.694	708.3503	1924.202
NS_3	ya	403.1976	2495.628	601.6496	2338.138
NS_4	ya	360.683	2446.068	469.5108	1859.942
NS_5	ya	480.9539	1493.426	443.42	1733.944

APPENDIX II: LEXICAL ITEMS AND FORMANT 1 MEASUREMENTS

speaker	vowel	context	f1_head	f2_head
NS_1	a	ohpEqtaw	578.7174	1820.125
NS_1	a	akIqtaw	504.1713	2234.255
NS_1	a	kecEqtawak	568.282	1674.733
NS_1	a	pEkonam	639.0437	1726.614
NS_1	a	pOtawaew	503.2203	1803.628
NS_1	a	saeqsiw <u>a</u> hekan	495.8484	1127.846
NS_1	a	saeqsiwaheka <u>n</u>	607.8192	1692.707
NS_1	a	sOwatow	628.6602	1235.87
NS_1	a	tapAsow	570.9324	1625.484
NS_1	a	yAtapew	571.556	1887.93
NS_1	a	akIqtaw	647.5029	1440.345
NS_1	a	akaehsemen	609.5307	1213.164
NS_1	a	amAskos	442.8221	1808.86
NS_1	a	akuahkOhsaeh	367.2279	1209.905
NS_1	a	akuahkihsen	400.2118	1476.964
NS_1	a	anAmAEhkwam	613.1206	1705.154
NS_1	a	apEw	680.235	1272.555
NS_1	a	ehkuahtawaew	486.0713	1717.066
NS_1	a	cEk <u>a</u> tahekaew	537.2641	1777.856
NS_1	a	cEk <u>a</u> hekaew	701.7257	1782.498
NS_1	a	kahpEh	829.2665	1436.616
NS_1	a	kEhkan	625.9763	1810.06
NS_1	a	kecEqtawak	655.5322	1200.193
NS_1	a	mAnestAnehsak	483.587	1924.502
NS_1	a	mahwAEw	760.9035	1189.179
NS_2	a	akIhAEw	1312.471	2292.232
NS_2	a	mAnAewak	729.8637	1602.692
NS_2	a	pesAEhkiwak	633.6049	1169.162
NS_2	a	maskUtiah	389.1354	1734.644
NS_2	a	kAkanAwehek	304.7149	1251.057
NS_2	a	kenah	649.7264	1548.985
NS_2	a	kemAEk- <u>a</u> sAqtamet	990.6489	2217.026
NS_2	a	kemAEk-asAq <u>t</u> amet	404.9958	1395.423
NS_2	a	kan	423.0622	1515.289
NS_2	a	nenAEman <u>a</u> n	359.7869	1627.434
NS_2	a	nenAEman <u>a</u> n	370.479	1510.903
NS_2	a	kan	553.6541	1981.364
NS_2	a	nepIcemiaht <u>a</u> nan	530.0703	867.7639
NS_2	a	nepIcemiaht <u>a</u> nan	780.6267	1535.487
NS_2	a	kanAwehet	447.5661	1079.446
NS_2	a	awEh	742.0136	1144.258
NS_2	a	maehsEwan	539.5525	2155.412

speaker	vowel	context	f1_head	f2_head
NS_2	a	taq	597.8685	1383.459
NS_2	a	nohAhkaniahkiw	340.0748	1819.74
NS_2	a	ayAwet	481.1183	1846.155
NS_2	a	kOhkOsahcekAEm	413.7843	1978.682
NS_2	a	nAEwAwak	539.9804	938.5013
NS_2	a	akuahkok	490.753	1161.68
NS_2	a	pahkIsekanem	735.6363	1093.286
NS_2	a	mAmianAceqtam	501.7645	1609.784
NS_2	a	nanAweyaw	367.2543	1621.68
NS_2	a	nanAweyaw	466.4813	1533.455
NS_3	a	osEhtaw	661.7472	1444.931
NS_3	a	wanEhnetaw	534.1825	1758.871
NS_3	a	kaehkEnawapahtam	692.3675	1578.664
NS_3	a	kecEqtaw	687.521	1154.534
NS_3	a	kocEqtaw	649.4216	1216.323
NS_3	a	kuahnepAhtaw	575.1648	1714.183
NS_3	a	mianAceqtawikamek	561.9139	1989.806
NS_3	a	mianAceqtaw	617.1801	755.227
NS_3	a	kaehkInUhamatIk	1360.746	1900.408
NS_3	a	nAEqtam	639.1339	2108.774
NS_3	a	nahAw	471.8293	1938.229
NS_3	a	namAEpen	569.6116	1849.966
NS_3	a	namAEwak	227.2447	1810.277
NS_3	a	namAEwak	248.0015	1514.005
NS_3	a	nayOmekow	929.7562	1738.486
NS_3	a	nesAEkepan	422.9021	996.7897
NS_3	a	osAmat	429.0751	1387.257
NS_3	a	pahpEsew	500.8943	1708.81
NS_3	a	pakAhcekaew	482.4964	1755.351
NS_3	a	pEqsesam	563.9067	885.6944
NS_3	a	pOhkoskam	623.0065	2560.444
NS_3	a	sakanah	558.3799	1617.133
NS_3	a	sakanah	538.8261	759.281
NS_3	a	sakanah	903.1265	1518.673
NS_3	a	sEwan	837.0774	1618.399
NS_3	a	tahkOnewaewak	460.2083	1701.584
NS_3	a	tahkOnewaewak	529.9154	1112.569
NS_3	a	tapAnAEw	564.5094	1815.321
NS_3	a	tAqtakacehkw	528.8432	2263.978
NS_3	a	tAqtakacehkw	734.642	898.0422
NS_3	a	tatAhkesew	509.9377	1582.914
NS_3	a	tAwAEham	680.0208	1550.621
NS_3	a	wAEpenam	940.35	1369.078

speaker	vowel	context	f1_head	f2_head
NS_3	a	w <u>a</u> nAenehtam	836.0775	1478.227
NS_3	a	wanAeneht <u>a</u> m	665.8173	1916.046
NS_3	a	wanEhnetaw	540.3911	1652.207
NS_3	a	wA <u>p</u> ahtam	677.8959	1973.21
NS_3	a	wA <u>p</u> aht <u>a</u> m	656.7453	1843.207
NS_3	a	wAq <u>n</u> aw	428.9868	1830.504
NS_3	a	wEhtamowA <u>E</u> w	539.0913	1729.036
NS_3	a	<u>h</u> k <u>a</u> nom	753.199	1585.632
NS_3	a	ah <u>k</u> <u>a</u> nom	529.7813	1852.168
NS_3	a	<u>a</u> nAmaehk <u>a</u> wA <u>E</u> w	758.5144	2716.362
NS_3	a	anAmaehk <u>a</u> wA <u>E</u> w	553.0288	771.0302
NS_3	a	anA <u>E</u> m2	600.5588	1859.508
NS_3	a	<u>a</u> kuatikamek	402.2857	1473.925
NS_3	a	akuatik <u>a</u> mek	575.4249	1594.256
NS_3	a	akuaceh	318.4538	1309.301
NS_3	a	<u>a</u> pEsamaepen	910.7684	1928.749
NS_3	a	apEs <u>a</u> maepen	702.6023	1868.981
NS_3	a	anohkIw	395.7599	1015.342
NS_3	a	anEp	584.2783	1327.717
NS_3	a	<u>a</u> sAqcekaewikamek	651.6129	1590.204
NS_3	a	asAqcekaewik <u>a</u> mek	521.8323	1421.337
NS_3	a	apIsIw	609.2851	870.2374
NS_3	a	cEp <u>a</u> y	699.5444	1974.198
NS_3	a	cEp <u>a</u> taewan	509.2498	1537.366
NS_3	a	cEpataew <u>a</u> n	442.841	949.0636
NS_3	a	cEpataew	663.9748	1770.582
NS_3	a	kaehkEn <u>a</u> wapahtam	480.7098	1911.84
NS_3	a	kaehkEnawap <u>a</u> htam	614.5629	1732.312
NS_3	a	kaehkEnawap <u>a</u> ht <u>a</u> m	570.5133	1928.122
NS_3	a	kaehkEnawaew	643.9963	1918.61
NS_3	a	enAenehtam	561.8592	814.7062
NS_3	a	kAsakaeh2	437.1752	2041.396
NS_3	a	kamAc	657.2134	1481.937
NS_3	a	kenUsIqsek <u>a</u> paweh	914.271	1543.527
NS_3	a	kenUsIqsek <u>a</u> paweh	551.9321	1026.649
NS_3	a	ma <u>s</u> Enahekan2	216.9723	1462.399
NS_3	a	masEn <u>a</u> hekan2	512.3155	2010.817
NS_3	a	masEnaheka <u>n</u> 2	871.9323	1705.558
NS_3	a	mAEn <u>a</u> wac	491.1826	1785.267
NS_3	a	mAEnaw <u>a</u> c	686.013	1784.943
NS_3	a	mianAceqtawikamek	491.1318	1433.206
NS_3	a	ahkuacemow	1101.804	2787.714
NS_3	a	ahkuaham	958.4894	2363.283

speaker	vowel	context	f1_head	f2_head
NS_3	a	ahkuaham	519.3299	1003.91
NS_3	a	ahkuahkihnaen	493.4853	1389.807
NS_3	a	<u>ah</u> kuahataew	449.1345	1744.196
NS_3	a	<u>ah</u> kuahataew	630.5403	1612.287
NS_3	a	ahkuah <u>ah</u> aeu	591.067	2006.419
NS_3	a	ahkUp <u>kat</u>	702.7602	1714.226
NS_3	a	Akuah <u>ah</u> ataem	623.9538	1021.338
NS_3	a	Akuahata <u>am</u>	588.454	1086.198
NS_3	a	akUtuaaw	668.06	1591.359
NS_3	a	anAEcemyakawew	524.1146	1880.718
NS_3	a	anAEcemyakawew	533.9164	1896.856
NS_3	a	an ⁱ piah <u>kan</u>	654.4513	2046.714
NS_3	a	<u>an</u> ⁱ piahkaneh	752.3558	1692.822
NS_3	a	anIpiah <u>kan</u> eh	701.9957	2092.485
NS_3	a	<u>an</u> Ipiahkaneh	895.1528	1845.948
NS_3	a	<u>an</u> Ipiahkan-kenUpikwas	628.2559	1940.657
NS_3	a	anIpiah <u>kan</u> -kenUpikwas	618.4658	1400.258
NS_3	a	<u>an</u> uakawew	804.9845	2086.195
NS_3	a	anuak <u>a</u> wew	555.3647	1024.18
NS_3	a	anUcepotaew	865.9377	1813.757
NS_3	a	apAEhsahkyah	445.3343	1799.567
NS_3	a	apAEhsahkyah	458.302	1832.325
NS_3	a	apIsemUhkehkwah	765.2424	1515.83
NS_3	a	apuan	729.5902	1571.736
NS_3	a	aqcIqnaeh	695.1674	2304.276
NS_3	a	AqnamAhkyah	525.4318	1720.095
NS_3	a	asAqsuahaeh	617.6428	1827.734
NS_3	a	AsawAhkyah	603.3127	1715.541
NS_3	a	<u>as</u> EkanEhsaeh	633.919	1870.148
NS_3	a	asE <u>kan</u> Ehsaeh	565.4781	2273.429
NS_3	a	<u>as</u> Ekan-wiahkwan	1572.103	2657.637
NS_3	a	asE <u>kan</u> -wiahkwan	766.1591	1895.372
NS_3	a	asiahnaew	646.3287	2169.499
NS_3	a	atUhpuaahaeh	609.0949	1873.504
NS_3	a	ayAkuamemaew	277.2429	1962.334
NS_3	a	cIkahkyah	720.0761	2174.827
NS_3	a	esiahkah	608.7172	1341.519
NS_3	a	esiahkam	562.8192	1414.059
NS_3	a	eskIciakan	1157.304	1897.219
NS_3	a	kaehkInUhamatIk	1558.554	2138.558
NS_3	a	kEmenaeciakan	461.7007	1572.81
NS_3	a	macInAkwat1	358.7466	1822.689
NS_3	a	miasek <u>a</u> kaweh	759.4987	1593.495

