The Social Distribution of a Regional Change: /æg, ɛg, eg/ in Washington State

John M. Riebold

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2015

Reading Committee:

Alicia Beckford Wassink, Chair

Richard A. Wright, Chair

Betsy E. Evans

Program Authorized to Offer Degree:
Linguistics

University of Washington

Abstract

The Social Distribution of a Regional Change:
/æg, ɛg, eg/ in Washington State

John M. Riebold

Co-Chairs of the Supervisory Committee:
Associate Professor Alicia Beckford Wassink
Linguistics

Professor Richard A. Wright
Linguistics

Recent studies at the University of Washington as part of the Pacific Northwest English (PNWE) Study have found that Washingtonians are raising /æ, ɛ/ before /g/ (e.g. "bag", "beg"), known as 'pre-velar raising' (Wassink, 2014, 2015b; Wassink, Squizzero, Schirra, & Conn, 2009), and lowering /e/ before /g/ (e.g. "vague") (Freeman, 2014b; Riebold, 2014a). However, there is much still to be understood about the social and geographical distribution of these changes.

This dissertation is a sociophonetic study of the character and spread of this change in the speech of 71 Washingtonians from five ethnic groups known to have a long history in the state: African Americans, Caucasians, Japanese Americans, Mexican Americans, and the Yakama Nation. First, the overall vowel space of Northwest English is situated in the landscape of US dialects, and the ethnicities are compared in order to investigate cross-ethnic differences. Following this, results from the pre-velar analysis are presented in which traditional vowel plots (F1 x F2) are used to locate each ethnicity's front vowels, while three-dimensional overlap (F1 x F2 x duration) (VOIS3D; Wassink, 2006) is used to assess the extent of raising and the contribution of duration in maintaining or erasing contrast. SS-ANOVA (Gu, 2002) plots are used to model vowel trajectories as curves connecting onset,

midpoint, and offset, which allows for a more realistic picture of vowel trajectory (Wassink & Koops, 2013). Finally, inferential statistics are used to test the influence of gender, ethnicity, generation, and social network on pre-velar raising.

Results from the vowel space analysis show that, in general, Northwest English speakers have a vowel space fairly similar to that of other dialect regions in the West. Northwesterners don't show evidence of front vowel lowering, associated with the Californian/Canadian Vowel Shift, and show /u, o/ (GOOSE, GOAT) fronting comparable to that of Californian speakers, but still not quite as advanced. In comparison to non-western dialects of American English, the Northwest's most distinguishing features are generally higher low vowels, /u/-fronting (GOOSE), and strong /ʊ/-fronting (FOOT).

The results of the pre-velar analysis show that all groups are participating in the changes. All speakers raise /æg, ɛg/ (BAG, BEG) and lower /eg/ (VAGUE), and although vowel plots show some small gender and cross-ethnic differences, these are not statistically significant. Although vowel and SS-ANOVA plots suggest a merger of /ɛg, eg/ (BEG, VAGUE), with /æg/ (BAG) stabilizing between /æ, ɛ/ (TRAP, DRESS), duration appears to be holding the two classes at least measurably different. As has been found in previous studies (Freeman, 2014b; Riebold, 2014a), the generational picture shows that middle-aged speakers raise the most. However, SS-ANOVA plots and statistical analyses suggest that younger speakers may be developing a split between the pre-velar and non-pre-velar wordclasses, leading to less overall raising, but more spectral separation between /æ, æg, ɛ, ɛg~eg, e/ (TRAP, BAG, DRESS, BEG~VAGUE, FACE). Finally, statistical analyses show that Network Strength Score has a significant effect on pre-velar raising/lowering, such that more locally-integrated speakers show more overlap. Taken together, these results suggest we may be nearing the completion of a change in progress (though there is much work still be done in order to conclusively establish this), and that at least as far as these changes are concerned, Washingtonians of various ethnicities share a common linguistic system.

The results of this study contribute to the literature surrounding a nascent change in an understudied dialect area. It sheds light on the linguistic consequences of the inter-ethnic contact that has characterized much of Washington's history, and provides further evidence for the participation of non-White ethnicities in regional changes, motivating their inclusion in future studies of regional dialects.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

It is well known that it takes a village to raise a child (a fact which I have become intimately acquainted with over the last 8 months), but it takes something else entirely to write a dissertation. So many people have helped me over the years, and I am grateful to each and every one of them.

Above all, I wish to thank the co-chairs of my committee, who have helped, advised, and mentored me during my time at the University of Washington. Alicia Beckford Wassink, thank you for always supporting me, for giving me the opportunity to participate in the PNWE Study, for never letting me take my eyes off the big picture, and of course for devoting your time and effort to making sure this dissertation was the best it possibly could be. Richard Wright, thank you for keeping me grounded, for the unwavering dedication you show your students, and for always managing to teach me something new (even in the most unlikely of conversations). Thanks also to the rest of my committee. To Betsy Evans, for always keeping me on my toes, and for making sure I'm prepared to defend every aspect of my research. And to Lynne Robins, for helping out as GSR over the years.

To my family, who have always been my champions. To my wife: Jos, you are my rock, my constant companion. You've always encouraged me, kept me going, and made me laugh, even when I was tired, frustrated, or simply stuck. I could never have done this without you. To my parents, Tom and Barb, my sister, Jane, and my parents in-law, Jana and Orazio: your help and guidance over the years (and in particular the last half year) were invaluable, and meant more to me than you will ever know. Mom, it's thanks to you that I got that first draft finished. Jana, you opened my eyes to the world of linguistics, and you and Orazio kept us afloat those first three months, and always managed to put things in perspective. Last, but not least, to little Niko, who makes me smile and laugh every day. I love you all.

To my friends and collaborators, Robert Sykes, Lisa Tittle, Valerie Freeman, Rachel Schirra. Rob and Lisa, thank you for keeping me on track (and sane) out there in the field. I may not have survived without you. Valerie, thanks for all your excellent advice and suggestions, and for always letting me bounce ideas off you. Special thanks to Dan McCloy: your help and patience over the years were invaluable, and I think it's safe to say that without you, the graphics in this dissertation would be nowhere near as pretty (and would likely have taken 10x the amount of time to produce).

Thanks also to Haver Jim and all the respondents who volunteered their time for this project, it very literally would not have been possible without your help.

And finally, thank you to Rick Grimm, the UW Phonetics and Sociolinguistics lab groups, and everyone else who's taken the time and effort to cheerfully dissect all of my abstracts, presentations, and papers over the years.

This research was supported in part by a grant from the National Science Foundation, grant #: BCS-1147678, "Dialect Evolution and Ongoing Variable Linguistic Input: Production and Perception of the English Spoken in the Pacific Northwest", PI: Alicia Beckford Wassink.

All errors are my own.

DEDICATION

To Josephine & Niko, the lights of my life.

Chapter 1

INTRODUCTION

This dissertation is a comprehensive sociophonetic study of the character and spread of /æg, ɛg/-raising (BAG, e.g. "bag", "rag", "nag"; BEG, e.g. "beg", "peg", "leg"[1]) and /eg/-lowering (VAGUE, e.g. "vague", "pagan", "vagrant"; also known as pre-velar raising[2] and lowering, or the pre-velar merger), in an attempt to situate it not only within the vowel space of the Northwest, but also within the social landscape of the region by applying sociolinguistic and phonetic theory and methods to dialectological questions. Using data from five major ethnic groups and three regions of Washington State, the study will address several questions. First, how the vowel space of Northwest English compares to other US dialect areas. Second, whether, or to what extent, there are similarities between the vowel systems of White and non-White Northwesterners. And third, how pre-velar raising patterns by ethnicity and gender, and what a cross-generational picture (in apparent-time) can tell us about the timing of the changes.

It is a common belief in the United States that natives of the region which includes Oregon, Washington, and parts of Idaho (occasionally also extended to British Columbia in Canada), known as the Northwest or the Pacific Northwest[3], "don't have an accent".

---

[1]Throughout this dissertation I will adhere to standard IPA notation alongside the word classes set forward by Wells (1982). Where Wells has not given a word class for a particular phonological environment, I will define one and give a list of words belonging to it, as I have done here.

[2]Pre-velar raising in the Northwest also includes the hyper-raising of the /æŋ/ (HANG, e.g. "hang", "bang", "language") word class (Wassink, 2015b; Wassink & Riebold, 2013), however this dissertation focuses only on the pre-/g/ environment.

[3]I prefer the term "Northwest", as it includes both the Pacific Northwest (i.e. the area west of the Cascades in Oregon and Washington which borders the Pacific Ocean), and the Inland Northwest (a term frequently used to mean east of the Cascades, or more conservatively Spokane and eastern Washington together with northern Idaho).

Although most Americans believe that Californians speak with some sort of discernible accent due in no small part to the caricatures of surfers, movie stars, valley girls, and other stereotypes found in film, television (e.g. the popular Saturday Night Live skit "The Californians"), and literature (Wolfram & Schilling-Estes, 1998), it is widely believed by laymen that the English spoken in the Northwest is simply "neutral" or at least close enough to "standard English" as to make no matter (Evans, 2011). This view of Northwest English is by no means limited to out-group perceptions of the variety: rather the idea that English in the Northwest is the standard is a treasured ideal held by many Oregonians or Washingtonians (Hartley, 1999), beyond the typical preference for one's own dialect so often seen in perceptual dialectology surveys where the speaker rates their own dialect as "normal" (cf. Preston, 1999, and others). But this is clearly contrary to one of the tenets of sociolinguistics, namely that *everyone* has an "accent". It is simply the case that much of the variation that characterizes the region is not subject to overt social evaluation, and a comprehensive description of the features of Northwestern English remains a work in progress.

A consequence of this is that Northwest English has seen relatively little scholarly investigation in contrast with other, more established dialect areas such as the North, South, and East, and even other regions in the West, such as California (cf. Eckert, 2005). Most often, "the West" is defined in relation to other major North American dialect areas in terms of its participation/non-participation in various hallmark variables, rather than the presence of any local innovations (Labov, Ash, & Boberg, 2006, p. 279). Despite evidence of lexical (Conn, 2006; Vaux & Golder, 2002; Ward, 2003), syntactic (McLarty, Kendall, & Farringon, 2014), and phonological (Conn, 2002; Ingle, Wright, & Wassink, 2005; Riebold, 2012; Squizzero, 2009; Ward, 2003; Wassink, 2011; Wassink, Squizzero, Schirra, & Conn, 2009) variation, scholars from outside of the region still tend to treat it as equivalent with English in California and other regions in the West.

This lack of research stems in part from the fairly young age of the dialect area. Indeed, Washington State, which is the focus of this study, was settled only just over 200 years ago, and wasn't formally inducted into the union until 1889. The age of the region means that English in the Northwest has only had a rather short time to develop regionally-marked features. But because the Northwest has also been the site of extensive inter-ethnic contact (Reiff, 1981; Sale, 1976), we have good reason to expect that this mixture will have linguistic consequences as part of the dialect contact process (Kerswill & Williams, 2005; G. Sankoff, 2004; Trudgill, 2004).

Despite the challenges facing researchers in the area, there have been some studies of Northwest English — chiefly in Seattle, Washington, and Portland, Oregon — whose results suggest that some distinctive characteristics are emerging. These studies have noted a tendency for back vowels to be centralized, with F2 values similar to central vowels (Conn, 2002; Ingle et al., 2005; Riebold, 2009; Ward, 2003), along with anecdotal evidence suggesting the presence of some features known to originate in the US Midlands, such as "positive anymore" and the "needs" + past participle construction. Lexical differences are one of the few features of Northwestern English that are reasonably well known, for example, Oregonians don't "go to the sea" or "the beach" or even "down the shore", they "go to the coast". Other lexical items come from contact with indigenous languages, especially for example via Chinook Jargon (e.g. "skookum", "high muckamuck") (Conn, 2006).

There have been relatively few studies of the Northwest English vowel space itself, however scholars have noted the presence of two sets of spectral changes taking place in the region. In the back vowel space, preliminary work has found that /ʊl, ol, ʌl/ (BULL, e.g. "bull", "pull"; BOWL, e.g. "bowl", "roll", "goal"; DULL, e.g. "dull", "mull", "null") are collapsing to [l̩] (Squizzero, 2009). In the front vowel space, a growing body of research has focused on pre-velar raising (Freeman, 2014b; Riebold, 2014a; Wassink, 2014, 2015b; Wassink, Squizzero, Schirra, & Conn, 2009). Interestingly, pre-velar /æg/-raising (BAG) similar to that found in the Northwest has also been reported in Wisconsin English (although in the absence of /ɛg/-raising, BEG) (Benson, Fox, & Balkman, 2011, Labov et al., 2006; Zeller, 1997). It is possible that the two phenomena are connected, however historical works don't show a large amount of immigration from Wisconsin to the Northwest, nor does the timing of the changes match up (Wassink, 2015b). Being phonetically-motivated, (Baker, Mielke, & Archangeli, 2008; Bauer & Parker, 2008; Purnell, 2008), pre-velar /æ/-raising (BAG) could conceivably have arisen separately. Other recent studies have focused on /æ/-backing (TRAP) (Swan, 2014), found in California as part of the California Vowel Shift, and in Canada in general (Boberg, 2008), although whether or not Northwesterners are participating in this remains unclear.

Although there is a growing body of literature surrounding pre-velar raising in the Northwest, there remain many unanswered questions. Until very recently, the majority of research in the region has either been dialectological in nature, focusing on Caucasians in the Seattle area (for both convenience and comparability), or sociolinguistic, investigating the use of ethnolects in the region (Scanlon & Wassink, 2010). A fusion of these two traditions has not yet emerged here, but given the Northwest's particular history, there is a special need for research dealing with theoretical sociolinguistic concerns such as the role of ethnicity and the urban/rural divide in the use of regional dialect features.

Ethnicity itself has of course been the subject of extensive research in sociolinguistics, with a sizable body of literature surrounding ethnolects such as African American English (Rickford, 1999; Smitherman, 1977; Wolfram & Thomas, 2002), Chicano English (Bayley & Santa Ana, 2004; Ornstein-Galicia, 1984; Santa Ana, 1993), and others. These studies typically abstract away from the speakers' use of regional features, just as regional dialect studies traditionally focus on the majority ethnic group in the area (i.e. Caucasians in the US). The motivation for the exclusion of non-White speakers in studies of regional dialects comes from early sociolinguistic work in the eastern US, where in several cities it was indeed found that the speech of minority groups differed significantly from that of Whites (Labov, 1994, p. 53–54). This has become a pervasive assumption, made most explicit by Labov:

> "All speakers who are socially defined as White, mainstream, or Euro-American, are involved in the changes to one degree or another. But for those children who are integral members of a sub-community that American society defines as non-White, Black, Hispanic, or native American the result is quite different. No

> matter how frequently they are exposed to the local vernacular, the new speech patterns of regional sound change do not surface in their speech." (2001, p. 506)

This is problematic for a variety of reasons. Circumscribing a speech community is difficult in the best of circumstances, and even narrowly defined groups will still contain speakers who break from the community norm, not to mention the fact that the speech community itself can be defined in various ways (cf. Labov, 1972; L. Milroy, 2008). Some researchers have broken from this, however, finding that non-White speakers do indeed participate in regional variation (Anderson, 2002; Fought, 1999; Fridland, 2003; Wolfram, Carter, & Moriello, 2004). In fact, some studies have found that minorities participate in regional sound changes to the same degree as White speakers (Thomas, 2007), and in some cases even lead (Hall-Lew, 2009). These studies alone are good reasons to adopt more broadly-defined regional speech communities, including multiple ethnicities, especially when those communities have a long history in the region.

Studies of both regional dialects and ethnolects also tend to assume that speakers are fundamentally monodialectal, which is highly unlikely, at least for the majority of speakers. There have been some studies of multi-dialectalism and code-switching in minority populations (Fought, 2002; Mendoza-Denton, 1997), suggesting that many speakers are in fact proficient in both an ethnic and a regional language variety.

This dissertation uses data from five major ethnic groups (African Americans, Caucasians, Japanese Americans, Mexican Americans, and members of the Yakama Nation) in three regions of Washington State (Seattle-area, the Yakima Valley, and the Spokane area), recorded for the Pacific Northwest English Study at the University of Washington to ask specific questions about the vowel space of Washington State. Chapter 2 is a discussion of ethnicity and the Speech Community, some important aspects of sociolinguistic theory, an overview of American English, a brief history of the Northwest, along with a summary of what is known about Northwest English, and a review of the literature surrounding prevelar raising in both the Northwest and Wisconsin. Chapter 3 enumerates the data and experimental methods used in this study. Chapter 4 presents results from the examination of the Northwest English vowel space, and chapter 5 focuses on the results of the analysis of pre-velar raising. Chapter 6 summarizes the main findings of the study, and ends with chapter 7: concluding remarks, and a reflection on the implications for studies of regional dialects and the Northwest in particular.

Studies of this type can shed light on the linguistic outcomes of inter-ethnic contact, as well as the process of dialect focusing that can occur in recently settled regions with a diverse array of immigrants, such as the Northwest.

Chapter 2
BACKGROUND

This chapter reviews the theoretical and methodological foundations of this study, moving from a discussion of sociolinguistic theory to a survey of American English dialects, followed by a brief history of the Northwest and a discussion of the literature on Northwest English, and finally a consideration of the linguistic factors that may condition pre-velar raising.

2.1 Sociolinguistic Theory

This section presents summaries of the roles of gender, generation, ethnicity, and socioeconomic class, and the concepts of the speech community, the social network, regionality, and indexicality. All of these topics have implications for the design of the Pacific Northwest English Study, as well as this dissertation and the interpretation of its results.

2.1.1 Linguistic Change

Above and Below

The concepts of 'change from above' and 'change from below' are central in studies of sociolinguistic change and variation (Labov, 1994). A change from above is one which is associated with a high degree of prestige, consciously adopted by the upper or dominant social classes. Changes from above are frequently imports from other speech communities (or other languages entirely), and do not arise as a result of internal linguistic forces. They are most frequent in careful speech, and may be inconsistent with the grammar of the variety.

A change from below is usually innovated in the interior or lower classes, as a result of language-internal factors. A change from below initially has no social evaluation, spreading below the level of consciousness. But, as it becomes associated with vernacular language or a particular social grouping, it may become negatively-evaluated over time. Thus, "above" and "below" refer to both the level of consciousness and the social class of the initial adopters.

Change in Progress

Another important concept in sociolinguistic research is 'change in progress', that is, a linguistic change which is moving from one state to another, e.g. from low frequency of use to high, or from the presence of a construction to the absence of it (Chambers, 2003). Change in progress stands in contrast to stable variation, where the community varies in their use of a certain form, but in a predictable way, with each generation replicating the same pattern. An example of a stable sociolinguistic variable is "ing", the participial suffix found on verbs (e.g. "talking", "singing"), which is variably realized as [ɪŋ] or [ɪn], with the latter occurring more frequently in casual speech (Chambers, 2003). This variation has persisted for a great deal of time, without either variant becoming categorical in usage.

The observation of a change in progress requires first that two (or more) states of the language be observed, and second, that those states can be shown to be connected to one another (i.e. that the samples are comparable in any relevant dimensions), such that if rates of usage are significantly different between them, a change can be inferred to have taken place (Labov, 1994). Studying a change while adhering to these criteria requires a particular experimental design: one in which data from multiple time points can be collected and analyzed. §2.1.2 describes some methods for the study of changes in progress.

2.1.2 The Apparent Time Hypothesis

Studying change in the use of a linguistic variable over time (i.e. its advancement or recession) must be approached carefully. One way to do so is to interview a set of speakers, then interview another (or the same) in some number of years, and repeat as needed. In doing so, the change in question can be directly observed by the researcher. In practice however, real-time studies like this are anything but simple. Due to the complexities involved with managing large-scale projects over a number of years (e.g. staff changes, difficulty in recontacting respondents, data storage, funding, etc.), studies of this type are rarely attempted (Labov, 1994) (but see Cedergren, 1988; D. Sankoff & Sankoff, 1973; Thibault & Vincent, 1990; Trudgill, 1988 for studies that have done so).

Another method of studying a change in progress is to interview a set of speakers from multiple generations or age-ranges at a single point in time. By comparing the results across age groups, trends in the data can be inferred to be evidence of change over time. That change over time can be inferred in this manner is known as the 'apparent time hypothesis' (Labov, 1994). It is important to note, however, that this assertion rests on two other theoretical notions. First, that the language use of the respondents has stabilized, that is, that they are past the critical period in first language acquisition (the period roughly from birth up until adolescence during which first language acquisition normally occurs, and after which it is much more difficult) (Lenneberg, 1967), and can be said to have acquired the norms of their speech community. And secondly that individuals do not change their speech habits over the course of their lives. Age-grading — the change in use of a variable over the life of a speaker, repeated for each generation — is a possible problem for this theory, however age-grading is rare, and tends to be easily recognizable in a community (Chambers, 2003). The apparent time construct has itself been tested, and largely confirmed, a number of times (Bailey, 2008; Bailey, Wikle, Tillery, & Sand, 1991; Cedergren, 1988; G. Sankoff & Blondeau, 2007; Thibault & Daveluy, 1989; Trudgill, 1988). Theoretical concerns aside, the apparent time hypothesis has been applied many times in sociolinguistic research, including in the experimental design of the PNWE Study, in large part because of the rapidity with which studies of this type can be carried out.

2.1.3 Gender

The role of gender, as a sociocultural construct, in language change and variation is complicated and multi-faceted, going far beyond the differences associated with physiological differences between males and females (Chambers, 2003). Gender is associated with the differential use of stable sociolinguistic variables (Labov, 1990), and most relevant for the study at hand, it has also been predictive of participation in changes in progress through a complicated interaction with social class and the type of linguistic change.

Labov (1990) formulates three general principles that describe the influence of gender on language. Principle 1 states "For stable sociolinguistic variables, men use a higher frequency of nonstandard forms than women", a claim which is supported by a vast array of studies; to name just a few: Labov (1966) for the use of the [ɪn] variant of "ing" in New York City, J. Milroy and Milroy (1978) for the stopping or affrication of /θ, ð/, and Wolfram (1969) for a host of variables in Detroit. Labov suggests that this can be viewed in two ways: either men are less influenced by the stigma associated with the use of vernacular forms, or women are more influenced by the prestige associated with standard forms.

Principle 1a states "In change from above, women favor the incoming prestige form more than men", and has been found in many studies, such as in New York City with the reintroduction of coda /r/ (Labov, 1966), in Belfast with the raising of /ɛ/ (DRESS) (J. Milroy & Milroy, 1985), and in Spain with the abandonment of traditional rural dialects (Holmquist, 1988).

In explaining these findings, Labov (1990) presents two alternatives. Either women must rely on symbolic capital (i.e. standard forms) due to their lack of equivalent access to material capital, or men use more non-standard forms for their covert prestige value.

And finally, principle 2 states "In change from below, women are most often the innovators". This has been found to be the case in many of the chain shifts currently ongoing across North America, such as the Northern Cities Shift in the Inland North (see §2.2.1) (Labov, 1966) and the Southern Vowel Shift in the South (see §2.2.4) (Mock, 1991). However, evidence for principle 2 is not as monolithic as for 1 and 1a. There exist some counter examples, where men appear to be leading in changes from below, such as on Martha's Vineyard (Labov, 1963) and in Belfast (J. Milroy & Milroy, 1985), however these are few in number, and it's unclear what drives this apparent reversal.

Because the goal of this study is to examine a change from below, we expect to find some gender differentiation, namely that women will show higher rates of pre-velar raising.

2.1.4 Ethnicity and the Speech Community

The notion of the speech community has a long history in sociolinguistics, but signifies very different entities in different research programs. Labov (1966) defined the speech community as a group of speakers which not only behaved similarly in their use of sociolinguistic variables (e.g. in style shifting, frequencies, etc.), but who also evaluated the use of those variables in the same manner. L. Milroy (2008), building on the work of Hymes (1974), argued that Labov's definition was not enough to account for intragroup differences, and that membership in a speech community meant frequent 'primary interaction' in addition to shared locality. These definitions are not necessarily irreconcilable, indeed, many communities would fit both definitions at once. Crucially, however, Labov's conception emphasizes (linguistic) behavior, whereas L. Milroy's emphasizes interaction.

Horvath and Sankoff (1987) follow L. Milroy's (2008) conception of the speech community in their study of the Sydney, Australia, speech community, suggesting that grouping speakers based purely on sociological categories is problematic, and may miss underlying patterns. They show that principal components analysis (PCA) can be used to group speakers from a multi-ethnic sample based on linguistic behavior, rather than group membership. The groupings that result from the PCA show that while ethnicity is an important predictor, it only explains the variation seen in speakers who immigrated as adults. Their children (born and raised in Sydney) pattern most closely with Anglo Sydney speakers, which Horvath and Sankoff take to mean they have become members of the Sydney speech community. They argue that excluding speakers from a study based on *a priori* assumptions about speech community membership can affect the adequacy of the study.

It has long been the case that for studies of regional dialects in the US, the speakers sampled were exclusively Caucasian. This practice has its roots in early dialectological and sociolinguistic traditions (e.g. the use of 'NORM's – Non-mobile Older Rural Males), but was also motivated by studies from the eastern US (Labov, 1994). Labov (1966), in his survey of New York City, justifies treating African Americans and Caucasians as separate speech communities by showing that they have fundamentally different linguistic systems, diverging sharply in their use of the variables (ay), (aw), and (oh). A divergence of Black and White speakers has been found in other regions as well (Bailey & Maynor, 1989; Labov & Harris, 1986).

Nonetheless, although viewing Caucasians as the most legitimate object of study for regional dialects may be justified in ethnically-monolithic communities, the history of the central and western US is very different from that of the eastern seaboard, and in many cases was much more integrated, without the sort of segregated areas and ghettos characteristic of the east coast in the 1800s and 1900s (Reiff, 1981).

Given these different histories, as well as continuing immigration from around the globe, it is increasingly difficult to ignore the diversity of the modern day urban speech community. In response to this, some scholars examined the speech of minority communities not just in relation to the ethnolect, but also in relation to local regional dialect. Tittle (2007) argues that describing someone as a speaker of some variety purely because of their ethnicity and use of a particular feature is short-sighted, and that shifting identities and ideologies make for a much more complex situation on the ground.

Ash and Myhill (1986) is a study of English in Philadelphia, Pennsylvania, focusing on the usage of a number of sociolinguistic variables by both White and Black members of the community who vary in the degree to which they have contact with the other ethnicity. Ash and Myhill find that social integration does indeed predict linguistic behavior. While Black and White speakers who have little-to-no contact with members of the other ethnicity show very divergent behavior, those respondents who report a high degree of contact with people of the other ethnicity behave much differently. White speakers who have a large number of Black friends accommodate to African American English patterns somewhat, and according to the same conditioning environments and factors, but show a large amount of variation with respect to the degree that they do so. Black speakers who frequently associate with Whites, on the other hand, appear to shift substantially towards Whites in their use of grammatical forms, but less so in the use of phonological and lexical features. These results suggest that inter-ethnic contact does indeed have linguistic consequences, and from this we may hypothesize that in more integrated areas, integration may be an important factor in language change.

Fridland and Bartlett (2006) is a sociophonetic study of back vowel fronting (/u, ʊ, o/, GOOSE, FOOT, GOAT) in Memphis, Tennessee, among both White and Black speakers. Their findings suggest that in general there is uniformity in the use of back vowel fronting across regional and social groupings, but that there remains some variation in the degree of advancement, with Caucasians leading.

In New York City, a speech community that was part of the original justification for excluding minorities from regional dialect research, things are changing. Becker (2010) finds that African Americans, Asians, and Latinos all produce some New York City English forms, and though ethnicity remains an important social category, the modern sociolinguistic landscape of the city is a far cry from the speech communities found by Labov (1966).

Fought (1999) is an analysis of Californian features in the speech of young Latinos, finding that although the speakers use Chicano English features, they also show consistent /u/-fronting (GOOSE), associated with the California Vowel Shift (CVS, also known as the Canadian Vowel Shift). She notes, however, that her speakers do not show the curvilinear pattern by social class typically associated with changes in progress. Instead, she finds a number of working class women who use the feature. She suggests that in this case, gang membership interacts with social class and other factors, resulting in a pattern that, on the surface, looks quite different from what might be expected. She concludes by suggesting that researchers shouldn't expect to find the same patterns of change in minority communities, or the simple replication of White patterns by non-White speakers, due to complicated issues of identity and class.

Elsewhere in the south, Points (2013) examines back vowel fronting and the low back merger among African Americans and Hispanics in East Austin, Texas. Points finds that her speakers are indeed fronting /u, o/ (GOOSE, GOAT), but that they may be doing so stylistically. Her speakers, both Hispanic and African American, also appear to be moving towards the low-back merger, which, while previously reported for Hispanics, is unexpected in the case of African Americans (Thomas, 2001).

Jones and Preston (2006) finds that higher-status African Americans in an Inland North city maintain both participation in the Northern Cities Shift (NCS) and a back vowel system characteristic of African American English. They argue that although this may not indicate degree of assimilation, it does suggest that these speakers are able to simultaneously acquire local norms while still retaining symbolic identity through the use of AAE features.

Hoffman and Walker (2010) is a large-scale survey examining the role of ethnicity in the speech community of Toronto, Canada, one of the most ethnically-diverse cities in the world (Anisef & Lanphier, 2003; Statistics Canada, 2011). Hoffman and Walker use production data from three generations (in apparent time) of three ethnicities: English/Irish, Chinese, and Italian – the three most populous ethnic groups in the city. It is important to note that first generation Chinese and Italian respondents were non-native speakers of English, having immigrated after the critical period. Hoffman and Walker find that while the rate of use of individual sociolinguistic variables varies by ethnicity, the conditioning environments do not. Another finding of importance to the present study is that despite evidence of transfer from respondents' first language among the first generation cohort, they find no evidence of this persisting into the second generation and beyond, echoing the findings of other scholars (Chambers, 2002; Labov, 2008). Hoffman and Walker suggest that a combination of the 'etic' (objective, analytically-meaningful) and 'emic' (subjective, socially-meaningful) approaches is necessary for the sociolinguistic study of ethnicity because even within a single social grouping (such as race), members may have differing attitudes towards the group itself.

Although not all research found convergence across dialects, and the results of many revealed more complex interactions of ethnicity, network, and language use, this research strongly motivates the inclusion of minorities in studies of regional dialect. As Points (2013) argues, "we cannot claim to have a thorough knowledge of the regional variety of English without investigating minority speakers". As the work of L. Milroy and others have suggested, it is difficult to study speech communities without also studying the social networks that they are made up of. §2.1.6 will explore the notion of the social network in more detail.

2.1.5 Socioeconomic Class

Socioeconomic class (SEC; also known as socioeconomic status, SES, or simply social class) is a complex measure of social standing, typically calculated using a person's income, education, and occupation (Chambers, 2003) and divided into middle and working classes (often further subdivided into upper, middle, and lower), that can be used to understand the social stratification of a society. SEC is a time-honored predictor in sociolinguistic research, having been used from the earliest (modern) studies up to present day. Labov's 'rapid and anonymous' survey of New York department stores (using the store itself as an index of social class) showed that employees of the lower class store (S. Klein) produced r-less forms (the vernacular variant) at a greater rate than employees in the higher class store (Saks Fifth Avenue). SEC has been successfully applied in sociolinguistic research many times since Labov's influential study, with the principle findings being the greater use of vernacular forms by the 'interior classes' (the middle classes and the upper working class) (Labov, 2001), suggesting that in changes from below, the interior classes may be the originators (Labov, 1994) (§2.1.1).

Nonetheless, SEC remains a social construct, and thus different societies and even different regions within a single society may pattern differently with respect to which class shows the greatest or least usage of a given linguistic form (Esling & Warkentyne, 1993; Ward, 2003).

2.1.6 Social Networks

The concept of the social network — a social structure consisting of individuals and the ties between them — has been applied fruitfully in linguistic research over the past few decades, having been used in studies of a variety of languages, and in a variety of locales. The impetus for these studies has been the observation that in many communities, speaker variables alone are not enough to explain the intricate patterning of sociolinguistic variation and change. The goal of a social network study, then, is not simply to describe the members of the network, but to use characteristics of the network itself to explain the linguistic behavior of those members (Mitchell, 1969).

There are two main approaches to the study of social networks: structural and ethnographic. The structural approach seeks to understand social networks in terms of their overall structure and the relationships between members of the structure, usually with whole network studies (Wellman, 1997). Under this approach then, the network itself and its structure are predicted to condition the behavior of its members. This paradigm is common in sociology, however, I am not aware of any applications of it in sociolinguistics research.

Far more common in sociolinguistics research is the ethnographic approach, employed by L. Milroy, Lippi-Green, and others, which is concerned with the relationship between the individual and their social network, typically through the use of 'ego network' (the network of informal contacts of a single individual) studies. In this approach, the number and types of contacts are important (L. Milroy, 2008), and seen as predictive of a speaker's linguistic behavior. The ethnographic approach is the one followed by the PNWE Study, and the results that have emerged from this research tradition will be the focus of the remainder of this section.

Social network information can be (and indeed has been) used in a number of ways in linguistic studies and otherwise, but some key concepts are important to understanding some aspects of the design of the Pacific Northwest English Study, chief among them the notions of network density, multiplexity, and integration. Social network density refers to networks in which the nodes of the network are highly interconnected (as opposed to being all connected by virtue of some central node). An example of a sparse network then would be a person's circle of friends, where every friend knows the person, but none of them know each other. That same network would be considered dense if the person's friends were all friends with each other as well. The importance of this concept is in the observation that networks, particularly dense ones, frequently act as norm-enforcement mechanisms (Cubitt, 1973; Labov, 1973).

Multiplexity refers to the strength of network ties, that is, the number of different types of ties between nodes in the network. For example, a relationship between two individuals could be said to be uniplex if they knew and interacted with each other in only a single way, say as classmates at school. A multiplex relationship would be one in which, for example, two individuals are friends and coworkers in addition to being family (as is common in working class communities) (Cubitt, 1973). Strong, highly multiplex ties are correlated with a greater degree of linguistic uniformity, whereas weak, uniplex ties seem to be important vectors for the spread of innovations (J. Milroy & Milroy, 1997).

Seeking to better understand the relationship between network composition and linguistic behavior, many researchers have attempted to quantify aspects of their respondents' social networks that may bear on their language use. Gal (1978) used a "peasantness" scale, Bortoni-Ricardo (1987) used integration and urbanization indices, L. Milroy (2008) and Lippi-Green (1989) used network strength scores, and Kirke (2005) used a (network) bias score. L. Milroy's Network Strength Score (NSS; ranging from 0–5) was based on five criteria combining network density (criterion 1) and multiplexity (criteria 2–5):

1. Membership of a high-density, territorially based cluster.
2. Having substantial ties of kinship in the neighborhood. (More than one household, in addition to his own nuclear family.)
3. Working at the same place as at least *two* others from the same area.
4. The same place of work as at least two others of the same sex from the area.
5. Voluntary association with workmates in leisure hours. This applies in practice only when conditions three and four are satisfied.

These criteria were chosen for two reasons: first, in order to represent those social conditions which have been found to be significant in previous studies of social networks, and second, in order to be easily recoverable and verifiable in a sociolinguistic interview. In a study of urban Belfast, L. Milroy reports that NSS is capable of sharply differentiating individuals. She finds a significant effect for gender and area, along with an interaction between the two, and furthermore that higher NSS scores are correlated with a greater usage of vernacular forms for the variables (a) and (th) (J. Milroy & Milroy, 1997; L. Milroy, 2008).

Lippi-Green (1989) uses a similar scoring method to quantify the social networks of her respondents in the village of Großdorf, Austria. Lippi-Green's NSS, ranging from 0–17, consists of 16 questions tailored to the sociolinguistic situation in the village. Lippi-Green's NSS differs from L. Milroy's in that the intent is not to measure how isolated or integrated a speaker is, but rather to distinguish speakers who are integrated into the community of Großdorf from those who are more integrated into that of the neighboring village, Egg. She finds that for men, high network integration scores (i.e. loyalty to Großdorf) predict linguistically conservative behavior. She concludes that without quantifying network integration, it would not have been possible to explain the behavior of her male respondents.

The use of a quantitative measure of network integration may prove important in describing the speech of Northwesterners, particularly in a multi-ethnic sample where speakers are expected to have more integrated, uniplex networks. Networks such as these may facilitate the spread of linguistic changes and lead to a shift from more local, community forms, to supralocal regional forms (Bortoni-Ricardo, 1987; J. Milroy & Milroy, 1997).

2.1.7 Regionality

Some scholars have sought to explain sociolinguistic variation using other means. Chambers (2000) created a 'Regionality Index' (RI) for his respondents. Regionality index is a measure of indigeneity that can be used to infer mobility, ranging from 1 ("true indigene") to 7 ("true interloper"), which takes into account speaker's birthplace, speaker's location during the critical period, and whether or not the speaker's parents are from the area. The intent behind the RI is to capture key indices of "nativeness" which may be important in some speech communities, such as those with a large number of migrants, or in which birthplace or ancestry is a relevant social category. Chambers shows that in three case studies, RI can be used to explain data that otherwise appear to vary unsystematically: indigenes and non-indigenes differ with respect to their preference for sociolinguistic variants.

Because the Northwest has historically seen a high degree of in-migration, we might expect a great deal of variability in the regionality scores of our speakers. Additionally, given that "true indigenes" are rather rare in the Northwest, it may be that they exhibit markedly different patterns from the "average" Northwesterner, who was born in the region but to interloper parents. The use of this variable will allow us to look beyond birthplace, and will hopefully expose some of the more subtle patterns present in the data.

2.1.8 Indexicality and Social Meaning

Social meaning is a driving force in language change and variation, and has been conceptualized in many different ways in sociolinguistic research. The taxonomy of the types of linguistic variables and the social meaning they carry, put forward by Labov (1972), distinguishes three levels: 'indicator', 'marker', and 'stereotype'. Sociolinguistic indicators are correlated with a group (e.g. usage or non-usage), but are not socially meaningful or subject to overt evaluation by the community, and do not vary stylistically. Markers are variables which have begun to accrue social meaning and thus show stylistic variation, but still remain largely below the level of consciousness. Finally, stereotypes are overtly meaningful variables whose use is commented on by the general public and which often show sharp stratification. Based on these criteria, evidence from the speech community showing the use and distribution of a linguistic variable can be used to identify its type.

Another framework for understanding social meaning in language is Silverstein's (1976) concept of non-referential indexicality. Non-referential indexicality (as opposed to referential indexicality, in which forms are understood to refer to particular entities) is the use and understanding of linguistic forms to construct various levels of social meaning, such as linguistic register, stance, and social identity (e.g. ethnicity, gender, class) (Bucholtz & Hall, 2005; Johnstone, Andrus, & Danielson, 2006; Silverstein, 1976). Sociolinguistic variables can be said to 'index' certain social characteristics when their use is statistically or socially associated with that characteristic. Silverstein's (2003) 'order of indexicals' can be understood to roughly parallel Labov's (1972) taxonomy of types of social meaning. A 'first-order' indexical is roughly equivalent to a sociolinguistic indicator: a feature which can be correlated with a sociodemographic identity. A 'second order' indexical, similar to a sociolinguistic marker, is a feature which has become associated with a style or speech and can be used deliberately by speakers for pragmatic and discourse purposes. Last, a 'third order' indexical resembles Labov's sociolinguistic stereotype in that it itself defines a register or grouping.

2.2 American English

Having reviewed the theoretical considerations which bear on this study, it is now important to situate the Northwest within the landscape of US dialects. This section presents a brief overview of the main phonological patterns found in the major dialect regions of the US in order to help contextualize the results presented later on.

The regions and definitions presented here are drawn from the *Atlas of North American English* (ANAE; Labov et al., 2006), which divides the US into three primary dialects (North, South, and West) and a number of subdialects, on the basis of the Telsur Project (a nationwide telephone survey eliciting a variety of sociolinguistic variables) data and the American dialectology literature. However, these classifications are not uncontroversial: some regions, such as the West, are not treated as monolithic by local scholars (e.g. this dissertation), and the results of local studies do not always match the broad generalizations set forward by Labov et al. (2006) (e.g. pre-velar raising in the NW: Freeman, 2014b; Riebold, 2014a; Wassink, 2015b, the California/Canadian Vowel Shift in Oregon: Becker, Aden, Best, & Jacobson, 2015, /æ/-raising (BAG) in a low-back-merged region: Benson et al., 2011). Nonetheless, the ANAE is an influential reference work, and is exceedingly useful in understanding the landscape of US dialects. Because chapter 4 presents overview plots which collapse across phonological environments (excluding pre-velar tokens), it is crucial to have an understanding of the subtle patterns that may simply not be visible in plots of that type, lest the reader come away with the impression that the dialects of US English are more similar than they in fact are. Particular attention will be paid to patterns that distinguish the regions from the (North)west.