speaker	vowel	context	f1_head	f2_head
NS_3	a	miasekaka <u>a</u> weh	621.2307	1350.573
NS_3	a	wEkemiahtaw	423.1918	1901.868
NS_4	a	nenAEhkeskaw	634.5302	2018.86
NS_4	a	onAhotaw	717.5223	1623.72
NS_4	a	pEkoskaw	927.1207	1469.959
NS_4	a	tAEqtepAEskaw	514.8609	1125.749
NS_4	a	wAEsEhotaw	611.7993	1281.594
NS_4	a	aqtaw	726.8841	1360.157
NS_4	a	kOhtakan	529.5462	2733.436
NS_4	a	nahAEkAc	539.2569	1250.814
NS_4	a	nahAEnesew	587.4908	1942.727
NS_4	a	nahAEnet	753.1737	2231.254
NS_4	a	na <u>t</u> AwApahtamowaew	449.0588	2914.7
NS_4	a	natAwAp <u>a</u> htamowaew	733.7188	1051.111
NS_4	a	natAwAp <u>a</u> ht <u>a</u> mowaew	691.4418	1347.44
NS_4	a	na <u>w</u> AsApahtam	504.9504	837.6603
NS_4	a	nawAsAp <u>a</u> htam	624.5234	864.2091
NS_4	a	nawAsAp <u>a</u> ht <u>a</u> m	638.803	892.1298
NS_4	a	netAEnaniw	527.9894	2726.452
NS_4	a	netAEnimAhk <u>a</u> nan	522.7375	814.3613
NS_4	a	netAEnimAhk <u>a</u> na <u>n</u>	505.3183	994.5864
NS_4	a	okAskisqak	529.904	1389.199
NS_4	a	pAhkenam	669.7899	1510.835
NS_4	a	p <u>a</u> kAhcekan	796.1202	1129.677
NS_4	a	pakAhce <u>k</u> a <u>n</u>	531.7245	1445.912
NS_4	a	pAkataen	432.3046	1492.924
NS_4	a	paskIpemIqsiw	523.3245	1462.099
NS_4	a	pemAEnehtam	625.3345	1414.112
NS_4	a	pesEwak	485.1622	1071.979
NS_4	a	poqsAEhkamokon	546.532	1375.585
NS_4	a	pO <u>t</u> awanAEhtam	497.7303	739.1091
NS_4	a	pO <u>t</u> awa <u>n</u> AEhtam	587.4687	1198.39
NS_4	a	pO <u>t</u> awanAEht <u>a</u> m	677.9051	1346.967
NS_4	a	sAhk <u>a</u> hekan	489.2734	956.8201
NS_4	a	sAhkahe <u>k</u> a <u>n</u>	623.704	1596.255
NS_4	a	s <u>a</u> kAqsenam	494.0737	1977.872
NS_4	a	sakAqse <u>n</u> a <u>m</u>	766.3283	1407.284
NS_4	a	tanAEnemaew	487.1458	2096.875
NS_4	a	taskuahkwat	358.483	2187.572
NS_4	a	tAwAEhekan	532.2732	1285.733
NS_4	a	tepAham	647.9842	1082.921
NS_4	a	tUkaniq	422.2249	1638.509
NS_4	a	wAEsEhocekan	808.5502	1494.284

speaker	vowel	context	f1_head	f2_head
NS_4	a	wApatow	515.1007	1292.332
NS_4	a	wAqsAhkonawAEt	503.9162	875.4294
NS_4	a	watOw	641.6421	1263.509
NS_4	a	AEhsep <u>a</u> nak	547.4439	1471.873
NS_4	a	AEhsep <u>a</u> nak	738.1728	1698.745
NS_4	a	akeq	598.4777	1414.093
NS_4	a	ahpApowaew	542.5495	1104.644
NS_4	a	anAhkOhsaeh	768.4159	1634.726
NS_4	a	anAEm1	843.6681	2115.649
NS_4	a	apEsen	506.3232	941.5577
NS_4	a	Apesehcekan	429.6644	1503.704
NS_4	a	anOnAEw	437.9492	2170.385
NS_4	a	anīpiahkan	599.4843	1399.142
NS_4	a	anIpiahkAEhsaeh	622.8874	1392.076
NS_4	a	asAqcekaew	471.0987	917.8967
NS_4	a	aqtaw	860.8434	1296.922
NS_4	a	<u>a</u> puahsokaneh	669.3048	2519.488
NS_4	a	apuahsok <u>a</u> neh	521.6915	1379.87
NS_4	a	apuahsok <u>a</u> n	533.48	1325.293
NS_4	a	emen <u>a</u> kah	732.3661	2209.897
NS_4	a	emen <u>a</u> kah	649.056	1069.637
NS_4	a	asAqswan	709.589	2454.112
NS_4	a	kayAEnet	370.5743	1975.28
NS_4	a	kAsakaeh1	450.7723	1768.691
NS_4	a	kEmOsAp <u>a</u> htam	703.4976	907.859
NS_4	a	kEmOsAp <u>a</u> ht <u>a</u> m	1073.999	1873.783
NS_4	a	kEmAp <u>a</u> htam	605.6016	896.3947
NS_4	a	kEmAp <u>a</u> ht <u>a</u> m	592.1745	1504.311
NS_4	a	kEskepocek <u>a</u> nan	442.9621	1262.082
NS_4	a	kEskepocek <u>a</u> nan	436.2556	1277.808
NS_4	a	kesEqnecekan	695.9513	1342.327
NS_4	a	kesEhekan	539.619	1604.977
NS_4	a	kEs <u>a</u> wetaepAEhkat	466.6172	1846.99
NS_4	a	kEsawetaepAEh <u>k</u> at	618.2456	912.8401
NS_4	a	kOht <u>a</u> kan	522.8424	1029.852
NS_4	a	kIskahAhkwan	557.7103	1519.328
NS_4	a	kIhkataew	470.0735	1191.316
NS_4	a	kuahnepesowak	472.1398	850.4941
NS_4	a	kotaeqnas	618.6337	2023.067
NS_4	a	mas <u>a</u> Enahekan1	466.6416	2053.181
NS_4	a	masEn <u>a</u> hekan1	463.1229	2218.848
NS_4	a	masEnahek <u>a</u> n1	528.3857	1592.322
NS_4	a	maeqnakwah	311.3533	1647.609

speaker	vowel	context	f1_head	f2_head
NS_4	a	miakonam	666.6465	1346.203
NS_4	a	AEhsepan	551.0566	1530.593
NS_4	a	AEhsepanak	547.4439	1471.873
NS_4	a	AEhsepanak	738.1728	1698.745
NS_4	a	miasenamAEkoh	496.5643	1186.053
NS_4	a	AEhsepan	551.0566	1530.593
NS_5	a	wAqnenekan	632.8889	1619.943
NS_5	a	asAqcekanAhtek	535.0011	1312.294
NS_5	a	asAqcekanAhtek	469.7602	1756.677
NS_5	a	kotApyacekan	498.828	1412.85
NS_5	a	kanew	514.0023	1273.041
NS_5	a	payItohnaet	815.5534	2127.931
NS_5	a	omas	301.9848	1583.127
NS_5	a	anAEmok	561.8039	1132.71
NS_5	a	pApemOhnaewak	484.6939	782.432
NS_5	a	aw	487.0017	1356.553
NS_5	a	mEcah	418.0457	2275.025
NS_5	a	omas	633.5475	1079.913
NS_5	a	kenaq	787.4944	1628.808
NS_5	a	katAEwesEqtayan	563.7406	1172.383
NS_5	a	katAEwesEqtayan	732.7963	1819.529
NS_5	a	pIcemiahtah	499.2951	1757.259
NS_5	a	akom	441.6575	957.3007
NS_1	A	yAtapew	778.7716	2030.386
NS_1	A	amAskos	970.2846	1313.174
NS_1	A	cEpAhkow	729.4978	1301.998
NS_1	A	ketAkApos	1077.418	1429.959
NS_1	A	ketAkAhsaeh	936.4238	1327.715
NS_1	A	mAnestAnehsak	616.9673	1659.183
NS_1	A	mAnestAnehsak	663.6361	1727.948
NS_1	A	nekAmow	592.9574	1436.513
NS_1	A	tapAsow	801.8846	1336.747
NS_1	A	anAmAEhkwam	815.7124	1622.844
NS_1	A	enAkIhcen	749.3747	1394.157
NS_1	A	ketAkApos	681.9682	1602.31
NS_1	A	ketAkAhsaeh	657.1392	1479.998
NS_1	A	meyAwAEw	766.0816	1487.074
NS_2	A	osAqsaehkwat	691.8578	1294.814
NS_2	A	wApAEhsyah	647.4039	1160.265
NS_2	A	mAnAEwak	506.4644	1289.29
NS_2	A	pApaehnaen	849.9177	1170.935
NS_2	A	kAkanAwehek	777.0006	1175.473
NS_2	A	kAkanAwehek	419.3882	1174.111

speaker	vowel	context	f1_head	f2_head
NS_2	A	nAnEpowenon	407.0658	1325.003
NS_2	A	kemAEk-asAqtamet	844.7058	1366.045
NS_2	A	paeqnAn	899.0553	1583.254
NS_2	A	kanAwehet	473.7964	1203.115
NS_2	A	nAteh	384.0642	1311.021
NS_2	A	nAEwAw	769.5543	1214.115
NS_2	A	nAteh	603.6555	1231.441
NS_2	A	Awew	610.1073	1304.865
NS_2	A	ayAwet	895.5059	1524.226
NS_2	A	nAEwAwak	806.033	1202.017
NS_2	A	yAh	751.3064	1733.058
NS_2	A	mAmianAceqtam	353.2804	1263.163
NS_2	A	mAmianAceqtam	657.8353	1537.982
NS_2	A	nanAweyaw	367.8837	1323.696
NS_2	A	Awew	825.7973	1331.178
NS_2	A	nekAt	571.8667	1613.551
NS_2	A	nemAmIcehsim	616.8551	1186.919
NS_3	A	naehkAt2	736.564	1042.78
NS_3	A	naeqnemAw	279.9437	1040.334
NS_3	A	nApAEw	419.0342	2868.519
NS_3	A	nemEsAtohnaem	916.0839	1564.739
NS_3	A	okEmAw	542.9092	1400.784
NS_3	A	onAkow	819.3443	1467.198
NS_3	A	osAmat	639.9093	1474.044
NS_3	A	osAmesew	1082.775	1676.532
NS_3	A	otAhpenaew	839.2323	1902.963
NS_3	A	sAkecwAEpenaew	817.8188	1486.419
NS_3	A	sEwApoh	754.911	1270.023
NS_3	A	tapAnAEw	770.9583	1434.348
NS_3	A	tAqtakacehkw	615.6904	1042.558
NS_3	A	tAwAEham	771.18	1662.432
NS_3	A	tAwAEhekaew	740.9654	1734.108
NS_3	A	wApahtam	1161.265	1438.748
NS_3	A	wApeskiw	989.8349	1431.266
NS_3	A	wAqnaw	664.9621	1114.652
NS_3	A	wAqnenekAEw	713.5492	1202.978
NS_3	A	ahsAmAEw	1057.662	1566.937
NS_3	A	kAsakaeh2	849.9892	1366.68
NS_3	A	kamAc	815.0021	1242.916
NS_3	A	kEwAtAEnemaew	799.6988	1346.256
NS_3	A	mianAceqtawikamek	862.9744	1630.396
NS_3	A	mianAceqtaw	709.9765	1480.886
NS_3	A	Akuaqnaehaew	425.3769	1576.924

speaker	vowel	context	f1_head	f2_head
NS_3	A	Aqnam <u>A</u> hkyah	979.1384	1497.891
NS_3	A	AqtenU <u>h</u> kuwaew	857.0037	1317.857
NS_3	A	Asaw <u>A</u> hkyah	508.0274	1520.178
NS_3	A	ayA <u>k</u> uamemaew	329.5458	2356.425
NS_3	A	macInAkwat1	902.0198	1670.736
NS_3	A	macInAkwat2	445.3625	2002.777
NS_3	A	nahAw	944.3937	1546.939
NS_3	A	pakA <u>h</u> cekaew	790.2609	1553.48
NS_3	A	tatA <u>h</u> kesew	730.4505	1125.708
NS_3	A	anAma <u>h</u> kawAEw	745.2034	1524.848
NS_3	A	asAq <u>ce</u> kaewikamek	595.7362	1007.521
NS_3	A	kuah <u>ne</u> pAhtaw	853.7134	1425.93
NS_3	A	<u>A</u> qnamAhkyah	1159.848	2285.566
NS_3	A	asAq <u>s</u> uahsaeh	922.2886	1393.298
NS_3	A	<u>A</u> sawAhkyah	788.6505	1177.849
NS_4	A	nahA <u>E</u> kAc	586.6499	1248.699
NS_4	A	nA <u>h</u> tekok	715.1707	1251.184
NS_4	A	nat <u>A</u> wApahtamowaew	736.8828	998.6879
NS_4	A	nawAs <u>A</u> pahtam	806.6472	1359.556
NS_4	A	nekE <u>k</u> AtAEpyan	656.8834	1301.044
NS_4	A	okA <u>s</u> kiqsak	660.1659	1190.259
NS_4	A	onA <u>n</u> ekosew	613.38	1223.765
NS_4	A	osA <u>q</u> sekop	505.8437	1538.36
NS_4	A	otA <u>ce</u> kwan	681.1004	1091.927
NS_4	A	pA <u>h</u> kenam	598.3952	1159.971
NS_4	A	pA <u>k</u> ataen	737.3478	1007.244
NS_4	A	sA <u>E</u> pAw	710.3624	1006.386
NS_4	A	sA <u>h</u> kahekan	754.3839	1300.566
NS_4	A	sakA <u>q</u> senam	687.5432	1197.874
NS_4	A	sE <u>w</u> Apemen	660.2958	1002.737
NS_4	A	tA <u>w</u> AEhekan	671.4733	1280.834
NS_4	A	wA <u>p</u> atow	677.9193	1077.474
NS_4	A	wA <u>p</u> emen	759.4251	1089.757
NS_4	A	wA <u>p</u> esken	664.8457	1047.596
NS_4	A	wA <u>p</u> os	805.9288	1643.805
NS_4	A	w <u>A</u> poweyAn	600.7249	819.9508
NS_4	A	wA <u>p</u> owey <u>A</u> n	697.7365	1710.265
NS_4	A	w <u>A</u> qsAhkonawAEt	439.3413	964.8473
NS_4	A	wA <u>q</u> sA <u>h</u> konawAEt	624.2499	1125.699
NS_4	A	wE <u>y</u> Atesew	874.2771	1356.018
NS_4	A	ahpA <u>p</u> owaew	772.9292	968.9825
NS_4	A	anA <u>h</u> kOhsaeh	565.0683	964.655
NS_4	A	Apes <u>h</u> cekan	808.7688	1141.649

speaker	vowel	context	f1_head	f2_head
NS_4	A	esInAkwat	854.1919	1307.16
NS_4	A	kAsakaeh1	722.0776	1333.649
NS_4	A	kAketow	687.0777	1631.881
NS_4	A	kAhtenaew	691.8923	1095.093
NS_4	A	kAEmAw	778.1282	993.2079
NS_4	A	kEsae hkAhtek	760.5677	1269.535
NS_4	A	kEmOsApahtam	645.2654	1016.261
NS_4	A	kEmApahtam	1050.849	1688.601
NS_4	A	kIskahAhkwan	689.9366	1144.434
NS_4	A	maehkAEnAh	457.5269	1149.745
NS_4	A	mEkAcekaew	702.4225	957.397
NS_4	A	mEsAc	676.5633	834.0519
NS_4	A	naehkAn	601.3271	969.1692
NS_4	A	natAw <u>A</u> pahtamowaew	724.1891	805.498
NS_4	A	naw <u>A</u> sApahtam	422.3128	986.2796
NS_4	A	neskAs	728.0205	1207.438
NS_4	A	netAEnimAhkanan	477.3019	1037.502
NS_4	A	netAnekom	688.6627	1638.494
NS_4	A	ohkOmAnEhsaeh	903.5083	1682.377
NS_4	A	onAhotaw	700.3285	1098.174
NS_4	A	onAqnaew	736.8133	1097.3
NS_4	A	pakAhcekan	742.9126	1505.087
NS_4	A	tepAham	657.6949	947.672
NS_4	A	asAqcekenon	798.2819	1219.916
NS_4	A	asAqcekaew	575.4836	1078.972
NS_4	A	asAqswan	556.7731	1046.329
NS_4	A	maehkAn	695.8776	1305.02
NS_5	A	wAqnenekan	790.5966	1693.5
NS_5	A	asAqcekan <u>A</u> htek	553.3516	1266.648
NS_5	A	kotApyacekan	768.3964	1393.408
NS_5	A	as <u>A</u> qcekanAhtek	719.8558	2057.979
NS_5	A	sekAk	800.3317	1148.912
NS_5	A	ewAh	664.8843	1130.997
NS_5	A	pApemOhnaewak	719.3564	1017.429
NS_5	A	nAten	789.0373	1173.174
NS_5	A	AEnAcen	516.5286	1240.75
NS_5	A	tAq	399.4913	1564.575
NS_5	A	tAq	627.6957	1672.884
NS_5	A	Am	532.3686	1297.576
NS_5	A	mIkAtituaq	622.6222	1459.293
NS_1	ae	pemOhnaew	657.9606	2082.861
NS_1	ae	pOtawaew	683.6833	1598.523
NS_1	ae	ehkuahtawaew	599.9553	1690.455

speaker	vowel	context	f1_head	f2_head
NS_1	ae	cEkatahekaew	472.1317	2401.247
NS_1	ae	kuahnaew	595.0449	2096.387
NS_1	ae	saeqsiwahekan	628.035	1460.218
NS_1	ae	akuahkOhsaeh	611.0406	1741.897
NS_1	ae	ketAkAhsaeh	728.8393	1857.114
NS_2	ae	osAqsae ^h kwat	565.9915	1415.645
NS_2	ae	maeqseh	327.8924	1606.084
NS_2	ae	pApae ^h naen	504.6775	1711.622
NS_2	ae	pApae ^h naen	766.1097	1928.299
NS_2	ae	paeqnAn	765.0918	1112.633
NS_2	ae	kaeqceh	759.9785	1891.254
NS_2	ae	maehsEwan	346.1049	1679.239
NS_2	ae	kesEqnaehkim	365.1706	2157.65
NS_3	ae	nemEsAtohnaem	444.3478	2209.292
NS_3	ae	otAhpenaew	636.1797	1864.204
NS_3	ae	pakAhcekaew	529.326	2492.772
NS_3	ae	sAkecwAEpenaew	500.4248	1797.135
NS_3	ae	tahkOnewaewak	556.3214	1579.376
NS_3	ae	tAwAEhekaew	655.3865	2210.928
NS_3	ae	apEsamaepen	1063.865	1885.186
NS_3	ae	cEpataewan	687.7888	2082.699
NS_3	ae	cEpataew	728.0641	2046.656
NS_3	ae	kaehkEnawaew	726.5572	1870.179
NS_3	ae	kEskesaew	792.3729	1960.106
NS_3	ae	kocEmonaew	934.6201	1625.617
NS_3	ae	kEwAtAEnemaew	824.4344	1101.291
NS_3	ae	mOsehaew	264.8692	2431.903
NS_3	ae	ahkuahtawaew	493.1928	1053.957
NS_3	ae	ahkuaqtahaew	587.0825	1996.003
NS_3	ae	Akuaqnae ^h aew	467.9987	1990.815
NS_3	ae	aqcIqnaeh	466.3884	2117.993
NS_3	ae	asAqcekaewikamek	561.0177	1096.054
NS_3	ae	naehkAt2	580.7276	2170.561
NS_3	ae	naeqnemAw	683.3333	2231.806
NS_3	ae	nImihaetiq	696.2263	2330.202
NS_3	ae	ahkAEhkOhsaeh	694.1526	1804.783
NS_3	ae	anAmaehkawAEw	438.7141	1069.4
NS_3	ae	kaehkEnawapahtam	505.4009	2013.242
NS_3	ae	kae ^h Enawaew	529.1024	2135.244
NS_3	ae	kAsakaeh2	630.9213	2104.459
NS_3	ae	ahkuahkihnaen	431.4073	1867.211
NS_3	ae	Akuaqnae ^h aew	713.07	2041.528
NS_3	ae	anUcepotuwaew	708.4653	1829.116

speaker	vowel	context	f1_head	f2_head
NS_3	ae	AqtenUhkuwaew	502.8084	2052.202
NS_3	ae	asAqsuahsaeh	602.6661	1755.174
NS_3	ae	asEkanEhsaeh	627.3911	1911.259
NS_3	ae	asiahnaew	426.8001	1850.118
NS_3	ae	atUhpuahsaeh	575.8441	1677.57
NS_3	ae	ayAkuamemaew	293.9782	1751.409
NS_3	ae	esImiakwat-kaehkoh	671.4714	2009.405
NS_3	ae	kaehkInUhamatIk	664.9757	2400.437
NS_3	ae	kaehpiawekow	776.4793	2330.209
NS_3	ae	kEmenaeciakan	376.3375	2031.889
NS_3	ae	kenUqcikaen	409.9703	1949.78
NS_4	ae	anIpiahkAEhsaeh	742.8874	2061.877
NS_4	ae	natAwApahtamowaew	741.528	2510.094
NS_4	ae	nOcpenaehAEw	409.2077	2103.707
NS_4	ae	omOhnaew	530.7642	1909.688
NS_4	ae	onAqnaew	592.7805	2044.239
NS_4	ae	oskAEhkiwaew	575.3743	1711.805
NS_4	ae	pemēcemaew	675.6987	2170.835
NS_4	ae	pemEqnaew	745.2883	2123.235
NS_4	ae	pOneqnaew	476.9038	737.4621
NS_4	ae	tanAEnemaew	596.751	1703.59
NS_4	ae	wAEpenaew	611.4049	1836.122
NS_4	ae	wAEsEhonaew	533.0205	1987.551
NS_4	ae	asAqcekaew	398.457	2652.237
NS_4	ae	esEcemaew	566.8724	1938.129
NS_4	ae	kAhtenaew	689.1683	2016.972
NS_4	ae	kIhkataew	590.8507	1130.113
NS_4	ae	mEkAcekaew	446.2005	2240.88
NS_4	ae	ahpApowaew	623.1293	1999.72
NS_4	ae	naehkAn	445.8816	1739.682
NS_4	ae	naeqnemaeh	680.8566	2012.16
NS_4	ae	naeqnemaeh	728.6532	1837.874
NS_4	ae	netIhsaeh	556.3478	1905.385
NS_4	ae	nOwaeqnaen	1071.463	1490.682
NS_4	ae	nOwaeqnaen	397.6853	2076.174
NS_4	ae	ohkOmAnEhsaeh	499.8807	1990.192
NS_4	ae	pAkataen	455.0897	1379.117
NS_4	ae	pEwaeqnaen	466.2371	1269.454
NS_4	ae	pEwaeqnaen	470.5293	842.6323
NS_4	ae	pEwaeqsew	674.5172	1706.651
NS_4	ae	saehkOm	728.6209	1712.879
NS_4	ae	anAhkOhsaeh	717.1622	1731.511
NS_4	ae	anIpiahkAEhsaeh	683.1192	1728.421

speaker	vowel	context	f1_head	f2_head
NS_4	ae	kaehkAEhkwan	450.6202	1775.126
NS_4	ae	enAEmaehkiw	443.6684	2502.933
NS_4	ae	kAsakaeh1	457.6569	1519.575
NS_4	ae	kEsae hkAhtek	466.5647	1827.464
NS_4	ae	kEsawetaepAEhkat	559.2903	2082.915
NS_4	ae	maehkAn	849.4844	1141.294
NS_4	ae	maehkAEnAh	448.1164	1571.818
NS_4	ae	kotaeqnas	691.0076	1860.838
NS_4	ae	maeqnakwah	603.5823	1895.43
NS_5	ae	payItohnaet	641.0905	1812.828
NS_5	ae	pIhtikaenon	700.5904	1919.999
NS_5	ae	pApemOhnaewak	682.0949	1918.247
NS_5	ae	taeh	486.9617	1919.712
NS_5	ae	taeh	397.266	1684.658
NS_5	ae	taeh	331.0948	1323.76
NS_1	AE	pAEc	480.7083	1817.153
NS_1	AE	pemEnesehAEw	765.0741	1826.96
NS_1	AE	penAEw	528.0119	1941.214
NS_1	AE	akAEhsemen	711.5483	1877.606
NS_1	AE	mahwAEw	733.3565	1628.62
NS_1	AE	meyAwAEw	712.3102	1827.322
NS_1	AE	anAmAEhkwam	567.8136	1655.967
NS_2	AE	akIhAEw	743.8994	1869.981
NS_2	AE	wApAEhsyah	903.5306	1509.835
NS_2	AE	mAnAEwak	795.1302	1727.113
NS_2	AE	pesAEhkiwak	798.366	1959.356
NS_2	AE	pesAEhkiw	858.9218	1657.515
NS_2	AE	kemAEk-asAqtamet	380.1916	1784.93
NS_2	AE	kAEqc	779.1655	1581.688
NS_2	AE	kAEqc	684.4728	1846.35
NS_2	AE	nenAEmanan	873.3824	1729.802
NS_2	AE	kAEkOh	772.0697	1969.383
NS_2	AE	nAEwAw	891.0082	1859.68
NS_2	AE	AEq	697.7121	1347.383
NS_2	AE	netOtAEm	578.9144	1704.881
NS_2	AE	nemAEk	378.9767	1156.055
NS_2	AE	nemAEk	824.0902	1779.597
NS_2	AE	kOhkOsahcekAEm	738.2362	1829.478
NS_2	AE	nAEwAwak	657.8183	1942.748
NS_3	AE	nAEqtam	1112.859	2170.653
NS_3	AE	namAEpen	522.8436	1984.506
NS_3	AE	namAEwak	474.9453	2015.877
NS_3	AE	nApAEw	757.7028	998.069