2.2.1 The Inland North

The Inland North stretches from approximately Herkimer, New York, to Green Bay, Wisconsin, along the Erie Canal, including the cities of Buffalo, New York; Chicago, Illinois; Cleveland, Ohio, Detroit, Michigan; Rochester, New York; and Syracuse, New York.

Linguistically, the Inland North is characterized by the resistance to the low back merger, no tense/lax split in /æ/ (TRAP; such as is found in New York City and the Mid-Atlantic region), and a non-fronted /o/ (GOAT) with F2 values less than normalized 1200 Hz (Telsur G method) (Labov et al., 2006). Perhaps the most distinguishing feature of the Inland North, however, is the Northern Cities Shift (NCS). The NCS is a dramatic reorganization of the vowel space, involving the raising and fronting of /æ/ (TRAP; F1 values less than normalized 700 Hz), the fronting of /ɑ/ (COT), lowering of /ɔ/ (CAUGHT), backing and lowering of /ɪ/ (KIT) and /ɛ/ (DRESS), and backing of /ʌ/ (STRUT) (Labov et al., 2006). Figure 2.1 is a graphical representation of the NCS from the ANAE.

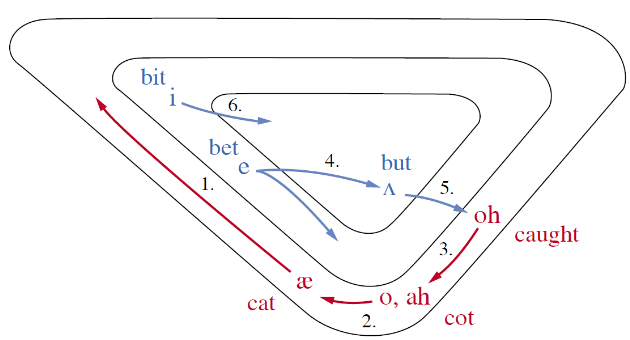


Figure 2.1: The Northern Cities Shift, from the ANAE.

2.2.2 The Mid-Atlantic

The Mid-Atlantic region includes Atlantic City, New Jersey; Baltimore, Maryland; New York City, New York; Philadelphia, Pennsylvania; Reading, Pennsylvania; Trenton, New Jersey; and Wilmington, Delaware.

While similar to the Inland North in general, the Mid-Atlantic is characterized by the 'split short-a' system (TRAP; /æ/-raising before voiceless fricatives and some nasals), and a raised /ɔ/ (CAUGHT) (Labov et al., 2006).

2.2.3 The Midland

The borders of US Midland are somewhat less well-defined than other dialect regions, in addition to being commonly divided into a North and South Midland on the basis of features those regions share with the Inland North and the South, respectively. Major cities in the area include Cincinnati, Ohio; Columbus, Ohio; Indianapolis, Indiana; Kansas City, Missouri; Omaha, Nebraska; and St. Louis, Missouri.

Some general features of the area relevant to this study include the absence of the NCS, transition towards low-back merger, and the fronting of /o/ (GOAT) and /ʌ/ (STRUT).

2.2.4 The South

The South chiefly includes Alabama, Arkansas, Georgia, Louisiana, Mississippi, North and South Carolina, and Tennessee, along with large parts of Florida, Kentucky, Oklahoma, Texas, Virginia, and West Virginia.

Figure 2.2 is a graphical representation of the SVS from the ANAE. Although figure 2.2 may give the impression that the South is not as different from the West as the Inland North is, Southern American English features the presence of the Southern Vowel Shift (SVS), which involves the fronting of /u, o/ (GOOSE, GOAT), and the inversion of /i/ (FLEECE) & /ɪ/ (KIT) and /e/ (FACE) & /ɛ/ (DRESS) (Labov et al., 2006). Like the NCS, the result of the SVS is a front vowel space very different from that of the West.

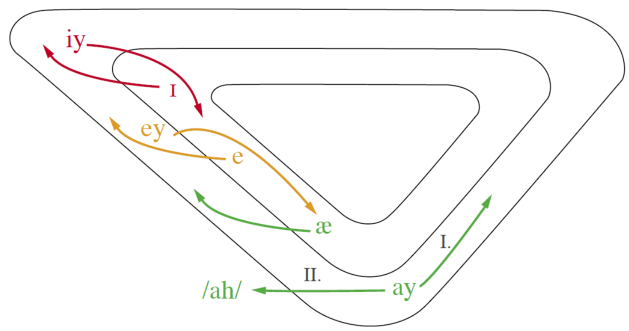


Figure 2.2: The Southern Vowel Shift, from the ANAE.

2.2.5 The West

The West is a large and diverse region, essentially the entire western half of the US, characterized by the relative recency with which it was settled. It includes the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Outside of California and now the Northwest, however, it has seen relatively little scholarly inquiry (although this is changing).

General findings in California include the presence of the low back merger, as well as the California Vowel Shift (CVS, also known as the Canadian Vowel Shift). The CVS involves the lowering of front vowels /ɪ, ɛ, æ/ (KIT, DRESS, TRAP; except before nasals, where they raise) and the fronting of /u, o/ (GOOSE, GOAT) (Eckert, 2005; Labov et al., 2006). Figure 2.3 is a graphical representation of the CVS adapted from Eckert (2005).

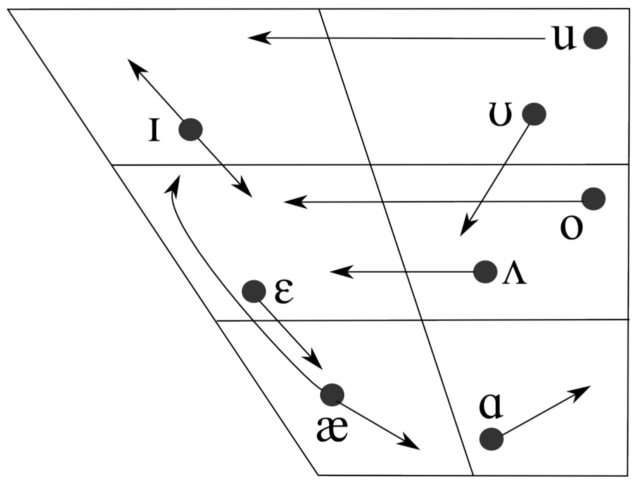


Figure 2.3: The Californian/Canadian Vowel Shift, adapted from Eckert (2005).

2.3 The Northwest

This section presents an overview of the history of the Northwest and a thorough review of the work that has been done on phonological variation in the area, with particular attention paid to findings on pre-velar raising.

2.3.1 Early History, Inter-Ethnic Contact, and Diversity

Inter-ethnic contact between Caucasians and indigenous and immigrant populations in the Northwest has a long history, having begun shortly after Washington became a territory in 1853 (Sale, 1976). The formation of ethnic enclaves and ghettos was less common than in other parts of the country (though it did still occur) (Reiff, 1981; Sale, 1976), and the continued trade and interaction resulted in the formation of a contact language: Chinook Jargon. Of the 7 million people now living in Washington State, the largest non-White ethnic groups are Hispanic (11.7%, mainly Mexican), Asian (7.7%), African American (4%), and Native American (1.8%, with the most numerous being the Yakama Nation) (US Census Bureau, 2013b). Of interest to this study are African Americans, Caucasians, Japanese Americans, Mexican Americans, and the Yakama Nation, which together constitute the main data to be analyzed.

Native Americans were the first inhabitants of the Northwest, and indeed the first widespread interethnic contact was among the regional Native American tribes. The Yakama Nation were instrumental in the early history of Washington, having brokered many deals with other tribes across the state. Formally the Confederated Tribes and Bands of the Yakama Nation, the Yakama Nation consists of approximately 10,000 people from fourteen tribes: Kah-milt-pay, Klickitat, Klinquit, Kow-was-say-ee, Li-ay-was, Ochechotes, Palus, Pisquouse, Se-ap-cat, Shyiks, Skin-pah, Wenatshapam, Wish-ham, and Yakama. Collectively, they speak a Sahaptin language called variously Ichishkíin, Ichishkíin Sínwit, Sahaptin, or Yakama (Sahaptin). Although few native speakers remain, and use of the language is decreasing among younger speakers, there are now some programs which have begun teaching the language to children. Most members of the Yakama Nation live on the Yakama Indian Reservation in the lower Yakima Valley (created by the Yakama Treaty of 1855), a rural, agrarian area of central Washington. Members of the Yakama Nation tend to be somewhat scattered, being the majority ethnicity (59%) in only one town: White Swan, population 793 (US Census Bureau, 2013a), and are split between the middle and working classes (54.5% and 45.5%, respectively, based on occupation[1]) (US Census Bureau, 2010). Given the Yakama Nation's influence during the early history of the area, it might be expected that the speech of members of the Yakama Nation would have an enduring influence on English in the Northwest via the 'Founder Effect' (Mufwene, 1996). This makes the Yakama Nation a reasonable choice for the first Native American population to be represented in the study. Yakama Sahaptin has a four-vowel system with only one front vowel: /i/ (Hargus & Beavert, 2014), making it unlikely for language transfer to have a large effect on pre-velar raising.

Washington is the site of a number of firsts for African Americans. African Americans have a particularly long history in the Northwest, with immigration beginning in the 1850s,

[1]Although this is a simple means of deriving SEC (see §2.1.5), it has been suggested that occupation is the most important factor in the determination of social class (Chambers, 2003), and the lack of many recent, detailed, large-scale studies of social class in the Northwest mean we often have no other choice.

and settlement along the railway corridor, in addition to in Seattle. In fact, Roslyn, a small coal-mining town just east of the Cascades was 22% African American in 1900, and went on to become the first town in the state with an African American mayor. Washington also has the first predominantly-White town to be founded by an African American: Centralia, and the Seattle Public School District was the first to voluntarily desegregate following Dr. Martin Luther King's "I have a dream" speech (BlackPast.org, 2015), although this is not to suggest that African Americans in Washington were free from the suffocating effects of racism and discrimination (Sale, 1976). Finally, and more directly related to the question at hand, Seattle's Yesler Terrace neighborhood was the first racially-integrated public housing development in the country. In contrast to some areas of the US such as the historically more segregated east coast and south (Reiff, 1981), an increasing number of African Americans in Washington are joining the middle classes, which now includes more than half the African American population (54.6%, based on employment) (Taylor, 1994; US Census Bureau, 2010). African American English (AAE) shares many similarities with Southern American English (also known as Southern White Vernacular English), including, and most relevant to this study, the SVS (see §2.2.4) (Thomas, 2007). Pre-velar raising, specifically the raising and fronting of /ɛg/ (BAG) and the lowering and backing of /eg/ (VAGUE), superficially resembles the inversion of /ɛ, e/ (DRESS, FACE) characteristic of the SVS, however the extremely restricted environments in which pre-velar raising occurs, as well as the lack of pronounced diph- or triphthongization, distinguish it from this particular feature of the SVS. Scanlon and Wassink (2010) examine AAE features in the speech of a highly-ethnically-integrated 65-year-old African American woman from Seattle, and find that interlocutor ethnicity has a significant effect on her usage of AAE features, however her non-pre-nasal /ɛ/ (DRESS) tokens don't appear to be significantly fronted and raised such that they would occur in the same spectral location as raised and fronted tokens of /ɛg/ (BEG).

Caucasians are the largest ethnic group in Washington, with 5.5 million people (81% of the state's population) (US Census Bureau, 2010). They are spread across the state, and mostly belong to the middle classes (63.6%, based on employment), due in part to the presence of Boeing in the Seattle metro area, which changed the economic landscape of the region in the post World War II period (Berner, 1991). In more recent years, the large and influential tech sector in the Seattle metro area has further bolstered the middle classes.

Japanese Americans were another group of early immigrants to the Northwest, playing a critical role in the construction of the railway lines that linked the region with the rest of the country in the mid to late 1800s (University of Washington Special Collections, 2014). Most Japanese immigrants settled in Seattle, and for a time they were the largest minority in the city (Sale, 1976), although there remains a smaller population in Spokane, where many of the Japanese Americans who were victims of internment moved following their release, being unable to return to their former homes (respondent ESP79SF1V, personal communication, 6/6/2013; Neiwert, 2005). Historically, Japanese Americans in Washington were nearly entirely working class (Miyamoto, 1939), but today the majority (74.5%, based on employment) belong to the middle classes (US Census Bureau, 2010). Being an older population, English/Japanese bilingualism is somewhat rare among Japanese Americans, and those that do speak Japanese typically learned it as a second language in a formal setting. Japanese has only one mid front vowel, typically described as [ɛ], or a lowered [e] (Okada, 1991).

Mexican immigration to the Northwest also began rather early in Washington's history, as early as the late 1800s. The vast majority of Mexicans immigrated much more recently, during and after World War II as part of an informal farm labor agreement between Mexico and the US, which authorized the use of 'bracero' labor as an emergency wartime measure designed to remedy the labor shortage in the Yakima Valley (Gamboa, 1981). Thousands immigrated during this period, and even after the end of the labor shortage, migration to Washington State from Mexico has continued. In contrast to the Yakama Nation, the highest concentrations of Mexican Americans tend to be in the towns and cities of the valley, such as Yakima (41%), the largest city in the region, population 91,067; Sunnyside (82%), population 15,858; Toppenish (82%), population 8,949; and Wapato (84%), population 4,997 (US Census Bureau, 2013a). The majority of Mexican Americans in the Yakima Valley are working class (73.2%, based on employment), most of whom work in the agricultural industry (US Census Bureau, 2010), although as the population ages and integrates into Washington State, this may change. Because most of the immigration from Mexico to Washington State occurred relatively recently, there is a still a moderate degree of bilingualism among the Mexican Americans of the Yakima Valley. Potentially relevant to this study is the fact that Spanish has only tense vowels in the front vowel space, and the use of /e/ for /ɛ/ and /i/ for /ɪ/ is a stereotype of Spanish-accented English.

2.3.2 Northwest English: The Story So Far

This section presents a review of the literature surrounding phonological change and variation in the Northwest. It moves from the early research of the 1950s to more recent large-scale research projects that have been carried out in the area.

Early Research

Northwest English was the subject of sporadic research in the 1950s up till the 1980s, primarily from researchers such as Carroll Reed (1952; 1957; 1961), author of the *Linguistic Atlas of the Pacific Northwest* (1965), Foster and Hoffman (1966), R. V. Mills (1950), and C. Mills (1980). It wasn't until the turn of the century that research resumed.

Although much of the early research into Northwest English focused on vowels, the studies are impressionistic in nature (by necessity), and by today's standards lack scientific rigor. Some findings from this era include *r*-insertion (Reed, 1952), and the presence of the low-back merger (Foster & Hoffman, 1966; C. Mills, 1980; Reed, 1961).

One of the earliest articles on English in the Northwest is Reed's "The Pronunciation of English in the Pacific Northwest" (1961). The article is a brief descriptive survey of Northwest English, taken from interviews with speakers in Washington, Oregon, and Idaho, and focused on relating variants in Northwest English with their possible origins in the eastern US. The main body of the article is devoted to a listing of the observed vowels and consonants of Northwest English, with comparisons to Kurath and McDavid's *Linguistic Atlas of New England* (1961). Reed observes that some speakers appear not to make a distinction between the COT and CAUGHT word classes. Most relevant to the present study, however, he notes that some speakers pronounce words such as "egg" and "keg" with [eɪ] or [e], although he lists these variants as infrequent (1961, p. 561). Reed also notes that pronunciations of the /æ/ in words like "bag" vary between [æ] and [æᴵ]. It can be inferred from the way Reed discusses these variants that what we might call /æg/-raising (BAG) is somewhat more common than /ɛg/-raising (BEG), but unfortunately he does not go more into detail on the relative frequency of the raised variants of /æg/ (BAG) and /ɛg/ (BEG), or who uses them. Despite the lack of more detailed information on the articulation of these variants, this suggests that /æg, ɛg/-raising (BAG, BEG) is at the very least not brand-new, linguistically speaking.

The Linguistic Atlas of the Pacific Northwest

Further evidence for the early appearance of pre-velar raising can be found in the *Linguistic Atlas of the Pacific Northwest* (LAPNW, Reed, 1965). The Atlas' data was collected from 1953 to 1963, and comes from 51 speakers from Oregon, Washington, and Idaho. Respondents were interviewed by fieldworkers, who transcribed the results for later tabulation. Although the atlas wasn't finished in Reed's lifetime, David Carlson managed to save some of the recordings and field records after Reed's death, which have been archived by the Linguistic Atlas Project.

Although Reed (1961) did not give token or variant counts, the LAPNW likely includes the data discussed therein. Of the 51 respondents recorded by the LAPNW fieldworkers, 50 produced at least one instance of /æg/ (BAG) or /ɛg/ (BEG), for a total of 133 tokens of /æg/ ("bag", "jag", and "rag"), and 145 tokens of /ɛ/ ("egg", "eggs", and "keg"). Analysis of data shows that 48% of /æg/ (BAG) tokens were produced with some raised variant, where "raised" means any variant that included an upglide, or where the nucleus was a vowel higher up in the system. Raised variants of /æg/ (BAG) include [æᵋ], [æᵉ], [æᴵ], [æ$^{\text{i}}$], and [ɛ$^{\text{ɪ}}$]. For the /ɛg/ (BEG) tokens, 71% were raised, with variants such as [ɛ$^{\text{e}}$], [ɛ$^{\text{ɪ}}$], [ɛ$^{\text{i}}$], [e$^{\text{ɪ}}$], [e], and [e$^{\text{e}}$]. Unfortunately no /eg/ (VAGUE) words were included in the LAPNW stimuli.

Despite fragmentary information on respondents and a lack of recordings for most of the speakers, this is crucial evidence that pre-velar raising has existed in the Northwest for generations, at rates much higher than suggested by Reed (1961), and with a similar pattern to that currently found in Northwest English, namely that the fronting/raising of /ɛg/ (BEG) is more common than that of /æg/ (BAG). Unfortunately, a full analysis of the data contained in the LAPNW is beyond the scope of this project, and will have to wait until another time.

The Atlas of North American English

The ANAE has relatively little to say about the Northwest, which it classifies as part of the so-called "third dialect" that includes the West in general, stating chiefly that it is a developing dialect area without sharply-defined boundaries, defined by participation in the COT–CAUGHT merger, a fronted /u/ (GOOSE) and a non-fronted /o/ (GOAT), a lack of participation in Canadian Raising, and a lack of glide deletion in /ai/ (PRIDE) (Labov et al., 2006, p. 279). Fortunately, the ANAE does have 11 recorded speakers from the Northwest (specifically in Washington, Oregon, and Idaho). These data show a fronted /u/ (GOOSE; F2 values between 1600 and 1800 Hz), and a moderately fronted /o/ (GOAT; F2 between 1200 and 1300 Hz) (Labov et al., 2006). For comparison, the ANAE lists Midland values for /o/ (GOAT) as being far more front (around F2 of 1400 Hz, with some even greater than 1550 Hz) (Labov et al., 2006).

The ANAE discusses /æg/-raising (BAG) in Wisconsin, and reports the presence of this system in western Canada as well (Labov et al., 2006, 182), but lists none in the Northwest. Two of the ANAE's Northwest speakers are marked as having the "continuous g>d system", however, where /æg/ (BAG) is raised somewhat compared to /æd/ (BAD) and other environments, but with no clear breaks (Labov et al., 2006, 180). The behavior of /ɛg, eg/

(BEG, VAGUE) is not mentioned.

The Pacific Northwest English Study

The Pacific Northwest English (PNWE) Study is a large-scale production and perception study conducted at the University of Washington, comprising two National Science Foundation grants, which aims to better describe the dialect spoken in the Northwest.

The first phase, titled "Dialect Evolution and Ongoing Variable Linguistic Input: English in the Pacific Northwest 200 years after Lewis and Clark" (BCS-0643374, PI: Alicia Beckford Wassink, hereafter PNWE Study I), ran from from autumn 2007 to summer 2009, and collected data from 30 Caucasian and African American speakers in the Seattle area. Speakers were recorded performing several tasks: 1) an informal conversation about various topics, such as growing up in the Northwest 2) a demographic and social network survey (see appendix A) 3) a lexical task which elicited semantic differentials and dialect variables (e.g. the low back merger, coda /ɹ/, etc.) 4) a short reading passage based on one of Aesop's fables, *The Cat and the Mice*, and 5) a wordlist targeting the vowels of General North American English in a wide variety of phonetic contexts.

The second phase, titled "Dialect Evolution and Ongoing Variable Linguistic Input: Production and Perception of the English Spoken in the Pacific Northwest" (BCS-1147678, PI: Alicia Beckford Wassink, hereafter PNWE Study II), began the summer of 2012, and ran till autumn 2014. The aim of PNWE Study II was to study the process and outcomes of the dialect- and ethnic-contact which has characterized the history of the region, and to do so it expanded the study eastward to the Yakima Valley and the Spokane area, collecting data from several other important ethnic groups (i.e. those with a long history in the area or who represent a significant fraction of the population): African Americans, Japanese Americans, Mexican Americans and members of the Yakama Nation, as well as both urban and rural Caucasians. The expansion of the study eastward was motivated not only by the desire for greater social and geographic coverage, but also to address a well-known ideological divide between western and eastern Washington State (with the Cascade Mountains acting as the dividing line), where western Washingtonians are seen as "urban", and "fast-paced", and eastern Washingtonians are seen as "country", and "hicks" (Evans, 2011).

Speakers were recorded performing a revised set of the PNWE Study I elicitation materials which included a larger selection of pre-velar words. The PNWE Study corpus contains 122 speakers, spread across western, central, and eastern Washington, and now includes a subsample from northern Idaho.

A perception study targeting numerous variables (including pre-velar /æ, ɛ, e/, BAG, BEG, VAGUE) in vowel-only, bigram, and sentential contexts, was conducted in the fall of 2014. The results are currently under analysis, however preliminary findings suggest that non-Northwesterners and Northwesterners alike have difficulty distinguishing merged tokens, which may indicate the degree to which context helps disambiguate these forms in everyday speech.

Oregon

Like the rest of the Northwest, Oregon saw relatively few studies up until the 2000s. A number of studies have been conducted recently though, many in connection with the "Language and life in Oregon and the Pacific Northwest" research program, headed by Tyler Kendall at the University of Oregon, which is concerned with sociophonetic investigations of both archival and contemporary recordings. McLarty and Kendall (2014) examine the relationship between the fronting of /u/ (GOOSE) and /o/ (GOAT). They find that although there was extensive /u/-fronting (GOOSE) in the Northwest, /o/-fronting (GOAT) was more varied. The fronting of both vowels has increased over time, however, and more importantly McLarty and Kendall find a strong correlation between the degree of /u/-fronting (GOOSE) and the degree of /o/-fronting (GOAT), with the F2 of /u/ (GOOSE) being a significant predictor of /o/-fronting (GOAT).

Becker, Aden, Best, and Jacobson (2015), a production study of Oregon English with a perceptual dialectology component (a map labeling task), find signs of the CVS in the speech of their respondents: 74% backed /æ/ (TRAP), while 32% lowered /ɛ/ (DRESS) and backed /ɑ/ (COT), in addition to some raising and fronting of /æg, ɛg/ (BAG, BEG). Results from the map labeling task show that respondents who labeled California separately were significantly more likely to have CVS features, and respondents who believe there are no differences in the region (e.g. "everyone talks the same!") are significantly more likely to raise /æg, ɛg/ (BAG, BEG). These results suggest that just as Oregon lies between California and Washington, so too does Oregon English show aspects of both systems.

McLarty, Kendall, and Farringon (in press) look at three generations of Oregonians, making use of both archival data and recent field recordings. Like Becker and her colleagues (2015), they find participation in the CVS, particularly the retraction of front vowels, along with little-to-no pre-velar raising. They close by suggesting that there is a need for more detailed work in the area, particularly that which focuses on different ethnic and cultural groups.

2.4 Pre-Velar Raising

This section reviews the literature on pre-velar raising in the Northwest, Wisconsin, and elsewhere.

2.4.1 The Northwest

Although Conn (2000) mentions some raising before /g/ (along with nasals and velars in general) in his study of /æ/ (TRAP) in Portland, OR, he doesn't go into detail, nor does he provide results for pre-/g/ tokens separately, instead including them in either the velar class (/k, g/) or the voiced velar class (/g, ŋ/). Given that the focus of his study was the presence/absence of the NCS the speech of Oregonians, it's possible that pre-velar raising of /æ/ (TRAP) was simply overlooked, however, he also mentions that many speakers produced no /g, ŋ/ tokens in the interview task, and that issues with Plotnik resulted in the mis-coding of some phones, including /g/, both of which may have further obscured the pattern.

Wassink, Squizzero, Schirra, and Conn (2009) is the first thorough study of pre-velar raising in Northwest English, using data from 17 PNWE Study I speakers, and addressing the following research questions: *i*) What are the phonetic features of the vowel system of the English used in the PNW? *ii*) Are there gender-related differences in front vowel production? *iii*) Are there style-related differences in front vowel production?

Wassink and her colleagues (2009) use VOIS3D to calculate 3D spectral overlap fractions (i.e. F1 x F2 x duration, see §3.5.4 for details) for /æg, ɛg, ek/ (BAG, BEG, BAKE, e.g. "bake", "rake", "take") in order to quantify the degree to which speakers overlap the three vowels. Results show that /ɛg, ek/ (BEG, BAKE) and /æg, ek/ (BAG, BAKE) are in close proximity in the speech of their subjects, occurring most frequently in casual speech, with many of the speakers who were partially merged in the wordlist task approaching complete merger in conversation. Furthermore, results suggest a tendency by males to merge /æg, ɛg/ (BAG, BEG), and by females to merge /ɛg, eg/ (BEG, VAGUE), although Wassink has since expressed doubts about the generalizability of this result (personal communication, 2011). Unfortunately, because /æg, ɛg/-raising (BAG, BEG) was unknown at the time the Pacific Northwest English Study's elicitation materials were devised, there are relatively few pre-velar tokens in the data, and no /eg/-words (VAGUE) at all, with /æg, ɛg/ (BAG, BEG) tokens being compared with the /ek/ (BAKE) class instead.

Riebold (2012) is an acoustic analysis of four speakers (2 males): three natives of Corvallis, OR (a small university town south of Portland, in the Willamette Valley), and one from Selah, WA (a suburb of Yakima) who moved to Corvallis in adolescence. The speakers are all White, middle class residents of the area, between 24–26 years of age. They were recorded performing the PNWE Study I tasks, but unfortunately because of this the study suffers the same drawbacks as Wassink et al. (2009) in being restricted to non-pre-velar /e/ (FACE) as a point of comparison for pre-velar /æ, ɛ/ (BAG, BEG).

In addition to examining each speaker's merger status, the study looked at the status of non-pre-velar /æ, ɛ/ (TRAP, DRESS). Results showed that in the pre-velar environment the two males partially merged /ɛg, eg/ (BEG, VAGUE), and two speakers partially merged /æg, ɛg/ (BAG, BEG). No speakers merged /æg, eg/ (BAG, VAGUE). Results also suggested that raising and non-raising environments might not be so different after all: three of the speakers' non-pre-/g/ tokens were in approximately the same location as their pre-velar tokens, meaning raising could be spreading to other environments.

Wassink and Riebold (2013) is a study of pre-velar raising in the Northwest, using data from PNWE Study I and II, with the goal of establishing *i*) whether or not the parallel raising of /æg, ɛg/ (BAG, BEG) is connected, *ii*) whether pre-velar raising is becoming increasingly uniform over time, *iii*) and whether pre-velar raising is phonetically motivated. They conclude that given the temporal and systemic relatedness of the changes, as well as their social relatedness (insofar as the majority of speakers who raise one class also raise the other), it is likely that they are indeed connected. Their results also suggest that speakers are becoming more uniform in their use of the variables over time, with raising possibly spreading to other (non-pre-velar) phonetic environments. Finally, they find that there is strong evidence for pre-velar raising being a phonetically-motivated phenomenon, as a phonologization of the velar pinch, and in connection with /ŋ/ (HANG), which is a hyper-raising environment in the Northwest.

Freeman (2014b) is a sociophonetic study of pre-velar raising in the Northwest, using data from 20 Caucasians (whose data are also included in this study), evenly split by gender and generation (young and middle-aged only) recorded for the PNWE Study. Freeman finds that Caucasians in the Northwest are merging /ɛg, eg/ (BEG, VAGUE), not simply by raising and fronting /ɛg/ (BEG), but also by lowering and backing /eg/ (VAGUE). Results also show that speakers are raising /æg/ (BAG), but that middle-aged speakers (the oldest in her sample) appear to be the most advanced in terms of /æg/-raising (BAG), a finding which has been confirmed by subsequent studies (Becker et al., 2015; Riebold, 2014a). She suggests that this may be due to a change in the social salience of the variants, or that they may simply be receding over time, although it is difficult to make a conclusive statement without further data, and this change in the rate of pre-velar raising may be indicative of something else entirely. Acoustic evidence from her study suggests that as /æg, ɛg/ (BAG, BEG) raise and front, they are also diphthongizing, further distinguishing them from their non-pre-velar counterparts. Interestingly however, Freeman finds that rather than lengthening, as might be expected for a vowel developing a glide, the pre-velar vowels are the same length or even slightly *shorter* than the non-pre-velar vowels, particularly /ɛg/ (BEG).

Riebold (2014a) is another sociophonetic study of pre-velar raising in the Northwest, this time drawing on the multi-ethnic PNWE Study II sample, and is a preliminary version of this study. The research questions addressed were do the non-White ethnicities in the PNWE Study II sample *i*) show evidence of pre-velar raising? *ii*) show evidence of merger? *iii*) appear to have similar front vowel systems. Riebold finds that the non-White ethnicities in the PNWE Study show very similar patterns to the Caucasian speakers in the study, with pre-velar raising across all social groupings, including a peak in the middle-aged speakers, and a spectral (if not temporal) merger of /ɛg, eg/ (BEG, VAGUE). The ethnic subsamples also show very similar patterns, albeit with some minor differences. Overall, Japanese Americans and Mexican Americans appear most similar to Caucasians, while African Americans and the Yakama Nation look less similar, possibly indicating differential integration with the Caucasian community.

Finally, Freeman (2015) is a perceptual study of pre-velar raising in the Northwest, using synthesized vowels-in-isolation stimuli and two experimental conditions: one where participants are lead to believe the vowels are from an /hVd/ context, and the other where they are lead to believe the vowels are pre-/g/. Results show that /ɛg/ (BEG) and /eg/ (VAGUE) are much more confusable in the pre-velar condition, suggesting that community differences in production have a measurable effect on perception. /æ/ (TRAP, BAG), on the other hand, exhibited some variation, in line with variation in production of the vowel, and expected for a change in progress.

Following the discussions of change in progress and the notions of change from above and below (§2.1.1), we may postulate *i*) that due to the significantly different rates of pre-velar raising found among the multi-generational sample studied by Freeman (2014b), Riebold (2014a) and Wassink (2015b), especially when compared with the rates reported by Reed (1965), pre-velar raising in the Northwest is a change in progress. *ii*) That due to the long reported history of pre-velar raising in the Northwest (Reed, 1965), the change is likely past the "new and vigorous" stage, which may result in less differentiation between generations (D'Arcy, in press). *iii*) That given the lack of a prestige variety featuring pre-velar raising, as well as the absence of widespread social evaluation of the phenomenon, pre-velar raising is a change from below. And finally *iv*) that based on the results of Wassink et al. (2009), pre-velar raising is a sociolinguistic marker, though likely one still operating below the level of consciousness. It is difficult to predict whether or not pre-velar raising will pattern according to SEC. African Americans, Caucasians, and Japanese Americans all have a large proportion of middle class members, with only Mexican Americans tending towards the working class. Previous sociolinguistic research in the region has been mixed with respect to the relevancy and effect of class (Conn, 2002; Ward, 2003). However, in the absence of strong evidence that social class is not a relevant category in the Northwest, it may be expected that the interior classes will show the greatest amount of pre-velar raising, as has been found to be the case for other sociolinguistic variables elsewhere in the US (Chambers, 2003; Labov, 2001).

2.4.2 Wisconsin

/æg/-raising (BAG) similar to that found in the Northwest has also been described as a feature of Wisconsin English. It is unlikely that immigration from Wisconsin had a large impact on the Northwest during its formative years (Wassink, submitted), however, it is still worth considering the similarities and differences between Wisconsin /æg/-raising (BAG) and Northwest pre-velar raising, especially since Wisconsin appears to be the only other region where /æg/-raising (BAG) has been thoroughly studied (excluding the rest of the Northern Cities area, where /æ/-raising (BAG) happens regardless of phonological environment and is different in character, see §2.2.1).

Benson, Fox, and Balkman (2011) is an investigation of the low vowels /æ, ɑ, ɔ/ (BAG, COT, CAUGHT) using data from interviews with 40 natives of Eau Claire, WI. Benson et al. find strong /æg/-raising (BAG), with /æg/ (BAG) being raised above /ɛ/ (DRESS) by nearly every speaker (24 out of 27). The majority of their speakers (21 out of 27) also raise

/æ/ (TRAP) in other phonetic environments (before /p, b, f, t, z, l, ʃ, k/) although not as dramatically, with only 6 of 24 speakers raising above /ɛ/ (DRESS). The results from the /æd/ (BAD) condition also showed some raising, but largely from the males, with females appearing to prefer raising in other contexts. They also note that /æ/-raising before /g/ (BAG) is relatively stable, occurring for all generations in the study, suggesting that it is not a change in progress, whereas /æ/-raising (TRAP) in other environments may be diminishing. They conclude that /æ/-raising (TRAP, BAG) is indeed present in areas where the low-back merger has occurred, contra Thomas (2001) and Labov et al. (2006), who suggest an association between /æ/-raising (TRAP) and maintenance of a distinction between the low back vowels, due to the low-back merger being connected with /æ/-*lowering* (TRAP) in their data. Finally, Benson and her colleagues (2011) challenge the ANAE's statement that Wisconsin /æ/-raising (TRAP) is part of the NCS, citing a lack of the subsequent changes associated with the NCS, such as /ɑ/-fronting (COT), and the absence of the NCS-like /æ/-raising (TRAP) where /æd/ (BAD) is more advanced that /æg/ (BAG). The lack of /ɛg/-raising (BEG) in Wisconsin, along with the reported raising of /æ/ (TRAP) in non-pre-velar contexts, suggest that the behavior of /æ/ (TRAP) in Wisconsin is quite different from that of /æ/ (TRAP) in the Northwest.

2.4.3 Other Regions

Although pre-velar raising similar to that found in the Northwest and Wisconsin has been reported in other areas of the West, such as Montana, and much of western Canada, unfortunately it remains unstudied. Given that these reports come from other linguists, we can safely assume that pre-velar raising is not unique to the Northwest and Wisconsin, but rather may be more widespread than we once imagined. In the absence of scholarly investigation, however, it is not possible to evaluate the similarity of the patterns shown in each region, or to venture a guess at the possible connections among the dialects.

2.5 Sources of Variability

This section summarizes the possible cause of pre-velar raising and lowering, discussing phonetic and lexical factors.

2.5.1 Coarticulation

One possible explanation for /æg, ɛg/-raising (BAG, BEG) is that it is a phonologization, or exaggeration of the coarticulatory effects of neighboring velars. The velar pinch, a coarticulatory effect named for the "pinching" of F2 and F3, with F2 rising, and F3 falling, is also associated with a drop in F1 (Stevens, 2000, 366–367), although the magnitude of this effect differs by vowel height.

If pre-velar raising is a purely articulatory process, we would predict /æg/ (BAG) to show the most dramatic raising, followed by /ɛg/ (BEG), with only slight raising of /eg/ (VAGUE). Interestingly, this is not the pattern we see in the data, rather, it appears that /ɛg/ (BEG) is raising and fronting the most, followed by /æg/ (BAG), and /eg/ (VAGUE) is actually lowering and backing.

Nonetheless, several researchers have proposed velar pinch/coarticulation as a mechanism for /æg/-raising (BAG) in the Upper Midwest (Baker et al., 2008; Bauer & Parker, 2008; Benson et al., 2011; Purnell, 2008; Zeller, 1997). Zeller (1997) is one of the earliest mentions of /æg/-raising (BAG) in Wisconsin, and situates it in a more general context alongside /æŋg, æŋk/-raising (ANGER, TANK). Zeller's study includes data from 10 speakers performing three tasks: 1) semantic differentials 2) a wordlist, and 3) a rhyming task. She also conducted surveys asking about rhyming /æ/-words (TRAP). Zeller finds strong raising of /æ/ (TRAP), and suggests that it is perhaps due to the fact that there are no minimal pairs which depend on /æ, e/ (TRAP, FACE) before voiced velar consonants, as well as the coarticulatory effects of following velars.

Bauer and Parker (2008) is an acoustic and articulatory study of /æg/-raising (BAG) in Wisconsin, finding that it is, in fact, raised. In contrast with other researchers (cf. Zeller,

1997) however, they maintain that it does not raise far enough to merge with /ɛ/ (DRESS) or /e/ (FACE). They argue that raising is caused by coarticulatory effects (i.e. the velar pinch), and note that because raised tokens of /æg/ (BAG) approach /eg/ (VAGUE), speakers seem to have reanalyzed /eg/ (VAGUE) words as being underlyingly /æg/ (BAG).

Purnell (2008) is an articulatory study of /æg/-raising (BAG), which found that canonical /æ/ (TRAP) is gesturally distinct from raised-/æg/ (BAG) in that it involves a greater degree of anterior stricture, in addition to lip-repositioning.

More recent studies of Wisconsin English have attempted to quantify the degree of coarticulation seen in speakers with pre-velar raising, vs. those without. Fox (2013) examines VC coarticulation in Wisconsin and North Carolina using locus equations. Locus equations are regression lines fitted between onset and midpoint F2, which can be used to indicate the degree of coarticulation (Krull, 1987; Sussman, Hoemeke, & Ahmed, 1993). Fox finds that while there is no difference between WI and NC speakers in the coarticulation effects of a following /t/ or /d/, there is a reliable difference between the degree of coarticulation for /k/ and /g/ for Wisconsin speakers, but not North Carolina speakers. This suggests that speakers with pre-velar raising also show more coarticulation than speakers from other dialect regions.

Given the preponderance of evidence for /æg/-raising (BAG) being a coarticulatory effect, it seems reasonable to posit the same articulatory motivation for /æg, ɛg/-raising (BAG, BEG) in the Northwest, though precise gestural details may differ from those found by Purnell (2008). /eg/-lowering (VAGUE), on the other hand, is harder to motivate as a purely coarticulatory effect, and may have more to do with characteristics of the word class itself than the phonetic environment.

2.5.2 The /eg/ Word Class

There are several reasons to believe that the class of /eg/-words (VAGUE) is unusual, and indeed much of the research into pre-velar raising in Wisconsin has identified this as well (cf. Baker et al., 2008; Zeller, 1997). /eg/-words (VAGUE) themselves are very rare in the

English lexicon, with only seven (excluding names and places) being reasonably common: "bagel", "vague", "plague", "pagan", "flagrant", "vagrant", "fragrant". Additionally, these words appear to be somewhat unstable anecdotally, with some speakers reportedly having [ɛg] or even [æg] natively (e.g. [plɛg]), as suggested by Baker et al. (2008).

/eg/-words (VAGUE) are also unusual within the English front vowel system, in that there are almost no system-internal minimal pairs. Indeed there is only one true minimal pair: "beagle"/"bagel", which contrasts /ig, eg/, and one near-minimal pair "big 'ol"/"bagel", contrasting /ɪg, eg/. As for /æg, ɛg/ (BAG, BEG), there are no minimal pairs whatsoever distinguishing either of them from /eg/ (VAGUE).

It is not hard to imagine, then, that the lack of a functional opposition between /æg, ɛg/ (BAG, BEG) and /eg/ (VAGUE) is responsible for the observed tendencies to merge (Labov, 1994). In fact, a merger would create no homophones whatsoever (although there are also no homographs). On the other hand, there are many minimal pairs for /æg/~/ɛg/ (e.g. "bag"/"beg", "lag"/"leg", "mag"/"meg"), so despite some spectral overlap in this region, it might be theoretically more sound to propose that /æg/ → /ɛg/ represents only a halfway point of sorts towards a higher terminus.

Naturally, however, it need not be the case that pre-velar raising in the Northwest is due to one factor alone. The rarity of /eg/-words (VAGUE) and the concomitantly low functional load of the pairs could act in concert with the aforementioned articulatory factor to condition raising. In a sense then, low functional load opens the door for the phonologization of the velar pinch, which acts to raise the vowels involved.

2.6 Research Questions & Hypotheses

From the findings in the literature and the discussion above, we arrive at the following research questions.

$\mathbf{RQ_{1a}}$: What is the general shape and configuration of the Northwest English vowel space?

RQ_{1b}: Are there socially-conditioned differences in the configuration of the Northwest English vowel space?

- **H_1:** There will be an effect of gender on the configuration of the vowel space.
- **H_2:** There will be an effect of generation on the configuration of the vowel space.
- **H_3:** There will be an effect of ethnicity on the configuration of the vowel space.