speaker	vowel	context	f1_head	f2_head
NS_3	AE	nekOtAEs	793.7405	2055.751
NS_3	AE	nesAEkepan	679.4401	2080.703
NS_3	AE	sAkecwAEpenaew	645.6288	1466.102
NS_3	AE	tapAnAEw	789.305	1991.551
NS_3	AE	tAwAEham	733.3722	1896.995
NS_3	AE	tAwAEhekaew	694.2309	1797.654
NS_3	AE	w <u>AE</u> pEhAEw	777.2311	1631.469
NS_3	AE	wAEpEh <u>AE</u> w	825.5956	2496.672
NS_3	AE	wAEpenam	763.8448	3069.082
NS_3	AE	wAEqpesow	680.7639	1488.182
NS_3	AE	wanAenehtam	705.6381	2131.945
NS_3	AE	wAqnenekAEw	724.6206	2093.238
NS_3	AE	wEhtamowAEw	773.575	1831.039
NS_3	AE	ahsAmAEw	388.9869	2111.278
NS_3	AE	anAmaehkawAEw	820.5278	1509.514
NS_3	AE	enAenehtam	264.1467	870.1261
NS_3	AE	kesIqnehciwAEw	649.1929	1920.035
NS_3	AE	kEwAtAEnemaew	560.5982	844.1696
NS_3	AE	mAE nawac	452.3453	1951.576
NS_3	AE	menAEq	613.7322	1242.434
NS_3	AE	AEskemot	598.4656	1954.435
NS_3	AE	anAECemyakosew	694.6239	2124.796
NS_3	AE	anAECemyakosow	834.138	2148.065
NS_3	AE	an <u>AE</u> mianAEw	453.8803	1602.259
NS_3	AE	apAEhsahkyah	771.204	1742.73
NS_3	AE	apuatAEw	664.7446	2111.942
NS_3	AE	kenUpikwamAEk	901.9091	2176.553
NS_3	AE	onAEsew	927.4064	2142.232
NS_3	AE	ohnAEqnomow	1128.029	2042.032
NS_3	AE	tepAEh	827.1195	1789.579
NS_3	AE	ahkAEhkOhsaeh	720.1815	2179.521
NS_3	AE	anAEm2	684.2027	2162.72
NS_3	AE	anAEmian <u>AE</u> w	791.7957	2180.349
NS_4	AE	nahAEkAc	426.2909	1906.879
NS_4	AE	nahAEnesew	859.1818	2317.54
NS_4	AE	nahAEnet	851.3134	2122.65
NS_4	AE	nekEkAtAEpyan	727.4413	1822.03
NS_4	AE	nepAEw	786.0053	1635.196
NS_4	AE	netAEnimAhkanan	661.781	2754.456
NS_4	AE	nOcpenaehAEw	913.8856	1842.237
NS_4	AE	pAetesew	767.448	1701.02
NS_4	AE	pemAenehtam	815.7069	2177.742
NS_4	AE	pesAEhkiw	650.3953	1730.686

speaker	vowel	context	f1_head	f2_head
NS_4	AE	pOhkosetAEw	487.8208	1087.79
NS_4	AE	pOtawanAEhtam	725.5205	1695.887
NS_4	AE	sAEpAw	751.9037	1725.118
NS_4	AE	tAEqtepAEskaw	684.7506	1842.952
NS_4	AE	tanAEnemaew	626.0975	2032.49
NS_4	AE	tAwAEhekan	754.5165	1633.95
NS_4	AE	wAEpenaew	837.3208	1525.071
NS_4	AE	wAEpEw	669.1265	1167.701
NS_4	AE	wAEsEhocekan	739.4023	1576.838
NS_4	AE	wAEsEhonaew	650.8992	1690.348
NS_4	AE	wAEsEhotaw	758.0873	1563.167
NS_4	AE	wAqsAhkonawAEt	755.1906	1258.947
NS_4	AE	AHsepanak	846.1428	1655.593
NS_4	AE	anOnAEw	597.9818	1860.12
NS_4	AE	hAEw	686.728	1783.807
NS_4	AE	kayAEnet	646.3652	1949.374
NS_4	AE	kAEmAw	689.3168	2074.444
NS_4	AE	m <u>AE</u> mAEw	673.5902	1947.726
NS_4	AE	mAE <u>mAE</u> w	851.6969	2017.044
NS_4	AE	mesEwAEken	641.0509	1030.448
NS_4	AE	AHsepan	751.4856	1596.387
NS_4	AE	AHsepanak	846.1428	1655.593
NS_4	AE	moswAEn	703.6378	1907.269
NS_4	AE	miasenamAEkoh	1026.445	1741.514
NS_4	AE	AHsepan	751.4856	1596.387
NS_4	AE	nekAEtek	721.7074	2016.67
NS_4	AE	nenAEh	668.4493	1727.629
NS_4	AE	nenAEhkeskaw	845.8768	1822.614
NS_4	AE	nepAEhkwan	788.5868	1753.384
NS_4	AE	netAEnaniw	682.2555	2491.342
NS_4	AE	oskAEhkiwaew	414.6376	2558.447
NS_4	AE	penAEhkwan	805.3552	2074.188
NS_4	AE	poqsAEhkamokon	821.9785	1710.654
NS_4	AE	t <u>AE</u> qtepAEskaw	691.2481	1737.124
NS_4	AE	anAEmI	774.2087	2275.857
NS_4	AE	kaehkAEhkwan	611.9096	1941.026
NS_4	AE	enAEMAehkiw	776.9657	2134.651
NS_4	AE	ketAEmIw	718.1603	2097.447
NS_4	AE	kEsawetaepAEhkat	829.6247	1711.24
NS_4	AE	maehkAEnAh	431.6448	674.1788
NS_5	AE	<u>AE</u> niwAEkiq	622.9581	1713.32
NS_5	AE	AEniw <u>AE</u> kiq	593.5233	1903.495
NS_5	AE	kAEkOh	685.7447	2085.931

speaker	vowel	context	f1_head	f2_head
NS_5	AE	nekOtAEs	631.2493	1711.767
NS_5	AE	anAEmok	765.0763	1751.088
NS_5	AE	mAEk	740.1871	1733.477
NS_5	AE	kAEkOh	565.0328	2226.831
NS_5	AE	AEnAcen	515.556	2115.592
NS_5	AE	katAEwesEqtayan	436.7906	1908.519
NS_5	AE	kotAEs	636.0972	1827.359
NS_5	AE	kAEkOh	752.7463	1264.012
NS_1	e	nekAmow	364.2047	2189.296
NS_1	e	nemUtIh2	446.1508	2518.624
NS_1	e	nEpowew	601.1109	1536.694
NS_1	e	p <u>e</u> mEnesehAEw	571.9035	1654.468
NS_1	e	pemEn <u>e</u> sehAEw	662.4772	2125.846
NS_1	e	pemEnese <u>h</u> AEw	501.4466	2301.4
NS_1	e	pemOhnaew	474.719	1531.693
NS_1	e	penAEw	401.6629	1919.885
NS_1	e	saeqsiwahekan	349.4556	1819.765
NS_1	e	yAtapew	567.2581	2226.54
NS_1	e	akAEh <u>s</u> emen	539.8514	1831.517
NS_1	e	akAEhsem <u>e</u> n	722.9526	1793.935
NS_1	e	akuahkihsen	466.0903	2190.414
NS_1	e	ehkuahtawaew	785.6084	1757.527
NS_1	e	cEkatahekaew	470.0507	2047.929
NS_1	e	<u>e</u> nAkIhcen	256.3526	1776.533
NS_1	e	enAkIh <u>c</u> e	393.9281	2192.662
NS_1	e	kecEqtawak	1132.361	2289.823
NS_1	e	ketAkApos	1002.425	2158.092
NS_1	e	ketAkAhsaeh	359.6457	2098.75
NS_1	e	mekEw	514.1968	2006.36
NS_1	e	mekEk	343.2893	1531.449
NS_1	e	mAn <u>e</u> stAnehsak	332.7683	2122.73
NS_1	e	mAnestAne <u>h</u> sak	269.9145	1902.753
NS_1	e	meyAwAEw	639.0258	1931.435
NS_2	e	kenIs	384.2567	867.9145
NS_2	e	pesAEhkiwak	460.7689	1965.03
NS_2	e	pesAEhkiw	470.6343	1776.61
NS_2	e	maeqseh	304.8559	2051.277
NS_2	e	kenIs	400.8219	1405.164
NS_2	e	nekEs	373.9709	2016.792
NS_2	e	kAkanAwe <u>h</u> ek	306.5299	1338.199
NS_2	e	kAkanAweh <u>e</u> k	476.994	574.6301
NS_2	e	kenah	430.9995	2067.845
NS_2	e	nAnEpowenon	329.8689	1625.493

speaker	vowel	context	f1_head	f2_head
NS_2	e	k <u>e</u> mAEk-asAqtamet	301.8402	1954.284
NS_2	e	kemAEk-asAqtam <u>e</u> t	340.5995	1655.082
NS_2	e	kepUcIsow	383.8166	1967.584
NS_2	e	nenAEmanan	366.9849	1797.401
NS_2	e	<u>e</u> neh	366.156	1815.883
NS_2	e	en <u>e</u> h	397.0005	2048.629
NS_2	e	n <u>e</u> pIcemiahtanan	463.4893	2440.232
NS_2	e	nepIc <u>e</u> miahtanan	408.2689	2383.809
NS_2	e	nekEs	378.5242	2155.753
NS_2	e	mIc <u>e</u> hsim	447.1702	2165.748
NS_2	e	<u>e</u> neq	541.1952	2145.884
NS_2	e	en <u>e</u> q	509.647	2088.419
NS_2	e	kaeq <u>e</u> h	426.3097	2162.459
NS_2	e	wE <u>e</u> ket	480.0871	1903.351
NS_2	e	en <u>e</u> q	572.1928	1768.776
NS_2	e	kanA <u>w</u> ehet	391.9	1050.4
NS_2	e	kanAwe <u>h</u> et	500.7333	2144.241
NS_2	e	nekot	462.5528	2003.047
NS_2	e	kenU <u>p</u> ik	445.93	2245.673
NS_2	e	nekEs	482.2089	2040.585
NS_2	e	kenuU <u>p</u> ikok	362.0285	2004.441
NS_2	e	kenuU <u>p</u> ik	398.6975	2335.876
NS_2	e	nA <u>t</u> eh	401.1494	2038.715
NS_2	e	kOnE <u>w</u> ew	687.1464	1633.337
NS_2	e	Aw <u>e</u> w	462.8412	1663.367
NS_2	e	netO <u>t</u> AEm	427.7762	2174.041
NS_2	e	ayA <u>w</u> et	637.5514	1432.253
NS_2	e	nemA <u>E</u> k	382.497	1159.779
NS_2	e	nemA <u>E</u> k	395.9796	1730.863
NS_2	e	kO <u>h</u> kOsahcekAEm	420.9139	1346.659
NS_2	e	nekEs	380.7186	1729.777
NS_2	e	nekEs	453.9394	1742.702
NS_2	e	pahkI <u>s</u> ekanem	498.4839	2061.457
NS_2	e	pahkIseka <u>n</u> em	575.7492	1967.502
NS_2	e	nekEs	321.9283	2436.178
NS_2	e	kesEq <u>n</u> aehkim	415.0056	2196.478
NS_2	e	n <u>e</u> kew	350.5609	2359.95
NS_2	e	ne <u>k</u> ew	410.0541	2402.392
NS_2	e	n <u>e</u> kew	323.5959	1944.892
NS_2	e	ne <u>k</u> ew	347.1187	2343.552
NS_2	e	n <u>e</u> kew	303.9411	2046.652
NS_2	e	ne <u>k</u> ew	376.6398	2248.112
NS_2	e	mAmianA <u>c</u> eqtam	370.2003	2236.064

speaker	vowel	context	f1_head	f2_head
NS_2	e	nanAweyaw	379.607	1563.842
NS_2	e	Awew	439.6687	1749.013
NS_2	e	mecinenew	487.9888	1822.401
NS_2	e	mecine <u>n</u> ew	503.0626	2316.902
NS_2	e	mecinen <u>e</u> w	499.4821	1880.529
NS_2	e	nekAt	417.5397	2109.159
NS_2	e	new	345.0751	1428.927
NS_2	e	n <u>e</u> mAmIcehsim	427.2357	2442.759
NS_2	e	nemAmIce <u>h</u> sim	382.9367	2475.606
NS_3	e	ke <u>n</u> UsIqsekapaweh	653.9996	2367.549
NS_3	e	miasekakaweh	576.9916	1740.381
NS_3	e	naeqnemAw	188.8171	2056.893
NS_3	e	namAEpen	586.8806	2283.714
NS_3	e	nayOmekow	513.2091	2485.238
NS_3	e	nekOtAEs	675.7632	2042.369
NS_3	e	nemEsAtohnaem	404.8476	2826.369
NS_3	e	ne <u>s</u> AEkepan	436.1582	2126.18
NS_3	e	nesAEke <u>p</u> an	452.3513	2357.468
NS_3	e	onAEsew	463.8006	2258.932
NS_3	e	osAm <u>e</u> sew	695.861	1513.396
NS_3	e	osAmes <u>e</u> w	436.6909	2066.148
NS_3	e	oskEhsekon	415.4628	2574.758
NS_3	e	otAhpnaew	532.5916	2003.977
NS_3	e	pahpEsew	438.5396	2464.515
NS_3	e	pakAhcekaew	474.1883	2457.336
NS_3	e	pEqsesam	493.0888	2226.948
NS_3	e	sAke <u>c</u> wAEpenaew	422.073	1958.691
NS_3	e	sAkecwAE <u>p</u> enaew	553.3421	2049.371
NS_3	e	sIpe <u>p</u> Iqnenot	464.0643	891.9717
NS_3	e	sIpepIqne <u>n</u> ot	733.9712	2016.526
NS_3	e	tahkOnewaewak	442.1005	2218.159
NS_3	e	tAqtakacehkow	435.9878	3237.196
NS_3	e	tatAhke <u>s</u> ew	515.3566	1431.809
NS_3	e	tatAhkes <u>e</u> w	493.2959	1304.886
NS_3	e	tAwAEhekaew	478.1111	2453.567
NS_3	e	tepAEh	468.4474	1807.068
NS_3	e	wAEpenam	587.3231	2131.552
NS_3	e	wAEqpesow	510.1008	2617.048
NS_3	e	wanAENEhtam	547.9938	2213.409
NS_3	e	wanEhnetaw	446.9801	2373.896
NS_3	e	wApeskiw	560.3254	2063.058
NS_3	e	wAqne <u>n</u> ekAEw	500.8969	2096.202
NS_3	e	wAqnen <u>e</u> kAEw	471.4892	1778.207

speaker	vowel	context	f1_head	f2_head
NS_3	e	akuatikamek	316.3595	839.3607
NS_3	e	akuaceh	365.0098	2766.121
NS_3	e	apEsamaepen	605.2173	2196.807
NS_3	e	asAqce <u>ka</u> ewikamek	499.8589	2267.929
NS_3	e	asAqcekaewikame <u>k</u>	344.9839	1359.276
NS_3	e	<u>en</u> AEnehtam	293.3118	887.1144
NS_3	e	enAEn <u>e</u> htam	269.3211	955.702
NS_3	e	ke <u>n</u> UsIqsekapaweh	560.7972	2169.782
NS_3	e	kenUsIqse <u>k</u> apaweh	490.1502	2337.796
NS_3	e	kEskesaew	368.5625	2306.916
NS_3	e	kesIqnehciwAEw	431.31	2151.136
NS_3	e	kesIqnehciwAEw	508.2891	2275.962
NS_3	e	kEwAtAEnemaew	428.3356	1885.605
NS_3	e	kuahnepAhtaw	590.4101	2095.429
NS_3	e	masEnahekan2	214.6123	924.9318
NS_3	e	mianA <u>ce</u> qtawikamek	460.7362	2199.261
NS_3	e	mianA <u>ce</u> qtawikame <u>k</u>	619.4037	1899.84
NS_3	e	mianA <u>ce</u> qtaw	544.6204	2023.241
NS_3	e	menUkwat	409.9676	1748.455
NS_3	e	menAEq	284.5716	1059.642
NS_3	e	Aeskemot	1642.451	2265.416
NS_3	e	mOsehaew	542.5659	2383.559
NS_3	e	ahkuacemow	366.2063	2252.702
NS_3	e	anAE <u>ce</u> myakosew	400.8661	2181.601
NS_3	e	anAE <u>ce</u> myakose <u>w</u>	381.8087	2235.846
NS_3	e	anAE <u>ce</u> myakosow	508.8414	2312.564
NS_3	e	anIpiahkaneh	419.2255	2648.327
NS_3	e	kenUpikwas	427.7093	2030.293
NS_3	e	anuakawew	664.4809	1324.971
NS_3	e	anUcepotuwaew	405.1036	2332.04
NS_3	e	apI <u>se</u> mUhkehkwon	321.0291	2730.57
NS_3	e	apI <u>se</u> mUh <u>ke</u> hkwon	1704.315	2120.56
NS_3	e	AqtenUhkuwaew	644.9541	2023.827
NS_3	e	kenUpikwas	612.9686	2163.468
NS_3	e	ayAkuamemaew	269.5912	1841.341
NS_3	e	esiahkah	760.482	1734.343
NS_3	e	esiahkam	243.181	2089.68
NS_3	e	esImiakosew	451.9084	2245.914
NS_3	e	esImiakosew	431.5604	2148.325
NS_3	e	esImiakwat-kaehkoh	327.0386	1806.05
NS_3	e	esImiakwat	224.008	2241.125
NS_3	e	eskIciakan	341.4972	2048.256
NS_3	e	kaehpiawekow	311.2028	1559.196

speaker	vowel	context	f1_head	f2_head
NS_3	e	kEmenaeciakan	452.6135	1857.366
NS_3	e	ke <u>n</u> UhkesEhkow	373.6957	1804.89
NS_3	e	kenUhke <u>s</u> Ehkow	375.1173	2031.018
NS_3	e	ke <u>n</u> UhkesIhkiw	392.1065	2163.259
NS_3	e	kenUhke <u>s</u> Ihkiw	384.8812	1864.546
NS_3	e	kenUpikwamAEk	452.6347	2552.624
NS_3	e	kenUqcikaen	1079.753	2447.643
NS_3	e	kepUcIsow	398.9504	2084.769
NS_3	e	mias <u>e</u> kakaweh	533.2861	1759.101
NS_3	e	wEkemiahtaw	465.3209	2407.728
NS_4	e	necIq <u>c</u> ekwam	444.6398	1954.966
NS_4	e	osAqsekop	465.5996	1999.022
NS_4	e	wApoweyAn	410.8252	2393.557
NS_4	e	asAqcekenon	530.6566	1876.724
NS_4	e	naeqnemaeh	520.4953	2218.469
NS_4	e	nahAEn <u>e</u> sew	444.9892	2373.715
NS_4	e	nahAEn <u>e</u> sew	448.5308	2285.719
NS_4	e	nahAEn <u>e</u> t	552.0884	2047.583
NS_4	e	nAhtekok	417.3944	2056.401
NS_4	e	necias	360.3189	2269.515
NS_4	e	ne <u>c</u> Iqcekwam	355.7915	2550.594
NS_4	e	ne <u>k</u> Aetek	424.0204	2043.635
NS_4	e	nekA <u>E</u> tek	457.9791	2023.275
NS_4	e	nekEkAtAEpyan	452.9218	2290.585
NS_4	e	nemUtIhI	497.3009	2697.844
NS_4	e	nenAEh	385.4418	1392.566
NS_4	e	ne <u>n</u> Aehkeskaw	516.0369	2213.297
NS_4	e	nenAEhke <u>s</u> kaw	447.6617	2431.737
NS_4	e	nepAEhkwan	541.1231	3137.003
NS_4	e	nepAEw	489.3064	2409.106
NS_4	e	nE <u>p</u> enowew	485.417	2081.028
NS_4	e	nE <u>p</u> enow <u>e</u> w	534.4752	1400.738
NS_4	e	neskAs	465.0603	2717.955
NS_4	e	ne <u>s</u> kEhsek	282.3953	1948.258
NS_4	e	neskEh <u>s</u> ek	448.7499	1962.838
NS_4	e	netAEnaniw	515.3972	2479.597
NS_4	e	netAEnimAhkanan	415.6963	2723.005
NS_4	e	ne <u>t</u> Aekom	424.0343	2387.444
NS_4	e	netAne <u>k</u> om	476.6641	1623.694
NS_4	e	netIhsaeh	436.6676	2527.237
NS_4	e	netOn	458.7765	1942.862
NS_4	e	nOcpenaehAEw	468.4134	1701.41
NS_4	e	onAnekosew	381.8725	2104.581

speaker	vowel	context	f1_head	f2_head
NS_4	e	onAneko <u>s</u> ew	475.3385	2190.429
NS_4	e	otAcekw <u>a</u> n	255.2902	1732.066
NS_4	e	pA <u>E</u> tesew	431.5845	2060.225
NS_4	e	pA <u>E</u> tes <u>e</u> w	449.3311	2259.649
NS_4	e	pA <u>h</u> kenam	472.0672	2582.54
NS_4	e	pakA <u>h</u> cekan	403.3646	2281.293
NS_4	e	paskIpemIq <u>s</u> iw	431.3035	886.4445
NS_4	e	p <u>e</u> mA <u>E</u> nehtam	404.195	782.4422
NS_4	e	pemA <u>E</u> ne <u>h</u> tam	371.7234	602.3399
NS_4	e	p <u>e</u> m <u>E</u> ce <u>m</u> aew	484.192	2159.633
NS_4	e	pem <u>E</u> ce <u>m</u> aew	457.5386	2473.467
NS_4	e	pemE <u>q</u> naew	546.2363	1929.399
NS_4	e	penA <u>E</u> hkwan	711.6464	2011.756
NS_4	e	pesA <u>E</u> hkiw	279.4972	1853.011
NS_4	e	pesE <u>w</u> ak	357.5276	2139.476
NS_4	e	pE <u>w</u> aeq <u>s</u> ew	359.4681	2164.108
NS_4	e	pI <u>c</u> ekew	394.3854	2316.297
NS_4	e	pI <u>c</u> ek <u>e</u> w	454.4612	2208.005
NS_4	e	pI <u>w</u> epIq <u>n</u> en	483.2855	861.1424
NS_4	e	pI <u>w</u> epIq <u>n</u> en	637.0963	2008.693
NS_4	e	pO <u>h</u> kosetA <u>E</u> w	482.3509	3201.099
NS_4	e	pO <u>n</u> e <u>q</u> naew	475.4502	962.2644
NS_4	e	sA <u>h</u> kahekan	427.7488	2183.806
NS_4	e	sakA <u>q</u> senam	514.4241	1683.446
NS_4	e	sE <u>w</u> Ap <u>e</u> men	429.8118	1080.465
NS_4	e	sE <u>w</u> Ap <u>e</u> men	428.8717	2114.673
NS_4	e	sI <u>k</u> epIq <u>n</u> en	1084.436	2051.297
NS_4	e	sI <u>k</u> epIq <u>n</u> en	711.4206	2126.655
NS_4	e	tA <u>E</u> q <u>t</u> epA <u>E</u> skaw	629.362	1865.259
NS_4	e	tanA <u>E</u> ne <u>m</u> aew	420.0282	2144.361
NS_4	e	tA <u>w</u> A <u>E</u> hekan	400.2658	2532.66
NS_4	e	tepA <u>h</u> am	551.207	1643.142
NS_4	e	wA <u>E</u> penaew	550.6821	1720.861
NS_4	e	wA <u>E</u> sE <u>h</u> ocek <u>a</u> n	468.8265	2370.384
NS_4	e	wA <u>p</u> emen	606.785	988.6012
NS_4	e	wA <u>p</u> emen	576.418	1744.936
NS_4	e	wA <u>p</u> es <u>k</u> en	413.7129	1916.935
NS_4	e	wA <u>p</u> es <u>k</u> en	412.5888	2410.736
NS_4	e	wE <u>h</u> ken	454.9282	2691.691
NS_4	e	wE <u>y</u> At <u>e</u> sew	441.2664	1832.138
NS_4	e	wE <u>y</u> At <u>e</u> se <u>w</u>	507.1421	1898.95
NS_4	e	A <u>E</u> hsepanak	448.7142	1238.248
NS_4	e	ake <u>q</u>	489.4905	1139.021