RQ_{2a}: To what extent, if any, do speakers participate in /æg, ɛg/-raising (BAG, BEG) and /eg/-lowering (VAGUE)?

RQ_{2b}: To what extent, if any, do speakers merge /æg, ɛg, eg/ (BAG, BEG, VAGUE)?

RQ_{2c}: Are there socially-conditioned differences in the raising of /æg, ɛg/ (BAG, BEG) and lowering of /eg/ (VAGUE), or the merger of /æg, ɛg, eg/ (BAG, BEG, VAGUE)?

- **H_1:** There will be an effect of gender on the /æg, ɛg, eg/ (BAG, BEG, VAGUE) word classes.
- **H_2:** There will be an effect of generation on the /æg, ɛg, eg/ (BAG, BEG, VAGUE) word classes.
- **H_3:** There will be an effect of ethnicity on the /æg, ɛg, eg/ (BAG, BEG, VAGUE) word classes.

"Raised" is defined as tokens that are either substantially raised/fronted with respect to non-pre-velar tokens on a vowel plot, or which have overlap fractions indicating partial/full merger. "Merged" is used when two vowels are found to have an overlap fraction falling within the "complete overlap" classification (see §3.5.4 for details). Given the multi-ethnic nature of the sample, it is worth exploring whether or not there are differences in how each ethnicity treats /æg, ɛg, eg/ (BAG, BEG, VAGUE).

Chapter 3
METHODS

This chapter enumerates the methods employed in this study, together with a description of the data being analyzed. It begins with an overview of the respondents and the materials used in the interviews, and proceeds to a listing of the analytical techniques (sociolinguistic, phonetic, and statistical) employed in the study.

3.1 Speakers

This study uses data from both PNWE Study I and II recordings, comprising 71 speakers and five ethnicities, spread across three major regions (Seattle area, Yakima Valley, Spokane area).

Participants were recruited using advertisements (flyers, craigslist), word-of-mouth, and "snowballing" techniques, which in this case included both requests that respondents bring a friend, and contacts made through existing respondents. Because this study focuses on English in the Northwest and the spread of linguistic change among various ethnicities, interviews were conducted exclusively in English with all respondents being native English speakers themselves. Participants were not screened for bi- or multilingualism, although this was a topic of discussion during the interview portion. The Japanese American, Mexican American, and the Yakama Nation communities each have a heritage language still spoken by some members, and although rates of self-reported bilingualism are fairly low in our sample, transfer effects from the heritage language to English are a possibility.

All but one speaker in the Mexican American subsample report some use of Spanish growing up, however only 4 self-identified as bilingual, and reported using Spanish frequently in their daily life. By contrast, all speakers in the Yakama Nation subsample reported some use of Yakama Sahaptin growing up (primarily community events and religious rituals), but only two reported frequent use of the language in daily life. Speakers in the Japanese American subsample also reported some use of Japanese in the home during childhood, however no speakers identified as bilingual in English and Japanese, with most speakers having learned Japanese formally rather than in the home. Because multilingualism was not controlled or balanced for in this study, and because assessing competence in another language is a difficult and multi-faceted task, possible language transfer effects will not be considered in the analysis.

Table 3.1 is a breakdown of the speakers by ethnicity, gender, and age, and table 3.2 explains the generation numbering scheme[1].

Table 3.1: Speakers by region, ethnicity, gender, and age

	Region			**Gender**		**Generation**			
	West	**Central**	**East**	**F**	**M**	**1**	**2**	**3**	**Total**
African American	5	0	1	5	1	3	0	3	6
Caucasian	20	0	11	18	13	4	13	14	31
Japanese American	10	0	5	9	6	5	7	3	15
Mexican American	0	9	2	9	2	0	3	8	11
Yakama Nation	0	8	0	4	4	0	5	3	8
Total	35	17	19	45	26	12	28	31	71

As should be clear from the table, the sample is not perfectly balanced. Only Mexican Americans and the Yakama have representation in central Washington, and the sample is skewed towards middle-aged and younger speakers, with Mexican Americans and the Yakama Nation having no generation 1 speakers. There's also a general skew towards females, who comprise 63% of the sample.

[1]One speaker was excluded from the sample, a generation 2 Yakama male, due to insurmountable issues with recording quality. He is not included in this table.

Table 3.2: Generations

Generation	**Ages**
1	≥ 62
2	37–61
3	18–36

Respondents in the PNWE study were also asked to self-report their SEC (both at the time of the interview and at birth) and occupation, with possible choices being working, lower-middle, middle, upper-middle, and upper. Table 3.3 shows self-reported SEC (at the time of interview) by ethnicity (excluding two speakers who did not report SEC).

Table 3.3: Speakers by socioeconomic class

Ethnicity	**Working**	**Lower-middle**	**Middle**	**Upper-middle**	**Upper**
African American	3	0	3	0	0
Caucasian	4	4	22	1	0
Japanese American	1	1	9	2	0
Mexican American	3	0	7	1	0
Yakama Nation	3	1	4	0	0
Total	14	6	45	4	0

These numbers match up well with data on the respondents' occupations, and show most respondents belonging to the middle class (65%), with the remaining 35% being working class, lower middle class, and upper middle class, respectively. By ethnicity, African Americans are evenly split between working and middle, Caucasians and Japanese Americans are nearly all in the middle classes, Mexican Americans are mostly in the middle classes, and members of the Yakama Nation are split between working and the (lower) middle classes, with 37.5% and 62.5%, respectively. No respondent reported being upper class. Distributions of SEC among the speakers in this sample are mostly consistent with general patterns in the region, however a higher proportion of Mexican Americans reported middle class status, and a somewhat lower proportion of Yakama Nation members did, which may be a side effect of the snowball sampling methods employed by the study's fieldworkers.

Figure 3.1 is a heat map of respondents by county, with major cities marked.

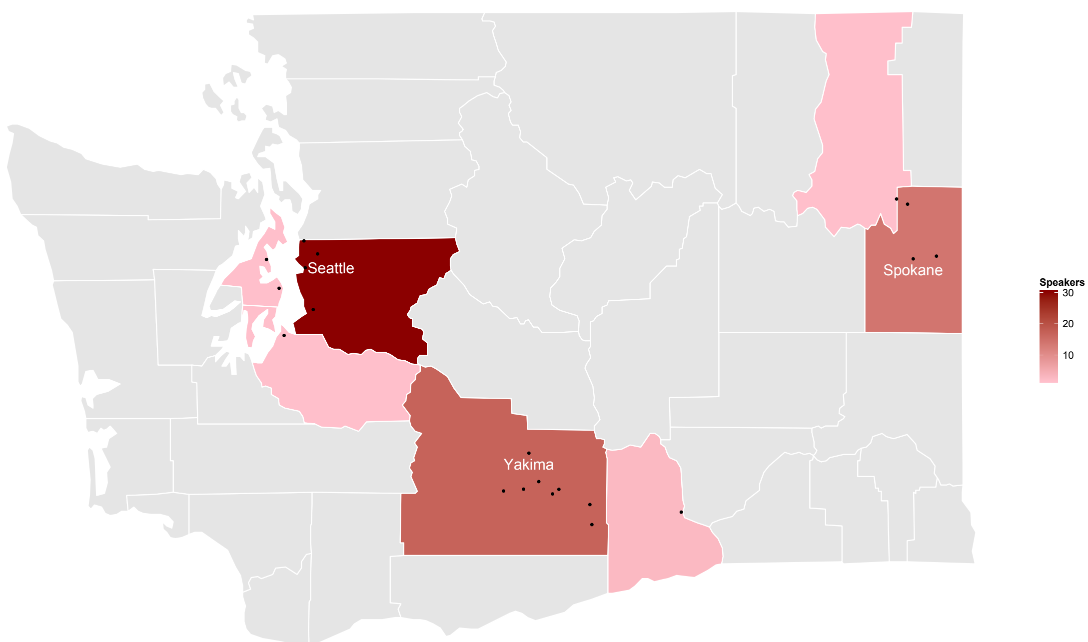


Figure 3.1: Respondents by Washington State county, with major cities labeled. Color indicates number of respondents, points mark locations with respondents.

3.2 Recordings

Interviews were conducted either in the field (typically in respondents' homes or a public place of their choosing), or at the University of Washington in the Sociolinguistics Laboratory or the Phonetics Laboratory. Interviews were carried out using sociophonetic techniques, which involve collecting data with the intent for both acoustic and sociolinguistic analysis. The recordings were made in mono at 44.1 kHz/16-bit using Zoom H4n flash recorders, and were encoded as uncompressed .wav files for analysis. During the recordings every attempt was made to minimize external, non-linguistic noise in hopes of obtaining the highest quality recordings possible, although of course being field recordings, the conditions were not always perfect, and ultimately resulted in the exclusion of a handful of tokens and one speaker's entire recording over the course of data analysis.

3.3 Materials

Participants in the study were recorded performing five tasks: 1) a short conversation (dyadic when possible, covering general topics such as family history, the area, etc.) 2) a demographic survey (covering personal history, social networks, etc.) 3) a lexical task (designed to elicit known US English dialect variables and sites of linguistic change, along with semantic differentials and syntactic variables) 4) a short reading passage (containing a number of keywords), and 5) a wordlist (consisting of three repetitions of a list of words targeting the vowels of General North American English, as well as dialect variables and changes in progress, all embedded within a carrier phrase so as to elicit tokens in a phonetically neutral context). Of particular interest to this study is the demographic survey and the wordlist.

The demographic survey (see appendix A) comprises the primary source of information about the subjects, and has two main sections: "personal background and linguistic repertoire", 9 questions covering personal and family history, and social network, 20 questions covering personal activities (e.g. "Do you participate in any local social activities?"), family activities (e.g. "Is your mother's family local?"), working relations (e.g. "Are any of your coworkers from the area?"), and voluntary association (e.g. "Are you involved in any social activities in this area?").

As a result of the pre-velar raising research done using PNWE Study I data (Wassink et al., 2009) and the limitations thereof, the wordlist, reading passage, and lexical task were expanded to include more pre-velar tokens at the beginning of PNWE Study II in 2012, allowing for a better comparison between classes (see appendix B). The wordlist was revised again in 2013 based on feedback from the early PNWE Study II interviews, removing a couple problematic tokens and again adding more pre-velar forms (see appendix C).

This paper analyzes tokens of /æ, ɛ, e[2]/ in pre-velar (BAG, BEG, VAGUE) and pre-voiced consonant position (e.g. "bad", "bed", "bade"), as well as several point vowels, from the wordlist data only. The wordlist includes both monosyllabic words, such as "bag", and multisyllabic words such as "leggings". It is important to note here that tautosyllabicity does not appear to be necessary to trigger raising/lowering (Freeman, 2014b; Riebold, 2014a), and thus these words will be analyzed together with monosyllabic forms.

The choice to use only wordlist data was motivated by several concerns. First, the casual tasks such as the conversation and demographic task, on average, contain very few tokens of interest to this study (especially in the case of the /eg/ (VAGUE) class). The implication is that we would almost certainly have a number of speakers with no pre-velar tokens whatsoever, and it is further unlikely that those speakers who did produce pre-velar tokens would have produced the same set. The decision to exclude the reading passage as well was motivated by a lack of comparability between wordlist and reading passage tokens in terms of length. Being produced in context, reading passage tokens varied in length as a function of their syntactic role, and the fact that some speakers gave dramatic readings of the passage further exaggerated this effect. In addition, the reading passage contained relatively few tokens, and thus the exclusion of this data is not detrimental to the study.

Tables 3.4 and 3.5 are breakdowns of the total possible tokens per speaker by word class for each version of the wordlist.

In addition to the pre-velar and non-pre-velar front vowels, the point vowels /i, ɪ, ɑ, ɔ, ʊ, u/ were measured in /(h)Vd/ contexts (i.e. "awed", "heed", "hid", "hode", "odd", "awed", "hood", "who'd", three repetitions each). This allows for a better view of the vowel

---

[2]Being a borrowing of sorts, "bagel" is somewhat controversial as an inclusion in the wordlist. Although it may be more variable in some dialect regions, statistical testing showed that tokens of "bagel" were not reliably different from other /eg/ words in F1 or F2, and therefore we have neither removed the tokens nor held them apart.

Table 3.4: Possible tokens per speaker by word class (2012)

Word class	**Words**	**Types**	**Tokens**
/eg/	bagel, pagan, plague, vague	4	12
/e/	aid, babe, bade, bathe, beige, Kay, say, day	8	24
/ɛg/	beg, egg, leg, leggings, negative, peg, regular	7	21
/ɛ/	bed, dead, head, measure	4	12
/æg/	bag, brag, crag, lag, nag, pragmatic	6	18
/æ/	babble, bad, dad, had	4	12
point vowels	awed, heed, hid, hode, hood, odd, who'd	7	21
Total		40	120

Table 3.5: Possible tokens per speaker by word class (2013)

Word class	**Words**	**Types**	**Tokens**
/eg/	bagel, pagan, plague, vague	4	12
/e/	babe, bathe, beige, Kay, say, day	6	18
/ɛg/	beg, egg, leg, leggings, negative, peg, regular	7	21
/ɛ/	bed, dead, head, measure	4	12
/æg/	bag, magnet, nag, lag, brag, drag, dragon, dragging	8	24
/æ/	babble, bad, dad, had, mad	5	15
point vowels	awed, heed, hid, hode, hood, odd, who'd	7	21
Total		41	123

space itself, and also enables the use of more sophisticated normalization techniques.

Although the speakers interviewed for PNWE I read a different wordlist (which, as has already been mentioned, included far fewer tokens of interest), all of the PNWE I speakers included in this study were reinterviewed in 2013, at which point they were asked to read an abbreviated version of the 2013 wordlist containing the items not present in the original. Thus, for the purposes of this study, they can be considered to have read the 2013 wordlist.

By arranging the tasks from least to most formal, data from the PNWE Study will be more readily comparable to data from "traditional" sociolinguistic interviews, as well as to the Labovian five-part survey (Labov, 1984). Beyond collecting a large amount of data, it is important that the results of this study and others that come out of the PNWE Study be comparable with the dialect research that has been done across the US, so that Northwest English can be better situated within the landscape of North American English.

3.4 Sociolinguistic Analysis

The primary focus of this study is on the use of and variation in pre-velar raising/lowering in various ethnicities across the state, but ethnicity is not the only sociolinguistic variable to be taken into account. Because gender and age have been shown to have significant effects on linguistic change (see §2.1.2 and §2.1.3), the results will be partitioned in this way so as not to obscure any potentially relevant patterns in the data. Collapsing across gender and generation could not only render opaque some of these patterns, it could also make it harder to identify any overall ethnicity-specific tendencies. Looking at gender and age may also provide important evidence of the status of pre-velar raising in the community.

In addition to age, gender, and ethnicity, however, a number of other measures were employed for use with inferential statistical testing.

3.4.1 Regionality

The following is an abbreviated and modified version of Chambers (2000)'s Regionality Index, designed for use in this study, and to distinguish between levels of indigeneity, encoding both the speaker and the speaker's parents' indigeneity status. Our Regionality score excludes the levels for speakers not born and raised outside the Northwest, and adds further granularity with the addition/alteration of levels R3.5 and R4.

R1: raised locally, indigenous parents

R1.5: raised locally, 1 indigenous parent

R2: raised locally, interloper parents

R3: partly raised outside the NW during the critical period, indigenous parents

R3.5: partly raised outside the NW during the critical period, 1 indigenous parent

R4: partly raised outside the NW during the critical period, interloper parents

All six levels of Regionality are accounted for in our sample.

3.4.2 Network Strength Score

Network Strength Score (NSS) is another composite measure, based on the ethnographic approach followed by L. Milroy (2008) and Lippi-Green (1989), and is intended to reflect integration into networks that are geographically-based in Washington State, as well as to uncover connections in key network subsectors to speakers of other dialect areas. The PNWE Study's implementation of NSS, ranging from 0 (weak ties) to 17 (strong ties), can be considered intermediate between these two studies in its focus on local loyalty (Lippi-Green, 1989) as well as network density and multiplexity (L. Milroy, 2008). Like L. Milroy (2008) network strength score, NSS was designed to be assessed rapidly, while still being explanatorily powerful. NSS was calculated from respondents' answers to 18 questions in the "social network" section of the demographic survey (see appendix A, which were broadly separated into three categories: family (questions 1–9), working relations (questions 10–15), and voluntary association (questions 16–18).

In contrast to regionality, NSS is intended to gauge the strength of speakers' ties to the area by assessing participating in local activities, association with other indigenes, and other factors. If this measure is working as intended, less locally-centered individuals should in general have a lower score, whereas those very involved in local life who have many local friends should score higher. L. Milroy (2008) found that speakers with high NSS used more vernacular forms more frequently than those with low scores. We are well prepared to ask this question, as our respondents' NSS varied from a low of 4 to a high of 16, with an average score of 9.03, and a median of 9 (see appendix M for individual scores[3]).

3.4.3 Network Bias

In order to understand the potential influence of network strength score on the speech of our respondents, it is necessary to have some idea of the composition of their social network itself. Part of the data collected in the demographic task includes a list of the ten people respondents interact with most frequently, including their gender and ethnicity.

In order to make use of this information, every speaker's network was tabulated, then broken down into the proportion of same-ethnicity friends, and the proportion of Caucasian friends. These two numbers were then used to create a Network Bias score (Kirke, 2005) ranging from -1 to 1, by subtracting the former from the latter, with negative scores indicating more contact with people of the same ethnicity, and positive scores indicating more contact with Caucasians. This allows us to quantify the degree of insularity or integration of a respondent's social network (Bortoni-Ricardo, 1987), and may prove instrumental in explaining the patterns in the data. Because pre-velar raising can be reasonably assumed to be a Caucasian-lead change (given the demographics of Washington State), the proportion of Caucasian contacts (vs. other ethnicities) may be of special significance.

3.5 Acoustic Analysis

Phonetic transcription of the data from the formal tasks was accomplished pseudo-automatically using the Penn Phonetics Lab Forced Aligner, while extraction of measures was done automatically using a Praat script. The data were normalized and plotted in traditional F1 x F2 vowel plots using phonR, and analyzed using three statistical methods: VOIS3D, which calculates degree of spectrotemporal overlap using F1, F2, and duration; SS-ANOVA, which uses multiple measurement intervals to extrapolate vowel trajectories; and multiple linear

[3]One speaker does not have an NSS, due to his interview being cut short.

regression.

3.5.1 Phonetic Transcription

The Penn Phonetics Lab Forced Aligner (P2FA) (Yuan & Liberman, 2008) is a Python script which performs forced alignments leveraging the Hidden Markov Model Toolkit (HTK; used for speech recognition, speech synthesis, and other purposes) and a language model trained on the SCOTUS corpus. P2FA takes a .wav file and corresponding .txt file transcript and generates a time-aligned Praat TextGrid at the word and phone level for all the words in the transcript, by retrieving phonetic transcriptions of each word from CMUDict (a large Arpabet-based pronouncing dictionary), then using the Viterbi algorithm to find the best match between the acoustic signal and its expectations of the words in the transcript. Provided the recording is of sufficient quality and the transcript is verbatim, P2FA can be used to shave potentially hundreds of hours off of analysis time for large-scale studies, depending on the accuracy needed in the analysis.

Useful as P2FA is however, it is not without its shortcomings. If transcripts aren't verbatim, P2FA can end up mis-aligning entire sections of the recording (having only a coarse set of criteria for distinguishing vowels/consonants), and can very easily be thrown off-track by extraneous non-linguistic noise. Additionally, although P2FA does align to the phone-level, it is not accurate enough to be used for precise automatic measurement (e.g. of formants, pitch, duration, etc.) without significant hand-correction of the TextGrid intervals used for those measurements. This means that it still requires some time and effort from a trained phonetician in order to generate high-quality annotations and to prepare them for use with other tools, such as Praat scripts.

The recordings analyzed in this paper were all forced aligned using P2FA. The procedure involved listening through the recordings, creating orthographic transcriptions of the speech, and when necessary, manipulating the recordings themselves in order to remove non-linguistic noise or other undesirable elements such as false starts, interviewers' speech, etc., by either setting relevant portions of the waveform to silence, or by filtering out extraneous frequencies. Following this, P2FA was run on the soundfiles/transcripts, and the resulting TextGrids were checked to ensure there were no significant errors in the alignment. In the event that serious or numerous errors were found, the transcript and/or recording was edited, and P2FA was run again until a satisfactory alignment could be obtained. Before automatic measurement, the TextGrid boundaries of all tokens of interest were corrected by hand. Vowels were assumed to begin upon release of the preceding consonant, and to end with a drop in pitch and amplitude, as well as a cessation of voicing.

3.5.2 Vowel Analysis

Acoustic analysis of all tokens was performed in Praat (Boersma & Weenink, 2015), using clean, unaltered copies of the recordings. After forced alignment of the data, each recording was examined individually to establish the optimal settings for maximum formant frequency and number of formant coefficients. Following this, a Praat script was used to locate the vowels in tokens of interest and automatically extract duration, F0, F1, F2, and F3 values at 20% of the duration of the vowel (onset), 50% (midpoint), and 80% (offset), along with preceding and following phonological contexts, and a set of metadata about the measurement (e.g. analyst, date, number of formants, maximum formant frequency) to assist with data-validation and replicability.

The resulting measures were then checked in order to ensure that no formant measurement errors (e.g. doubling/halving, interference, etc.) were present, and were corrected if necessary. This was done in stages, first by using a function in Microsoft Excel to look for larger-than-normal changes in frequency (conservatively set to 100 Hz for F1, 200 Hz for F2, and 300 Hz for F3) for each formant over the time points recorded. Approximately 3800 tokens showed potentially problematic changes in formant frequency, and after reviewing these, 600 were marked for remeasurement. The recording for each of these tokens was inspected to determine whether reanalysis was necessary. Following this, individual speaker plots were generated and examined for potential outliers, and 270 outliers were examined and corrected when necessary. Those outliers that weren't the result of a measurement error were tagged and excluded from further analysis.

3.5.3 Visualizing the Vowel Space

In order to address the research questions and get a more general sense for respondents' vowel spaces, the resulting tokens were normalized and plotted using the phonR package (McCloy, 2015) in R (R Core Team, 2015).

Normalization allows for a better comparison among different groups (i.e. genders, ethnicities) and was done using the Nearey2 method (Nearey, 1978). Nearey2 is speaker-intrinsic and vowel- and formant-extrinsic, calculated from the grand mean of the vowel space (necessitating the inclusion of point vowels), and yields easily interpretable plots, albeit at a different scale (distance from the grand mean: 0,0). Normalization was done using all three time points in the data for F1–3.

Traditional F1 x F2 vowel plots were also generated in phonR, with both normalized and raw values, by various social variables. Although this study also includes other methods of vowel analysis (see §3.5.4, 3.5.5, 3.5.6, 3.5.7, and 3.6.1), traditional vowel plots are still an effective way of getting a broader view of the movements in the vowel space, and can help interpret the results from other methods (i.e. *where* the vowels are merging, not just to what extent).

3.5.4 Vowel Overlap

Vowel Overlap Indication Software in 3D (VOIS3D) is a program designed to assist in the measurement of spectral overlap which improves on traditional techniques which use auditory transcription or impressionistic analysis (cf. Labov's LCV study, Labov, 1994), or more recently, 2D F1 x F2 plots (Wassink, 2006). VOIS3D's process, referred to as the 'Spectral Overlap Assessment Metric', takes normalized formant and duration values and plots vowels as 3D volumetric ellipsoids (F1 x F2 x duration) and calculates overlap quotients for each pairing. These overlap fractions (OF) represent the portion of the smaller distribution which is contained within the larger one, ranging from 0–1. Wassink (2006) calls 0.0–0.2 separation (i.e. full spectral and temporal separation), 0.21–0.74 partial overlap, and 0.75–1.0 complete spectral overlap (i.e. total overlap in all dimensions). This study makes use of the same definitions.

Because VOIS3D uses duration in its calculations of 3D spectral overlap, extra precautions must be taken to ensure that stress is properly controlled for, so as not to skew the results. Contrastive stress, for example, has the effect of lengthening the vowel it is applied to (Ladefoged & Johnson, 2014) and can even induce hyperarticulation (Labov, 1966), meaning that any words which bear contrastive stress might make it appear as if two segments are less overlapping than they actually are otherwise, both spectrally and temporally. In order to control for these effects, only data for vowels bearing primary stress was used for VOIS3D calculations.

Research into pre-velar raising has yet to firmly establish general tendencies, all logical pairings were tested (i.e. /æg/ (BAG) vs. /ɛg/ (BEG), /æg/ (BAG) vs. /eg/ (VAGUE), /æg/ (BAG) vs. /e/ (FACE), /ɛg/ (BEG) vs. /eg/ (VAGUE), /ɛg/ (BEG) vs. /e/ (FACE), /eg/ (VAGUE) vs. /e/ (FACE)).

3.5.5 Vowel Duration

To assess the contribution of vowel duration to either the maintenance of separation or merger, duration was measured for all tokens. In order to compare across speakers and word classes, durations were normalized by converting them to ‘z-scores’, that is, the number of standard deviations a token is away from the overall mean. This abstracts away from the raw duration itself, and facilitates the overall analysis of patterns and relationships in duration. It also allows for the comparison of vowel duration across speakers, who cannot be expected to have the same raw durations as any other speaker, but who may be expected to share an overall pattern (e.g. the duration of word X and is always less than that of word Y).

3.5.6 Approximation

In order to quantify the overall amount of pre-velar raising and lowering, it was necessary to devise a composite measure that could be applied to individual speakers. Because it is not possible to simply count the occurrences/non-occurrences of raising/lowering, and because it is not clear what the target of /æg/-raising (BAG) is, and how the /eg/-lowering (VAGUE) plays into pre-velar raising, a number of different possible combinations were explored, namely the use of the overlap fractions for /æg/ (BAG) vs. /ɛg/ (BEG) or /æg/ (BAG) vs. /eg/ (VAGUE), and the inclusion/non-inclusion of /eg/-lowering (VAGUE) OF (/eg/ vs. /e/) (VAGUE, FACE). All formulae represent the arithmetic mean of the overlap fractions included in them, and thus range from 0–1. The four possible formulae were:

1: $\frac{/\text{æ}g,\varepsilon g/OF+/\varepsilon g,eg/OF}{2}$

2: $\frac{/\text{æ}g,eg/OF+/\varepsilon g,eg/OF}{2}$

3: $\frac{/\text{æ}g,\varepsilon g/OF+/\varepsilon g,eg/OF+(1-/eg,e/OF)}{3}$

4: $\frac{/\text{æ}g,eg/OF+/\varepsilon g,eg/OF+(1-/eg,e/OF)}{3}$

Equations 1 and 3 use /æg/ (BAG) vs. /ɛg/ (BEG) OF, whereas 2 and 4 use /æg/ (BAG) vs. /eg/ (VAGUE) OF, and 3 and 4 additionally include the inverse of /eg/ (VAGUE) vs. /e/ (FACE) OF (representing proportion of *non*-overlap of /eg, e/, VAGUE, FACE).

Because /eg/-lowering (VAGUE) appears to be a crucial piece of this change (Freeman, 2014b), and because /æg/ (BAG) does not appear to raise as high as /ɛg/ (BEG) (meaning the use of the /æg, eg/, BAG, VAGUE, pairing could favor only extremely advanced speakers), formula 3 will be used as the principle means of comparing speakers statistically.

For formula 3, a 0 represents total separation between /æg, ɛg/ (BAG, BEG) and /ɛg, eg/ (BEG, VAGUE), and total spectrotemporal overlap between /eg, e/ (VAGUE, FACE). A score of 1, on the other hand, represents total spectrotemporal overlap between /æg, ɛg/

(BAG, BEG) and /ɛg, eg/ (BEG, VAGUE), and total separation between /eg, e/ (VAGUE, FACE; see appendix D for an example calculation). Approximation scores ranged from 0.241–0.818, meaning all speakers had at least some overlap and /eg/-lowering, though none reached the ceiling.

3.5.7 Vowel-Inherent Spectral Change

Vowel-inherent spectral change (VISC) refers to the variance in formant frequencies that is a property of the vowels themselves, even in monophthongs and in the absence of flanking consonants (Nearey & Assmann, 1986).

Previous research on pre-velar raising in the Northwest found that raised tokens of /æg, ɛg/ (BAG, BEG) were also diphthongal (Freeman, 2014b; Riebold, 2014a). In order to assess this quantitatively, I will make use of a measure I refer to as 'Displacement'. Displacement is the change in mean F1 and F2 (in Nearey2 normalized units) from onset to offset for a given speaker and word class — essentially a measure of how monophthongal or diphthongal a vowel is — and is calculated with the following formula:

$$\text{Displacement} = |\overline{F1_{\text{onset}}} - \overline{F1_{\text{offset}}}| + |\overline{F2_{\text{onset}}} - \overline{F2_{\text{offset}}}|$$

Displacement can be thought of as the sum of the change in F1 and F2 methods described by Nearey and Assmann (1986). Lower displacement values indicate less movement in F1/F2, and therefore a more monophthongal vowel, whereas higher values indicate a more diphthongal vowel (see appendix D for an example calculation). In my data, Displacement ranged from 0.017–0.547.

3.6 Statistical Analysis

3.6.1 Modeling Vowel Trajectories

Another approach to vowel analysis is to model the vowel trajectory itself. Smoothing spline analysis of variance (SS-ANOVA) is a means of interpolating between formant values from discrete measurement points (Gu, 2002) by computing and plotting a best-fit line segment-wise through multiple points of measurement — in this case, normalized vowel formant measures at onset, midpoint, and offset. By modeling trajectories as curves, SS-ANOVAs allow for a more naturalistic view of vowel trajectory when compared to traditional methods, which simply plot a straight line from onset or midpoint to offset.

Because SS-ANOVAs require all three time points for the calculations, aspirated tokens (3 words for 9 tokens per speaker) were excluded, as the 20% interval (onset) frequently contained only frication noise and was therefore not suitable for analysis.

Calculation of the SS-ANOVAs was done in R (R Core Team, 2015) using the gss package (Gu, 2014). Plotting of the resulting data was accomplished using the ggplot2 package (Wickham, 2009), also in R. Vowel trajectories were plotted with 95% confidence intervals (CIs). Note that in these plots, axes were not normalized across speakers/groups. This was done deliberately, as the focus here is not on the location of the vowels in absolute space, but on the trajectories themselves and their locations relative to one another. See appendix E for the code used.

3.6.2 Inferential Tests

When attempting to identify quantitative patterns in a dataset, it is not enough to simply look at the data and declare that there is or is not a pattern. Rather, these assertions must be subjected to inferential statistical testing (when possible). This acts not only as a safeguard against the well-known human tendency to see patterns where there are none (Shermer, 2011), but may also uncover subtle patterns that are near-invisible to the naked eye. The notion of 'statistical significance' – conventionally defined as a less than 5% chance that the observations could have been caused by purely random variation – is a further check against subjective analyses and suppositions. The number of measures employed in this study, along with the potential complexity of the patterns involved, to say nothing of the size of the dataset and speaker sample, necessitate the use of inferential statistics.

In order to test the effects of the various predictors in the data, linear regressions were performed using R (R Core Team, 2015). Linear regressions were used to test both the significance and the magnitude of effects, using several different measures as dependent variables: Approximation, Duration, and Displacement.

3.7 Limitations

Although the sample is generally well-balanced for ethnicity, this is not the case for generation, as some ethnicities have no generation 1 speakers, or region, as the ethnicities are unevenly spread across the three regions covered by the study. The implications of this are that we do not have a truly complete picture of the speech community, and are less able to draw definitive conclusions about older speakers for some ethnicities, and for region in general.

The use of snowballing techniques, which were responsible for a significant number of contacts (vs. flyers and advertisements) means that our sample is likely disproportionately weighted towards certain social networks. In addition to this, the nature of academic fieldwork means that only certain types of people were able to be interviewed. The Yakama Nation in particular were somewhat difficult to engage with, as they are naturally skeptical of (White) researchers, having been exploited and misrepresented by them in the past. They also have a complicated relationship with English, which, even though it is nearly all Yakama Nation members' native language, is nonetheless viewed as a second language by some.

As with all sociolinguistic interviews, the observer's paradox is a factor here as well. All interviews were conducted by a small group of researchers, none of whom were members of the non-White communities interviewed for the study. This means that we may generally expect more standard speech from our respondents, particularly the non-Whites.

Furthermore, the choice to use only wordlist data in the analysis means that we are by definition only getting more formal speech. But, given that Wassink et al. (2009) found more raising in the more casual interview tasks, if the respondents in this study do show consistent pre-velar raising, we can be reasonably certain that it is part of their linguistic system.

Finally, three of the five ethnicities in the study (Japanese Americans, Mexican Americans, and the Yakama Nation) have a heritage language that is still spoken by some members of the community (see §2.3.1 for more details). There was some discussion of bilingualism in the interviews, and all respondents were asked what other languages they spoke, but bilingual ability was not controlled for, so transfer from another language remains a possibility (although in light of Hoffman & Walker, 2010, we believe this unlikely). On a related note, we also have not examined these speakers' use of any ethnolectal features, and cannot make any claims about the presence or absence of such features.

Chapter 4

RESULTS: VOWEL SPACE

In order to address this study's first set of research questions, 1a and 1b, regarding the general shape of the Northwest English vowel space and whether there are socially-conditioned differences within it, this section presents results using traditional F1 x F2 vowel plots (collapsing across phonetic environments, but excluding the pre-/g/ environment for the Northwest data so as not to misrepresent the front vowel space), represented as polygons with lines drawn between vowels. Because these plots collapse phonetic environments, the focus is on the overall shape of the vowel space and gross differences between dialect regions, abstracting away from segmentally-conditioned patterns (e.g. the PIN–PEN merger, phonolexical splits, pre-velar raising, etc.). An unfortunate side effect of this is that where there exist substantial, but conditioned, phonological differences, some dialect areas may appear more similar than they actually are. I will attempt to point out such superficial similarities where relevant.

First, the Caucasian subsample of the PNWE Study will be compared with representative data from other dialect areas drawn from the dialectological and sociolinguistic literature so as to situate the Northwest in the landscape of US dialectology. Following this, the PNWE Study's ethnic subsamples will be compared against one another in order to investigate cross-ethnic variation in the Northwest.

Although the data presented in the ethnicity section were normalized (see appendix I for plots of the raw data), there appear to still be some differences between the plots of males and females that may reflect physiological differences. Thus, as a precautionary measure, males and females will be plotted separately for all groupings.

4.1 By Dialect Area

Apart from early scholars like Reed, Foster, and Hoffman, few have set out to describe in general terms the shape and configuration of the Northwest English vowel space (although cf. Wassink, 2015b; Wright & Souza, 2012). However, an understanding of the Northwest English vowel space is important in order to set the stage for a more thorough discussion of the changes going on in the front vowel space. Because nearly all studies of regional dialects in the US sample exclusively Caucasian speakers (see §2.1.4), and many of the studies used as reference points here did not record female speakers, the Caucasian male subsample (n = 13; see §3.1 for more details) was used as a reference point. Once relation to other dialect areas is established, it will be possible to discuss differences by ethnicity in our sample.

In addition to comparisons with other major US dialect areas, a comparison to Peterson and Barney (1952) — a well-known study of "general American English" commonly cited in the phonetics literature[1] — will be included.

Figure 4.1 plots Caucasian vowel means by gender and generation.

[1]Though this practice is changing, as research into sociolinguistic variation becomes more widely known (Hagiwara, 1997)

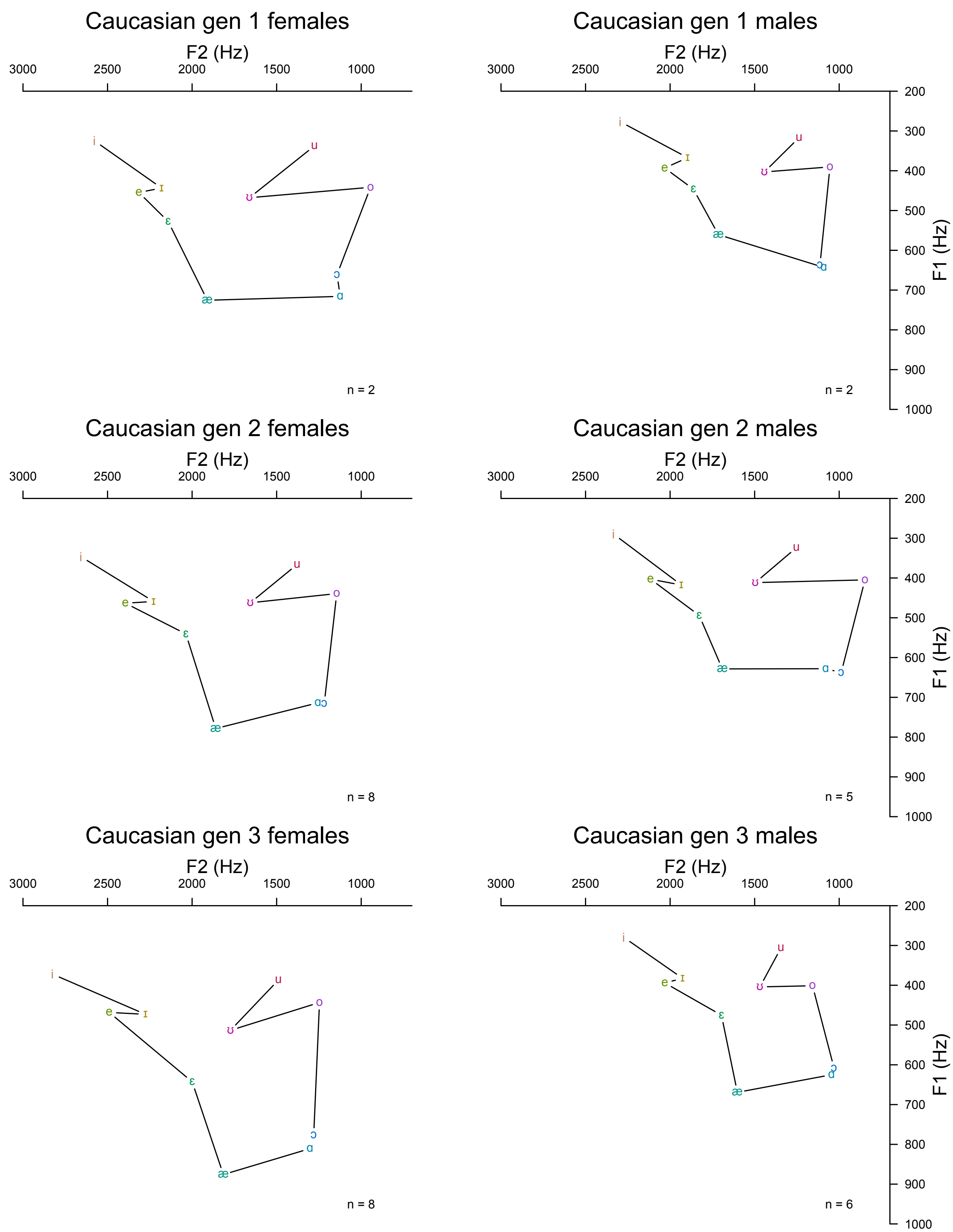


Figure 4.1: NW Caucasian vowel means by gender and generation (midpoint, non-normalized)

A few things warrant mention here. First, the overall shape of the vowel space is roughly ʊ-like (albeit at a rakish angle). The low vowels in this system appear rather high across the board, /i/ (FLEECE) is fairly high and front, and /u, ʊ/ (GOOSE, FOOT) are both fronted (/ʊ/ particularly so), with the merged /ɑ, ɔ/ (COT, CAUGHT) pair (indicative of the extent of the low back merger in the region) in the low back corner (such as it is). Interestingly, there doesn't appear to be much fronting of /o/ (GOAT), which ends up being the backest part of the system for all groups, sometimes by a wide margin. Moving on to the front space, /æ/ (TRAP) is roughly in its canonical location, with some distance between /ɛ, e/ (DRESS, FACE), and is the lowest vowel in the system for all except generation 1 males. Otherwise, /ɪ/ (KIT) appears fairly back and lowered, close to /e/ (FACE). Lastly, it appears that the system as a whole is fairly stable across generations (in apparent time), with each generation showing approximately the same configuration.

These plots replicate the findings of Wassink (2015b), which analyzes a partially-overlapping subsample of Caucasians from the PNWE study, and extend those of Wright and Souza (2012) (although their speakers show lower low values than these), in addition to providing a slightly broader view of the community, with three generations of speakers represented.

4.1.1 California

California English is a relevant point of comparison here, being another region in the Western US, and one that is frequently lumped in with the Northwest. Figure 4.2 is a comparison of Northwest English and Californian English vowel spaces, using data from Hagiwara (1997), which consists of 15 undergraduates from UCLA (but note that Hagiwara did not distinguish between /ɑ, ɔ/, COT, CAUGHT in this data).