speaker	vowel	context	f1_head	f2_head
NS_4	e	apEsen	492.5142	1954.032
NS_4	e	Ap <u>e</u> sehcekan	422.4288	1648.355
NS_4	e	Apes <u>e</u> hcekan	485.1912	1675.937
NS_4	e	Apese <u>h</u> cekan	463.1198	855.6281
NS_4	e	asAqcek <u>e</u> non	438.6917	1997.929
NS_4	e	asAqcekaew	479.2207	2854.764
NS_4	e	apuahsokane <u>h</u>	461.6492	2065.297
NS_4	e	<u>e</u> menakah	719.7202	2267.28
NS_4	e	eme <u>n</u> akah	444.9895	881.645
NS_4	e	esInAkwat	521.4817	1918.442
NS_4	e	<u>e</u> sEcemaew	398.396	2256.285
NS_4	e	esE <u>c</u> emaew	437.1341	2029.298
NS_4	e	kayAEnet	608.0514	1946.134
NS_4	e	kAketow	359.9779	2229.582
NS_4	e	kAhtenaew	519.3697	1905.806
NS_4	e	kEsaehkAhtek	480.5439	2331.729
NS_4	e	kenEw	479.1475	1946.739
NS_4	e	kemOt	446.4422	2306.93
NS_4	e	ketAEmIw	414.876	2111.766
NS_4	e	kEs <u>k</u> epocekanaan	483.8913	2067.222
NS_4	e	kEs <u>k</u> epo <u>c</u> ekanaan	262.2887	1921.032
NS_4	e	<u>k</u> esEqnecekan	354.913	1757.998
NS_4	e	kesEq <u>n</u> cekan	428.6237	2315.209
NS_4	e	kesEqne <u>c</u> ekan	392.0584	2064.335
NS_4	e	<u>k</u> esEhekan	1108.049	2042.384
NS_4	e	kesE <u>h</u> ekan	448.0968	1280.622
NS_4	e	kEsawetaepAEhkat	662.8638	1138.723
NS_4	e	kEt <u>e</u> sew	450.9673	2417.74
NS_4	e	kE <u>t</u> esew	478.6775	2267.77
NS_4	e	kuahn <u>e</u> pesowak	402.8028	791.2905
NS_4	e	kuahn <u>e</u> pesowak	445.4797	1800.536
NS_4	e	mEkAcekaew	385.8893	1455.843
NS_4	e	masEnahekanl	484.8416	2533.874
NS_4	e	<u>m</u> esEwAEken	380.4533	1278.798
NS_4	e	mesEwAE <u>k</u> en	523.4441	739.4925
NS_4	e	menUkuapos	407.976	1568.416
NS_4	e	AHsepan	497.2371	1571.027
NS_4	e	AHsepanak	448.7142	1238.248
NS_4	e	mUcehkiw	430.7707	2136.187
NS_4	e	miasenamA <u>E</u> koh	455.0476	1515.478
NS_4	e	AHsepan	497.2371	1571.027
NS_5	e	wAq <u>n</u> enekan	475.8696	1746.144
NS_5	e	wAqnen <u>e</u> kan	469.8457	2383.912

speaker	vowel	context	f1_head	f2_head
NS_5	e	asAq <u>ce</u> kanAhtek	417.7176	1962.036
NS_5	e	asAqcekanAht <u>e</u> k	427.6721	2199.319
NS_5	e	kotApyacekan	429.0496	2011.245
NS_5	e	sekAk	391.0727	2165.421
NS_5	e	kanew	646.404	2075.804
NS_5	e	ewAh	413.247	1412.577
NS_5	e	enoh	441.9016	2223.596
NS_5	e	pew	408.6073	2085.855
NS_5	e	pew	451.6303	2443.203
NS_5	e	menUkwat	380.4123	2329.816
NS_5	e	nekOtAEs	476.5404	2061.637
NS_5	e	new	506.289	2308.259
NS_5	e	pApemOhnaewak	501.919	1896.808
NS_5	e	nekEs	552.832	2001.683
NS_5	e	nAten	481.0754	2006.07
NS_5	e	kenaq	376.2917	2240.074
NS_5	e	nekot	414.6267	2222.368
NS_5	e	new	580.9279	2217.352
NS_5	e	AEnAcen	510.5872	1977.04
NS_5	e	katAEwesEqtayan	401.6829	2232.025
NS_5	e	<u>e</u> nes	473.5568	1478.523
NS_5	e	en <u>e</u> s	515.5253	2054.348
NS_5	e	akuaceh	403.6922	2244.68
NS_5	e	new	412.5868	2123.264
NS_5	e	<u>e</u> neq	366.7843	2241.528
NS_5	e	en <u>e</u> q	452.9404	2100.93
NS_5	e	pIcemiahtah	342.8783	2376.011
NS_5	e	<u>e</u> neq	358.9876	2201.814
NS_5	e	en <u>e</u> q	476.8662	2056.114
NS_1	E	nEpowew	407.9657	2348.116
NS_1	E	pEkonam	541.3813	2143.598
NS_1	E	cEpAhkow	406.6515	2388.708
NS_1	E	cEkatahekaew	462.8147	1689.536
NS_1	E	kahpEh	538.632	2140.138
NS_1	E	kEhkan	509.3162	2326.061
NS_1	E	mekEk	402.9387	2459.556
NS_1	E	ohpEqtaw	427.0037	1856.039
NS_1	E	pemEnesehAEw	670.5387	2253.739
NS_1	E	apEw	542.2012	1955.916
NS_1	E	kecEqtawak	421.054	2344.031
NS_1	E	mekEw	486.261	2530.001
NS_2	E	kEs	346.0411	1899.418
NS_2	E	nekEs	366.27	2273.635

speaker	vowel	context	f1_head	f2_head
NS_2	E	nAnEpowenon	433.0033	992.9393
NS_2	E	Eh	523.5516	2071.542
NS_2	E	nekEs	382.939	2428.902
NS_2	E	wEket	459.5932	1769.716
NS_2	E	kEs	387.7413	2088.792
NS_2	E	awEh	431.6968	2098.871
NS_2	E	nekEs	530.051	2394.529
NS_2	E	wEh	373.8276	1867.361
NS_2	E	maehsEwan	534.8552	1960.682
NS_2	E	kOnEwew	521.7087	1634.628
NS_2	E	nekEs	380.3476	1844.468
NS_2	E	nekEs	431.389	1923.516
NS_2	E	nekEs	526.5242	2187.997
NS_2	E	kesEqnaehkim	428.4577	2426.474
NS_2	E	onEm	607.1434	2146.222
NS_2	E	onEm	411.6842	1940.649
NS_3	E	nemEsAtohnaem	401.7348	2332.784
NS_3	E	oskEhsekon	414.9914	2451.131
NS_3	E	pEqsesam	548.3251	2481.675
NS_3	E	sEwan	531.6936	2365.317
NS_3	E	sEwApoh	506.6291	2142.413
NS_3	E	wAEpEhAEw	516.2082	2531.233
NS_3	E	wEhtamowAEw	475.3686	1964.651
NS_3	E	apEsamaepen	512.9155	2679.851
NS_3	E	anEp	529.858	2463.093
NS_3	E	cEpay	514.6541	2324.562
NS_3	E	cEpataewan	450.2667	2456.757
NS_3	E	cEpataew	457.4412	2444.31
NS_3	E	kEskesaew	560.8116	2643.628
NS_3	E	kEwAtAEnemaew	482.3625	1554.148
NS_3	E	asEkanEhsaeh	410.1282	2217.832
NS_3	E	asEkanEhsaeh	610.6882	2502.935
NS_3	E	asEkan-wiahkwan	469.8324	2368.903
NS_3	E	kEmenaeciakan	322.3081	2595.35
NS_3	E	wEkemiahtaw	430.3844	1010.194
NS_3	E	okEmAw	440.5991	2446.207
NS_3	E	osEhtaw	552.8898	2507.802
NS_3	E	pahpEsew	500.6473	2484.983
NS_3	E	wanEhnetaw	535.2813	2451.784
NS_3	E	kaehkEnawapahtam	526.1941	2472.161
NS_3	E	kaehkEnawaew	533.3067	2475.844
NS_3	E	kecEqkaw	481.4767	2610.969
NS_3	E	kohkEw	492.1998	2518.171

speaker	vowel	context	f1_head	f2_head
NS_3	E	kocEqkaw	461.3661	2508.862
NS_3	E	kocEmonaew	490.8042	2235.917
NS_3	E	masEnahekan2	393.5975	1012.779
NS_3	E	kenUhkesEhkow	534.2718	2321.652
NS_4	E	nEpenowew	458.8817	3047.579
NS_4	E	neskEhsek	436.179	1335.945
NS_4	E	ohkOmAnEhsaeh	488.8861	2432.457
NS_4	E	pEkoskaw	417.6287	3007.269
NS_4	E	pEwaeqnaen	479.5746	2561.857
NS_4	E	pEwaeqsew	395.4523	2612.851
NS_4	E	sEwApemen	404.0223	1792.95
NS_4	E	wAEpEw	431.8439	2811.913
NS_4	E	wAEsEhocekan	543.8584	2330.903
NS_4	E	wAEsEhonaew	486.3359	2254.014
NS_4	E	wAEsEhotaw	547.6918	2222.31
NS_4	E	wEhken	545.4711	2599.825
NS_4	E	wEyAtesew	374.9032	1312.277
NS_4	E	apEsen	467.7343	2260.996
NS_4	E	kEsaehkAhtek	388.1035	2776.056
NS_4	E	kEmOsApahtam	344.89	615.5309
NS_4	E	kEmApahtam	371.5923	585.2581
NS_4	E	kEskepocekanan	424.6695	2610.603
NS_4	E	kesEqnecekan	570.4898	1779.342
NS_4	E	kEsawetaepAEhkat	439.5259	2617.556
NS_4	E	kEtesew	407.3695	2670.139
NS_4	E	mEkAcekaew	422.1609	684.4724
NS_4	E	mEsAc	447.404	2637.421
NS_4	E	nekEkAtAEpyan	417.5291	2486.812
NS_4	E	pemEcemaew	434.8178	2649.229
NS_4	E	pemEqnaew	446.8883	2649.964
NS_4	E	pesEwak	493.6601	3022.267
NS_4	E	esEcemaew	396.6977	2503.526
NS_4	E	kenEw	638.4469	2399.931
NS_4	E	kesEhekan	472.3513	1332.666
NS_4	E	masEnahekan1	540.1289	2215.404
NS_4	E	mesEwAEken	380.4542	1958.912
NS_5	E	nekEs	461.5834	2285.752
NS_5	E	mEcah	477.1397	2305.896
NS_5	E	katAEwesEqtayan	530.3787	2010.632
NS_1	i	saeqsiwahekan	452.2788	1464.447
NS_1	i	akuahkihsen	300.0343	1817.108
NS_2	i	pesAEhkiwak	391.1389	1893.007
NS_2	i	pesAEhkiw	465.7664	2229.89

speaker	vowel	context	f1_head	f2_head
NS_2	i	mIcehsim	442.2344	1710.043
NS_2	i	kenUpik	463.5243	1860.135
NS_2	i	kenuUpikok	454.5282	1967.03
NS_2	i	kenuUpik	478.6662	1872.233
NS_2	i	nohAhkaniahkiw	341.7358	1971.995
NS_2	i	mIcehsim	392.5878	1000.934
NS_2	i	kesEqnaehkim	346.8839	2261.649
NS_2	i	mecinew	408.9405	2225.627
NS_2	i	nemAmIcehsim	503.5508	2140.622
NS_3	i	wApeskiw	386.6215	2677.337
NS_3	i	kenUhkesIhkiw	1006.374	2405.879
NS_3	i	nImihaeti <i>q</i>	349.6583	2287.6
NS_3	i	nImihaeti <i>q</i>	453.2293	2498.326
NS_3	i	akuatikamek	406.7982	1275.932
NS_3	i	asAqcekaewikamek	406.6128	1915.702
NS_3	i	kesIqnehciwAEw	422.0719	2431.862
NS_3	i	mianAceqtawikamek	509.1789	1834.692
NS_3	i	ahkuahkihnaen	414.182	2379.649
NS_3	i	kenUpikwas	467.7298	2351.305
NS_3	i	anIphiahkan-kenUpikwas	389.2628	1622.162
NS_3	i	kenUpikwas	1476.117	2913.145
NS_3	i	kenUpikwamAEk	456.8937	2562.756
NS_3	i	kenUpik	474.2562	2210.64
NS_3	i	otUnepih	426.8695	2445.208
NS_4	i	okAskisqak	363.4083	2636.25
NS_4	i	paskIpemIqsiw	426.0042	2696.849
NS_4	i	tUkaniq	563.3138	2128.477
NS_4	i	oskAEhkiwaew	427.1688	2308.826
NS_4	i	netAEnaniw	455.9504	2765.743
NS_4	i	netAEnimAhkanan	660.7953	2533.579
NS_4	i	pesAEhkiw	338.1642	2809.83
NS_4	i	enAEMAehkiw	396.4477	2734.798
NS_4	i	mUcehkiw	430.8577	2304.709
NS_4	i	tUkaniq	607.236	2343.866
NS_4	i	tUkaniq	407.0154	2095.869
NS_4	i	mUcehkiwak	410.1445	2673.836
NS_4	i	wAEkiq	398.9164	2704.801
NS_4	i	AEsiyan	428.7108	2686.891
NS_4	i	naeqniw	447.3178	2502.283
NS_4	i	mIcehsiyah	347.0305	2705.408
NS_5	i	pIhtikaenon	488.3417	2376.774
NS_5	i	AEniwAEkiq	475.7553	2147.13
NS_5	i	mIkAtituaq	576.761	2191.235

speaker	vowel	context	f1_head	f2_head
NS_1	I	nemUtIh2	455.0765	2425.219
NS_1	I	enAkIhcen	370.5369	2795.431
NS_1	I	akIqtaw	428.6256	2766.052
NS_2	I	akIhAEw	318.8506	2239.211
NS_2	I	kenIs	395.1245	763.6136
NS_2	I	kepUcIsow	324.9647	1903.179
NS_2	I	nepIcemiahtanan	357.429	2295.078
NS_2	I	mIcehsim	361.6553	2212.624
NS_2	I	mIcehsim	329.2397	1193.003
NS_2	I	pahkIsekanem	448.0386	2330.118
NS_2	I	nemAmIcehsim	624.9324	2367.231
NS_3	I	nImihaeti <i>q</i>	562.9837	2659.252
NS_3	I	sIpepIqnenot	435.4683	2598.546
NS_3	I	sIpepIqnenot	482.3209	2659.144
NS_3	I	anohkIw	458.2886	2188.664
NS_3	I	apI <i>s</i> Iw	457.2714	2013.078
NS_3	I	kenUsIqsekapaweh	452.4488	2279.562
NS_3	I	kesIqnehciwAEw	393.8463	2595.389
NS_3	I	ahkUpIkat	516.0166	1898.737
NS_3	I	anIpiahkan	450.4626	2668.775
NS_3	I	anIpiahkaneh	429.7821	2718.098
NS_3	I	anIpiahkan	382.7391	2715.392
NS_3	I	apIsemUhkehkw <i>an</i>	391.9845	2571.14
NS_3	I	aqcIqnaeh	398.5789	2700.772
NS_3	I	cIkahkyah	389.1019	2629.032
NS_3	I	kepUcIsow	408.5731	3016.697
NS_3	I	mianIw	392.6065	2416.592
NS_3	I	esImiakosew	439.3209	2432.54
NS_3	I	esImiakwat-kaehk <i>oh</i>	532.3861	2080.885
NS_3	I	esImiakwat	387.1021	2098.643
NS_3	I	eskIciakan	367.6068	2547.851
NS_3	I	kaehkI <i>n</i> UhamatIk	448.7345	2679.258
NS_3	I	kaehkInUhamatI <i>k</i>	392.5218	2368.825
NS_3	I	kenUhkesIhkiw	373.252	2498.565
NS_3	I	macInAkwat1	465.214	2463.758
NS_3	I	macInAkwat2	434.7919	2609.655
NS_4	I	necIqcekwam	442.7433	2696.571
NS_4	I	nemUtIh1	325.8954	2704.507
NS_4	I	netIhsaeh	382.7562	2792.037
NS_4	I	ocIk	331.6863	1540.909
NS_4	I	pIcekew	395.7682	2192.393
NS_4	I	pI <i>w</i> epIqnen	421.1459	2736.427
NS_4	I	pIwepI <i>q</i> nen	498.883	2806.717

speaker	vowel	context	f1_head	f2_head
NS_4	I	sIkepIqnen	391.7166	2869.443
NS_4	I	slkepIqnen	463.4987	2892.369
NS_4	I	sIkwan	365.6416	2997.289
NS_4	I	anIphiahkan	359.1122	2875.86
NS_4	I	anIphiahkaEhsaeh	409.7059	1253.918
NS_4	I	cIs	464.3829	1826.323
NS_4	I	ketAEmIw	422.4956	2363.767
NS_4	I	kIskahAhkwan	368.5026	2511.659
NS_4	I	kIhkataew	427.747	2770.945
NS_4	I	paskIpemIqsiw	377.4027	2694.25
NS_4	I	paskIpemIqsiw	432.458	2736.477
NS_4	I	esInAkwat	395.5866	2451.82
NS_4	I	mUcekIhwak	395.5249	2368.462
NS_4	I	mUcehkIhsak	477.9625	2374.218
NS_4	I	okIqsan	390.952	2692.884
NS_4	I	nIphiahkanan	314.2873	2420.533
NS_4	I	nImwan	404.4834	2104.359
NS_4	I	mIcehsiyah	400.4359	2867.344
NS_5	I	payItohnaet	395.4009	2526.493
NS_5	I	pIhtikaenon	492.1842	2343.757
NS_5	I	nIs	471.0709	2705.403
NS_5	I	nIs	424.975	2608.784
NS_5	I	pIcemiahtah	325.1298	2470.144
NS_5	I	mIkAtituaq	352.6721	2453.798
NS_5	I	nIs	373.9723	2258.712
NS_2	ia	maskUtiah	392.2925	2103.565
NS_2	ia	maskUtiah	497.9173	1829.452
NS_2	ia	nepIcemiahtanan	701.4895	1949.605
NS_2	ia	nohAhkaniahkiw	336.4808	1766.492
NS_2	ia	mAmianAceqtam	320.1556	2068.651
NS_3	ia	mianAceqtawikamek	431.7001	2404.017
NS_3	ia	mianAceqtaw	680.2817	2100.46
NS_3	ia	anAEmianAEw	321.921	2199.933
NS_3	ia	anIphiahkan	450.3997	2150.461
NS_3	ia	anIphiahkaneh	451.5359	2292.667
NS_3	ia	anIphiahkan	392.2787	2229.935
NS_3	ia	asEkan-wiahkwan	459.2522	2186.483
NS_3	ia	asiahnaew	460.6855	2398.653
NS_3	ia	esiahkah	428.8641	2399.187
NS_3	ia	esiahkam	372.8599	2461.239
NS_3	ia	esImiakosew	423.7147	2434.888
NS_3	ia	esImiakwat-kaehkoh	362.1425	2590.145
NS_3	ia	esImiakwat	429.6609	2483.002

speaker	vowel	context	f1_head	f2_head
NS_3	ia	eskIciakan	392.2642	2602.032
NS_3	ia	kaehpiawekow	387.6843	2411.206
NS_3	ia	kEmenaeciakan	435.5884	2072.371
NS_3	ia	mianIw	431.0647	2652.552
NS_3	ia	miasekakaweh	404.1951	2383.586
NS_3	ia	wEkemiahtaw	403.1603	1673.947
NS_4	ia	necias	411.0705	2103.905
NS_4	ia	anIphiahkan	377.568	2557.094
NS_4	ia	anIphiahkaEhsaeh	429.9395	1512.616
NS_4	ia	miakonam	408.0202	2523.082
NS_4	ia	miasenamAEkoh	363.9521	2504.06
NS_4	ia	maeqtehkuahkihkih	414.2971	2566.802
NS_4	ia	nIphiahkanan	426.6903	1829.677
NS_4	ia	mAciam	421.7007	2128.751
NS_5	ia	pIcemiahtah	675.9285	2010.987
NS_1	o	nEpowew	487.8305	832.4461
NS_1	o	nekAmow	562.1969	975.8932
NS_1	o	ohpEqkaw	1312.306	2300.285
NS_1	o	pEkonam	553.0817	1259.933
NS_1	o	sOwatow	560.8294	1593.196
NS_1	o	tapAsow	559.6514	1229.145
NS_1	o	amAskos	431.0049	1029.755
NS_1	o	cEpAhkow	498.9229	1005.151
NS_1	o	ketAkApos	484.164	974.7294
NS_2	o	osAqsahkwat	988.3909	1823.483
NS_2	o	nAnEpowenon	414.0485	899.82
NS_2	o	nAnEpowenon	369.6643	1145.293
NS_2	o	kepUcIsow	486.9355	1519.158
NS_2	o	nekot	502.1282	1349.096
NS_2	o	kenuUpikok	538.2627	983.1243
NS_2	o	akuahkok	528.6791	792.4838
NS_2	o	onEm	347.8505	1049.428
NS_2	o	onEm	383.3888	1066.42
NS_3	o	tAqtakacehkwow	474.3418	807.6751
NS_3	o	kenUhkesEhkwow	563.3497	1008.538
NS_3	o	nayOmekow	623.4025	1155.988
NS_3	o	nemEsAtohnaem	631.7452	1710.39
NS_3	o	ohnAEqnomow	627.305	1489.761
NS_3	o	ohnAEqnomow	239.9774	1830.435
NS_3	o	ohnAEqnomow	834.7498	1875.575
NS_3	o	okEmAw	654.3889	2404.161
NS_3	o	onAEsew	1168.015	2445.339
NS_3	o	onAkow	615.7292	1877.397

speaker	vowel	context	f1_head	f2_head
NS_3	o	onAk <u>ow</u>	494.1166	941.7376
NS_3	o	osAmat	237.5976	1436
NS_3	o	osAmesew	657.2127	1227.375
NS_3	o	osEhtaw	498.898	1159.779
NS_3	o	<u>osk</u> Ehsekon	550.3718	2033.946
NS_3	o	oskEhse <u>kon</u>	811.5683	1245.319
NS_3	o	otAhpenaew	931.9346	2020.666
NS_3	o	pOhkoskam	512.3704	1328.677
NS_3	o	sEwApoh	487.2367	963.1652
NS_3	o	sIpepIqnenot	753.7273	1104.18
NS_3	o	wAEqpesow	616.7223	1375.874
NS_3	o	wEhtamowAEw	462.3925	1129.444
NS_3	o	ahkanom	716.531	1743.716
NS_3	o	anohkIw	375.5237	1636.104
NS_3	o	kohkEw	486.074	1522.255
NS_3	o	k <u>oc</u> Emonaew	346.1121	2347.63
NS_3	o	kocEm <u>onaew</u>	676.8782	1167.06
NS_3	o	AEskemot	619.579	1461.65
NS_3	o	ahkuacemow	684.9397	2020.104
NS_3	o	akUtuasow	591.3088	1200.489
NS_3	o	anAEcemyakosew	438.2108	1956.048
NS_3	o	anAEcemyak <u>osow</u>	434.6223	1922.265
NS_3	o	anAEcemyakos <u>ow</u>	530.2731	1668.354
NS_3	o	anUcepotuwaew	487.7147	1708.89
NS_3	o	esImiakosew	460.1962	1692.731
NS_3	o	esImiakwat-kaehkoh	568.5481	1189.609
NS_3	o	kaehpiawekow	520.5259	1360.827
NS_3	o	kepUcIsow	556.4471	1745.623
NS_4	o	nEpenowew	700.0222	1288.505
NS_4	o	pOhkosetAEw	446.7266	1326.824
NS_4	o	wApatow	589.8129	1165.03
NS_4	o	nAhtekok	475.7137	918.4427
NS_4	o	natAwApahtamowaew	583.0573	815.5266
NS_4	o	netAnekom	467.9396	1209.39
NS_4	o	ocIk	479.6208	1391.954
NS_4	o	okAskisak	489.8229	1156.103
NS_4	o	omOhnaew	404.8657	750.4942
NS_4	o	<u>on</u> Ahotaw	502.4554	895.6602
NS_4	o	onA <u>hotaw</u>	496.0413	848.7515
NS_4	o	<u>on</u> Anekosew	261.1102	1005.864
NS_4	o	onAnek <u>osew</u>	461.3765	636.2396
NS_4	o	onAqnaew	731.8081	2709.974
NS_4	o	osAqsek <u>op</u>	468.4338	731.1905