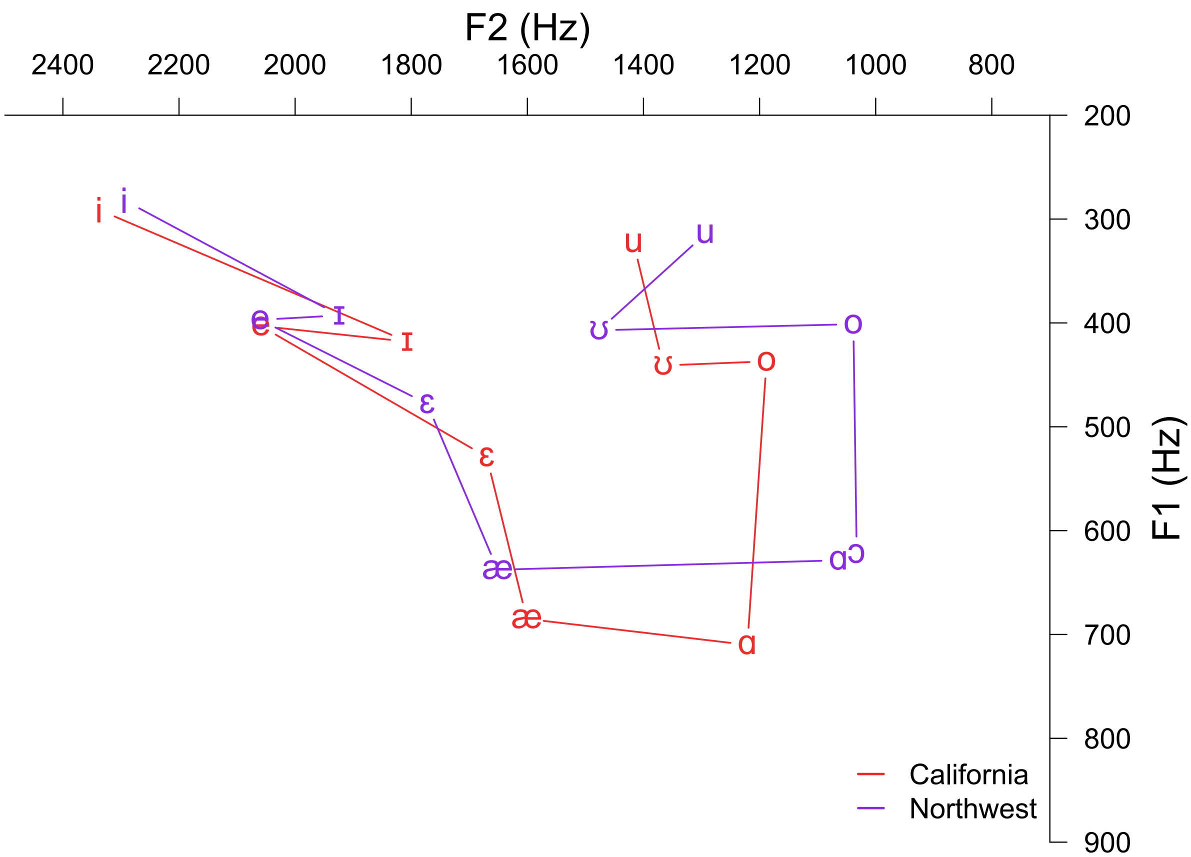


Figure 4.2: Californian and Northwest vowel means (midpoint, non-normalized) (Hagiwara, 1997). Color indicates dialect region.

As hinted at in figure 4.1, the Northwest English speakers have a slightly raised system overall, an observation which is maintained in comparison to the Californian speakers (though this may be due in part to the CVS). As expected, the two data sets look very similar otherwise, particularly in the front vowel space (though recall that this does not include pre-/g/ tokens). The Californians show a more fronted /u/ (GOOSE) and /o/ (GOAT), which is consistent with the literature (Eckert, 2005; Hagiwara, 1997; Labov et al., 2006), however Northwest speakers have a more fronted /ʊ/ (FOOT), and a backer /ɑ/ (COT).

4.1.2 The Inland North

The presence of the NCS in Inland North English makes it look very different from the Northwest. Figure 4.3 is a comparison between speakers of Northwest English and speakers from the Inland North, using data from Clopper, Pisoni, and de Jong (2005), which consists of four talkers (all male) from western New York, Indiana, and Wisconsin.

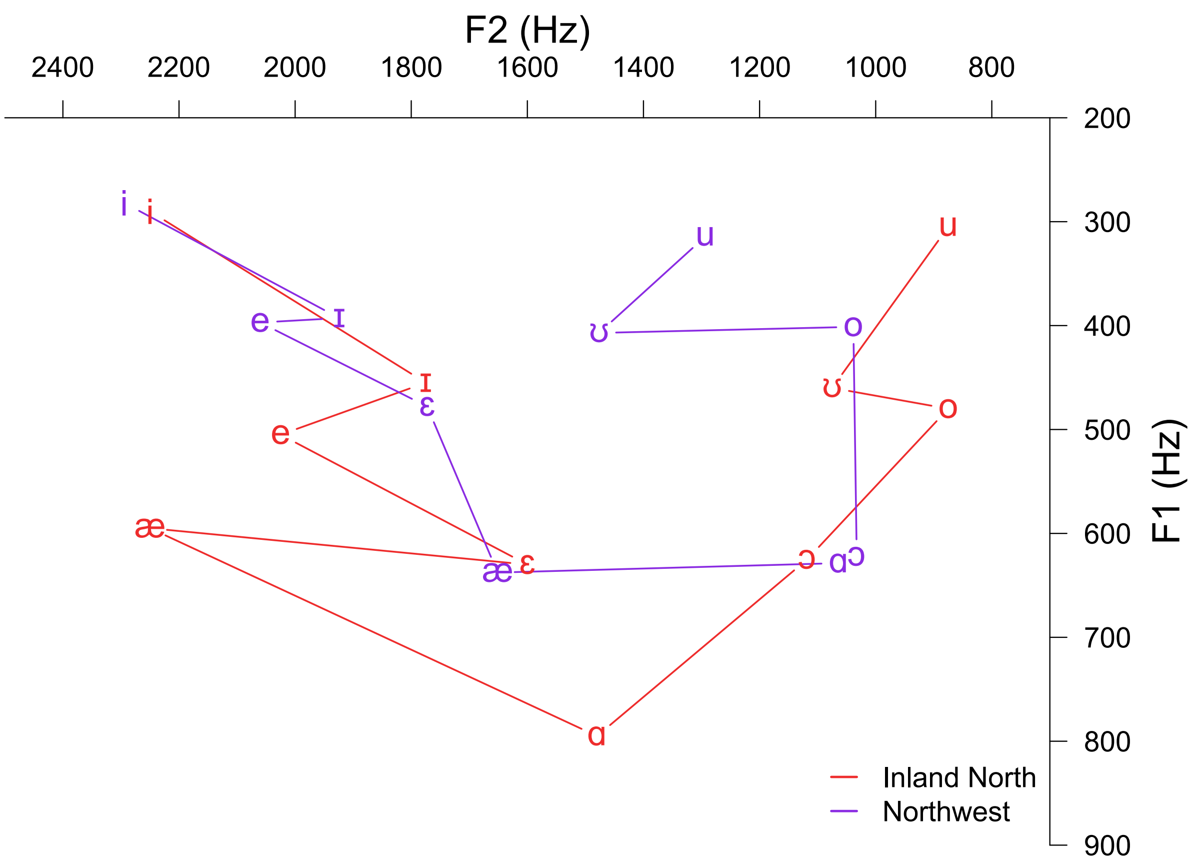


Figure 4.3: Inland North and Northwest vowel means (midpoint, non-normalized) Clopper et al. (2005). Color indicates dialect region.

It is immediately clear from figure 4.3 that the two dialect areas differ markedly from one another. The Inland Northern speakers' /æ/ (TRAP) is much further front, in addition to being somewhat raised relative to Northwestern /æ/ (TRAP), and their /ɛ/ (DRESS) is actually at the same spectral location as Northwest /æ/ (TRAP). Also as expected, /ɑ/ (COT) is much more fronted relative to the Northwestern speakers, and not merged with /ɔ/ (CAUGHT). There also isn't the same degree of /u, ʊ, o/-fronting (GOOSE, FOOT, GOAT) as there is for Northwestern speakers.

4.1.3 The Mid-Atlantic

Figure 4.4 includes data from four New Jersey and eastern New York speakers (all male) from Clopper et al. (2005).

Much like the Inland Northern speakers, the Mid-Atlantic speakers have a very central /ɑ/ (COT) in comparison to the Northwesterners, as well as a lowered /ɪ, ɛ/ (KIT, DRESS). Despite the Mid-Atlantic region being typically described as similar to the Inland North (Labov et al., 2006), these plots don't show the dramatic fronting of /æ, ɛ/ (TRAP, DRESS) that can be seen in figure 4.3, though they do show an unmerged low back space. Mid-Atlantic /æ/ (TRAP) in this data is rather close to Northwest /æ/ (TRAP). Once again, Northwesterners show a very fronted /u, ʊ/ (GOOSE, FOOT) relative to the Mid-Atlantic speakers.

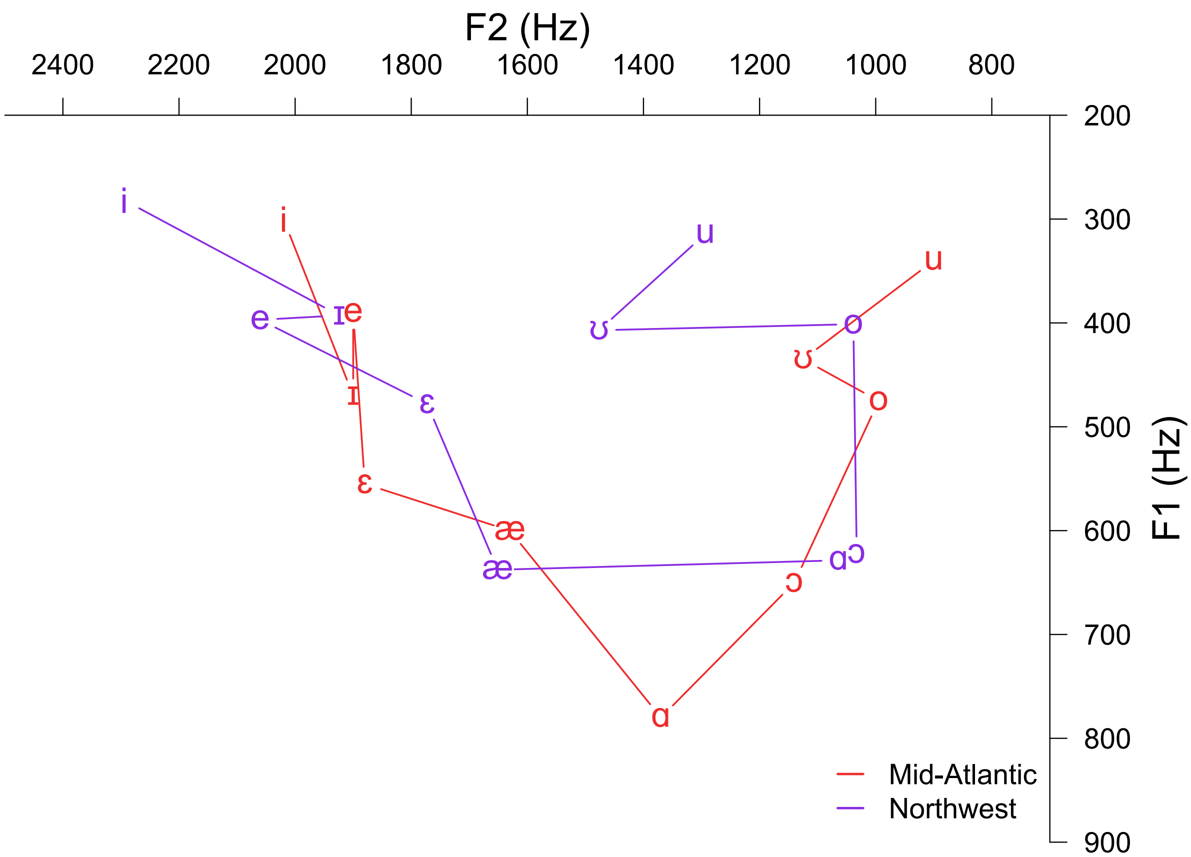


Figure 4.4: Mid-Atlantic and Northwest vowel means (midpoint, non-normalized) Clopper et al. (2005). Color indicates dialect region.

4.1.4 The South

Although not so different as the Inland North, the presence of the SVS is still a distinguishing feature. Figure 4.5 compares Southern speakers to Northwestern speakers, using data from Assmann and Katz (2000), which consists of 10 speakers (all male) from Dallas, TX.

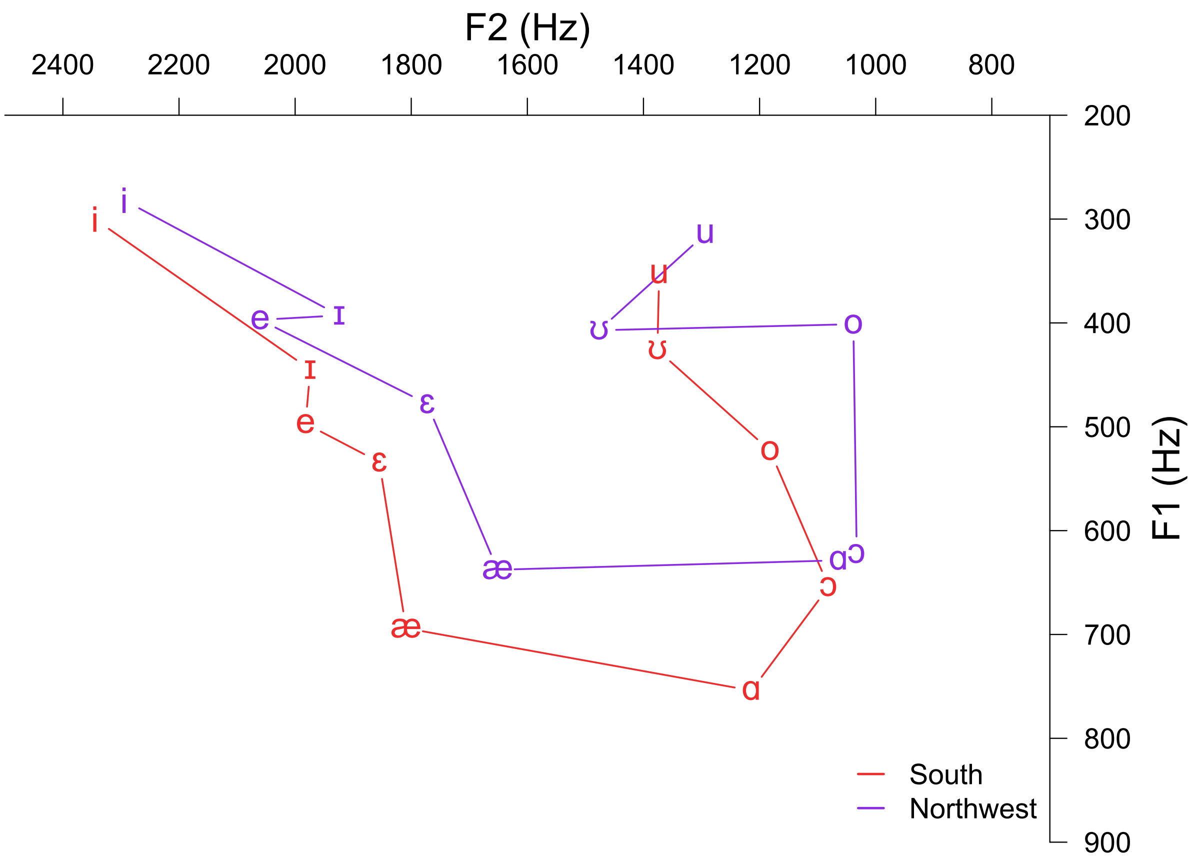


Figure 4.5: Southern and Northwest vowel means (midpoint, non-normalized) Assmann and Katz (2000). Color indicates dialect region.

Once again, the Northwest speakers appear to be raised across the board, with a less fronted /o/ (GOAT) and a merged /ɑ, ɔ/ (COT, CAUGHT), however the similarities shown in this plot are likely an example of the plotting methods minimizing phonological differences between varieties, in particular because this data is midpoint only, thereby hiding the effects of the /ai/ (PRIDE) monophthongization which is characteristic of many Southerners (Labov et al., 2006). The effects of the SVS (see §2.2.4) are also not readily apparent from this plot, and given the reversals that occur in the front vowel space of speakers participating in these changes, we would expect them to look much more different from Northwesterners than they do here.

4.1.5 The Midlands

Figure 4.6 uses data from Clopper et al. (2005), namely 4 speakers from Indiana.

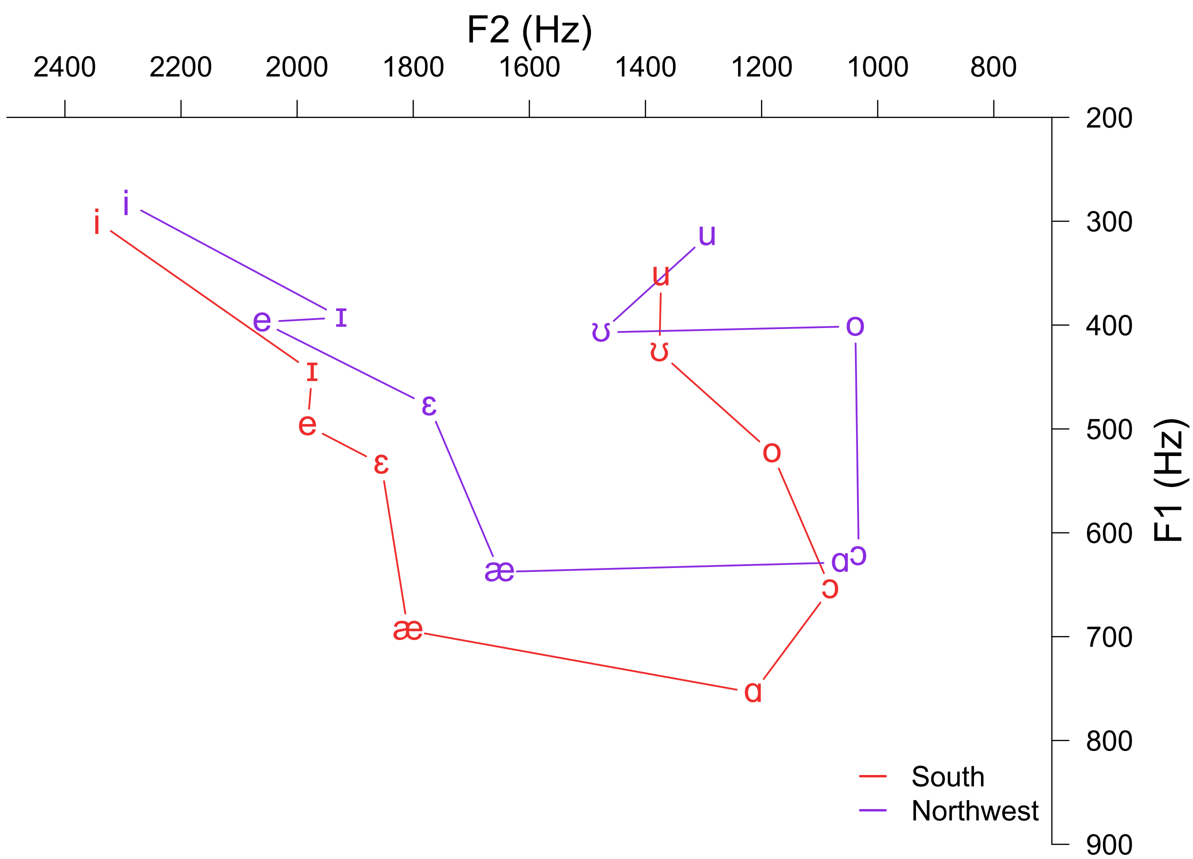


Figure 4.6: US Midlands and Northwest vowel means (midpoint, non-normalized) Clopper et al. (2005). Color indicates dialect region.

As with the previous dialect areas treated here, the Northwest speakers' low vowels are much higher than the Midland speakers'. Low vowels aside, Northwest and Midland /o/ (GOAT) appear to be fronted to approximately the same degree (contra Labov et al., 2006), and Northwest speakers show a much more fronted /u/ (GOOSE).

4.1.6 Peterson & Barney, 1952

Figure 4.7 plots Peterson and Barney (1952) against our Northwestern speakers. Peterson and Barney (1952) is an early study of American English, indeed one of the most frequently cited in the acoustic phonetics literature, which, although purportedly a description of General American English, did not control for dialect region or native language.

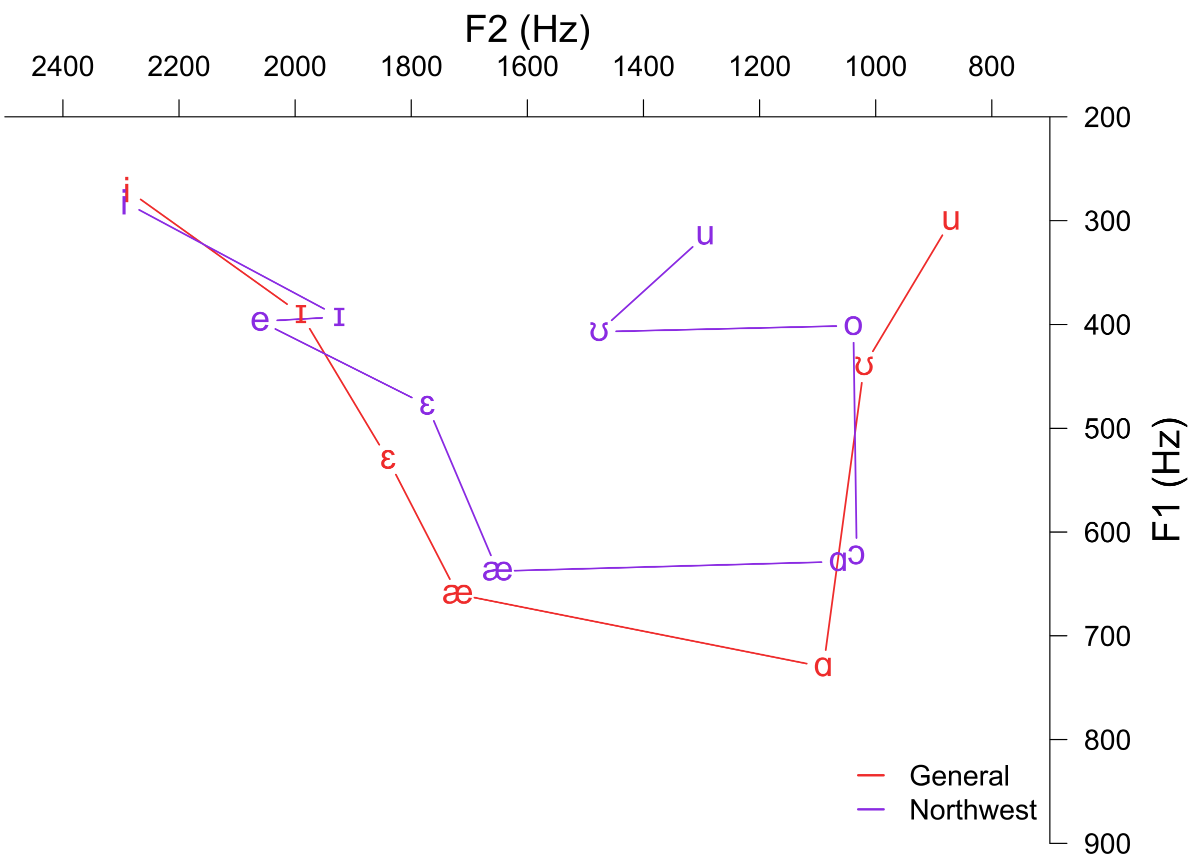


Figure 4.7: GAE and Northwest vowel means (midpoint, non-normalized) Peterson and Barney (1952). Color indicates dialect region.

Despite the drawbacks to Peterson and Barney (1952), the Northwestern speakers actually look fairly similar here, with the most obvious differences being a raised /ɑ/ (COT), and a very fronted /u, ʊ/ (GOOSE, FOOT) relative to Peterson and Barney (1952). Once again, however, this may be a side-effect of the plots themselves.

4.2 By Ethnicity

4.2.1 African Americans

Moving on to the non-White subsamples, the African American speakers are unfortunately perhaps the most difficult to make generalizations from, due to the sample being very unbalanced. In our sample, all generation 1 speakers are also female, and from Seattle ($n = 3$), whereas we have only a single male speaker, who is generation 3 and from Spokane. Figure 4.8 plots the African American speakers' vowel space.

Despite the sampling issues, the vowel spaces of the African American speakers look very similar to the Caucasian speakers in the previous section. Indeed for these speakers as well we see /ɪ/ (KIT) lower and backer than /i/ (FLEECE), sitting right behind /e/ (FACE). Also like the Caucasian sample, /u/ (GOOSE) is less fronted for the oldest generation, but is much more fronted by the youngest females and /ʊ/ (FOOT) is quite fronted for both generations of females. /o/ (GOAT) remains solidly back for all groupings.

The single male looks a little different, without much /u, ʊ/-fronting (GOOSE, FOOT) at all and with a reversal of /ɑ, ɔ/ (COT, CAUGHT), though the configuration of his front vowel space is similar to the other speakers'. Given that he is the only male in the African American sample however, and the only speaker from the Spokane-area, it's not possible to conclude anything about gender or region within this subsample.

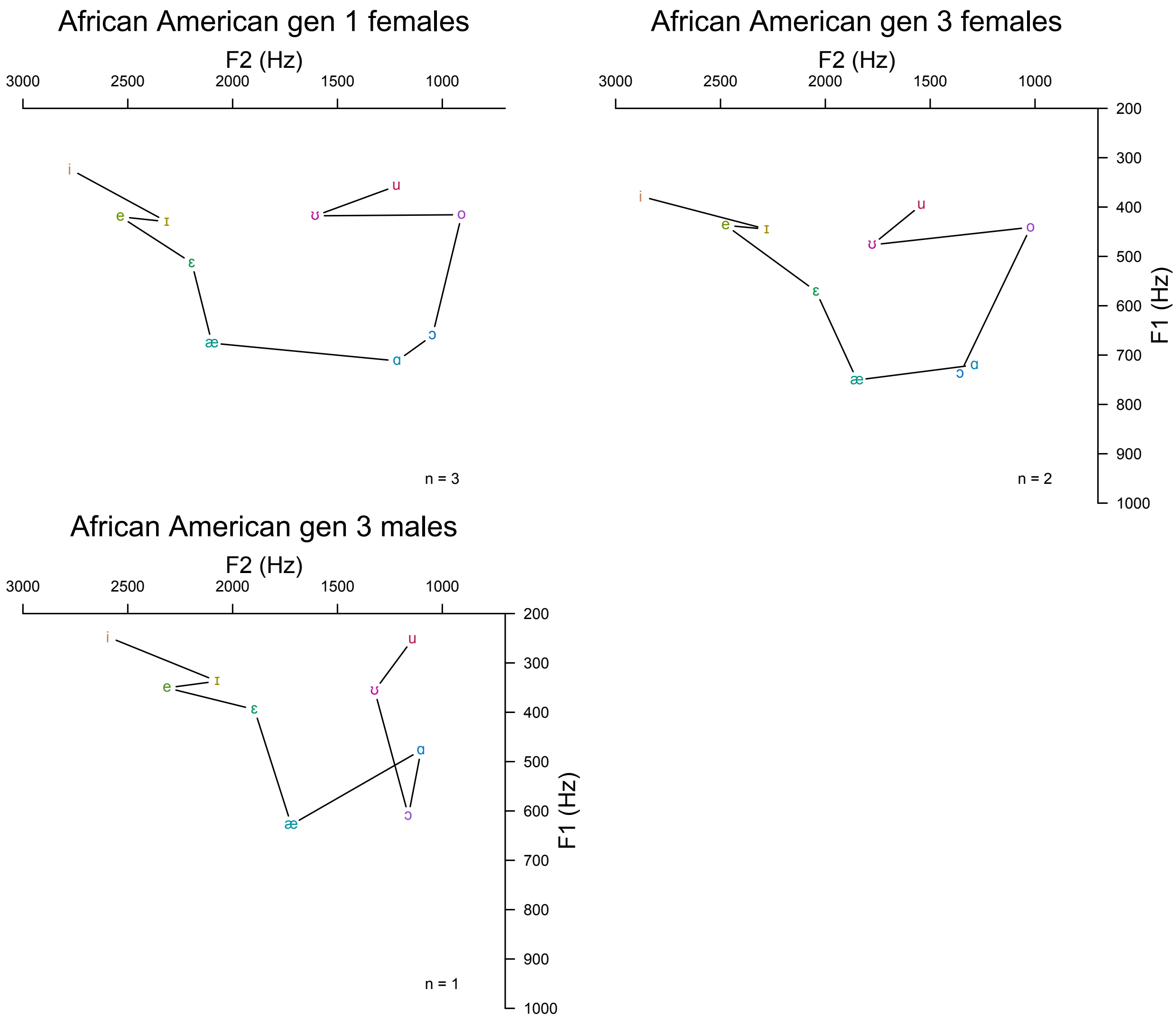


Figure 4.8: African American vowel means (midpoint)

4.2.2 Japanese Americans

The Japanese American subsample is better balanced for generation and gender, although like most of the other subsamples (excluding African Americans), there are fewer generation 3 speakers. Figure 4.9 plots the vowel space of the Japanese American speakers.

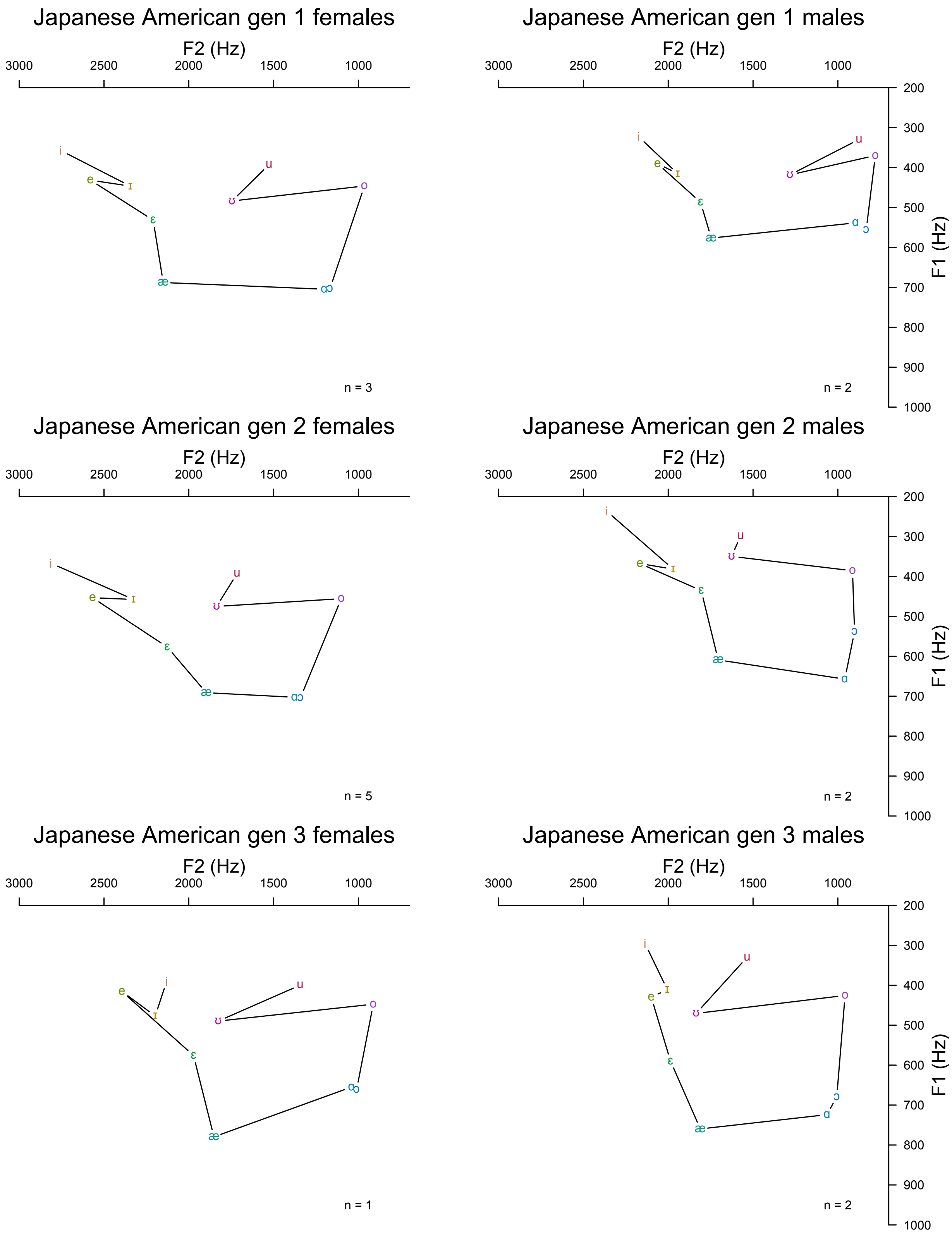


Figure 4.9: Japanese American vowel means (midpoint)

Once again we see a pattern similar to that exhibited by the Caucasian speakers in figure 4.1. In this case however the similarities run deeper: with the exception of the generation 1 males, the Japanese American respondents show a rather fronted /u/ (GOOSE), as well as the very fronted /ʊ/ (FOOT) seen in the Caucasian plots. Surprisingly, generation 2 males appear to have some distance between their /ɑ, ɔ/ (COT, CAUGHT) classes, suggesting that they may not be fully merged yet. Given that all other groupings appear to show evidence of the low back merger, it may be that the two generation 2 Japanese American males are atypical, or reacted exceptionally strongly to the formal wordlist context. The front vowel space is in a similar configuration for all groupings, much like both the Caucasians and the African Americans.

4.2.3 Mexican Americans

The Mexican American sample is primarily from the Yakima Valley, with two speakers from the Spokane area, but none from the Seattle area, and unfortunately no generation 1 respondents at all. Figure 4.10 is a plot of the Mexican American speakers' vowel space.

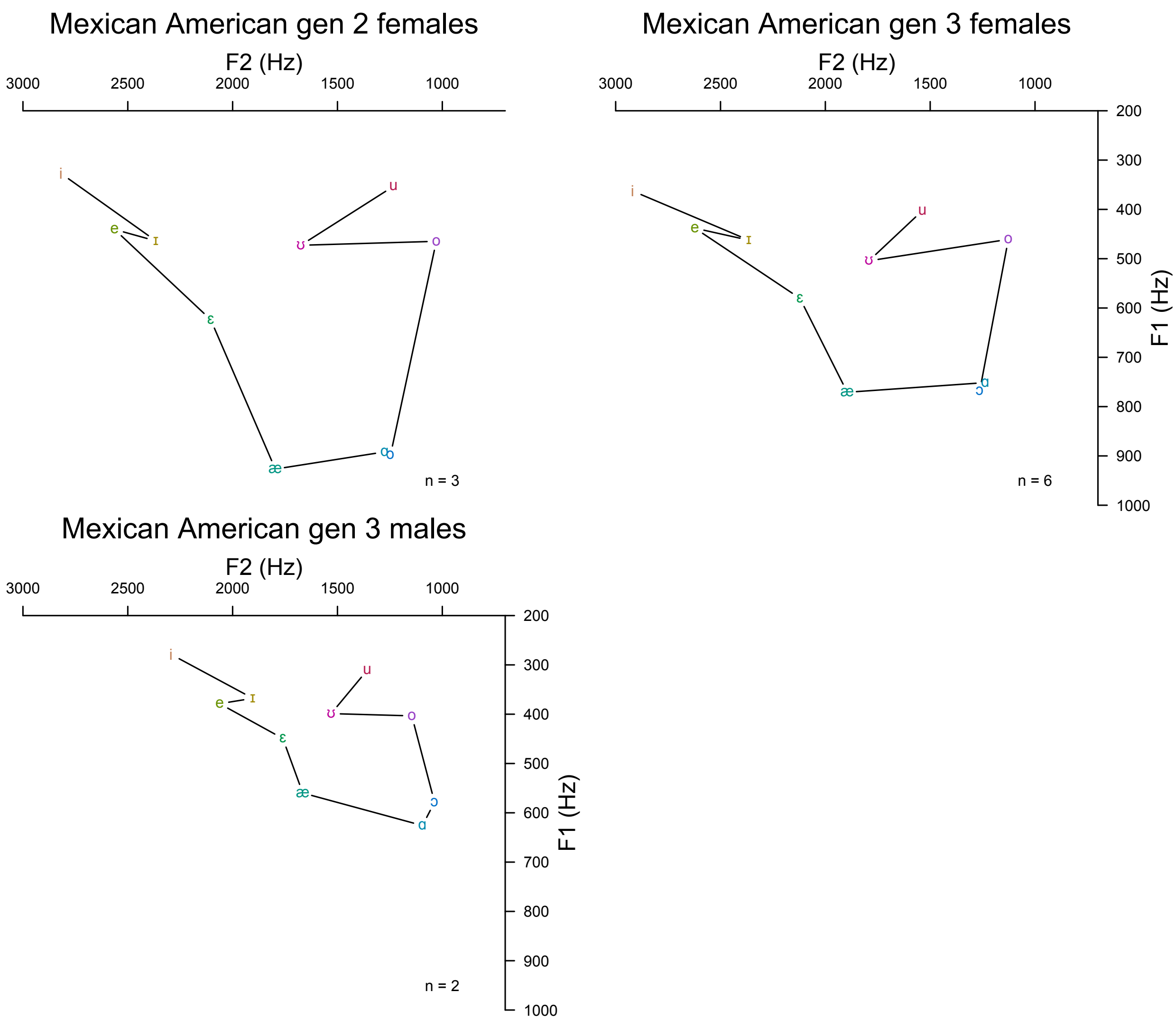


Figure 4.10: Mexican American vowel means (midpoint)

Like the Japanese Americans, the Mexican American subsample looks very much like the Caucasian speakers, with a fronted /u, ʊ/ (GOOSE, FOOT), a back /o/ (GOAT), and the same familiar front vowel configuration. All speakers appear to have the low back merger. The only other noteworthy feature of these plots is that generation 2 females appear to have much lower low vowels than the other two groupings.

4.2.4 Yakama Nation

The Yakama Nation subsample is fairly well balanced male/female, however like the Mexican Americans, we were unable to record any generation 1 speakers. Figure 4.11 shows the vowel space of the Yakama Nation speakers.

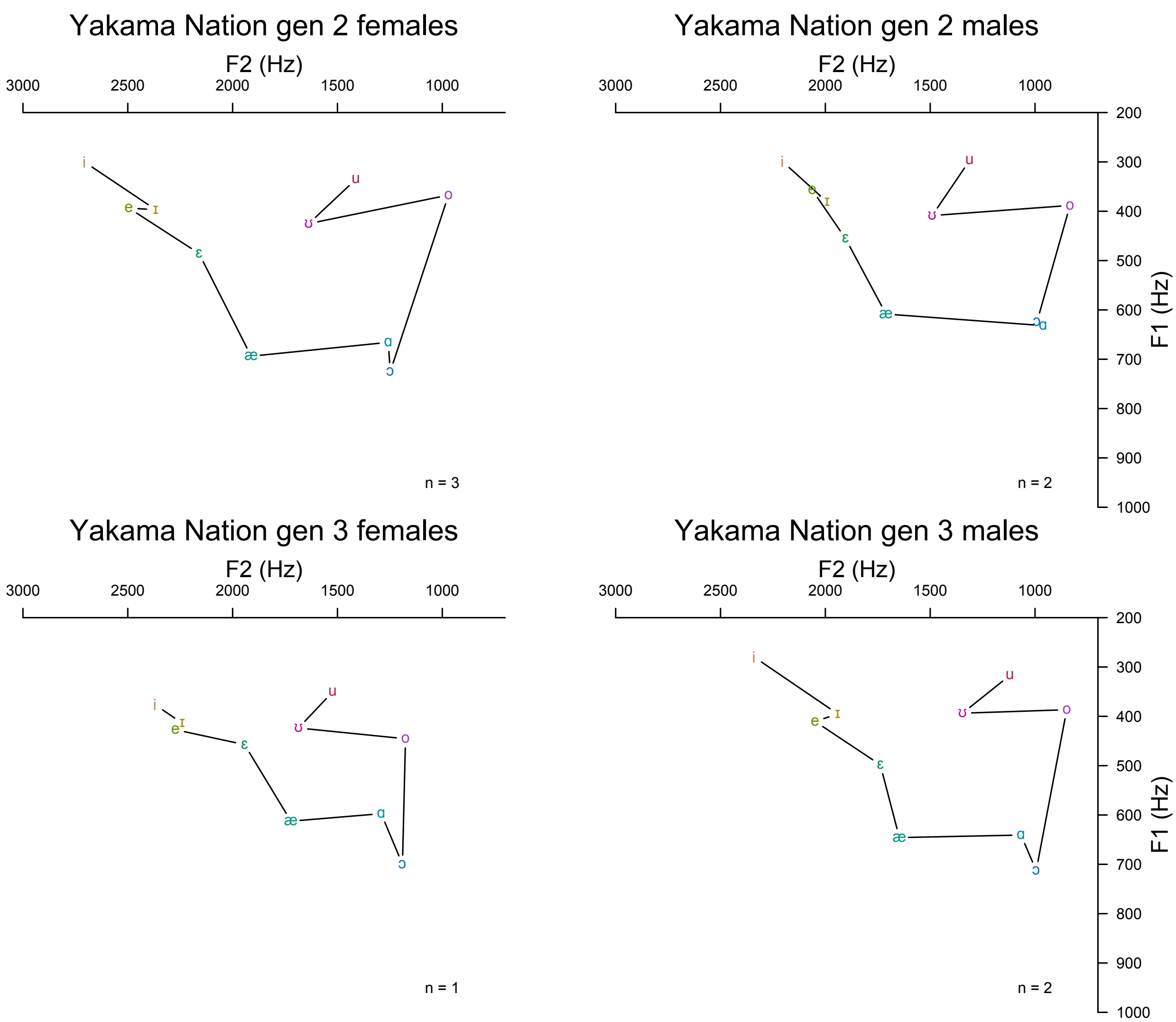


Figure 4.11: Yakama Nation vowel means (midpoint)

Overall, these speakers also resemble Caucasians, although generation 3 males appear to have a rather back /u/ (GOOSE), and generation 3 males and females both show some distance between /ɑ, ɔ/ (COT, CAUGHT) word classes.