speaker	vowel	context	f1_head	f2_head
NS_4	o	oskAEhkiwaew	446.4714	1523.268
NS_4	o	osOw	451.555	988.1512
NS_4	o	otAcekwan	253.4692	959.2261
NS_4	o	pEkoskaw	616.996	1116.507
NS_4	o	p <u>o</u> qsAEhkamokon	600.7138	834.8393
NS_4	o	poqsAEhkam <u>o</u> kon	493.057	911.8294
NS_4	o	poqsAEhkamok <u>o</u> n	508.5851	1037.697
NS_4	o	wAEsEhocekan	415.2664	902.3377
NS_4	o	wAEsEhonaew	421.8108	830.5854
NS_4	o	wAEsEhotaw	457.0523	696.3239
NS_4	o	wApos	490.0709	1666.484
NS_4	o	wApoweyAn	421.5878	797.8238
NS_4	o	wAqsAhkonawAEt	398.4776	1219.742
NS_4	o	ahpApowaew	429.2038	707.5516
NS_4	o	asAqcekenon	441.6236	759.696
NS_4	o	apuahsokaneh	390.8905	1798.786
NS_4	o	apuahsokan	414.1994	1579.053
NS_4	o	kAketow	499.8979	1917.884
NS_4	o	kEskepocekanan	366.5682	849.6231
NS_4	o	kuahnepesowak	558.1169	1402.368
NS_4	o	kotaeqnas	483.4546	1268.278
NS_4	o	miakonam	455.4938	941.8225
NS_4	o	menUkuapos	498.9183	1264.981
NS_4	o	moswAEn	334.5802	958.0267
NS_4	o	mOhsow	528.068	905.1021
NS_4	o	miasenamAEkoh	482.4466	938.4638
NS_4	o	apEsenok	441.1384	1982.757
NS_4	o	onAEsew	495.6003	981.3908
NS_4	o	askAqnemowak	392.9159	1475.121
NS_4	o	akom	476.7411	934.6458
NS_4	o	kemAEhsoh	529.3652	1317.556
NS_4	o	otAcekwan	706.042	1278.057
NS_5	o	kotApyacekan	446.8292	928.1323
NS_5	o	payItohnaet	405.8002	1882.257
NS_5	o	pIhtikaenon	738.5251	1445.329
NS_5	o	enoh	457.6848	1012.345
NS_5	o	omas	506.7922	2201.11
NS_5	o	anAEmok	642.857	1079.554
NS_5	o	omas	677.7805	1338.184
NS_5	o	nekot	421.6685	1127.291
NS_5	o	kotAEs	385.899	879.1524
NS_5	o	akom	440.5724	938.6268
NS_1	O	pOtawaew	508.6945	1020.232

speaker	vowel	context	f1_head	f2_head
NS_1	O	sOwatow	540.2308	1487.461
NS_1	O	akuahkOhsaeh	519.6987	961.6076
NS_1	O	mOs	784.7235	1283.984
NS_1	O	pemOhnaew	726.3	1094.433
NS_2	O	kOn	397.7205	964.7081
NS_2	O	kAEkOh	440.2337	623.0178
NS_2	O	kOnEwew	725.7402	1961.417
NS_2	O	netOtAEm	557.3296	1651.552
NS_2	O	k <u>Oh</u> kOsahcekAEm	620.0456	1009.226
NS_2	O	kOhk <u>O</u> sahcekAEm	536.9236	898.4247
NS_3	O	nayOmekow	549.5102	1418.417
NS_3	O	pOhkoskam	562.477	1089.222
NS_3	O	t <u>On</u> Oh	508.5836	1341.488
NS_3	O	tOn <u>Oh</u>	642.549	1296.429
NS_3	O	ahkAEhkOhsaeh	519.5992	896.156
NS_3	O	mOsehaew	217.7587	998.5359
NS_3	O	nekOtAEs	545.1281	1092.034
NS_3	O	tahkOnewaewak	484.6406	787.0109
NS_3	O	kemOtaehkow	633.8115	1194.099
NS_4	O	netOn	567.0543	1483.098
NS_4	O	nOcpnaehAEw	418.8823	1264.161
NS_4	O	nOwaeqnaen	404.116	1512.805
NS_4	O	omOhnaew	402.285	742.7392
NS_4	O	osOw	555.8319	1094.688
NS_4	O	pOhkosetAEw	414.6609	811.4013
NS_4	O	pOneqnaew	439.9494	766.6266
NS_4	O	pOtawanAEhtam	450.9939	659.4842
NS_4	O	watOw	528.883	1068.287
NS_4	O	anAhkOhsaeh	460.9917	687.35
NS_4	O	kEmOsApahtam	529.8275	836.3006
NS_4	O	kOhtakan	428.2991	768.0641
NS_4	O	k <u>Oh</u> kOs	480.757	1269.462
NS_4	O	kOhk <u>O</u> s	481.4617	1400.193
NS_4	O	kOn	437.5146	700.3514
NS_4	O	mOhsow	377.5212	735.4687
NS_4	O	saehkOm	508.3819	937.2889
NS_4	O	anOnAEw	632.12	1450.566
NS_4	O	kemOt	443.7351	838.7978
NS_4	O	ohkOmAnEhsaeh	717.9513	1444.903
NS_4	O	Ohnan	479.1776	843.773
NS_4	O	nenAwAEtOhsan	446.0839	893.1751
NS_4	O	yOm	498.9885	1375.008
NS_4	O	kAEkOh	532.3895	1051.496

speaker	vowel	context	f1_head	f2_head
NS_5	O	kAEkOh	457.3781	1013.201
NS_5	O	nekOtAEs	444.4082	777.9475
NS_5	O	pApemOhnaewak	527.7958	866.9521
NS_5	O	kAEkOh	516.5588	1037.488
NS_5	O	kAEkOh	465.8571	994.6304
NS_3	u	AqtenUhkuwaew	444.2657	2186.371
NS_3	u	anUcepotuwaew	494.3875	2240.406
NS_1	U	nemUtIh2	380.3307	1129.185
NS_2	U	maskUtiah	360.0732	998.9362
NS_2	U	maskUtiah	514.9937	1311.256
NS_2	U	kepUcIsow	375.1669	1157.537
NS_2	U	kenUpik	582.1468	1293.575
NS_2	U	kenuUpikok	439.1131	1683.213
NS_2	U	kenuUpik	394.5957	1513.647
NS_3	U	menUkwat	415.4916	1414.96
NS_3	U	kenUpikwas	440.9576	2119.399
NS_3	U	anIphiahan-kenUpikwas	395.8088	1579.666
NS_3	U	anUcepotuwaew	185.9097	1549.229
NS_3	U	apIsemUhkehkwon	277.5537	1938.531
NS_3	U	AqtenUhkuwaew	608.922	1998.137
NS_3	U	kenUpikwas	421.1347	1690.603
NS_3	U	atUhpuahsaeh	384.5339	1571.982
NS_3	U	kaehkInUhamatIk	528.4047	2548.657
NS_3	U	kenUpikwamAEk	371.0309	1586.821
NS_3	U	kenUsIqsekapaweh	694.6245	1678.213
NS_3	U	ahkUpIkat	312.678	1410.535
NS_3	U	akUtusow	401.6954	912.6757
NS_3	U	kenUhkesEhkow	423.9914	1480.988
NS_3	U	kenUhkesIhkiw	422.6318	1591.71
NS_3	U	kenUqcikaen	372.7312	1713.422
NS_3	U	kepUcIsow	445.1012	854.0694
NS_3	U	tUkanIqsak	405.7154	1575.865
NS_3	U	nakUtIh	412.8285	969.6972
NS_3	U	kUhkwaqsew	436.7396	1048.912
NS_3	U	kUhkwaqset	485.2042	1112.156
NS_3	U	kUhkwaqsem	499.5103	977.56
NS_3	U	kenUpik	445.742	1573.51
NS_3	U	mUceh	360.9635	1274.051
NS_3	U	otUnepih	464.5561	1472.988
NS_4	U	tUkaniq	400.2716	1172.869
NS_4	U	menUkuapos	421.0926	1422.811
NS_4	U	mUcehkiw	375.2423	903.5888
NS_4	U	nemUtIh1	408.094	2710.355

speaker	vowel	context	f1_head	f2_head
NS_4	U	tUkaniqsak	482.2266	2262.356
NS_4	U	tUkaniq	404.8131	1218.474
NS_4	U	tUkaniq	366.6741	1106.922
NS_4	U	mUcekIhwak	363.737	1633.807
NS_4	U	mUcehkIhsak	461.6167	1044.262
NS_4	U	mUcehkiwak	373.627	1821.736
NS_5	U	menUkwat	476.8986	1835.761
NS_1	ua	akuahkOhsaeh	371.8966	941.8405
NS_1	ua	akuahkihsen	438.7904	898.2964
NS_1	ua	ehkuahtawaew	471.4912	889.22
NS_1	ua	kuahnaew	383.7561	963.0945
NS_2	ua	akuahkok	402.3772	822.4157
NS_3	ua	akuatikamek	452.8684	1226.288
NS_3	ua	akuaceh	464.5592	895.5731
NS_3	ua	kuahnepAhtaw	411.4834	913.9159
NS_3	ua	ahkuacemow	648.5616	2255.151
NS_3	ua	ahkuahkihnaen	404.9123	916.8892
NS_3	ua	ahkuahtawaew	430.8102	927.1806
NS_3	ua	ahkuaqtahaew	481.4386	1052.466
NS_3	ua	Akuapahtwatam	587.891	1279.734
NS_3	ua	Akuaqnaehaew	418.1273	667.3699
NS_3	ua	anuakawew	473.3899	1472.212
NS_3	ua	apuan	488.2351	1663.773
NS_3	ua	apuatAEw	444.4801	806.7886
NS_3	ua	ayAkuamemaew	506.6181	2308.127
NS_3	ua	ahkuaham	739.5142	1660.959
NS_3	ua	akUtuasow	368.114	1152.135
NS_3	ua	asAqsuahsaeh	499.5379	1792.174
NS_3	ua	atUhpuahsaeh	412.009	923.6811
NS_4	ua	taskuahkwat	442.4203	860.2813
NS_4	ua	apuahsokaneh	431.5278	777.2833
NS_4	ua	apuahsokan	452.636	733.7737
NS_4	ua	kuahnepesowak	383.5649	768.885
NS_4	ua	menUkuapos	447.4024	930.0088
NS_4	ua	AEtuaq	436.476	829.8031
NS_4	ua	maeqtehkuahkihkih	461.7082	1999.766
NS_5	ua	akuaceh	485.5799	1022.951
NS_5	ua	mIkAtituaq	430.0243	2138.377
NS_1	wa	anAmAEhkwam	422.6961	1027.182
NS_2	wa	osAqsaehkwat	464.3767	1252.162
NS_3	wa	Akuapahtwatam	440.5955	1760.537
NS_3	wa	menUkwat	479.6798	1528.859
NS_3	wa	kenUpikwas	790.8118	1275.183

speaker	vowel	context	f1_head	f2_head
NS_3	wa	kenUpikwas	646.4709	1470.524
NS_3	wa	apIsemUhkehkwan	524.0559	1596.109
NS_3	wa	kenUpikwas	497.1249	1619.589
NS_3	wa	asEkan-wiahkwan	789.806	2184.761
NS_3	wa	esImiakwat-kaehkoh	687.3659	1870.351
NS_3	wa	esImiakwat	653.871	2218.458
NS_3	wa	kenUpikwamAEk	555.6251	996.0187
NS_3	wa	macInAkwat1	582.5983	1129.8
NS_3	wa	macInAkwat2	633.0753	1003.193
NS_3	wa	kUhkwaqsew	523.8006	1293.95
NS_3	wa	kUhkwaqset	488.6846	1229.433
NS_3	wa	kUhkwaqsem	521.1271	1323.573
NS_4	wa	necIqcekwam	438.0652	861.8393
NS_4	wa	nepAEhkwan	455.958	995.6208
NS_4	wa	otAcekwan	401.1196	1099.446
NS_4	wa	penAEhkwan	435.1173	834.6708
NS_4	wa	sIkwan	412.2878	854.993
NS_4	wa	taskuahkwat	470.3147	1073.223
NS_4	wa	asAqswan	411.365	844.3128
NS_4	wa	kaehkAEhkwan	370.8953	1189.617
NS_4	wa	esInAkwat	437.237	852.9596
NS_4	wa	kIskahAhkwan	593.9034	1414.585
NS_4	wa	maeqnakwah	504.4723	912.8561
NS_4	wa	otAcekwan	314.479	1173.191
NS_5	wa	menUkwat	493.9828	1090.928
NS_2	ya	wApAEhsyah	562.7591	2032.705
NS_3	ya	anAEcemyakosew	344.6396	2528.465
NS_3	ya	anAEcemyakosow	485.4693	2545.602
NS_3	ya	apAEhsahkyah	409.1861	2379.898
NS_3	ya	AqnamAhkyah	447.6279	2434.965
NS_3	ya	AsawAhkyah	447.402	2481.694
NS_3	ya	cIkahkyah	403.1976	2495.628
NS_4	ya	nekEkAtAEpyan	360.683	2446.068
NS_5	ya	kotApyacekan	480.9539	1493.426