4.3 Discussion

The results by dialect area paint a picture of a solidly western vowel space, without evidence of the NCS, SVS, or CVS, as suggested by Labov et al. (2006). Despite these similarities, however, the Northwesterners still exhibit some distinctive patterns. In addition to the oft-reported fronting of /u, ʊ/ (GOOSE, FOOT), Northwestern speakers appear to have rather high low vowels (around 700 Hz) by comparison with other regions, though it is not clear why this should be, especially given that the speakers analyzed in Wright and Souza (2012) show mean F1 values for low vowels between 800–900 Hz. The inclusion of pre-velar tokens in the next chapter will further differentiate the Northwest from the other dialect regions in the US.

Results from the cross-ethnic section, on the other hand, seem to suggest that despite a few differences (primarily generational), the five subsamples all strongly resemble each other. What differentiation there is between groupings tends to be in the back vowel space, with /u, ʊ/ (GOOSE, FOOT) being fronted (or not) to various degrees, and a few groups who may be less-than-completely low-back-merged. The latter result may simply be due to a low number of speakers, combined with the presence of a few who still maintain some separation between the classes.

The front vowel space looks relatively stable cross-ethnically, with all groupings showing the same basic configuration. /æ/ (TRAP) appears rather low for all speakers, with a tighter clustering of /i, ɪ, e, ɛ/ (FLEECE, KIT, FACE, DRESS), and /ɪ/ (KIT) sitting right behind /e/ (FACE).

Based on the above results, we confirm H_2 (generational differences) and H_3 (ethnicity differences), and reject H_1 (gender differences) for RQ_{1b}.

Chapter 5

RESULTS: PRE-VELAR RAISING

Having spent some time examining the Northwest English vowel space as a whole, we can now turn to the second set of research questions, 2a–c, having to do with movements within the front vowel space, namely the behavior of /æ, ɛ, e/ before /g/ (BAG, BEG, VAGUE).

This chapter presents results from the pre-velar tokens in three ways: traditional F1 x F2 vowel plots using normalized formant values, plotted by word class, colored by vowel, and with following class indicated by linetype (dashed for pre-/g/), and ellipses at the 95% confidence interval (CI) so that overlap between classes can be assessed. Like the previous chapter, males and females will be plotted separately.

Next come VOIS3D overlap fractions, which are pairwise measures of 3D overlap (F1 x F2 x duration), and indicate the percentage of the smaller distribution that is contained within the larger one. These quantify the degree of spectrotemporal overlap at midpoint, and offer a clearer picture of the status of pre-velar word classes.

SS-ANOVA plots provide a view of vowel formant trajectories over time, making it easier to compare the movements of the vowels themselves, rather than just their spectral location. All three methods use normalized measures so as to facilitate comparisons among groupings.

Finally, multiple linear regression is used to test the relationships seen in the vowel plots among word classes and social groupings, using Approximation, Duration, and Displacement.

5.1 Gender

Looking first at gender, the following plots collapse across all generations and ethnicities. Although there are more females than males in the sample, there are enough of each to be able to draw conclusions from the data.

5.1.1 Vowel Plots

Figure 5.1 compares male and female front vowel spaces by word class.

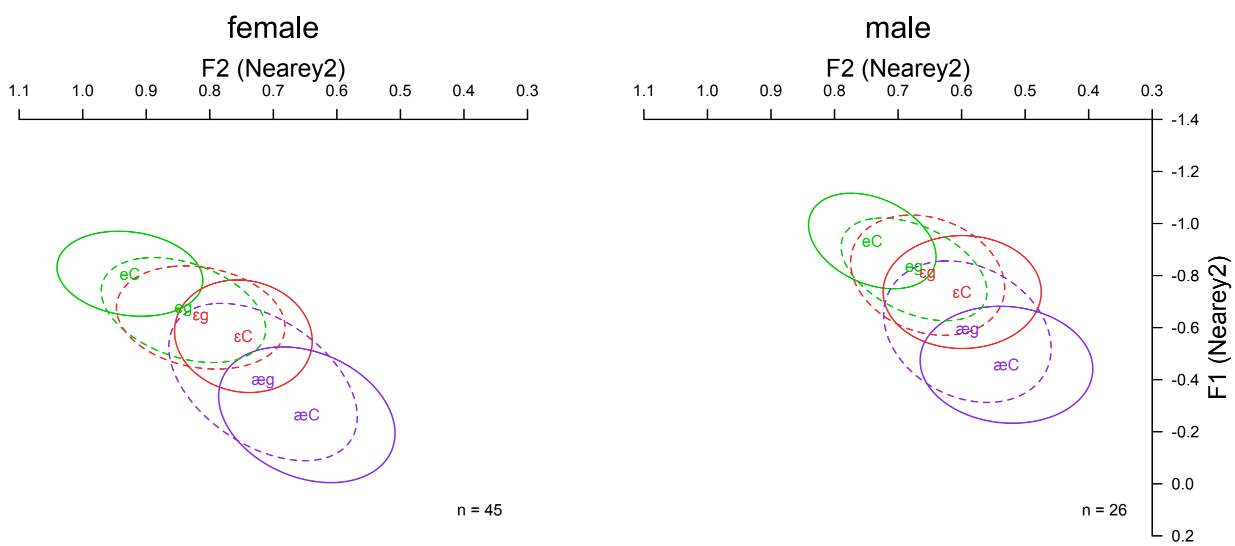


Figure 5.1: Vowel means by gender, pooling across ethnicity and generation (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

Although previous research has found some differences in the degree and character of pre-velar raising across genders (Wassink et al., 2009), it's difficult to find any large differences between them in this plot. Both females and males raise /æg/ (BAG) somewhat, and show nearly entirely overlapping /eg, ɛg/ (VAGUE, BEG) distributions centered between the respective non-pre-velar classes.

5.1.2 Overlap

Table 5.1 presents overlap fractions by gender for all logical pairings.

Table 5.1: VOIS3D overlap fractions by genderVOIS3D overlap fractions by gender, pooling across ethnicity and generation (midpoint) (midpoint)

Gender	**æg/ɛg**	**æg/eg**	**æg/e**	**ɛg/eg**	**ɛg/e**	**eg/e**	**Approximation**
Female	0.25*	0.26*	0.06	0.56*	0.14	0.23*	0.53
Male	0.27*	0.26*	0.06	0.64*	0.11	0.17	0.58

** Partially merged, ** Fully merged*

Like in figure 5.1, comparing across genders shows no appreciable differences. Both genders partially overlap /æg/ (BAG) with /ɛg/ (BEG) and /eg/ (VAGUE) (but not /e/, FACE), and substantially (although not fully) overlap /ɛg, eg/ (BEG, VAGUE). The degree of /eg/-lowering (VAGUE; i.e. low /eg, e/ overlaps) is also made clear here: both males and females show low amounts of overlap for /eg, e/ (VAGUE, FACE), although females do partially merge the two.

5.1.3 Formant Trajectories

Figure 5.2 plots SS-ANOVA models by gender and environment. The cause of the large CIs here is not clear, but given that this plot collapses across ethnicity, it may be the case that there is more variance in this partitioning of the data, leading to a larger standard error.

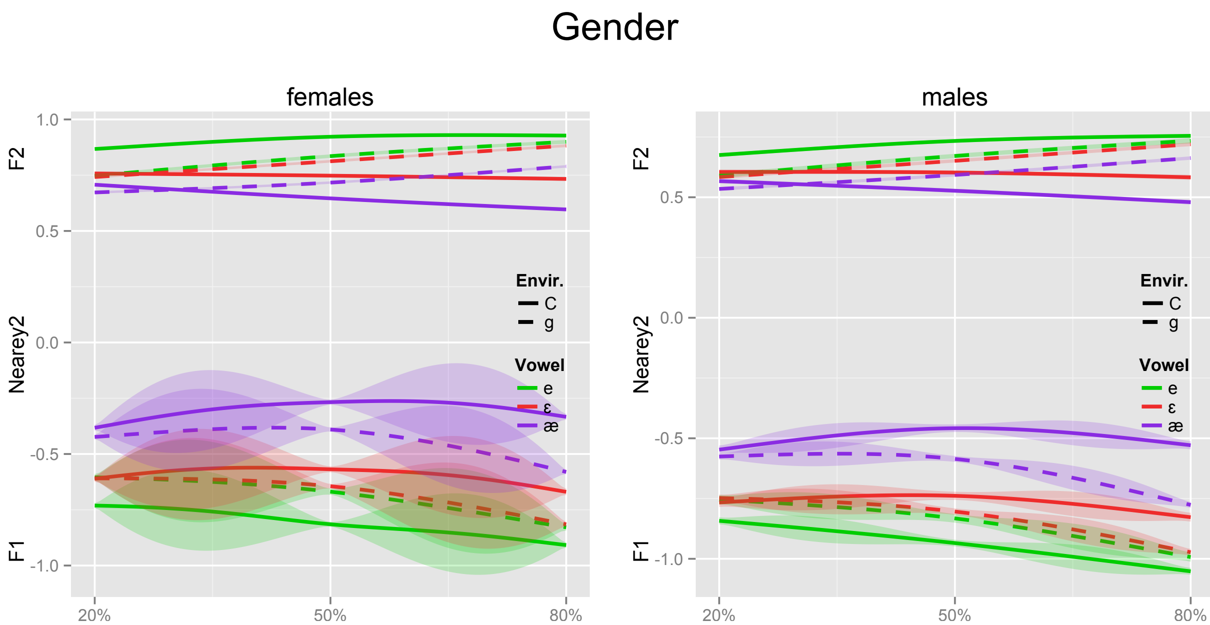


Figure 5.2: SS-ANOVA plots by gender and environment, pooling across ethnicity and generation. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

Once again, there are few differences between males and females in terms of vowel trajectory. Pre-velar and non-pre-velar classes overlap at onset, but are separate by midpoint, and even more so by offset. Pre-velar /eg, ɛg/ (VAGUE, BEG) are right on top of each other in F1 for the duration of the vowel, and although /æg/ (BAG) comes close, it doesn't overlap with their trajectories. In F2, pre-velar and non-pre-velar classes are moving in opposite directions over the course of vowel duration: F2 increases for the pre-velar classes, whereas it decreases for the non-pre-velar classes.

5.2 Generation

The generational picture is always interesting for a potential change in progress, as it is expected that there will be an increase or decrease in the usage of the variable over time. Previous research on pre-velar raising and /eg/-lowering (VAGUE) in the Northwest has indeed found generational differences, although not the ones we might expect *a priori*. Freeman (2014b) (whose speakers are in the data for this study, although with a slightly different set of tokens and a different normalization method) found that although there was an increase in /æg, ɛg/-raising (BAG, BEG) from generation 1 to generation 2, it decreased from generation 2 to generation 3.

5.2.1 Vowel Plots

The plots in figure 5.3 depict the front vowel space broken out by word class for all three generations, separated into males and females.

Comparing across generations there are a number of interesting differences. Like Freeman found, /æg, ɛg/-raising (BAG, BEG) peaks in generation 2 speakers, with a small difference in /ɛg/-raising (BEG), but a larger one in /æg/-raising (BAG) (although the difference between generations 2 and 3 is less than that between generations 1 and 2). It should be noted here that despite this apparent decrease in /æg/-raising (BAG), the /æg/ word class (BAG) is still very much raised, both acoustically and perceptually. /eg/-lowering remains largely the same across generations, with the oldest speakers showing /eg/ (VAGUE) situated between /e/ (FACE) and /ɛ/ (DRESS) even without a strongly raised /ɛg/ (BEG). Similar to the results presented in the previous section, males and females look very similar here, even cross-generationally. This time, however, there is at least one difference to be seen: female and male distributions for /æ, æg/ (TRAP, BAG) differ in shape, most notably for the youngest speakers.

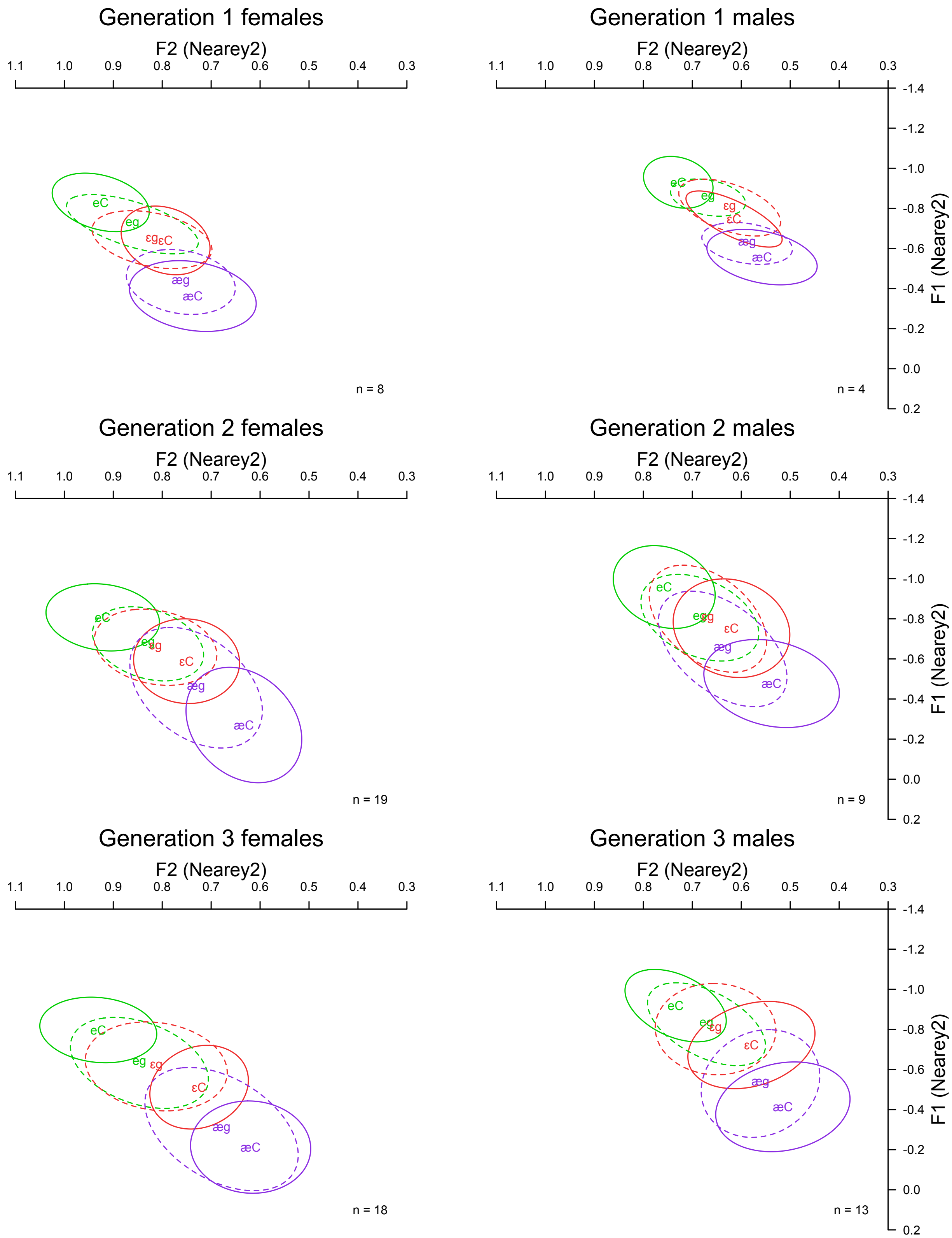


Figure 5.3: Vowel means by generation and gender, pooling across ethnicity (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

5.2.2 Overlap

Table 5.2 presents overlap fractions by generation for all logical pairings.

Table 5.2: VOIS3D overlap fractions by generation, pooling across gender and ethnicity (midpoint)

Generation	æg/ɛg	æg/eg	æg/e	ɛg/eg	ɛg/e	eg/e	Approximation
1	0.18	0.12	0.03	0.56*	0.03	0.14	0.51
2	0.35*	0.31*	0.08	0.61*	0.13	0.18	0.58
3	0.21*	0.26*	0.05	0.58*	0.16	0.26*	0.53

** Partially merged, ** Fully merged*

The same generational pattern seen in figure 5.3 can be seen here: there is an increase in overlap fractions from generations 1 to 2, and a slightly smaller decrease from generations 2 to 3. This is also born out in Approximation ratings, with generation 2 having the highest overall. As with the overlap fractions for gender in the previous section, no pair is fully merged. Interestingly, /eg, e/ (VAGUE, FACE) overlap increases with generation, with the youngest speakers being partially merged, whereas middle-aged and older speakers have full separation.

5.2.3 Formant Trajectories

Figure 5.4 plots SS-ANOVA models by generation and environment.

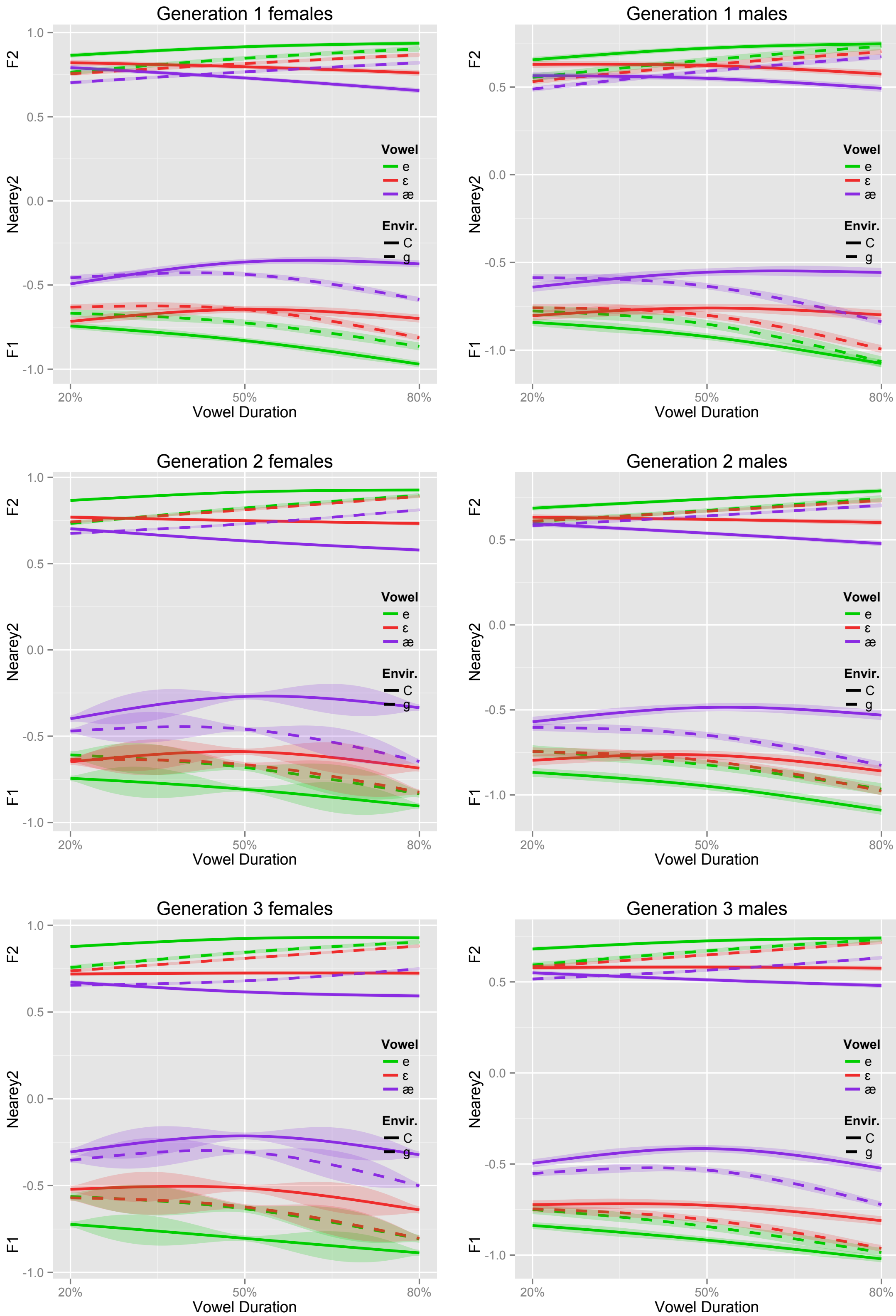


Figure 5.4: SS-ANOVA plots by generation, gender and environment (all ethnicities). Vowel indicated by color, following environment by linetype, shading at the 95% CI.

Looking now at the trajectories themselves, some different patterns emerge. /ɛg, eg/ (BEG, VAGUE) appear to be completely spectrally overlapping for generations 2 and 3, and the generational peak in /æg/-raising (BAG; at midpoint, i.e. the amount of distance between the classes) is visible, and in fact appears even wider at offset. Not apparent from the vowel plots, however, is the fact that non-pre-velar and pre-velar word classes start to separate at onset, with generation 3 showing the most overall separation. Perhaps the most intriguing thing about these plots though is the observation that it's the *non*-pre-velar word classes that appear to be shifting the most, as the pre-velar trajectories remain roughly similar in shape and location from generations 2 to 3. The shift in the location of non-pre-velar word classes, together with their flattening in the F1 and F2 dimensions, is creating space between them and the pre-velar classes in F1, most noticeably for the younger speakers who show separation (if only slightly) at all points in the vowel.

5.3 Ethnicity

This section presents the results from the analysis of pre-velar raising in the ethnic subsamples of the PNWE Study data. Each section presents the results from a single ethnicity, with vowel plots and SS-ANOVA plots. VOIS3D overlap are presented in a summary table at the end of the section.

5.3.1 African Americans

Vowel Plots

Figure 5.5 plots the African American male and female front vowel spaces by word class.

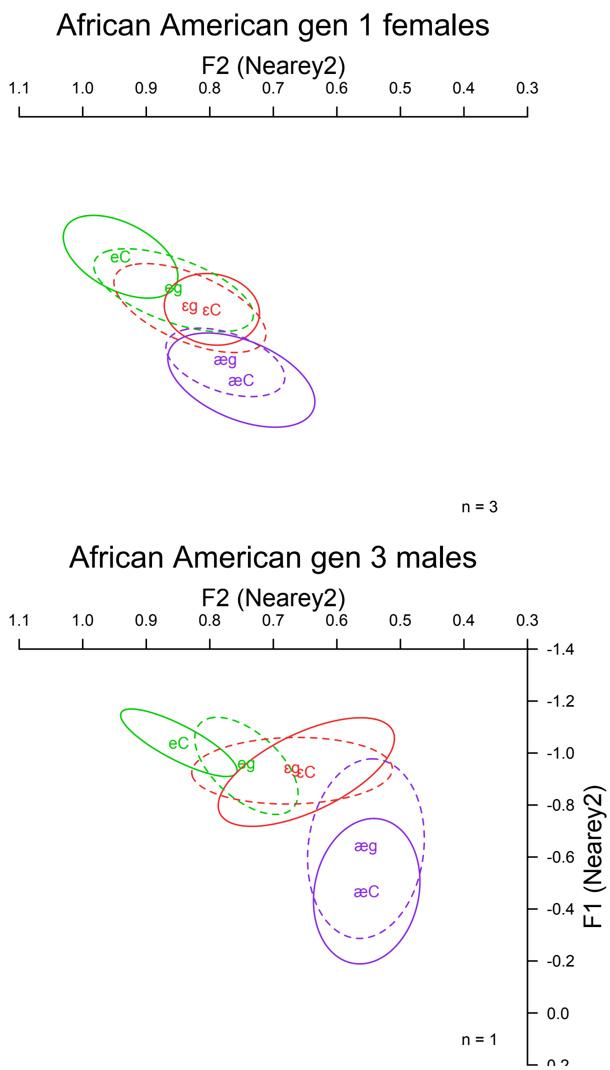


Figure 5.5: African American front vowel means by environment, generation, and gender (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

These plots show some interesting gender differences (although recall the uneven distribution of speakers across generations and genders).

African American females show relatively little /æg/-raising (BAG; though the /æg/ class does still overlap with /εg, ε/, BEG, DRESS), however the /εg/ (BEG) class is noticeably different from non-pre-velar /ε/ (DRESS) being raised and fronted with only about two thirds of its distribution overlapping with the non-pre-velar class. Even more interesting is /eg/ (VAGUE), which is significantly lowered and backed, only about 50% overlapping with non-pre-velar /e/ (FACE), and almost entirely overlapping with /ɛ/ (DRESS).

The African American male, on the other hand, looks quite different. He appears to show more /æg/-raising (BAG) than females, but without any noticeable fronting. His /ɛg, ɛ/ (BEG, DRESS) classes are mostly overlapping, but the distributions vary somewhat in shape. Finally, /eg/ (VAGUE) is nearly separate from /e/ (FACE), being lowered and backed into the /ɛg, ɛ/ (BEG, DRESS) region.

In the generation 3 plots, many of the distributions are wider than they are for the other groupings. This may be indicative of a high level of variability among younger speakers in general. /æg/ (BAG) is slightly raised away from /æ/ (TRAP; particularly for the male), as is the case for /ɛg, ɛ/ (BEG, DRESS), however /eg/ (VAGUE) remains quite lowered and back, occupying the midpoint between /e/ (FACE) and /ɛ/ (DRESS).

Formant Trajectories

Figure 5.6 plots SS-ANOVA models by generation and environment.

Although the females looked fairly similar in the vowel plots, there are some clear differences between the generation 1 and generation 3 females here. While the pre-velar word classes behave roughly the same for both generations of females, as suggested by figure 5.4, the non-pre-velar classes look strikingly different. The onsets for all non-pre-velar classes have spaced out in F1, and the trajectories have flattened in both dimensions, so that there is slight (although not statistically significant) separation at all points.

As for the pre-velar word classes, there doesn't appear to be a large degree of raising for any grouping, particularly not when it comes to /ɛg/ (BEG). Both generations of females show /eg/-lowering (VAGUE), however, but the male speaker breaks from them here.

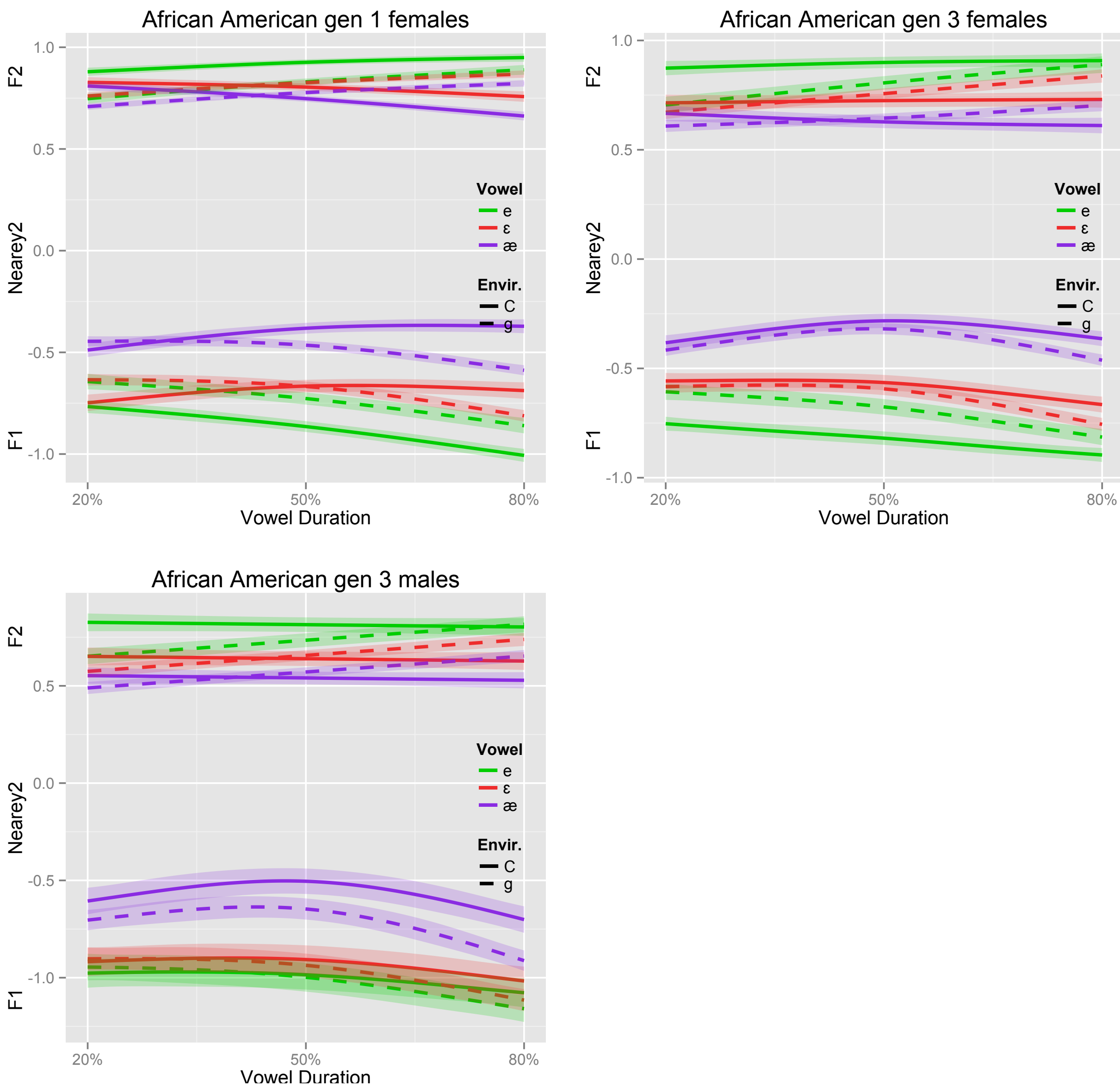


Figure 5.6: African American SS-ANOVA plots by environment, generation, and gender. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

The generation 3 male resembles the generation 3 females in most respects, but appears more variable (i.e. larger 95% CI), with more /æg/-raising (BAG), and more overlap in general between pre-velar and non-pre-velar /ɛ, e/ (DRESS, FACE).

5.3.2 Caucasians

Vowel Plots

Figure 5.7 plots the Caucasian male and female front vowel spaces by word class.

Looking across genders, although males and females are very similar, females do appear to be a bit more advanced in terms of /æg/-raising (BAG), especially for generations 1 and 3. Their /ɛg, eg/ (BEG, VAGUE) word classes behave about the same.

Turning now to the generational picture, we see a familiar pattern: generation 2 speakers appear to lead in /æg/-raising (BAG). Although generation 1 does show some /æg/-raising (BAG), and generation 3 shows even more, they are both surpassed by the generation 2 speakers, whose /æg/ (BAG) distribution is solidly overlapping with /ɛg, eg/ (BEG, VAGUE). The latter pair, like in the previous figure, are nearly entirely overlapping, although generations 2 and 3 they are clearly at the midpoint between the non-pre-velar classes, whereas for generation 1 they are closer to /ɛ/ (DRESS).

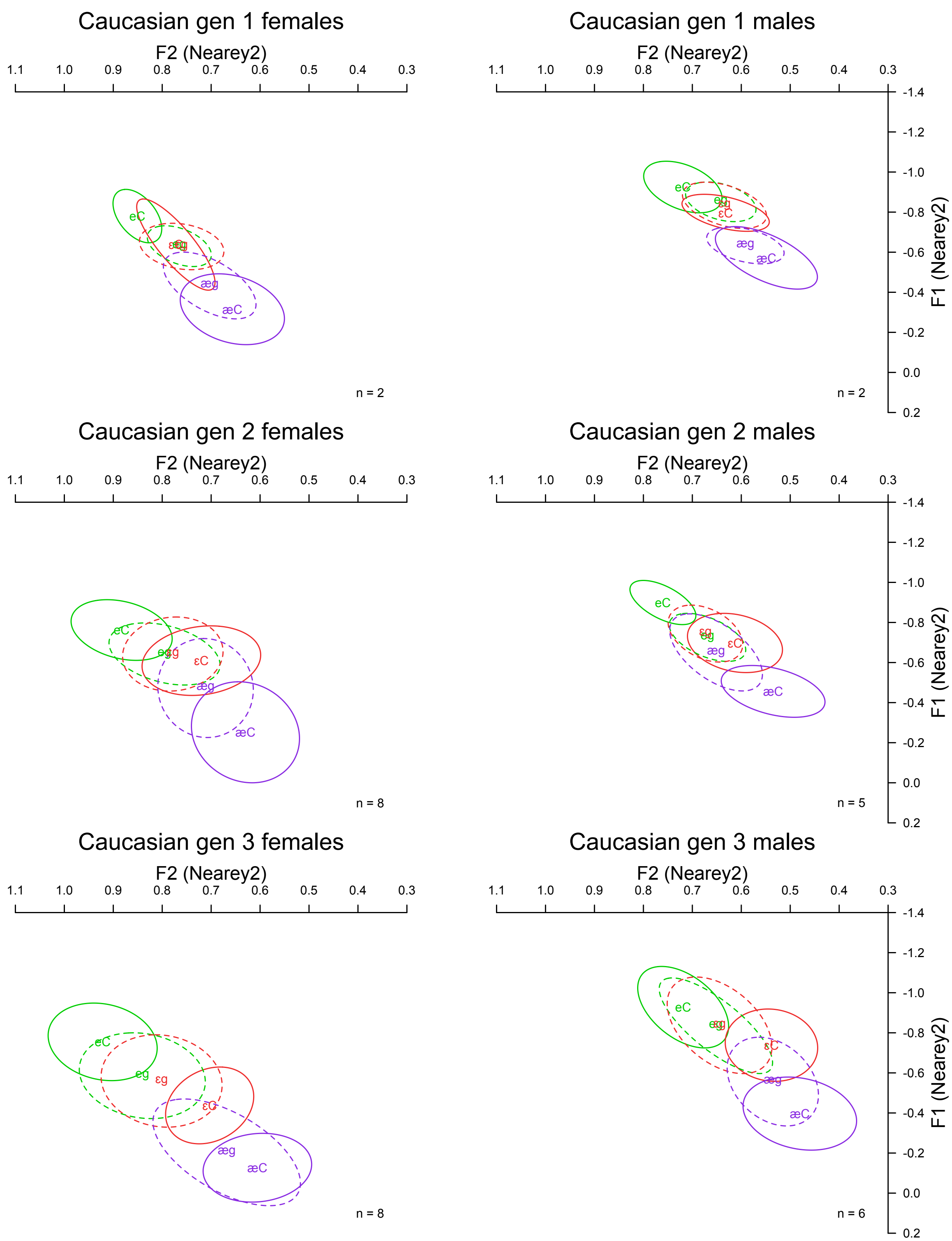


Figure 5.7: Caucasian front vowel means by environment, generation, and gender (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

Formant Trajectories

Figure 5.8 plots SS-ANOVA models by generation and environment.

In contrast to the African American subsample, Caucasian males and females in our sample look much more uniform by generation, with the exception of /æg/-raising (BAG), in which generation 3 males appear to lead.

The generational picture is, once again, very interesting. The oldest generation shows little differentiation between non-pre-velar and pre-velar word classes at onset, with separation increasing with vowel duration. In generation 2 there is more separation at onset, and at midpoint /æg/ (BAG) is particularly far from /æ/ (TRAP). At offset /æg/ (BAG) is approximately on top of /ɛ/ (BEG) in terms of height, although it is still further forward. By generation 3 we see a different pattern: there is less overall separation between pre-velar and non-pre-velar classes, but the trajectories are separate at all points in the vowel with non-pre-velar vowels doing the bulk of shifting, just as was seen in the overall generational results presented in figure 5.4.

/ɛg, eg/ (BEG, VAGUE), meanwhile, are so overlapping as to be indistinguishable for all three generations.

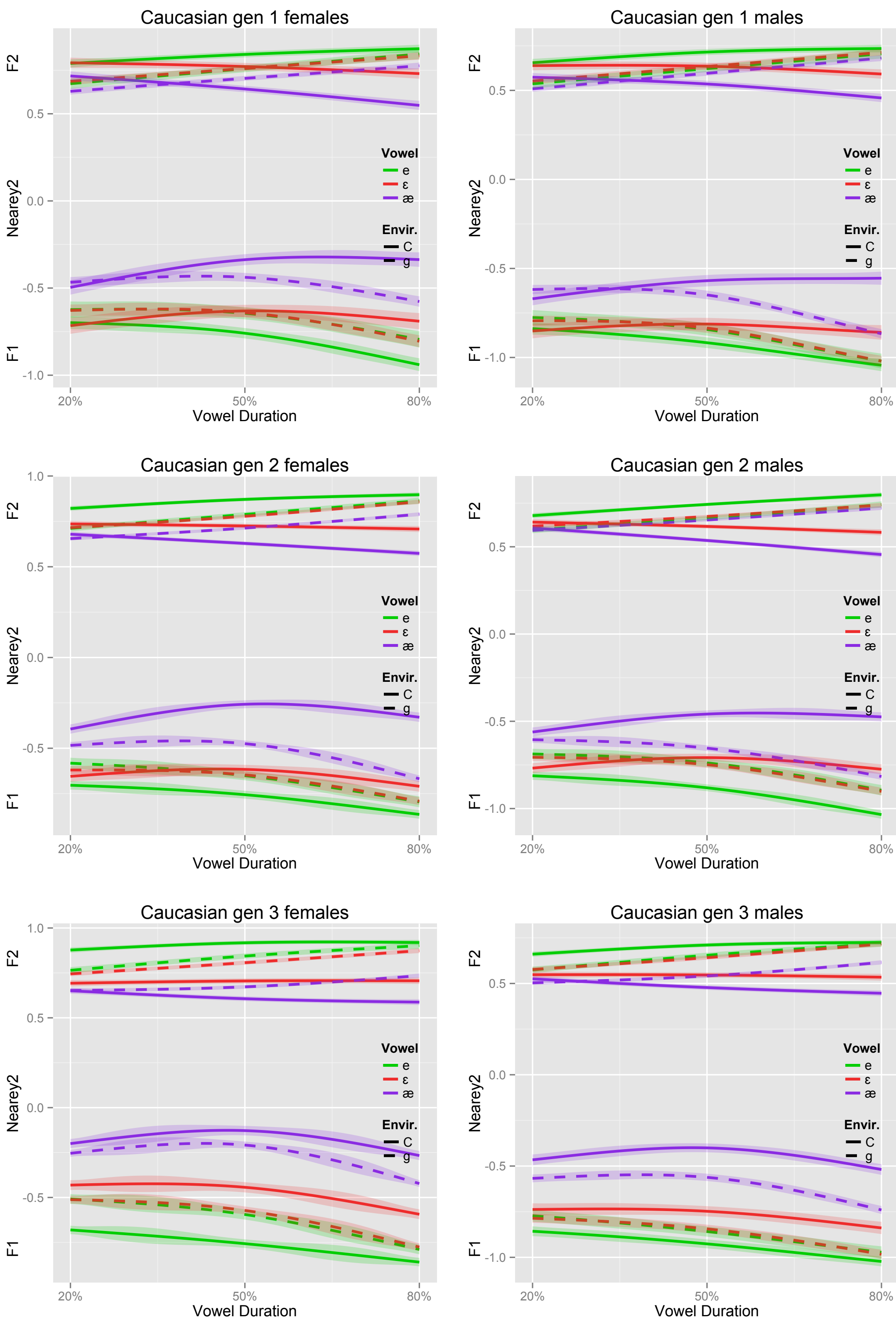


Figure 5.8: Caucasian SS-ANOVA plots by environment, generation, and gender. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

5.3.3 Japanese Americans

Vowel Plots

Figure 5.9 plots the Japanese American male and female front vowel spaces by word class.

Though generation 1 Japanese American females and males resemble each other, some differences emerge for generation 2 and 3 speakers, likely due to the low number of speakers in these cells. Generation 2 males have very different looking distributions, which all tend to raise rather than front. Generation 2 and 3 females show a large degree of overlap within the front vowel space, with non-pre-velar /æ/ (TRAP) partially overlapping with /ɛ/ (DRESS), and the single generation 3 female is extremely advanced, with no overlap whatsoever between /æg, æ/ (BAG, TRAP).

The cross-generational patterns visible in the Japanese American subsample are somewhat different from those of the Caucasian subsample. For generation 1 there is little raising of /æg, ɛg/ (BAG, BEG), and little lowering of /eg/ (VAGUE). By generation 2 we see a configuration more similar to that of the Caucasian speakers: an overlapping /ɛg, eg/ (BEG, VAGUE) and a strongly raised /æg/ (BAG). Generation 3 males look very similar to generation 2, but with differently-shaped distributions.

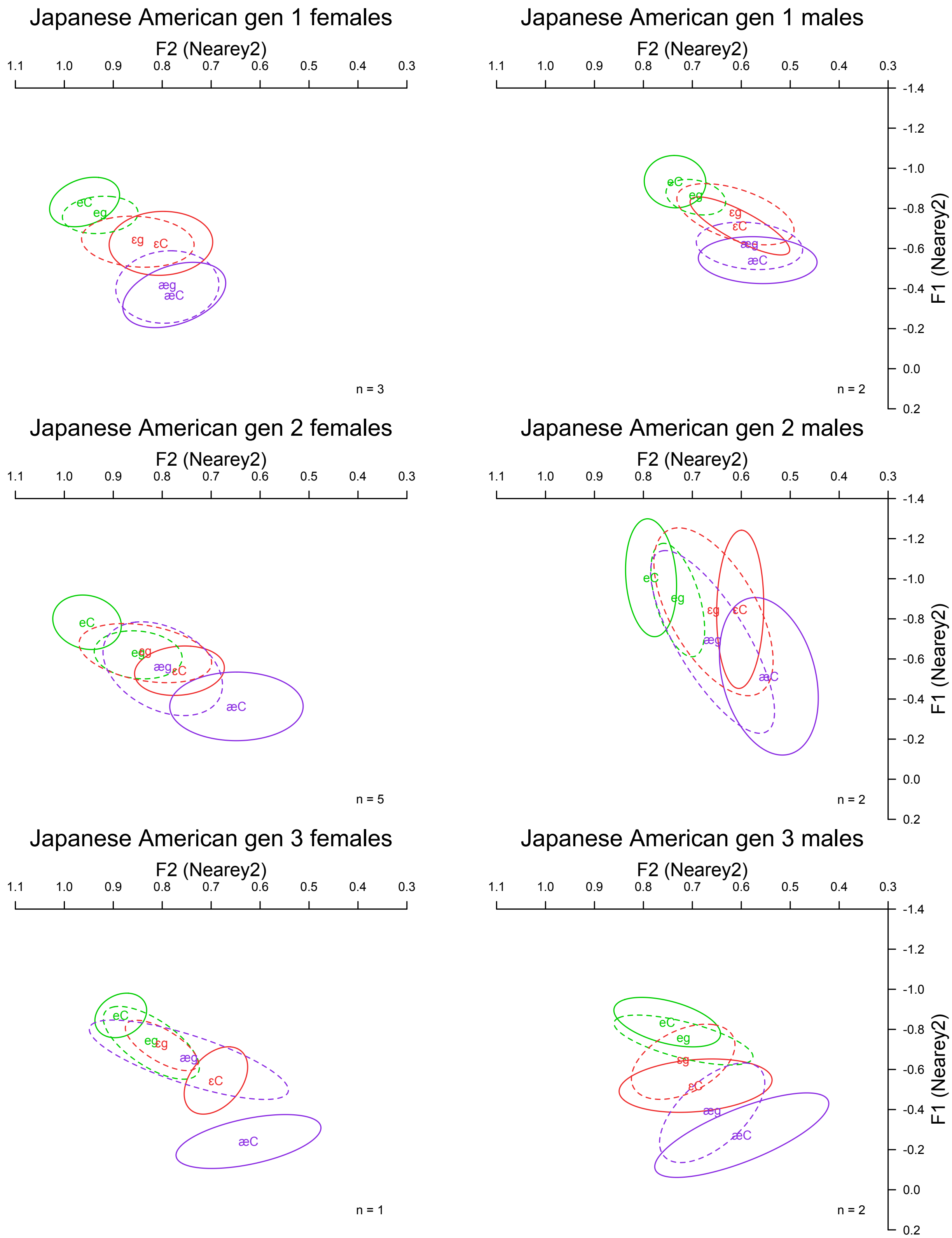


Figure 5.9: Japanese American front vowel means by environment, generation, and gender (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

Formant Trajectories

Figure 5.10 plots SS-ANOVA models by generation and environment.

As suggested by figure 5.9, Japanese American females and males look similar for generation 1, but diverge in generations 2 and 3. The generation 2 males show lots of movement in F1, while generation 2 and 3 females show extreme /æg/-raising (BAG), with /æg, ɛ, ɛg/ (BAG, DRESS, BEG) all in close proximity. In fact, the single generation 3 female looks like she has a near three-way merger between /æg, ɛg, eg/ (BAG, BEG, VAGUE) in the spectral location between /ɛ, e/ (DRESS, FACE), making her by far the most innovative speaker in the sample.

Looking across apparent time, a pattern very similar to the Caucasians, but with more variation, emerges. Generation 1 speakers show little separation in F1 at onset, but separation at offset, while generation 2 speakers have a more dramatic curvature, with separation by the midpoint. Generation 3 males seem to be trending in the direction of the Caucasians in figure 5.8, as they are close to having separation at all points between pre-velar and non-pre-velar vowels.

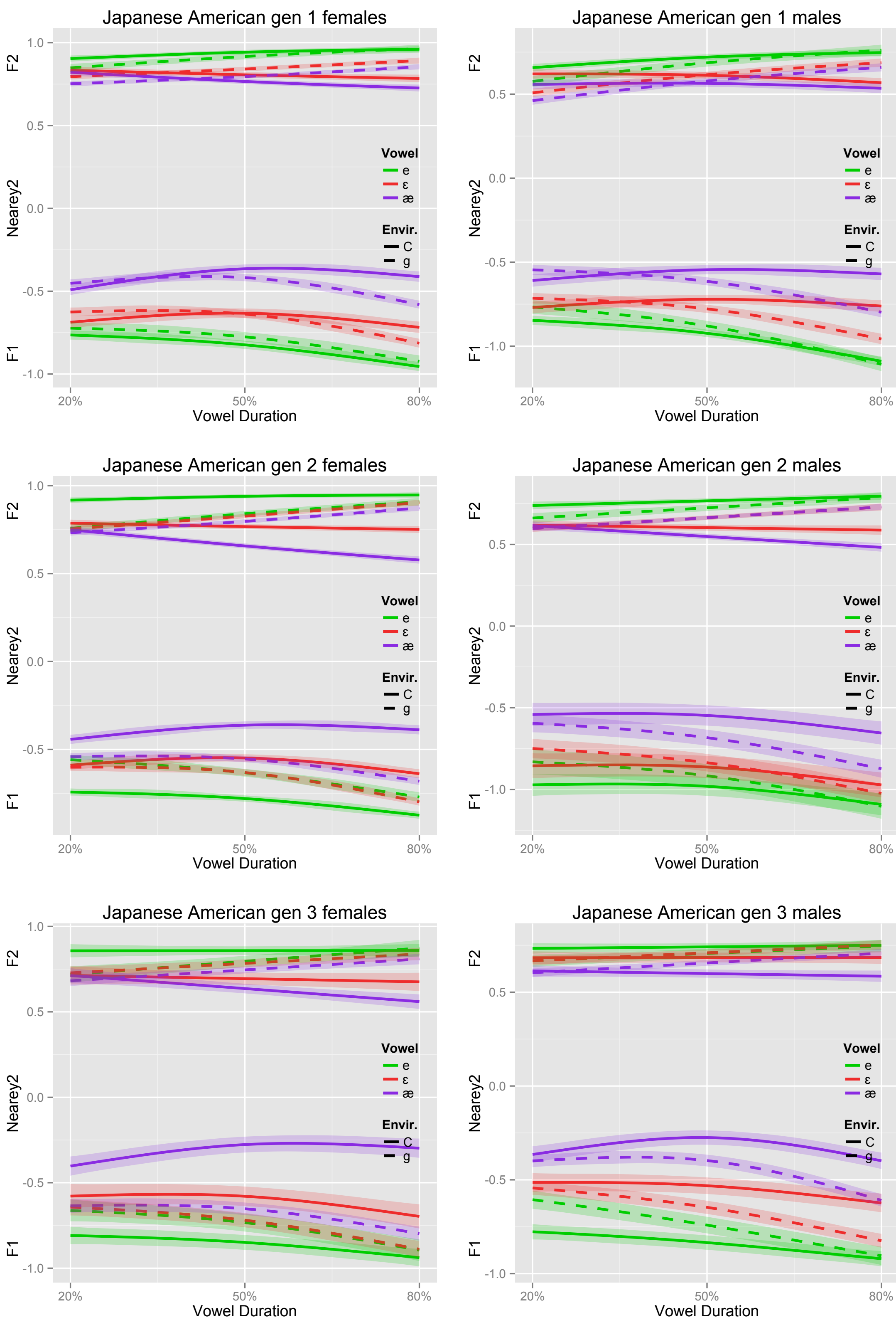


Figure 5.10: Japanese American SS-ANOVA plots by environment, generation, and gender. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

5.3.4 Mexican Americans

Vowel Plots

Figure 5.11 plots the Mexican American male and female front vowel spaces by word class.

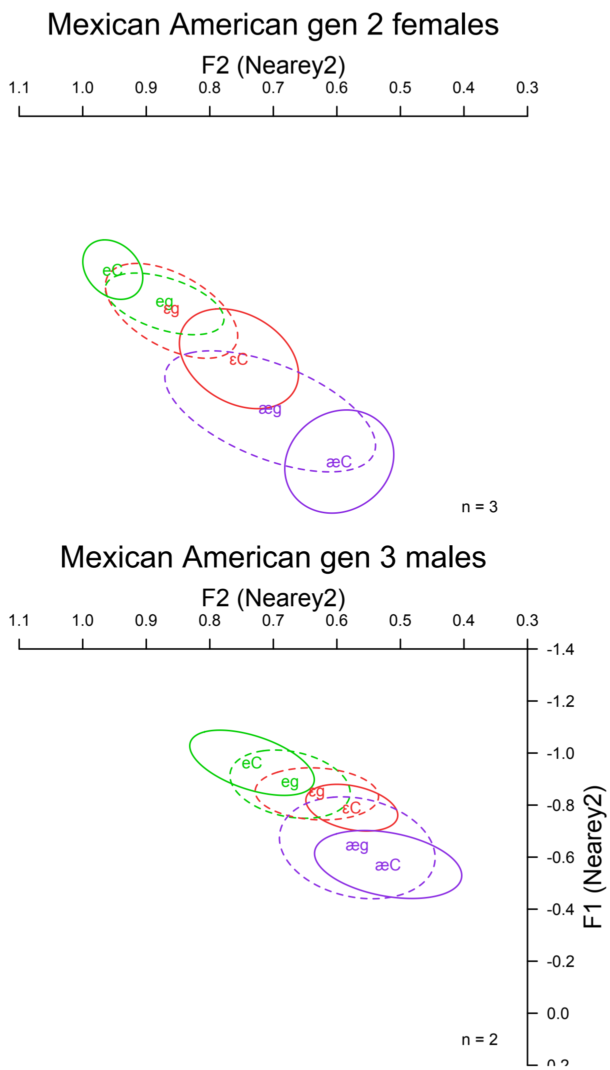


Figure 5.11: Mexican American front vowel means by environment, generation, and gender (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

Unlike Japanese Americans and Caucasians, Mexican American males and females show slightly different front vowel systems. Both generations of females look very much like Caucasians, with a raised /æg/ (BAG), overlapping /ɛg, eg/ (BEG, VAGUE), and possibly with even more separation between non-pre-velar /ɛ, e/ (DRESS, FACE). Males don't show the same tendencies: there is more overlap in the male vowel system in general, but with less overlap with /ɛg, eg/ (BEG, VAGUE) and a smaller amount of /æg/-raising (BAG).

Much like the Caucasian Americans and Japanese Americans, the generational picture shows middle aged speakers (females) leading younger speakers in /æg/-raising (BAG).

Formant Trajectories

Figure 5.12 plots SS-ANOVA models by generation and environment.

Vowel trajectories for (generation 3) male and female Mexican Americans don't differ markedly, although males appear to have much less distance between word classes, and less separation at onset.

Like we've seen in previous plots, generation 3 appears to show flatter non-pre-velar trajectories, that at least for the females are nearly separate from pre-velar classes at all points, though non-pre-velar classes don't appear to shift as dramatically as for Caucasians and African Americans.

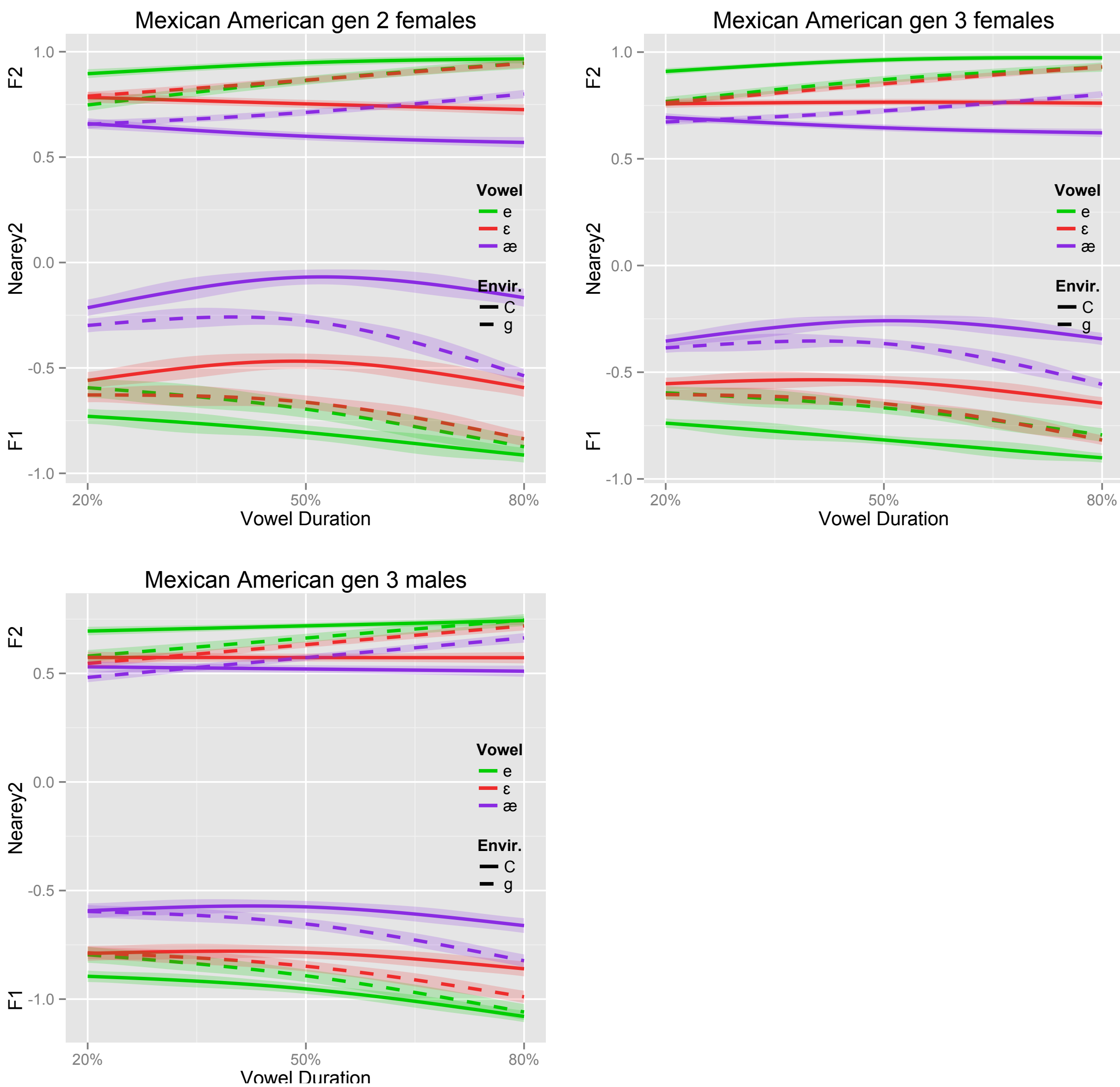


Figure 5.12: Mexican American SS-ANOVA plots by environment, generation, and gender. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

5.3.5 Yakama Nation

Vowel Plots

Figure 5.13 plots the Yakama Nation male and female front vowel spaces by word class.

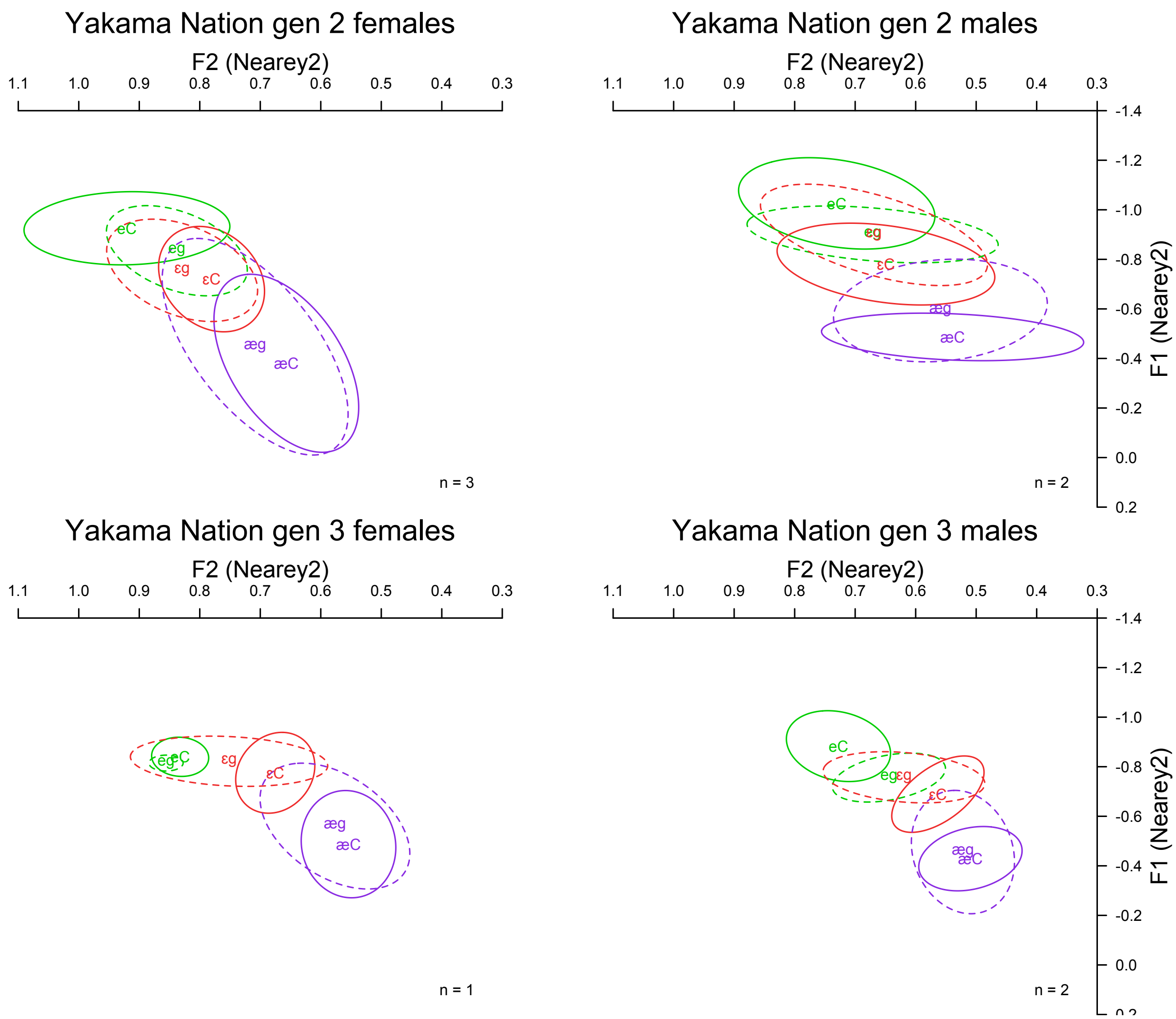


Figure 5.13: Yakama Nation front vowel means by environment, generation, and gender (midpoint). Vowel indicated by color, following class by linetype, ellipses at the 95% CI.

The Yakama Nation vowel space looks different from the other ethnicities examined here, being rather heterogeneous across both gender and generation.

There are some clear differences between males and females, at least in generation 2. Generation 2 females appear to favor raising, whereas males appear to favor fronting.

The generational picture is also different than the other data examined so far. For generation 2, there appears to be much more variability and overlap in the vowel space in general, although general patterns, such as /æg/-raising (BAG) and the overlap of /ɛg, eg/ (BEG, VAGUE) are rather similar to other ethnicities. Generation 3 speakers look more like other ethnicities, with smaller distributions, and a more typical (for the Northwest) pre-velar pattern.

Formant Trajectories

Figure 5.14 plots SS-ANOVA models by generation and environment.

Looking at vowel trajectories, Yakama Nation speakers continue to differentiate themselves from the other ethnicities in the study. There is much less /æg/-raising over all, and although males and females show similar patterns, pre-velar and non-pre-velar classes don't differ as markedly in F2, and although the classes appear to be separate in F1 by offset, there is less distance between them.

Many of the same things could be said about the generational picture of the Yakama Nation subsample. Generations 2 and 3 look roughly similar, although generation 2, as for other ethnicities, appears to lead slightly in /æg/-raising (BAG), although neither generation really shows much in the way of /æg/-raising (BAG).

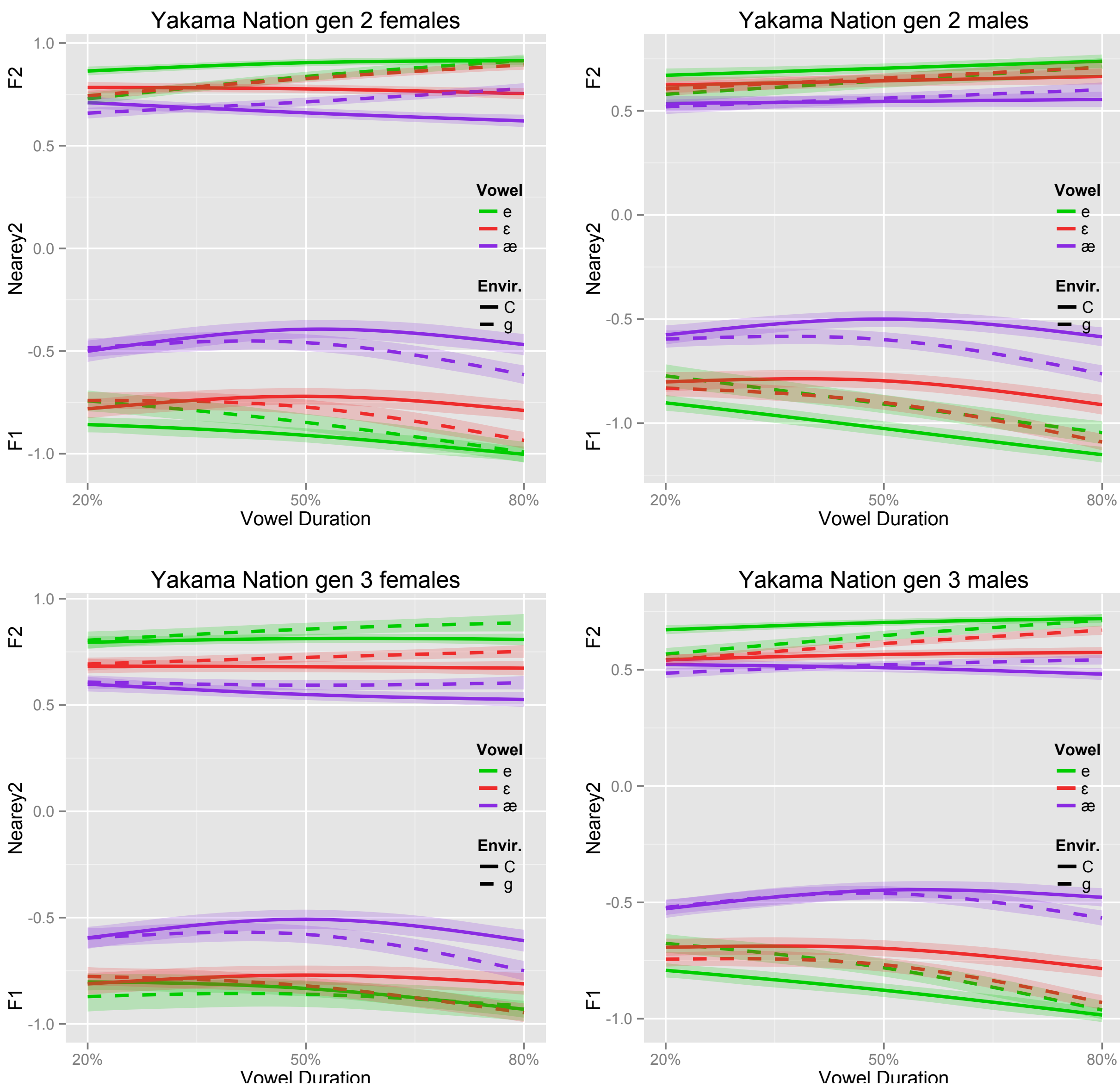


Figure 5.14: Yakama Nation SS-ANOVA plots by environment, generation, and gender. Vowel indicated by color, following environment by linetype, shading at the 95% CI.

5.3.6 Overlap

Table 5.3 presents overlap fractions by ethnicity for all logical pairings.

Overlap fractions by ethnicity confirm many of the patterns seen in the vowel plots.

Table 5.3: VOIS3D overlap fractions by ethnicity (midpoint)

Ethnicity	**æg/ɛg**	**æg/eg**	**æg/e**	**ɛg/eg**	**ɛg/e**	**eg/e**	**Approximation**
African American	0.2	0.1	0.00	0.64*	0.03	0.11	0.55
Caucasian	0.29*	0.28*	0.03	0.63*	0.15	0.21*	0.57
Japanese American	0.31*	0.31*	0.12	0.5*	0.04	0.15	0.55
Mexican American	0.2	0.24*	0.08	0.54*	0.19	0.28*	0.5
Yakama Nation	0.19	0.23*	0.1	0.67*	0.15	0.28*	0.54
Overall	0.24*	0.23*	0.07	0.59*	0.12	0.21*	0.54

** Partially merged, ** Fully merged*

All ethnicities substantially overlap /ɛg, eg/ (BEG, VAGUE) (though none reach the total overlap threshold), but there is some variability in the raising and overlap of /æg/ (BAG). Caucasians and Japanese Americans show the highest /æg, ɛg/ (BAG, BEG) overlap fractions, but while every other ethnicity shows an equal or lesser /æg, eg/ (BAG, VAGUE) overlap score relative to their /æg, ɛg/ (BAG, BEG) overlap fractions, Yakama Nation and Mexican American speakers both show a slight increase. There is also substantial lowering of the /eg/ (VAGUE) class with African Americans and Japanese Americans having full separation.

Looking at the bigger picture, it is apparent that, despite some small differences in overlap scores, all ethnicities are comparable, and have very similar Approximation scores.

5.4 Inferential Statistics

Having seen an interesting set of patterns in preceding plots and tables, it also is important to test these patterns. The following sections present linear regression models testing the relationships in the data in terms of Approximation, Duration, and Displacement.

After fitting each model, Q-Q plots were created and diagnostic tests were performed to ensure that no assumptions were violated.

5.4.1 Duration

Duration is the last piece of the puzzle with respect to the merger status of these speakers, insofar as it may lead to an increase or decrease in overlap fractions. Durations were normalized using Z-scores, then averaged by speaker and word class.

Like Approximation, the statistical model was the result of multiple linear regressions created by adding and removing predictors. In this case however, the predictors used were linguistic in nature, rather than social. Table 5.4 is the final Duration model, with the intercept set to /e/ (FACE) and non-pre-velar following environment.

Table 5.4: Linear regression model for Duration

Coefficients	**Estimate**	**Std. Error**	t **value**	**Pr** $> (\|t\|)$
(intercept)	0.764	0.067	11.376	$< 2 * 10^{-16***}$
/ɛ/	−1.506	0.095	−15.845	$< 2 * 10^{-16***}$
/æ/	−0.517	0.095	−5.437	$9.23 * 10^{-8***}$
/g/	−0.891	0.095	−9.375	$< 2 * 10^{-16***}$
/ɛ/ + /g/	1.110	0.134	8.258	$1.94 * 10^{-15***}$
/æ/ + g/	0.730	0.134	5.434	$9.38 * 10^{-8***}$

*p<0.1; **p<0.05; ***p<0.01

Observations: 426

R^2: 0.438, Adjusted R^2: 0.431

Residual Std. Error: 0.566 (df = 420)

F Statistic: 65.451 (df = 5; 420) (p = $< 2.2 * 10^{-16***}$)

Results show that vowel and following environment, along with the interaction between the two, are all significant predictors of Duration. Non-pre-velar /e/ (FACE) is much longer than non-pre-velar /ɛ/ (DRESS), but only somewhat longer than non-pre-velar /æ/ (TRAP), neither of which are surprising given /e/'s (FACE) status as a (minor) diphthong. Interestingly though, /eg/ (VAGUE) is substantially shorter than /e/ (FACE), while /ɛg/ (BEG) is longer than /ɛ/ (DRESS). Although their means are still significantly different, this shift could indicate that they're converging in length, being already very overlapping spectrally. /æ/ (TRAP) also gets longer in the pre-velar environment although it remains close to the grand mean.

5.4.2 Approximation

In order to ascertain whether a composite of overlap fractions can be used to describe some of the relationships visible in plots of the data, multiple regression runs were conducted using Approximation and a number of the predictors in the data.

The statistical model was created by adding and removing predictors to obtain best fit (i.e. the highest f-statistic, and lowest p value). The first model contained only generation (used as a factor with generation 2 set to the intercept, based on the observation that generation 2 appears to lead in raising). Adding gender improved the model's fit, but ethnicity (with Caucasians set as the intercept) did not. SEC (as a factor, and as numeric) and the interaction of SEC and ethnicity both decreased model fit, as did adding region, both as a ternary variable (west-central-east) and as a binary one (west-east). Regionality and Network Bias also failed to improve model fit. The last variable added was NSS, which came up as a significant effect, and improved overall model fit. Table 5.5 is the final Approximation model.

Table 5.5: Linear regression model for Approximation

Coefficients	**Estimate**	**Std. Error**	t **value**	**Pr** $> (\|t\|)$
(intercept)	0.435	0.066	6.6	$8.76 * 10^{-09***}$
Generation 1	-0.046	0.046	-0.998	0.321
Generation 3	-0.076	0.034	-2.254	0.028^{*}
Male	0.058	0.032	1.79	$0.078^{\cdot}$
NSS	0.015	0.006	2.347	0.022^{**}

*p<0.1; **p<0.05; ***p<0.01

Observations: 70

R^2: 0.19, Adjusted R^2: 0.14

Residual Std. Error: 0.128 (df = 65)

F Statistic: 3.808 (df = 4; 65) (p = 0.008^{**})

Results show a significant effect for generation 3 with an estimated decrease in Approximation, but not for generation 1. Gender was not significant, however Network Strength Score was significant, with a positive estimate for higher values of the variable, indicating that speakers at both ends of the NSS scale have significantly different means such that the higher the NSS, the higher the Approximation score.

5.4.3 Displacement

SS-ANOVA plots for most groupings showed that generation 3 speakers appeared to have flatter trajectories for non-pre-velar vowels. In order to test this, the change in (normalized) formant values over the duration of the non-pre-velar vowels was calculated using generation as a numeric predictor, with the expectation that there will be a more traditional, linear change over time in this case. Table 5.6 is the final Displacement model.

Results show that there is a significant effect for generation, such that there is a de-

Table 5.6: Linear regression model for Displacement

Coefficients	**Estimate**	**Std. Error**	t **value**	**Pr** $> (\|t\|)$
(intercept)	0.246	0.024	10.319	$< 2 * 10^{-16***}$
Generation	-0.024	0.010	-2.408	0.017^{**}
*p<0.1; **p<0.05; ***p<0.01				
Observations: 213				
R^2: 0.027, Adjusted R^2: 0.022				
Residual Std. Error: 0.107 (df = 211)				
F Statistic: 5.800 (df = 1; 211) (p = 0.017^{**})				

crease in Displacement from generations 1 to 3 (i.e. younger speakers have flatter trajectories than do older ones).

5.5 *Discussion*

The above results show that Northwest speakers of all ethnicities and generations are participating in /æg, ɛg/-raising (BAG, BEG) and /eg/-lowering (VAGUE). It also appears that /ɛg, eg/ (BEG, VAGUE) are in near-merger position, being measurably separate on the basis of Duration, if nothing else. Given that the location of the near-merged /ɛg, eg/ (BEG, VAGUE) pair is in the spectral location between /ɛ, e/ (BEG, VAGUE; as shown in both vowel and SS-ANOVA plots) it would appear to be a merger of approximation, that is, the gradual approximation of two categories which often ends up in an intermediate location between the original two categories (Labov, 1994). This meshes well with previous findings on the merger of /ɛg, eg/ (BEG, VAGUE) in the Northwest (Riebold, 2012; Wassink, 2011), and further differentiates Northwest pre-velar raising from that found in Wisconsin, where it has been claimed that the /eg/ (VAGUE) word class may have been reanalyzed as /æg/ (BAG), possibly heralding a merger between those classes (Zeller, 1997). /æg/ (BAG) on the other hand does not appear to be merging with any other word class, remaining partly overlapping with /æ/ (TRAP), and partly between /æ/ (TRAP) and /ɛ/ (DRESS).

Although there is some variation across gender in the ethnic subsamples, particularly in the Japanese American and Mexican American subsamples, it may be the result of a few particularly innovative speakers in a relatively small sample. Otherwise, the overall results suggest that females and males have the same fundamental system. Where there is variation between genders, females usually appear to be more advanced, though these differences aren't statistically significant. Still, this a null result, and thus should not be taken as conclusive proof that there is *no* gender differentiation. It may indeed be the case that, as has been found elsewhere (Labov, 1990) (§2.1.3), females do actually lead, but that given the late stage of this change the differences simply aren't pronounced enough (D'Arcy, in press) to reach statistical significance.

Cross-ethnically there are some interesting results in the data. Although all ethnicities raise /æg, ɛg/ (BAG, BEG) and lower /eg/ (VAGUE), there is of course some variation within these patterns. Much of this variation occurs with the /æg/ word class (BAG): Japanese American generation 2 and 3 females show very raised tokens, and although the males appear to be trending in the direction of the other subsamples, they remain different from them. These results may be indicative of a difference between the Japanese American subsample and the rest of the subsamples, or they may reflect uneven sampling or other uncontrolled-for factors. As for the other subsamples, African Americans and Yakama Nation speakers appear to be the most conservative groupings, but as with gender statistical analysis suggests that there aren't any statistically reliable differences here. Due to sampling issues, however, we must be cautious about drawing too many firm conclusions from their data.

The cross-generational picture is intriguing. Although the peak in /æg, ɛg/-raising (BAG, BEG) for generation 2 speakers has puzzled researchers in the Northwest for some time (Freeman, 2014b; Riebold, 2014b; Wassink, 2015a; Wassink & Riebold, 2013), these results suggest that while this is a statistically significant pattern, it isn't the whole story. Generation 3 speakers remain "raised" by all definitions, but overall the cross-generational results of most ethnicities show that their non-pre-velar classes are shifting in F1 and flattening in F1 and F2 (signaled by significant a decrease in Displacement for the younger speakers[1]), leading to separation in F1 at all points in vowel duration.

There are a number of possible explanations for this. One is that the peak in apparent time (and by extension the differences observed between generations 2 and 3) is due to incrementation, a well-known phenomenon where the incremental change in the use of a variable from one generation to the next creates a peak in apparent time. Unfortunately, this explanation can be rejected out of hand, as the incrementation-type peak in apparent time always occurs for speakers in the late teens or early 20's (approximately 17–21) (D'Arcy, in press), whereas it is the middle-aged speakers who show a peak in this study. In addition, although the PNWE study has respondents as young as 18, most of the generation 3 subsample are in their 20's, and thus, even if there is an incrementation-like peak in pre-velar raising, we likely don't have enough teenaged speakers to be able to see it.

Another possible explanation is that the changes in the trajectories and distributions of the non-pre-velar word classes are the result of other changes ongoing in the region. /æ/-backing (BAG) as part of the CVS is extensive in Canada (Boberg, 2008; Swan, 2014) and California (Labov et al., 2006) (where it is part of front vowel lowering more generally), and is under study in the Northwest as well. If generation 3 speakers are beginning to participate in the CVS, with /g/ acting as a preserving environment, that could lead to the sudden separation of the classes. However, this does not appear to be the case, as there is no evidence that the /æ/ (TRAP) word class for the speakers in this study is backing in a way that might be expected from speakers participating in the CVS. Rather both /æ/ (TRAP) and /ɛ/ (DRESS) are lowering (primarily at onset) for most younger speakers, while remaining in approximately the same F2 location, and it's this which creates separation between pre-velar and non-pre-velar word classes.

---

[1]Although generation was a significant predictor of Displacement, Displacement may not be the most accurate way to quantify the changes seen in the vowel space as it does not take into account the spacing between word classes, which is major difference between the generations in this study.

A third potential cause of this pattern is a sudden change in the social evaluation of pre-velar raising (Freeman, 2014a). If pre-velar raising has begun to index some social characteristic, for example "Northwesternness", generation, or even social class, it could lead to a decrease in the overall rate of pre-velar raising as speakers seek to distance themselves from a social grouping they do not see themselves as part of. Although I am not aware of any negative evaluations associated with pre-velar raising, and indexicality alone would not explain the shift in non-pre-velar word classes, it is still a distinct possibility. It may even be an inevitability, as no vernacular form can go unnoticed forever.

A final possible explanation for this phenomenon is a split, similar to that found in /æ/ (TRAP) in New York City and the Mid-Atlantic region (Labov et al., 2006; see also §2.2.2). Due to the impending merger of /ɛg, eg/ (BEG, VAGUE), and the raising and fronting of /æg/ (BAG), it may be that the pre-velar and non-pre-velar word classes in the speech of generation 2 were so drastically different that generation 3 speakers reanalyzed them as being distinct, resulting in a split between /æ, ɛ, e/ (TRAP, DRESS, FACE) and /æg, ɛg~eg/ (BAG, BEG~VAGUE). This would explain why the distributions of the pre-velar classes seem to change relatively little from generation 2 to generation 3, while the non-pre-velar classes have begun flattening and distributing themselves in F1, particularly at onset, the former site of overlap between pre-velar and non-pre-velar word classes. The flattening of the non-pre-velar word classes would also explain the apparent decrease in /æg/-raising (BAG), as the changing shape of the trajectory brings the midpoints of pre-velar and non-pre-velar /æ/ (TRAP, BAG) slightly closer to one another. The changes seen in the non-pre-velar word classes could thus be a way of reestablishing equilibrium in a system that has recently had a great deal of instability. If reanalysis has indeed taken place, it may signal the end of this change in progress, but unfortunately it will be some years before this can be conclusively assessed. In order to establish that this is truly the case, a more detailed look at the front vowel system is required (i.e. a comprehensive analysis of all phonological environments), and we must see a subsequent generation of speakers with a system very similar or identical to that of the generation 3 speakers in this study, with the merger or near merger of /ɛg, eg/

(BEG, VAGUE) between /ɛ/ (DRESS) and /e/ (FACE), the /æg/ (BAG) word class spectrally between /æ/ (TRAP) and /ɛ/ (DRESS), and separation at all points between pre-velar and non-pre-velar vowels. On the other hand, if /æ, ɛ/ (TRAP, DRESS) are beginning to raise in other phonological environments parallel to their pre-velar counterparts as has been suggested by some research (Riebold, 2012; Wassink & Riebold, 2013) (but for which this study finds no direct evidence), then the picture may become even more complex in the future.

Statistical analysis also showed no significant effects were found for SEC. This may indicate that pre-velar raising does not index SEC, which might be expected due to the lack of any widespread social evaluation of the feature, but given the uneven distribution of SEC in the sample, it is likely that even a reliable pattern would not have been statistically significant. It is possible, however, that the analysis of other forms in the PNWE study (i.e. stigmatized ones such as "Warshington", or ethnolectal features such as from AAE) may still pattern by SEC, or through an interaction with ethnicity and SEC.

Returning to indexicality, the lack of statistically-reliable differences between ethnicities and socioeconomic classes may actually support the assertion that pre-velar raising does not index any particular social grouping or characteristic (positive or negative) in the Northwest. If pre-velar raising truly is linguistically "neutral", we might predict the participation of all ethnicities and social classes simply because the variable is not yet doing any social "work", and cannot yet act to stratify society. Given that pre-velar raising is now or will soon be a sociolinguistic marker (as is suggested by Wassink et al., 2009) though, we may expect this state of affairs to change.

The last interesting result of the statistical analysis is the significance of Network Strength Score in predicting Approximation ratings, with higher NSS scores yielding higher Approximation scores. That stronger local ties lead to more participation in pre-velar raising suggests that the phenomenon may be a regional norm, with participation "enforced" by strong ties and dense networks (Cubitt, 1973; Labov, 1973; J. Milroy & Milroy, 1997). This is also an important validation of the PNWE Study's implementation of NSS as a metric, and is encouraging for the use of it in future research. That Regionality and Network Bias weren't significant is interesting. In the case of the former, it may have to do with the fact that peers are a more important influence in the acquisition of dialect features than parents are, which is part of the calculation of NSS, but does not factor into Regionality. As for the latter, this is somewhat surprising, given that the ethnicities do differ markedly in terms of mean Bias scores, with a high of 0.01 for Japanese Americans, and a low of -0.68 for the Yakama Nation. It may be the case that our implementation of Network Bias is not fine-grained enough to capture the variation.

Following the above discussion, we confirm H_2 (generational differences) and H_3 (ethnicity differences), and tentatively reject H_1 (gender differences) for RQ_{2c}.

Chapter 6

SUMMARY

This dissertation has been concerned with two primary goals, one dialectological, and one sociophonetic. The first was to describe the general vowel space of Northwest English, and to characterize and quantify the changes going on in the front vowel space. The second was to situate those results within the social landscape of the region, by looking at the effects of gender, generation, and ethnicity, and by leveraging social network analytic techniques in addition to sociophonetic analysis.

It began with a summary of theoretical foundations of this study. Following this was a review of recent literature showing that non-White ethnicities do, in fact, make use of regional dialect features in many areas. Next there was a brief history of the Northwest, with particular attention paid to the ethnicities of interest to this paper, along with a summary of the current state of scholarship on Northwest English. Finally, the section ended with a description of pre-velar raising, and the phonetic and lexical factors that may have contributed to its appearance.

The overall vowel space results section showed that, in general, Northwest English speakers have a vowel space fairly similar to that of other dialect regions in the West. Northwesterners don't show evidence of front vowel lowering, associated with the CVS, and show /u, o/ (GOOSE, GOAT) fronting comparable to that of California, but still not quite as advanced.

In comparison with non-western dialects of American English, the Northwest looks very different. It doesn't show evidence of the Northern Cities Shift or the Southern Vowel Shift, with the most distinguishing features being generally higher low vowels, /u/-fronting (GOOSE), and strong /ʊ/-fronting (FOOT), in addition to the pre-velar raising/lowering discussed in chapter 5.

As for gender and generation, the vowel space looks fairly stable across both of these dimensions, particularly for the larger subsamples, like Caucasians. The general patterns seen in the data are the presence of the low-back merger, a canonical-looking front vowel space (from the perspective of /hVd/ data), with /ɪ/ (KIT) lowered and backed somewhat in proximity with /e/ (FACE), and fronting of /u, ʊ/ (GOOSE, FOOT), all of which hold across generation and gender with little substantial variability.

The cross-ethnic picture of the data is somewhat more variable, but nonetheless exhibits the same basic patterns, namely, fronting of /u, ʊ/ (GOOSE, FOOT), etc. There is some variation here across both genders and generations, but where it is most prominent is in those cells with particularly low numbers of speakers. Thus, it is difficult to conclude whether this is true variation or simply the result of some unusually conservative or advanced speakers.

The second focus of this dissertation, pre-velar-raising, has yielded some interesting results. Despite some variation across gender in the various ethnic subsamples, just as in the vowel system in general, females and males appear to have the same basic system, supported by statistical analysis which found no significant effect for gender.

Looking across ethnicity, all ethnicities raise /æg, ɛg/ (BAG, BEG) and lower /eg/ (VAGUE), but as with gender, statistical analysis suggests that there aren't any reliable differences between them, which has potential implications for sociolinguistic theory, in so far as it is further evidence of non-White participation in regional dialects.

The cross-generational results confirm the peak in /æg, ɛg/-raising (BAG, BEG) in generation 2, but additional analyses using SS-ANOVAs and multiple regression suggest that there is more to the story. Generation 3 speakers of all ethnicities show shifted non-pre-velar word classes, with significantly flatter F1 and F2 trajectories, resulting in separation between pre-velar and non-pre-velar classes in F1 at all points in vowel duration. This may signal the beginnings of a split, as younger speakers reinterpret pre-velar and non-pre-velar vowels as being distinct, and would explain the apparent decrease in raising from generation

2 to generation 3 as having to do with a movement of non-pre-velar /æ, ɛ/ (TRAP, DRESS), rather than a change in the amount of raising. In order to confirm or reject this hypothesis, however, further studies will have to be performed some years in the future, both in order to establish stability and to explore the rest of the front vowel space.

In addition, although the /æg/ (BAG) word class is substantially raised for many speakers, it appears to be occupying the spectral area in between /æ, ɛ/ (TRAP, DRESS), in much the same way that /ɛg, eg/ (BEG, VAGUE) are merging between their respective non-pre-velar distributions.

Regression runs also show that higher Network Strength Scores are predictive of higher Approximation scores, which may indicate that pre-velar raising is a local norm. Regionality was not significant, suggesting that a speaker's place of birth (so long as the speaker moved to the Northwest within the critical period) and parents do not have a significant effect on pre-velar raising.

Inferential testing of Duration suggests that, while /ɛg, eg/ (BEG, VAGUE) are certainly merging spectrally, Duration is keeping them measurably (if not perceptually) distinct, as has been found with other mergers (Fridland, Kendall, & Farrington, 2014). The mean durations for /ɛg, eg/ (BEG, VAGUE) are approaching each other, however, so total spectrotemporal merger may be close at hand.

Chapter 7
CONCLUSIONS

In conclusion, this dissertation has shown that speakers of Northwest English have a vowel system somewhat different from that of California, and significantly different from those of other US dialect regions, characterized primary by a lack of participation in the other vowel shifts ongoing around the country (Labov et al., 2006), in addition to fronting of /u, ʊ/ (GOOSE, FOOT), the near-merger of /ɛg, eg/ (BEG, VAGUE), and the raising of /æg/ (BAG).

Following a potential split of the word classes involved in the change, the resulting system may be progressing towards stability with differentiation between /æ/ (TRAP), /æg/ (BAG), /ɛ/ (DRESS), /ɛg~eg/ (BEG~VAGUE), and /e/ (FACE), although future studies are required in order to confirm or deny this.

The Northwest English speech community also appears rather homogenous within generation, without large differences between social groupings, including ethnicity. This adds to the growing body of evidence showing that non-Whites can and do participate in regional dialect variation. In the case of these data, all the ethnicities sampled appear to be very similar to one another, although participation in local norms does not, of course, rule out the use of ethnolects.

Future directions include a more detailed study of the PNWE Study respondents' network composition and the relationship between that and NSS, a more in-depth study of social class in the region, and more research into the historical story of pre-velar raising through archival data and the analysis of existing materials such as the *Linguistic Atlas of the Pacific Northwest.* Given the limitations of this sample, more speakers from subsequent generations, together with data from a more diverse array of phonological environments and speech styles, are necessary in order to confirm or reject the hypotheses put forward here about the current state of pre-velar raising. In addition to this, new and better methods for the quantification of the changes in vowel trajectory shape and distribution between generations 1 and 3 must be sought. And finally, Northwest English must be the subject of ongoing research, in the hopes of completing the story told by this data.

References

Anderson, B. L. (2002). Dialect leveling and /ai/ monophthongization among African American Detroiters. *Journal of Sociolinguistics*, *6*(1), 86–98.

Anisef, P., & Lanphier, C. M. (2003). *The world in a city.* University of Toronto Press.

Ash, S., & Myhill, J. (1986). Linguistic correlates of inter-ethnic contact. In D. Sankoff (Ed.), *Diversity and diachrony* (pp. 33–44). Philadelphia, PA: John Benjamins Publishing Company.

Assmann, P., & Katz, W. (2000). Time-varying spectral change in the vowels of children and adults. *The Journal of the Acoustical Society of America*, *108*, 1856–1866.

Bailey, G. (2008). Real and apparent time. In J. K. Chambers, P. Trudgill, & N. Schilling-Estes (Eds.), *The handbook of language variation and change* (Vol. 24, pp. 312–332). Malden, MA: Wiley-Blackwell.

Bailey, G., & Maynor, N. (1989). The divergence controversy. *American Speech*, *64*(1), 12–39.

Bailey, G., Wikle, T., Tillery, J., & Sand, L. (1991). The apparent time construct. *Language Variation and Change*, *3*(3), 241–264.

Baker, A., Mielke, J., & Archangeli, D. (2008). More velar than /g/: Consonant coarticulation as a cause of diphthongization. In C. B. Chang & H. J. Haynie (Eds.), *Proceedings of the 26th West Coast Conference on Formal Linguistics* (pp. 60–68). Somerville, MA: Cascadilla Proceedings Project.

Bauer, M., & Parker, F. (2008). /æ/-raising in Wisconsin English. *American Speech*, *83*(4), 403–431.

Bayley, R., & Santa Ana, O. (2004). Chicano English grammar. In B. Kortmann, E. W. Schneider, K. Burridge, R. Mesthrie, & C. Upton (Eds.), *A handbook of va-*

rieties of English: Morphology and syntax (Vol. 2, pp. 167–183). Berlin: Mouton de Gruyter.

Becker, K. (2010). *Regional dialect features on the Lower East Side of New York City: Sociophonetics, ethnicity, and identity* (Unpublished doctoral dissertation). New York University.

Becker, K., Aden, A., Best, K., & Jacobson, H. (2015). *Variation in West Coast English: The case of Oregon.* Paper presented at the 2015 annual meeting of the American Dialect Society, Portland, OR.

Benson, E. J., Fox, M. J., & Balkman, J. (2011). The bag that Scott bought: The low vowels in Northwest Wisconsin. *American Speech*, *86*(3), 271–311.

Berner, R. C. (1991). *Seattle in the 20th century* (Vol. 3). Seattle, WA: Charles Press.

BlackPast.org. (2015). http://www.blackpast.org/timeline-state/washington.

Boberg, C. (2008). Regional phonetic differentiation in Standard Canadian English. *Journal of English Linguistics*, *36*(2), 129–154.

Boersma, P., & Weenink, D. (2015). *Praat: Doing phonetics by computer.* http://www.praat.org/.

Bortoni-Ricardo, S. M. (1987). *The urbanization of rural dialect speakers: A sociolinguistic study in Brazil.* Cambridge, MA: Cambridge University Press.

Bucholtz, M., & Hall, K. (2005). Identity and interaction: A sociocultural linguistic approach. *Discourse Studies*, *7*(4-5), 585–614.

Cedergren, H. (1988). The spread of language change: Verifying inferences of linguistic diffusion. In P. H. Lowenberg (Ed.), *Language spread and language policy: Issues, implications and case studies* (pp. 45–60). Washington, DC: Georgetown University Press.

Chambers, J. K. (2000). Region and language variation. *English World-Wide*, *21*(2), 169–199.

Chambers, J. K. (2002). Dynamics of dialect convergence. *Sociolinguistics*, *6*(1), 117–130.

Chambers, J. K. (2003). *Sociolinguistic theory* (2nd ed.). Malden, MA: Wiley-Blackwell.

Clopper, C. G., Pisoni, D. B., & de Jong, K. (2005). Acoustic characteristics of the vowel systems of six regional varieties of American English. *Journal of the Acoustical Society of America*, *118*(3), 1661–1676.

Conn, J. (2000). *The story of /æ/ in Portland* (Unpublished master's thesis). Portland State University.

Conn, J. (2002). *It's not all rain and coffee: An investigation into the western dialect of Portland, Oregon.* Paper presented at New Ways of Analyzing Variation 31, Stanford, CA.

Conn, J. (2006). Dialects in the mist (Portland, OR). In W. Wolfram & B. Ward (Eds.), *American voices: How dialects differ from coast to coast* (pp. 149–155). Malden, MA: Wiley-Blackwell.

Cubitt, T. (1973). Network density among urban families. In *Network analysis: Studies in human interaction* (pp. 67–82). The Hague, NL: De Gruyter Mouton.

D'Arcy, A. (in press). Variation, transmission, incrementation. In P. Honeybone & J. Salmons (Eds.), *The Oxford handbook of historical phonology* (pp. 583–602). Oxford: Oxford University Press.

Eckert, P. (2005). *California vowels.* http://www.stanford.edu/~eckert/vowels.html.

Esling, J. H., & Warkentyne, H. J. (1993). Retraction of/æ/in Vancouver English. *Focus on Canada*, *11*, 229–246.

Evans, B. (2011). "Seattletonian" to "Faux Hick": Mapping perceptions of English in Washington State. *American Speech*, *86*(4), 383–413.

Foster, D. W., & Hoffman, R. J. (1966). Some observations on the vowels of Pacific Northwest English (Seattle area). *American Speech*, *41*(2), 119–122.

Fought, C. (1999). A majority sound change in a minority community: /u/-fronting in Chicano English. *Journal of Sociolinguistics*, *3*(1), 5–23.

Fought, C. (2002). Ethnicity. In J. K. Chambers, P. Trudgill, & N. Schilling-Estes (Eds.), *The handbook of language variation and change* (pp. 444–472). Malden, MA: Wiley-Blackwell.

Fox, M. J. (2013). *Quantifying cross-dialectal consonant variation in vowel-to-consonant coarticulation using locus equations* (Unpublished master's thesis). University of North Carolina.

Freeman, V. (2014a). Bag, beg, bagel: Prevelar raising and merger in Pacific Northwest English. *University of Washington Working Papers in Linguistics*, *32*.

Freeman, V. (2014b). BAG, BEG, BAGEL*: Prevelar raising and merger in Seattle Caucasians.* Paper presented at New Ways of Analyzing Variation 43, Chicago, Oct. 23–26.

Freeman, V. (2015). *Perceptual distribution of merging phonemes.* Paper presented at the 41st annual meeting of the Berkeley Linguistics Society, Berkeley, CA.

Fridland, V. (2003). Network strength and the realization of the Southern Vowel Shift among African Americans in Memphis, Tennessee. *American Speech*, *78*(1), 3–30.

Fridland, V., & Bartlett, K. (2006). The social and linguistic conditioning of back vowel fronting across ethnic groups in Memphis, Tennessee. *English Language and Linguistics*, *10*(1), 1–22.

Fridland, V., Kendall, T., & Farrington, C. (2014). Durational and spectral differences in American English vowels: Dialect variation within and across regions. *The Journal of the Acoustical Society of America*, *136*(1), 341–349.

Gal, S. (1978). Peasant men can't get wives: Language change and sex roles in a bilingual community. *Language in Society*, *7*(1), 1–16.

Gamboa, E. (1981). Mexican immigration into Washington State: A history, 1940–1950. *Pacific Northwest Quarterly*, *72*(3), 121–131.

Gu, C. (2002). *Smoothing spline ANOVA models.* New York, NY: Springer.

Gu, C. (2014). Smoothing spline ANOVA models: R package gss. *Journal of Statistical Software*, *58*(5), 1–25. Retrieved from http://www.jstatsoft.org/v58/i05/

Hagiwara, R. (1997). Dialect variation and formant frequency: The American English vowels revisited. *The Journal of the Acoustical Society of America*, *102*(1), 655–658.

Hall-Lew, L. (2009). *Ethnicity and phonetic variation in a San Francisco neighborhood* (Unpublished doctoral dissertation). Stanford University.

Hargus, S., & Beavert, V. (2014). Northwest Sahaptin. *Journal of the International Phonetic Association*, *44*, 319-242.

Hartley, L. (1999). A view from the West: Perceptions of U.S. dialects by Oregon residents. In D. R. Preston (Ed.), *The handbook of perceptual dialectology* (Vol. 1, pp. 315–332). Philadelphia, PA: John Benjamins Publishing Company.

Hlavac, M. (2014). stargazer: LaTeX/HTML code and ASCII text for well-formatted regression and summary statistics tables [Computer software manual]. Cambridge, USA. (R package version 5.1, http://CRAN.R-project.org/package=stargazer)

Hoffman, M. F., & Walker, J. A. (2010). Ethnolects and the city: Ethnic orientation and linguistic variation in Toronto English. *Language Variation and Change*, *22*, 37–67.

Holmquist, J. C. (1988). *Language loyalty and linguistic variation: A study in Spanish Cantabria*. Berlin: Mouton de Gruyter.

Horvath, B., & Sankoff, D. (1987). Delimiting the Sydney speech community. *Language in Society*, *16*, 179–204.

Hymes, D. (1974). *Foundations in sociolinguistics: An ethnographic approach*. Philadelphia, PA: University of Pennsylvania Press.

Ingle, J. K., Wright, R., & Wassink, A. (2005). Pacific Northwest vowels: A Seattle neighborhood dialect study. *The Journal of the Acoustical Society of America*, *117*(4), 2459–2459.

Johnstone, B., Andrus, J., & Danielson, A. E. (2006). Mobility, indexicality, and the enregisterment of "pittsburghese". *Journal of English Linguistics*, *34*(2), 77–104.

Jones, J., & Preston, D. (2006). AAE and identity: Constructing and deploying linguistic resources. *Journal of African Language Learning and Teaching*, *Special issue*. (Festschrift for David Dwyer)

Kerswill, P., & Williams, A. (2005). New towns and koineization: Linguistic and social correlates. *Linguistics*, *43*(5), 1023–1048.

Kirke, K. D. (2005). When there's more than one norm-enforcement mechanism: Accommodation and shift among Irish immigrants to New York City. *University of Pennsylvania Working Papers in Linguistics*, *11*(2).

Krull, D. (1987). Second formant locus patterns as a measure of consonant-vowel coarticulation. *Phonetic Experimental Research at the Institute of Linguistics University of Stockholm*, *5*, 43–61.

Kurath, H., & McDavid, R. (1961). *The pronunciation of English in the Atlantic states: Based upon the collections of the Linguistic Atlas of the Eastern United States.* Ann Arbor, MI: University of Michigan Press.

Labov, W. (1963). The social motivation of a sound change. *Word*, *19*(3), 273–309.

Labov, W. (1966). *The social stratification of English in New York City.* Washington, D.C.: Center for Applied Linguistics.

Labov, W. (1972). *Sociolinguistic patterns.* Philadelphia, PA: University of Pennsylvania Press.

Labov, W. (1973). The linguistic consequences of being a lame. *Language in Society*, *2*(1), 81–115.

Labov, W. (1984). *Field methods of the project on linguistic change and variation.* Southwest Educational Development Laboratory.

Labov, W. (1990). The intersection of sex and social class in the course of linguistic change. *Language Variation and Change*, *2*(2), 205–254.

Labov, W. (1994). *Principles of linguistic change, internal factors* (Vol. 1). Malden, MA: Wiley-Blackwell.

Labov, W. (2001). *Principles of linguistic change, social factors* (Vol. 2). Malden, MA: Wiley-Blackwell.

Labov, W. (2008). Mysteries of the substrate. In M. Meyerhoff & N. Nagy (Eds.), *Social lives in language – sociolinguistics and multilingual speech communities: Celebrating the work of Gillian Sankoff* (pp. 315–326). Philadelphia, PA: John Benjamins Publishing Company.

Labov, W., Ash, S., & Boberg, C. (2006). *The atlas of North American English: Phonetics, phonology and sound change*. Berlin: De Gruyter Mouton.

Labov, W., & Harris, W. A. (1986). De facto segregation of black and white vernaculars. *Diversity and Diachrony*, *53*.

Ladefoged, P., & Johnson, K. (2014). *A course in phonetics*. Cengage Learning.

Lenneberg, E. H. (1967). *Biological foundations of language* (Vol. 68). Malden, MA: Wiley-Blackwell.

Lippi-Green, R. L. (1989). Social network integration and language change in progress in a rural alpine village. *Language in Society*, *18*(2), 213–234.

McCloy, D. R. (2015). phonR: tools for phoneticians and phonologists [Computer software manual]. (R package version 1.0-3)

McLarty, J., & Kendall, T. (2014). *The relationship between the high and mid back vowels in Oregonian English.* Paper presented at New Ways of Analyzing Variation 43, Chicago, IL.

McLarty, J., Kendall, T., & Farringon, C. (2014). Perhaps we used to, but we don't anymore: The habitual past in Oregonian English. In (Vol. 20).

McLarty, J., Kendall, T., & Farringon, C. (in press). Investigating the development of the contemporary Oregonian English vowel system. In V. Fridland, B. Evans, T. Kendall, & A. B. Wassink (Eds.), *Speech in the western states, the Pacific coast* (Vol. 1). Durham, NC: Duke University Press.

Mendoza-Denton, N. C. (1997). *Chicana/Mexicana identity and linguistic variation: An ethnographic and sociolinguistic study of gang affiliation in an urban high school* (Unpublished doctoral dissertation). Stanford University.

Mills, C. (1980). The sociolinguistics of the [ɑ]-[ɒ] merger in Pacific Northwest English: A subjective reaction test. *Papers in Linguistics: International Journal of Human Communication*, *13*(2), 345–388.

Mills, R. V. (1950). *Oregon speechways.* New York, NY: Columbia.

Milroy, J., & Milroy, L. (1978). Belfast: Change and variation in an urban vernacular.

In P. Trudgill (Ed.), *Sociolinguistic patterns in British English* (pp. 19–36). London: Edwin Arnold.

Milroy, J., & Milroy, L. (1985). Linguistic change, social network and speaker innovation. *Journal of Linguistics*, *21*(2), 339–384.

Milroy, J., & Milroy, L. (1997). Network structure and linguistic change. In N. Coupland & A. Jaworski (Eds.), *Sociolinguistics: A reader and coursebook.* New York, NY: St. Martin's Press.

Milroy, L. (2008). *Language and social networks* (Vol. 13). Malden, MA: John Wiley & Sons.

Mitchell, J. C. (1969). The concept and use of social networks. In J. C. Mitchell (Ed.), *Social networks in urban situations.* Manchester, UK: Manchester University Press.

Miyamoto, S. F. (1939). *Social solidarity among the Japanese in Seattle.* Seattle, WA: University of Washington Press.

Mock, C. C. (1991). Impact of the Ozark Drawl: Its role in the shift of the diphthong /ey/. In P. Eckert (Ed.), *New ways of analyzing sound change.* San Diego, CA: Academic Press.

Mufwene, S. S. (1996). The founder principle in creole genesis. *Diachronica*, *13*(1), 83–134.

Nearey, T. M. (1978). *Phonetic feature systems for vowels* (Unpublished doctoral dissertation). University of Alberta.

Nearey, T. M., & Assmann, P. F. (1986). Modeling the role of inherent spectral change in vowel identification. *The Journal of the Acoustical Society of America*, *80*(5), 1297–1308.

Neiwert, D. A. (2005). *Strawberry days: How internment destroyed a Japanese American community.* New York, NY: Palgrave Macmillan.

Okada, H. (1991). Japanese. *Journal of the International Phonetic Association*, *21*(2), 94–96.

Ornstein-Galicia, J. (1984). *Form and function in Chicano English.* Malabar, Florida: Krieger Publishing Company.

Peterson, G. E., & Barney, H. L. (1952). Control methods used in a study of the vowels. *The Journal of the Acoustical Society of America*, *24*, 175–184.

Points, K. M. (2013). *Language use in East Austin, Texas* (Unpublished doctoral dissertation). University of Texas at Austin.

Preston, D. R. (1999). *Handbook of perceptual dialectology* (Vol. 1). Amsterdam, NL: John Benjamins Publishing.

Purnell, T. C. (2008). Prevelar raising and phonetic conditioning: Role of labial and anterior tongue gestures. *American Speech*, *83*(4), 373–402.

R Core Team. (2015). R: A language and environment for statistical computing [Computer software manual]. Vienna, Austria. Retrieved from http://www.R-project.org/

Reed, C. E. (1952). The pronunciation of English in the State of Washington. *American Speech*, *27*(3), 186–189.

Reed, C. E. (1957). Word geography of the Pacific Northwest. *Orbis*, *6*, 86–93.

Reed, C. E. (1961). The pronunciation of English in the Pacific Northwest. *Language*, *37*(4), 559–564.

Reed, C. E. (1965). *Linguistic Atlas of the Pacific Northwest.* http://us.english.uga.edu/cgi-bin/lapsite.fcgi/lapnw/.

Reiff, J. L. (1981). *Urbanization and the social structure: Seattle, Washington, 1852–1910* (Unpublished doctoral dissertation). University of Washington.

Rickford, J. R. (1999). *African American Vernacular English: Features, evolution, educational implications.* Malden, MA: Wiley-Blackwell.

Riebold, J. M. (2009). *Local spoken here: English in Oregon.* Poster presented at New Ways of Analyzing Variation 38, Ottawa, ON, Canada.

Riebold, J. M. (2012). *Please merge ahead: The vowel space of Pacific Northwestern English.* Paper presented at the Northwest Linguistics Conference, University of Washington, Seattle, WA.

Riebold, J. M. (2014a). *The ethnic distribution of a regional change: /æg, ɛg, eg/ in*

Washington State. Paper presented at New Ways of Analyzing Variation 43, Chicago, Oct. 23–26.

Riebold, J. M. (2014b). *Language change isn't only skin deep: Inter-ethnic contact and the spread of innovation in the Northwest* (Generals paper). University of Washington.

Sale, R. (1976). *Seattle, past to present.* Seattle, WA: University of Washington Press.

Sankoff, D., & Sankoff, G. (1973). Sample survey methods and computer-assisted analysis in the study of grammatical variation. In R. Darnell (Ed.), *Canadian languages in their social context* (pp. 7–64). Edmonton, Alberta: Linguistic Research.

Sankoff, G. (2004). Linguistic outcomes of language contact. In J. K. Chambers, P. Trudgill, & N. Schilling-Estes (Eds.), *The handbook of language variation and change* (pp. 638–668). Malden, MA: Wiley-Blackwell.

Sankoff, G., & Blondeau, H. (2007). Language change across the lifespan: /r/ in Montreal French. *Language*, *83*, 560–588.

Santa Ana, O. (1993). Chicano English and the nature of the Chicano language setting. *Hispanic Journal of Behavioral Sciences*, *15*(1), 3–35.

Scanlon, M., & Wassink, A. B. (2010). African American English in urban Seattle: accommodation and intra-speaker variation in the Pacific Northwest. *American Speech*, *82*(2), 205–224.

Shermer, M. (2011). *The believing brain.* New York, NY: Henry Holt & Company.

Silverstein, M. (1976). Shifters, linguistic categories, and cultural description. In K. Basso & H. Selby (Eds.), *Meaning in anthropology* (pp. 11–57). Albuquerque, NM: University of New Mexico Press.

Silverstein, M. (2003). Indexical order and the dialectics of sociolinguistic life. *Language & Communication*, *23*(3), 193–229.

Smitherman, G. (1977). *Talkin' and testifyin': The language of Black America.* Detroit, MI: Wayne State University Press.

Squizzero, R. (2009). *Bulls and bowls in china shops: A perceptual experiment investigating pre-lateral vowels in Seattle English* (Undergraduate thesis). University of Washington.

Statistics Canada. (2011). *Census 2011 profile: Toronto.* https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=3520005&Geo2=PR&Code2=35&Data=Count&SearchText=Toronto&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=3520005.

Stevens, K. N. (2000). *Acoustic phonetics.* Cambridge, MA: MIT press.

Sussman, H. M., Hoemeke, K. A., & Ahmed, F. S. (1993). A cross-linguistic investigation of locus equations as a phonetic descriptor of place of articulation. *Journal of the Acoustical Society of America*, *94*, 1256–1268.

Swan, J. T. (2014). *Sociolinguistic cues and nationality: A comparison of /æ/ among Seattle and Vancouver, B.C. speakers.* Paper presented at the Cascadia Workshop on Sociolinguistics 1, Victoria, B.C., Canada.

Taylor, Q. (1994). *The forging of a Black community: Seattle's Central District, from 1870 through the Civil Rights Era.* Seattle, WA: University of Washington Press.

Thibault, P., & Daveluy, M. (1989). Quelques traces du passage du temps dans le parler des Montréalais, 1971–1984. *Language Variation and Change*, *1*(1), 19–45.

Thibault, P., & Vincent, D. (1990). Un corpus de français parlé. *Recherches Sociolinguistiques*, *1*.

Thomas, E. R. (2001). *An acoustic analysis of vowel variation in New World English.* Durham, NC: Duke University Press.

Thomas, E. R. (2007). Phonological and phonetic characteristics of African American Vernacular English. *Language and Linguistics Compass*, *1*(5), 450–475.

Tittle, L. G. (2007). *Alternatives to authenticity and assimilation: A third-wave approach to the study of dialects* (Unpublished master's thesis). Stanford University.

Trudgill, P. (1988). Norwich revisited: recent linguistic changes in an English urban dialect. *English World-Wide*(9), 33–49.

Trudgill, P. (2004). *New-dialect formation: The inevitability of Colonial Englishes.* Edinburgh, Scotland: Edinburgh University Press.

University of Washington Special Collections. (2014). *Japanese Americans in the Pacific Northwest.* http://guides.lib.washington.edu/nikkei.

US Census Bureau. (2010). *American FactFinder.* http://factfinder2.census.gov.

US Census Bureau. (2013a). *Incorporated places and minor civil divisions datasets: Subcounty resident population estimates: April 1, 2010 to July 1, 2012: Washington.* http://www.census.gov/popest/data/cities/totals/2012/files/SUB-EST2012_53.csv.

US Census Bureau. (2013b). *State and county quickfacts: Washington.* http://quickfacts.census.gov/qfd/states/53000.html.

Vaux, B., & Golder, S. A. (2002). *The dialect survey.* http://www4.uwm.edu/FLL/linguistics/dialect/index.html.

Ward, M. (2003). *Portland Dialect Study: The fronting of /ow, u, uw/ in Portland, Oregon* (Unpublished master's thesis). Portland State University.

Wassink, A. B. (2006). A geometric representation of spectral and temporal vowel features: Quantification of vowel overlap in three linguistic varieties. *The Journal of the Acoustical Society of America*, *119*(4), 2334–2350.

Wassink, A. B. (2011). Vowel reduction and merger in Pacific Northwest English. *The Journal of the Acoustical Society of America*, *129*(4), 2452–2452.

Wassink, A. B. (2014). *Vowel raising in Washington English: Whats the* BAG *deal?* Paper presented at Cascadia Workshop in Sociolinguistics 1, University of Victoria, Victoria, BC.

Wassink, A. B. (2015a). *Dialect evolution in the Pacific Northwest: Reanalysis and conventionalization of a universal phonetic pattern.* Plenary presentation given at the 89th Annual Meeting of the Linguistic Society of America, Portland, OR.

Wassink, A. B. (2015b). Sociolinguistic patterns in Seattle English. *Language Variation and Change*, *27*, 31–58.

Wassink, A. B. (submitted). *Dialect contact in Seattle English. Journal of English Linguistics*.

Wassink, A. B., & Koops, C. (2013). *Quantifying and interpreting vowel formant trajectory information.* Paper presented at New Ways of Analyzing Variation 42, Pittsburgh, PA.

Wassink, A. B., & Riebold, J. M. (2013). *Individual variation and linguistic innovation in the American Pacific Northwest.* Paper presented at the Chicago Linguistic Society 49 Workshop on Sound Change Actuation.

Wassink, A. B., Squizzero, R., Schirra, R., & Conn, J. (2009). *Effects of style and gender on fronting and raising of /æ/, /e:/ and /ɛ/ before /g/ in Seattle English.* Paper presented at New Ways of Analyzing Variation 38, Ottawa, ON, Canada.

Wellman, B. (1997). Structural analysis: From method and metaphor to theory and substance. *Contemporary Studies in Sociology*, *15*, 19–61.

Wells, J. C. (1982). *Accents of English* (Vol. 1). Cambridge, MA: Cambridge University Press.

Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis.* New York, NY: Springer. (http://had.co.nz/ggplot2/book)

Wickham, H. (2011). The split-apply-combine strategy for data analysis. *Journal of Statistical Software*, *40*(1), 1–29. Retrieved from http://www.jstatsoft.org/v40/i01/

Wolfram, W. (1969). *A sociolinguistic description of Detroit Negro speech.* Arlington, VA: Center for Applied Linguistics.

Wolfram, W., Carter, P., & Moriello, B. (2004). Emerging Hispanic English: New dialect formation in the American South. *Journal of Sociolinguistics*, *8*(3), 339–358.

Wolfram, W., & Schilling-Estes, N. (1998). *American English: Dialects and variation.* Malden, MA: Wiley-Blackwell.

Wolfram, W., & Thomas, E. R. (2002). *The development of African American English.* Malden, MA: Wiley-Blackwell.

Wright, R. A., & Souza, P. (2012). Comparing identification of standardized and regionally valid vowels. *Journal of Speech, Language, and Hearing Research*, *55*, 182–193.

Yuan, J., & Liberman, M. (2008). Speaker identification on the SCOTUS corpus. *Journal of the Acoustical Society of America*, *123*(5), 3878.

Zeller, C. (1997). The investigation of a sound change in progress: /æ/ to /e/ in Midwestern American English. *Journal of English Linguistics*, *25*(2), 142–155.

APPENDIX A: DEMOGRAPHIC QUESTIONNAIRE

PART II: DEMOGRAPHIC AND SOCIAL NETWORK QUESTIONNAIRE

****To be completed individually and delivered orally, with responses written by interviewer. Write additional comments in margins, below.**

I. Personal Background and Linguistic Repertoire

1. What neighborhood/city/town do you live in? ________________________________
   Do you think the neighborhoods/cities/towns are really different from each other? (If yes, how?)

2. ☐Male ☐Female

3. What year were you born? __________________

4a. How would you describe the social class of your family growing up? (if appropriate)
☐ Working Class ☐ Middle Class ☐ Upper Class

4b. How would you describe your social class now? (if appropriate)
☐ Working Class ☐ Middle Class ☐ Upper Class

5a. Where were you born? (city/town)___________________________________
(neighborhood/suburb)____

5b. Are there any other places you've lived (for more than 6 continuous months/location)? Can you remember how old you were when you lived in each location?:

Place	Length of time there	Ages

6a. Where was your mother/primary caregiver born? (city/town)___________________

(state)____________________

6b. Where does your mother/primary caregiver currently live? (city/town)__________________

(state)____________________

6c. If she lived other places (for more than 6 continuous months/location), please list these places here:

____
____

6d. Where was your father/other primary caregiver born? (city/town)_____________________

(state)____________________

6e. Where does your father/other primary caregiver currently live? (city/town)_______________

(state)____________________

6f. If he lived other places (for more than 6 continuous months/location), please list these places here:

____
____

7a. Level of schooling completed:
- ☐ Elementary ☐ Jr. High/High/GED
- ☐ B.A./B.S. ☐ M.A./Ph.D.

7b. Where did you go to high school?

7c. What were the main racial and ethnic groups in your school? (*approx. %, if appropriate*)

(skip if known) 7d. What's your own family's ethnic background? ____________________

8a. What are/were your parents' occupation(s)? ______________________________

8b. What is/was your spouse's occupation? ________________________________

(skip if known) 8c. What is your occupation?__________________________________
- Do you enjoy your job?
- What exactly does it involve?
- So tell me, since you're an expert in this, I've always wondered ...?
- *etc., as appropriate*.

9a. What languages were spoken in your family when you were growing up? Were there any members of your family that had a different dialect from you?

language: ________________ length of time studied: ______________
________________ ______________
________________ ______________
________________ ______________

family member: ____________ place this kin was from: ______________
____________ ______________
____________ ______________
____________ ______________

9b. Have you studied any foreign languages? If so, please answer the following:

language(s): ______________ length of time studied: ______________
______________ ______________
______________ ______________
______________ ______________

II. Social Network

A. Family residence history

1. Was your mother's family from the area?
- ☐ yes. Going back how long? _____ generations (1 pt.)
- ☐ no. They moved here in ________

2. Was your father's family from the area?
- ☐ yes. Going back how long? _____ generations (1 pt.)
- ☐ no. They moved here in ________

3. Is/was your mother involved in many local activities? (1 pt.)
(ex. local community groups, church, local politics, neighborhood watch, etc.)
☐ yes. What were they? ____________________
☐ no.

4. Is/was your father involved in many local activities? (1 pt.)
☐ yes. What were they? ____________________
☐ no.

5. Is/was your grandmother involved in many local activities? (.5 pt.)
☐ yes. What were they? ____________________
☐ no.

6. Is/was your grandfather involved in many local activities? (.5 pt.)
☐ yes. What were they? ____________________
☐ no.

7. (If applicable) Has your spouse's family lived the area for a long time?
☐ unmarried.
☐ yes. How long? __ generations (1 pt.)
☐ no. We moved here in ___.

8. Do you have close relatives (visit or talk to regularly) living in the area?
☐ yes. Where? (1 pt.) ____________________
☐ no.

9. Do you have close relatives (visit or talk to regularly) living in other towns or states?
☐ yes. Where? ____________________
Have you visited them? ☐no ☐yes ☐I have visited several times
☐ no. (1 pt.)

B. Nature of working relationships

10. Have you always worked in the area?
☐ yes. (1 pt.)
☐ no. Where else? ____________________

11. Have you ever worked outside the area?
☐ yes.
☐ no. (1 pt.)

12. Are any of your co-workers from the area?
☐ yes. (1 pt.)
☐ no.

13. Are any of your co-workers related to you?
☐ yes. (1 pt.)
☐ no.

14. Do you spend time outside of work with any of your co-workers?
☐ yes. (1 pt.)
☐ no.

15. In your work, do you meet any people from other parts of the U.S.?
    - ☐ yes.
    - ☐ no. (1 pt.)

C. Voluntary Association

16. Are you involved in any social activities in this area?
    - ☐ yes. What? ____
      (1 pt. for each organization)
    - ☐ no.

17. Do you have close friends who were born and raised here (yes/no)? ____________
    If yes, roughly how many? _________

18. Do they live in this area?
    - ☐ yes. (1 pt.)
    - ☐ mostly, yes. (.5 pt.)
    - ☐ mostly, no.
    - ☐ no.

19. Think of the 10 people you talk to most frequently. Can you tell me their gender, how they identify ethnically (African-American, Anglo-American, Asian, Native –American etc.), and where they live. Don't tell me their name. If it would help you remember everyone, you can jot it down on a piece of paper and then tell me their gender, ethnicity and where they live.

#	Neighborhood	Ethnicity (circle one)	Gender	Code (e.g. SAF)
1		Af-Am As-Am His-Am Ang-Am N-Am		
2		Af-Am As-Am His-Am Ang-Am N-Am		
3		Af-Am As-Am His-Am Ang-Am N-Am		
4		Af-Am As-Am His-Am Ang-Am N-Am		
5		Af-Am As-Am His-Am Ang-Am N-Am		
6		Af-Am As-Am His-Am Ang-Am N-Am		
7		Af-Am As-Am His-Am Ang-Am N-Am		
8		Af-Am As-Am His-Am Ang-Am N-Am		
9		Af-Am As-Am His-Am Ang-Am N-Am		
10		Af-Am As-Am His-Am Ang-Am N-Am		

20. Would you say that your types of close friends have changed since you were younger? How? (e.g., some people might say their friends now are of different social classes, races, from different parts of the country than when they were younger)?

APPENDIX B: WORDLIST (2012)

actually
aid
angry
aunt
awed
babble
babe
back
bad
bade
bag
bagel
bail
bait
bake
balance
ban
bane
bang
bap
bare
base
bash
bass
bat
bath
bathe
beat
beckon
bed
beg
beige
bell
Ben
Ben Gay
Bess
best
bet
Beth
bide
big
Bill
bin
boat
boot
bowl
Boyd
brag
bug
bull
bust
but
button
calm
car
caught
choice
cot
cough
couldn’t
crack
crag
creek
dad
dance
date
dawn
day
dead
den
dew
did
didn’t
din
do
dog
doll
Don
door
dot com
down
duck
dull
egg
face
fail
fair
family
fast
father
fear
feel

fell
fight
fill
food
fool
foot
full
funny
fur
girl
goat
good
gosh
grandma
guy
had
hall
ham
hang
hard
hat
hate
head
heard
heat
heed
height
hett
hid
hidden
hide
hill
hit
hittin'
hitting
hode
hole
home
hood
hoot
hot
house
how'd
Hoyt
hud
hurt
hut
job
Kay
kitten
lag
lane
language
leg
leggings
Len
length
mangy
marry
Mary
mash
measure
merry
mesh
mess
method
mice
might
milk
mine
miss
mountain
move
my
nag
negative
nice
night
noise
now
oat
odd
off
often
on
Oregon
other
ought
out
pa
paced
pagan
pal
pan
pause
paw
paws
peg
pen
phone
pie
pin
plague
plaque
pool
posh
Powell
pragmatic
pull
push
put
regular

rider
roof
room
root
route
sat
say
school
set
side
sight
sit
sort
south
spider
stain
suit
take
talk
tan
tang
ten
that
thick
thought
tide
tie
tight
tile
time
tire
toast
tock
ton
took
tore
tour
tower
Tuesday
until
up
vague
wash
Washington
who'd
wise
writer
zoo

APPENDIX C: WORDLIST (2013)

actually
angry
aunt
awed
babble
babe
back
bad
bag
bagel
bail
bait
bake
balance
ban
bang
bare
bash
bat
bath
bathe
beat
beckon
beg
beige
bell
Ben
bet
Beth
big
bill
bin
bitten
boat
bog
boot
bowl
Boyd
brag
bug
bull
but
button
calm
car
cat
catch
caught
choice
cot
couldn't
crack
creek
dad
dance
dangerous
dawn
day
dead
deck
den
dew
didn't
dig
din
do
dog
doll
don
dot com
down
drag
dragging
dragon
duck
dull
eager
eagle
egg
English
fail
fair
family
father
fear
feel
fell
fill
fish
food
fool
foot

full
funny
fur
garbage
girl
goat
good
gosh
grandma
had
hall
ham
hang
hard
hat
hatch
hate
head
heard
heed
height
hid
hidden
hide
hill
hitting
hode
hole
home
hood
house
how'd
hudd
Kay
king
kitten
lack
lag
lane
language
leg
leggings
Len
length
mad
magnet
make
marry
Mary
mean
measure
merry
method
mice
might
milk
mine
mountain
move
my
nag
negative
next
odd
off
on
Oregon
pa
pace
pagan
pain
painkillers
pal
pan
pass
passage
pause
paw
paws
peek
peg
pen
pest
phone
pick
pie
pin
plague
pool
posh
Powell
pull
raincoat
regular
rider
roof
room
root
route
sat
say
school
selfish
set
shellfish
sit
six
sort
south
speak
spider
stain

strength
suit
take
talk
tan
tang
teen
ten
thanks
thick
think
thought
tide
tie
tight
tile
time
tire
toast
tock
ton
took
tore
tour
tower
Tuesday
until
up
vague
village
vogue
wash
Washington
who'd
wise
writer

APPENDIX D: WORKED EXAMPLES

The following are demonstrations of the calculation of Approximation and Displacement for speaker ECL83CM1Z, a generation 1 Caucasian male.

$$Approximation = \frac{/æg,\varepsilon g/OF + /\varepsilon g,eg/OF + (1 - /eg,e/OF)}{3} = \frac{0.1+0.99+(1-0)}{3} = \frac{2.09}{3} = 0.69$$

The calculation of Displacement below is for the /æg/ word class, using mean normalized formant values.

$$/æg/Displacement = |\overline{F1_{\text{onset}}} - \overline{F1_{\text{offset}}}| + |\overline{F2_{\text{onset}}} - \overline{F2_{\text{offset}}}| = |-0.626 - -0.818| + |0.502 - 0.657| = 0.192 + 0.155 = 0.347$$

APPENDIX E: SS-ANOVA SCRIPT

```
# Imports for reshaping data, SS-ANOVA functions, and ggplot
library(ggplot2)
library(grid)
library(gss)
library(reshape2)



# Multiple plot function
#
# ggplot objects can be passed in ..., or to plotlist (as a list of ggplot
   objects)
# - cols:   Number of columns in layout
# - layout: A matrix specifying the layout. If present, 'cols' is ignored.
#
# If the layout is something like matrix(c(1,2,3,3), nrow=2, byrow=TRUE),
# then plot 1 will go in the upper left, 2 will go in the upper right, and
# 3 will go all the way across the bottom.
#
multiplot <- function(..., plotlist = NULL, cols = 1, layout = NULL, title =
   "default") {
    # Make a list from the ... arguments and plotlist
    plots <- c(list(...), plotlist)

    numPlots = length(plots)

    # If layout is NULL, then use 'cols' to determine layout
    if (is.null(layout)) {
        # Make the panel
```

```
        # ncol: Number of columns of plots
        # nrow: Number of rows needed, calculated from # of cols
        layout <- matrix(seq(1, cols * ceiling(numPlots / cols)),
                         ncol = cols, nrow = ceiling(numPlots / cols))
    }

    if (numPlots==1) {
        print(plots[[1]])

    } else {
        # Set up the page
        grid.newpage()

        # Add extra row for title, set heights so that title row is smaller
        pushViewport(viewport(layout = grid.layout(nrow(layout) + 1,
          ncol(layout), heights = unit(c(0.5, rep(5, nrow(layout))),
          "null"))))

        # Make each plot, in the correct location
        for (i in 1:numPlots) {
            # Get the i,j matrix positions of the regions that contain this
              subplot
            matchidx <- as.data.frame(which(layout == i, arr.ind = TRUE))

            print(plots[[i]], vp = viewport(layout.pos.row = matchidx$row + 1,
                                            layout.pos.col = matchidx$col))
        }

        # Add title (defaults to "default")
        grid.text(title, vp = viewport(layout.pos.row = 1, layout.pos.col =
          1:ncol(layout)), gp = gpar(fontsize = 22))
    }
}
```

```
# Extract a legend from a plot
g_legend <- function(a.gplot) {
    tmp <- ggplot_gtable(ggplot_build(a.gplot))
    leg <- which(sapply(tmp$grobs, function(x) x$name) == "guide-box")
    legend <- tmp$grobs[[leg]]
    return(legend)
}


setwd("~/School/UW/Dissertation/Graphics")

# Read in data
data <- read.delim(file = "../Data/Vowel-Data-R.txt", header = T, encoding =
   "UTF-8")

# Reorder vowel factor
data$Vowel <- factor(data$Vowel, levels = c("i", "\U026A", "e", "\U025B",
   "  ", "\U0251", "\U0254", "o", "\U028A", "u"))

# Lowercase gender
data$Gender <- tolower(data$Gender)
data$Gender <- as.factor(data$Gender)

# Set generation to factor
data$Generation <- as.factor(data$Generation)

# Select wordlist, unaspirated, non-outlier tokens from PVR front vowels
data <- droplevels(subset(data, Task == "wordlist" & Aspirated == "n"))

# Collapse # and C environments, set following class to factor
data$Following.Class <- gsub("#", "C", data$Following.Class)
```

```
data$Following.Class <- gsub("G", "g", data$Following.Class)
data$Following.Class <- as.factor(data$Following.Class)

# Create token number
data$Token <- 1:nrow(data)

# Change column names so interval will have correct factors after reshape
colnames(data)[c(29, 30, 31)] = c("20", "50", "80")

# Reshape F1 & F2 values, merge, and fix column name
data.f1 <- melt(data, id.vars = c("Speaker", "Region", "Gender", "Ethnicity",
    "Generation", "Vowel", "Following.Class", "Token"), measure.vars = c("20",
    "50", "80"), variable.name = "Interval", value.name = "F1")
data.f2 <- melt(data, id.vars = c("Speaker", "Region", "Gender", "Ethnicity",
    "Generation", "Vowel", "Following.Class", "Token"), measure.vars =
    c("Normalized.F2.20.", "Normalized.F2.50.", "Normalized.F2.80."),
    variable.name = "Interval", value.name = "F2")
data <- cbind(data.f1, data.f2$F2)
colnames(data)[11] <- "F2"

# Set interval to numeric
data$Interval <- as.numeric(levels(data$Interval))[data$Interval]

# Set line colors
colors <- c("green3", "firebrick2", "blueviolet")
alt_colors <- c("darkolivegreen", "firebrick2", "blueviolet")

# Select only vowels involved in pre-velar raising/lowering
data.pv <- droplevels(subset(data, (Vowel == "  " | Vowel == "\U025B" | Vowel
    == "e")))

# Select only vowels involved in pre-velar raising/lowering
data.npv <- droplevels(subset(data, Following.Class != "g"))
```

```
######################
# Overall (pre-velar) #
######################

# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data = data.pv)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data =
       data.pv)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
       levels(data.pv$Vowel), Following.Class =
       levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Set output file
cairo_pdf("Plots/Group/SS-ANOVA␣(all).pdf", width = 10, height = 10)
```

```
# Set font size
theme_set(theme_gray(base_size = 20))

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel, fill =
    Vowel, linetype = Following.Class))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd =
    2) + geom_line(aes(y = F2.Fit), lwd = 2)

# Plot error bars
formant.comparison <- formant.comparison + geom_ribbon(aes(ymin = F1.Fit -
    (1.96 * F1.SE), ymax = F1.Fit + (1.96 * F1.SE), fill = Vowel), alpha =
    0.2, color = NA, show_guide = F) + geom_ribbon(aes(ymin = F2.Fit - (1.96 *
    F2.SE), ymax = F2.Fit + (1.96 * F2.SE), fill = Vowel), alpha = 0.2, color
    = NA, show_guide = F)

# Scale axes
formant.comparison <- formant.comparison + scale_x_continuous(breaks = c(20,
    50, 80), labels = c("20%", "50%", "80%"))

# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration") + ylab("F1␣␣
    ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2") + ggtitle("All␣
    Speakers")

# Set colors
formant.comparison <- formant.comparison + scale_colour_manual(labels =
    levels(grid$Vowel), values = colors) + scale_fill_manual(labels =
    levels(grid$Vowel), values = colors) + scale_linetype_manual(name =
    "Envir.", values = c("solid", "dashed"))
```

```
# Tweak legend
formant.comparison <- formant.comparison + theme(legend.justification = c(1,
   0.5), legend.position = c(1, 0.5), legend.background = element_rect(fill =
   "transparent"), legend.key = element_blank()) + guides(colour =
   guide_legend(override.aes = list(size = 3)), linetype =
   guide_legend(override.aes = list(size = 1))) + theme(legend.title =
   element_text(size = 18), legend.text = element_text(size = 18),
   legend.key.width = unit(2, "line"))

print(formant.comparison)

# Close device
dev.off()


#################
# Overall (NPV) #
#################

# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Vowel * Interval, data = data.npv)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Vowel * Interval, data = data.npv)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
       levels(data.npv$Vowel))

    # Predict F1/F2, standard error
```

```
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Set output file
cairo_pdf("Plots/Group/SS-ANOVA␣(all,␣NPV).pdf", width = 10, height = 10)

# Set font size
theme_set(theme_gray(base_size = 20))

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd =
   2) + geom_line(aes(y = F2.Fit), lwd = 2)

# Plot error bars
formant.comparison <- formant.comparison + geom_ribbon(aes(ymin = F1.Fit -
   (1.96 * F1.SE), ymax = F1.Fit + (1.96 * F1.SE), fill = Vowel), alpha =
   0.2, color = NA, show_guide = F) + geom_ribbon(aes(ymin = F2.Fit - (1.96 *
   F2.SE), ymax = F2.Fit + (1.96 * F2.SE), fill = Vowel), alpha = 0.2, color
   = NA, show_guide = F)

# Scale axes
formant.comparison <- formant.comparison + scale_x_continuous(breaks = c(20,
   50, 80), labels = c("20%", "50%", "80%"))
```

```
# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration") + ylab("F1␣␣
    ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2") + ggtitle("All␣
    Speakers")

# Tweak legend
formant.comparison <- formant.comparison + theme(legend.justification = c(1,
    0.5), legend.position = c(1, 0.5), legend.background = element_rect(fill =
    "transparent"), legend.key = element_blank()) + guides(colour =
    guide_legend(override.aes = list(size = 3)), linetype =
    guide_legend(override.aes = list(size = 1))) + theme(legend.title =
    element_text(size = 18), legend.text = element_text(size = 18),
    legend.key.width = unit(2, "line"))

print(formant.comparison)

# Close device
dev.off()


#############
# Breakdown #
#############

# Set output file
cairo_pdf("Plots/Group/SS-ANOVA␣(breakdown).pdf", width = 10, height = 15,
    onefile = T)

# Set font size
theme_set(theme_gray(base_size = 12))

for (i in 1:nlevels(data.pv$Ethnicity)) {
```

```
# Reset plot list and counter
plots <- vector("list")
plot.count = 0

# Subset by ethnicity
data.ethnicity <- droplevels(subset(data.pv, Ethnicity ==
   levels(data.pv$Ethnicity)[i]))

for (j in 1:nlevels(data.ethnicity$Generation)) {

    # Subset by generation
    data.generation <- droplevels(subset(data.ethnicity, Generation ==
       levels(data.ethnicity$Generation)[j]))

    for (k in 1:nlevels(data.generation$Gender)) {

        # Increment plot count
        plot.count = plot.count + 1

        # Subset by gender
        data.gender <- droplevels(subset(data.generation, Gender ==
           levels(data.generation$Gender)[k]))

        # Generate SS-ANOVA model for F2
        f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data
           = data.gender)

        # Make sure F1 SE doesn't get crazy. Recreate model if it does
        repeat {
            # Generate SS-ANOVA model for F1
            f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class,
               data = data.gender)
```

```
    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100),
       Vowel = levels(data.pv$Vowel), Following.Class =
       levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color =
   Vowel, fill = Vowel, linetype = Following.Class))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y =
   F1.Fit), lwd = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

# Plot error bars
formant.comparison <- formant.comparison + geom_ribbon(aes(ymin =
   F1.Fit - (1.96 * F1.SE), ymax = F1.Fit + (1.96 * F1.SE), fill
   = Vowel), alpha = 0.2, color = NA, show_guide = F) +
   geom_ribbon(aes(ymin = F2.Fit - (1.96 * F2.SE), ymax = F2.Fit
   + (1.96 * F2.SE), fill = Vowel), alpha = 0.2, color = NA,
   show_guide = F)
```

```
        # Scale axes
        formant.comparison <- formant.comparison +
            scale_x_continuous(breaks = c(20, 50, 80), labels = c("20%",
            "50%", "80%"))

        # Label plot and axes
        formant.comparison <- formant.comparison + xlab("Vowel␣Duration")
            + ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣
            ␣␣␣␣F2") + ggtitle(paste(levels(data.pv$Ethnicity)[i], "␣gen␣
            ", levels(data.ethnicity$Generation)[j], "␣",
            levels(data.generation$Gender)[k], "s", sep = ""))

        # Set colors
        formant.comparison <- formant.comparison +
            scale_colour_manual(labels = levels(grid$Vowel), values =
            colors) + scale_fill_manual(labels = levels(grid$Vowel),
            values = colors) + scale_linetype_manual(name = "Envir.",
            values = c("solid", "dashed"))

        # Tweak legend
        formant.comparison <- formant.comparison +
            theme(legend.justification = c(1, 0.5), legend.position = c(1,
            0.5), legend.background = element_rect(fill = "transparent"),
            legend.key = element_blank()) + guides(colour =
            guide_legend(override.aes = list(size = 1)), linetype =
            guide_legend(override.aes = list(size = 1))) +
            theme(legend.title = element_text(size = 10), legend.text =
            element_text(size = 10), legend.key.height = unit(0.75,
            "line"), legend.key.width = unit(1, "line"))

        plots[[plot.count]] <- formant.comparison
    }
}
```

```
    # Print page
    multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4, 5, 6), nrow =
        3, byrow = T), title = levels(data.pv$Ethnicity)[i])

}

dev.off()



#########################
# Breakdown presentation #
#########################

# Set output file
cairo_pdf("Plots/Group/SS-ANOVA␣(breakdown,␣presentation).pdf", width = 15,
    height = 10, onefile = T)

# Set font size
theme_set(theme_gray(base_size = 12))

for (i in 1:nlevels(data.pv$Ethnicity)) {

    # Reset plot list and counter
    plots <- vector("list")
    plot.count = 0

    # Subset by ethnicity
    data.ethnicity <- droplevels(subset(data.pv, Ethnicity ==
        levels(data.pv$Ethnicity)[i]))

    for (j in 1:nlevels(data.ethnicity$Gender)) {
```

```
# Subset by generation
data.gender <- droplevels(subset(data.ethnicity, Gender ==
    levels(data.ethnicity$Gender)[j]))

for (k in 1:nlevels(data.gender$Generation)) {

    # Increment plot count
    plot.count = plot.count + 1

    # Subset by gender
    data.generation <- droplevels(subset(data.gender, Generation ==
        levels(data.gender$Generation)[k]))

    # Generate SS-ANOVA model for F2
    f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data
        = data.generation)

    # Make sure F1 SE doesn't get crazy. Recreate model if it does
    repeat {
        # Generate SS-ANOVA model for F1
        f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class,
            data = data.generation)

        # Create dummy data
        grid <- expand.grid(Interval = seq(20, 80, length = 100),
            Vowel = levels(data.pv$Vowel), Following.Class =
            levels(data.pv$Following.Class))

        # Predict F1/F2, standard error
        grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
        grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
        grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
        grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit
```

```
    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color =
   Vowel, fill = Vowel, linetype = Following.Class))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y =
   F1.Fit), lwd = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

# Scale axes
formant.comparison <- formant.comparison +
   scale_x_continuous(breaks = c(20, 50, 80), labels = c("20%",
   "50%", "80%"))

# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration")
   + ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣
   ␣␣␣␣F2") + ggtitle(paste("Generation␣",
   levels(data.ethnicity$Generation)[k], "␣",
   levels(data.ethnicity$Gender)[j], "s", sep = ""))

# Set colors
formant.comparison <- formant.comparison +
   scale_colour_manual(labels = levels(grid$Vowel), values =
   alt_colors) + scale_fill_manual(labels = levels(grid$Vowel),
   values = alt_colors) + scale_linetype_manual(name = "Envir.",
   values = c("solid", "dashed"))
```

```
            formant.comparison <- formant.comparison + theme(legend.position
               = "none")

            plots[[plot.count]] <- formant.comparison
        }
    }

    # Print page
    multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4, 5, 6), nrow =
       2, byrow = T), title = levels(data.pv$Ethnicity)[i])

}

dev.off()


##########
# Gender #
##########

cairo_pdf("Plots/Group/SS-ANOVA␣(gender).pdf", width = 10, height = 15,
   onefile = T)

# Reset plot list and counter
plots <- vector("list")
plot.count = 0

# Plot genders (means)
for (i in 1:nlevels(data.pv$Gender)) {

    # Increment plot count
    plot.count = plot.count + 1
```

```
# Subset by gender
data.gender <- droplevels(subset(data.pv, Gender ==
   levels(data.pv$Gender)[i]))

# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data =
   data.gender)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data =
       data.gender)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
       levels(data.pv$Vowel), Following.Class =
       levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel, fill
   = Vowel, linetype = Following.Class))
```

```
# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd
   = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

# Plot error bars
formant.comparison <- formant.comparison + geom_ribbon(aes(ymin = F1.Fit
   - (1.96 * F1.SE), ymax = F1.Fit + (1.96 * F1.SE), fill = Vowel), alpha
   = 0.2, color = NA, show_guide = F) + geom_ribbon(aes(ymin = F2.Fit -
   (1.96 * F2.SE), ymax = F2.Fit + (1.96 * F2.SE), fill = Vowel), alpha =
   0.2, color = NA, show_guide = F)

# Scale axes
formant.comparison <- formant.comparison + scale_x_continuous(breaks =
   c(20, 50, 80), labels = c("20%", "50%", "80%"))

# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration") +
   ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2")
   + ggtitle(paste(levels(data.pv$Gender)[i], "s", sep = ""))

# Set colors
formant.comparison <- formant.comparison + scale_colour_manual(labels =
   levels(grid$Vowel), values = colors) + scale_fill_manual(labels =
   levels(grid$Vowel), values = colors) + scale_linetype_manual(name =
   "Envir.", values = c("solid", "dashed"))

# Tweak legend
formant.comparison <- formant.comparison + theme(legend.justification =
   c(1, 0.5), legend.position = c(1, 0.5), legend.background =
   element_rect(fill = "transparent"), legend.key = element_blank()) +
   guides(colour = guide_legend(override.aes = list(size = 1)), linetype
   = guide_legend(override.aes = list(size = 1))) + theme(legend.title =
```

```
        element_text(size = 10), legend.text = element_text(size = 10),
        legend.key.height = unit(0.75, "line"), legend.key.width = unit(1,
        "line"))

    plots[[plot.count]] <- formant.comparison
}

# Print page
multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4, 5, 6), nrow = 3,
   byrow = T), title = "Gender")

dev.off()


######################
# Gender Presentation #
######################

cairo_pdf("Plots/Group/SS-ANOVA␣(gender,␣presentation).pdf", width = 10,
   height = 5, onefile = T)

# Reset plot list and counter
plots <- vector("list")
plot.count = 0

# Plot genders (means)
for (i in 1:nlevels(data.pv$Gender)) {

    # Increment plot count
    plot.count = plot.count + 1

    # Subset by gender
    data.gender <- droplevels(subset(data.pv, Gender ==
```

```
    levels(data.pv$Gender)[i]))

# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data =
    data.gender)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data =
        data.gender)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
        levels(data.pv$Vowel), Following.Class =
        levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel, fill
    = Vowel, linetype = Following.Class))

# Layer trajectories
```

```
    formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd
       = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

    # Scale axes
    formant.comparison <- formant.comparison + scale_x_continuous(breaks =
       c(20, 50, 80), labels = c("20%", "50%", "80%"))

    # Label plot and axes
    formant.comparison <- formant.comparison + xlab("Vowel␣Duration") +
       ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2")
       + ggtitle(paste(levels(data.pv$Gender)[i], "s", sep = ""))

    # Set colors
    formant.comparison <- formant.comparison + scale_colour_manual(labels =
       levels(grid$Vowel), values = alt_colors) + scale_fill_manual(labels =
       levels(grid$Vowel), values = alt_colors) + scale_linetype_manual(name
       = "Envir.", values = c("solid", "dashed"))

    # Tweak legend
    #formant.comparison <- formant.comparison + theme(legend.justification =
       c(1, 0.5), legend.position = c(1, 0.5), legend.background =
       element_rect(fill = "transparent"), legend.key = element_blank()) +
       guides(colour = guide_legend(override.aes = list(size = 1)), linetype
       = guide_legend(override.aes = list(size = 1))) + theme(legend.title =
       element_text(size = 10), legend.text = element_text(size = 10),
       legend.key.height = unit(0.75, "line"), legend.key.width = unit(1,
       "line"))
    formant.comparison <- formant.comparison + theme(legend.position = "none")

    plots[[plot.count]] <- formant.comparison
}

# Print page
```

```
multiplot(plotlist = plots, layout = matrix(c(1, 2), nrow = 1, byrow = T),
    title = "Gender")

dev.off()


##############
# Generation #
##############

cairo_pdf("Plots/Group/SS-ANOVA␣(generation).pdf", width = 10, height = 15,
    onefile = T)

# Reset plot list and counter
plots <- vector("list")
plot.count = 0

# Plot generations (means)
for (i in 1:nlevels(data.pv$Generation)) {

    # Subset data by current ethnicity
    data.generation <- droplevels(subset(data.pv, Generation ==
        levels(data.pv$Generation)[i]))

    for (j in 1:nlevels(data.generation$Gender)) {

        # Increment plot count
        plot.count = plot.count + 1

        # Subset by gender
        data.gender <- droplevels(subset(data.generation, Gender ==
            levels(data.generation$Gender)[j]))
```

```
# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data =
    data.gender)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data
        = data.gender)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
        levels(data.pv$Vowel), Following.Class =
        levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel,
    fill = Vowel, linetype = Following.Class))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit),
    lwd = 1) + geom_line(aes(y = F2.Fit), lwd = 1)
```

```
# Plot error bars
formant.comparison <- formant.comparison + geom_ribbon(aes(ymin =
    F1.Fit - (1.96 * F1.SE), ymax = F1.Fit + (1.96 * F1.SE), fill =
    Vowel), alpha = 0.2, color = NA, show_guide = F) +
    geom_ribbon(aes(ymin = F2.Fit - (1.96 * F2.SE), ymax = F2.Fit +
    (1.96 * F2.SE), fill = Vowel), alpha = 0.2, color = NA, show_guide
    = F)

# Scale axes
formant.comparison <- formant.comparison + scale_x_continuous(breaks
    = c(20, 50, 80), labels = c("20%", "50%", "80%"))

# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration") +
    ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣
    F2") + ggtitle(paste("Generation␣", levels(data.pv$Generation)[i],
    "␣", levels(data.generation$Gender)[j], "s", sep = ""))

# Set colors
formant.comparison <- formant.comparison + scale_colour_manual(labels
    = levels(grid$Vowel), values = colors) + scale_fill_manual(labels
    = levels(grid$Vowel), values = colors) +
    scale_linetype_manual(name = "Envir.", values = c("solid",
    "dashed"))

# Tweak legend
formant.comparison <- formant.comparison + theme(legend.justification
    = c(1, 0.5), legend.position = c(1, 0.5), legend.background =
    element_rect(fill = "transparent"), legend.key = element_blank())
    + guides(colour = guide_legend(override.aes = list(size = 1)),
    linetype = guide_legend(override.aes = list(size = 1))) +
    theme(legend.title = element_text(size = 10), legend.text =
```

```
            element_text(size = 10), legend.key.height = unit(0.75, "line"),
            legend.key.width = unit(1, "line"))

        plots[[plot.count]] <- formant.comparison
    }
}

# Print page
multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4, 5, 6), nrow = 3,
   byrow = T), title = "Generation")

dev.off()



######################
# Ethnicity Combined #
######################

# Set output file
cairo_pdf("Plots/Group/SS-ANOVA␣(ethnicity␣combined).pdf", width = 15, height
   = 10, onefile = T)

# Set font size
theme_set(theme_gray(base_size = 12))

# Reset plot list and counter
plots <- vector("list")
plot.count = 0

for (i in 1:nlevels(data.pv$Ethnicity)) {
    # Increment plot count
    plot.count = plot.count + 1
```

```
# Subset by ethnicity
data.ethnicity <- droplevels(subset(data.pv, Ethnicity ==
   levels(data.pv$Ethnicity)[i]))

# Generate SS-ANOVA model for F2
f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data =
   data.ethnicity)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data =
       data.ethnicity)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
       levels(data.pv$Vowel), Following.Class =
       levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel, fill
   = Vowel, linetype = Following.Class))
```

```
# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd
   = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

# Scale axes
formant.comparison <- formant.comparison + scale_x_continuous(breaks =
   c(20, 50, 80), labels = c("20%", "50%", "80%"))

# Label plot and axes
formant.comparison <- formant.comparison + xlab("Vowel␣Duration") +
   ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2")
   + ggtitle(levels(data.pv$Ethnicity)[i])

# Set colors
formant.comparison <- formant.comparison + scale_colour_manual(labels =
   levels(grid$Vowel), values = alt_colors) + scale_fill_manual(labels =
   levels(grid$Vowel), values = alt_colors) + scale_linetype_manual(name
   = "Envir.", values = c("solid", "dashed"))

# Tweak legend
#formant.comparison <- formant.comparison + theme(legend.justification =
   c(1, 0.5), legend.position = c(1, 0.5), legend.background =
   element_rect(fill = "transparent"), legend.key = element_blank()) +
   guides(colour = guide_legend(override.aes = list(size = 1)), linetype
   = guide_legend(override.aes = list(size = 1))) + theme(legend.title =
   element_text(size = 10), legend.text = element_text(size = 10),
   legend.key.height = unit(0.75, "line"), legend.key.width = unit(1,
   "line"))
formant.comparison <- formant.comparison + theme(legend.position = "none")

# Print page
plots[[plot.count]] <- formant.comparison
```

```
}

# Print page
multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4, 5, 6), nrow = 2,
   byrow = T), title = "Ethnicity")

dev.off()


######################
# Generation Combined #
######################

cairo_pdf("Plots/Group/SS-ANOVA␣(generation␣combined).pdf", width = 10,
   height = 10, onefile = T)

# Reset plot list and counter
plots <- vector("list")
plot.count = 0

# Plot generations (means)
for (i in 1:nlevels(data.pv$Generation)) {

    # Subset data by current ethnicity
    data.generation <- droplevels(subset(data.pv, Generation ==
       levels(data.pv$Generation)[i]))

    # Increment plot count
    plot.count = plot.count + 1

    # Generate SS-ANOVA model for F2
    f2.model <- ssanova(F2 ~ Interval * Vowel * Following.Class, data =
```

```
   data.generation)

# Make sure F1 SE doesn't get crazy. Recreate model if it does
repeat {
    # Generate SS-ANOVA model for F1
    f1.model <- ssanova(F1 ~ Interval * Vowel * Following.Class, data =
        data.generation)

    # Create dummy data
    grid <- expand.grid(Interval = seq(20, 80, length = 100), Vowel =
        levels(data.pv$Vowel), Following.Class =
        levels(data.pv$Following.Class))

    # Predict F1/F2, standard error
    grid$F1.Fit <- predict(f1.model, newdata = grid, se = T)$fit
    grid$F1.SE <- predict(f1.model, newdata = grid, se = T)$se.fit
    grid$F2.Fit <- predict(f2.model, newdata = grid, se = T)$fit
    grid$F2.SE <- predict(f2.model, newdata = grid, se = T)$se.fit

    if (max(grid$F1.SE) < 0.1) {
        break
    }
}

# Generate plot
formant.comparison <- ggplot(grid, aes(x = Interval, color = Vowel, fill
   = Vowel, linetype = Following.Class))

# Layer trajectories
formant.comparison <- formant.comparison + geom_line(aes(y = F1.Fit), lwd
   = 1) + geom_line(aes(y = F2.Fit), lwd = 1)

# Scale axes
```

```
    formant.comparison <- formant.comparison + scale_x_continuous(breaks =
        c(20, 50, 80), labels = c("20%", "50%", "80%"))

    # Label plot and axes
    formant.comparison <- formant.comparison + xlab("Vowel␣Duration") +
        ylab("F1␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Nearey2␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣F2")
        + ggtitle(paste("Generation␣", levels(data.pv$Generation)[i]))

    # Set colors
    formant.comparison <- formant.comparison + scale_colour_manual(labels =
        levels(grid$Vowel), values = alt_colors) + scale_fill_manual(labels =
        levels(grid$Vowel), values = alt_colors) + scale_linetype_manual(name
        = "Envir.", values = c("solid", "dashed"))

    # Tweak legend
    #formant.comparison <- formant.comparison + theme(legend.justification =
        c(1, 0.5), legend.position = c(1, 0.5), legend.background =
        element_rect(fill = "transparent"), legend.key = element_blank()) +
        guides(colour = guide_legend(override.aes = list(size = 1)), linetype
        = guide_legend(override.aes = list(size = 1))) + theme(legend.title =
        element_text(size = 10), legend.text = element_text(size = 10),
        legend.key.height = unit(0.75, "line"), legend.key.width = unit(1,
        "line"))
    formant.comparison <- formant.comparison + theme(legend.position = "none")

    plots[[plot.count]] <- formant.comparison

}

# Print page
multiplot(plotlist = plots, layout = matrix(c(1, 2, 3, 4), nrow = 2, byrow =
    T), title = "Generation")
```

```
dev.off()


# Extract and save legend
#cairo_pdf("Plots/Group/SS-ANOVA legend.pdf", width = 5, height = 5)
#legend <- g_legend(formant.comparison)
#grid.draw(legend)
#dev.off()


# Clear workspace and finish
rm(data, data.ethnicity, data.f1, data.f2, data.gender, data.generation,
   data.npv, data.pv, grid, colors, f1.model, f2.model, formant.comparison,
   i, j, k, multiplot, plots, plot.count)
```

APPENDIX F: VOWEL MEANS BY SPEAKER (ALL)

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ECL83CM1Z	m	1	C	East	i	167.510	0.074	292	2247	-1.221	0.822
ECL83CM1Z	m	1	C	East	ɪ	124.750	-0.634	384	1837	-0.947	0.620
ECL83CM1Z	m	1	C	East	e	227.540	1.068	390	1990	-0.932	0.700
ECL83CM1Z	m	1	C	East	ɛ	150.510	-0.208	444	1844	-0.803	0.621
ECL83CM1Z	m	1	C	East	æ	199.010	0.596	561	1690	-0.571	0.534
ECL83CM1Z	m	1	C	East	ɑ	236.170	1.211	643	1066	-0.430	0.075
ECL83CM1Z	m	1	C	East	ɔ	232.770	1.155	657	1121	-0.409	0.124
ECL83CM1Z	m	1	C	East	o	184.250	0.351	390	1055	-0.931	0.065
ECL83CM1Z	m	1	C	East	ʊ	116.420	-0.772	375	1471	-0.969	0.396
ECL83CM1Z	m	1	C	East	u	137.870	-0.417	338	1206	-1.078	0.195
ECL84CF1Z	f	1	C	East	i	225.990	1.042	317	2636	-1.138	0.981
ECL84CF1Z	f	1	C	East	ɪ	118.520	-0.737	461	2120	-0.764	0.763
ECL84CF1Z	f	1	C	East	e	253.240	1.494	482	2305	-0.719	0.846
ECL84CF1Z	f	1	C	East	ɛ	150.690	-0.204	578	2069	-0.538	0.738
ECL84CF1Z	f	1	C	East	æ	223.150	0.995	738	1863	-0.293	0.633
ECL84CF1Z	f	1	C	East	ɑ	234.070	1.176	710	1060	-0.331	0.070
ECL84CF1Z	f	1	C	East	ɔ	297.980	2.234	695	1096	-0.353	0.100
ECL84CF1Z	f	1	C	East	o	212.850	0.825	498	989	-0.686	0.001
ECL84CF1Z	f	1	C	East	ʊ	154.560	-0.140	497	1649	-0.690	0.510
ECL84CF1Z	f	1	C	East	u	241.470	1.299	355	1226	-1.024	0.215
EDP74CF1T	f	1	C	East	i	185.180	0.367	332	2520	-1.096	0.936
EDP74CF1T	f	1	C	East	ɪ	102.260	-1.006	426	2241	-0.844	0.818
EDP74CF1T	f	1	C	East	e	219.690	0.938	427	2325	-0.841	0.855
EDP74CF1T	f	1	C	East	ɛ	138.040	-0.414	477	2214	-0.738	0.806
EDP74CF1T	f	1	C	East	æ	198.130	0.581	712	1962	-0.339	0.683
EDP74CF1T	f	1	C	East	ɑ	197.230	0.566	724	1220	-0.311	0.200
EDP74CF1T	f	1	C	East	ɔ	242.220	1.311	627	1190	-0.457	0.172
EDP74CF1T	f	1	C	East	o	172.220	0.152	400	912	-0.907	-0.086
EDP74CF1T	f	1	C	East	ʊ	91.010	-1.193	439	1673	-0.813	0.526
EDP74CF1T	f	1	C	East	u	133.050	-0.497	320	1327	-1.152	0.294
EDP75CM1T	m	1	C	East	i	182.710	0.326	267	2328	-1.310	0.857
EDP75CM1T	m	1	C	East	ɪ	141.340	-0.359	342	1985	-1.060	0.698

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
EDP75CM1T	m	1	C	East	e	268.040	1.739	396	2074	-0.919	0.739
EDP75CM1T	m	1	C	East	ɛ	147.210	-0.262	449	1881	-0.790	0.643
EDP75CM1T	m	1	C	East	æ	216.370	0.883	560	1741	-0.572	0.564
EDP75CM1T	m	1	C	East	ɑ	274.240	1.841	643	1129	-0.432	0.132
EDP75CM1T	m	1	C	East	ɔ	272.820	1.818	617	1106	-0.470	0.109
EDP75CM1T	m	1	C	East	ʊ	130.760	-0.534	431	1413	-0.832	0.354
EDP75CM1T	m	1	C	East	u	216.600	0.887	296	1269	-1.207	0.249
ERI96CF2G	f	2	C	East	i	152.470	-0.175	344	2305	-1.060	0.846
ERI96CF2G	f	2	C	East	ɪ	110.420	-0.871	488	2191	-0.707	0.796
ERI96CF2G	f	2	C	East	e	259.750	1.601	483	2458	-0.717	0.910
ERI96CF2G	f	2	C	East	ɛ	144.570	-0.306	542	2135	-0.606	0.767
ERI96CF2G	f	2	C	East	æ	219.720	0.939	635	2005	-0.451	0.706
ERI96CF2G	f	2	C	East	ɑ	269.730	1.767	602	1177	-0.505	0.174
ERI96CF2G	f	2	C	East	ɔ	295.290	2.190	748	1179	-0.279	0.175
ERI96CF2G	f	2	C	East	o	207.880	0.743	492	1268	-0.700	0.249
ERI96CF2G	f	2	C	East	ʊ	135.460	-0.457	497	1776	-0.689	0.586
ERI96CF2G	f	2	C	East	u	182.250	0.318	389	1584	-0.938	0.469
ERI97CF3G	f	3	C	East	i	121.680	-0.685	363	2830	-1.002	1.052
ERI97CF3G	f	3	C	East	ɪ	65.540	-1.615	417	2288	-0.863	0.838
ERI97CF3G	f	3	C	East	e	156.250	-0.113	410	2551	-0.886	0.948
ERI97CF3G	f	3	C	East	ɛ	81.080	-1.357	622	1975	-0.472	0.692
ERI97CF3G	f	3	C	East	æ	127.560	-0.588	966	1800	-0.025	0.598
ERI97CF3G	f	3	C	East	ɑ	140.310	-0.376	911	1292	-0.086	0.267
ERI97CF3G	f	3	C	East	ɔ	163.580	0.009	838	1199	-0.174	0.192
ERI97CF3G	f	3	C	East	o	124.210	-0.643	407	1174	-0.887	0.172
ERI97CF3G	f	3	C	East	ʊ	72.090	-1.506	427	1795	-0.840	0.597
ERI97CF3G	f	3	C	East	u	97.190	-1.090	372	1674	-0.978	0.526
ERI98CF3G	f	3	C	East	i	133.300	-0.492	343	3009	-1.060	1.112
ERI98CF3G	f	3	C	East	ɪ	79.510	-1.383	481	2371	-0.721	0.874
ERI98CF3G	f	3	C	East	e	198.840	0.593	501	2583	-0.683	0.959
ERI98CF3G	f	3	C	East	ɛ	102.290	-1.006	598	1984	-0.509	0.696
ERI98CF3G	f	3	C	East	æ	151.720	-0.187	816	1823	-0.195	0.611
ERI98CF3G	f	3	C	East	ɑ	167.010	0.066	667	1296	-0.399	0.269
ERI98CF3G	f	3	C	East	ɔ	203.470	0.669	660	1322	-0.410	0.289
ERI98CF3G	f	3	C	East	o	151.970	-0.183	479	1326	-0.737	0.294
ERI98CF3G	f	3	C	East	ʊ	93.790	-1.147	538	1818	-0.612	0.609
ERI98CF3G	f	3	C	East	u	93.240	-1.156	371	1635	-0.990	0.499
ESP102CF2J	f	2	C	East	i	118.640	-0.735	343	2797	-1.059	1.040
ESP102CF2J	f	2	C	East	ɪ	84.580	-1.299	414	2184	-0.870	0.793

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ESP102CF2J	f	2	C	East	e	195.370	0.535	415	2496	-0.874	0.924
ESP102CF2J	f	2	C	East	ɛ	111.320	-0.856	518	2003	-0.650	0.706
ESP102CF2J	f	2	C	East	æ	159.480	-0.059	930	1921	-0.063	0.663
ESP102CF2J	f	2	C	East	ɑ	195.630	0.540	986	1232	-0.003	0.218
ESP102CF2J	f	2	C	East	ɔ	194.940	0.528	963	1343	-0.027	0.307
ESP102CF2J	f	2	C	East	o	147.390	-0.259	409	1086	-0.884	0.094
ESP102CF2J	f	2	C	East	ʊ	95.460	-1.119	421	1619	-0.853	0.493
ESP102CF2J	f	2	C	East	u	136.570	-0.438	354	1505	-1.027	0.420
ESP110CF2Q	f	2	C	East	i	118.330	-0.740	352	2778	-1.036	1.033
ESP110CF2Q	f	2	C	East	ɪ	114.080	-0.811	516	2332	-0.651	0.858
ESP110CF2Q	f	2	C	East	e	199.250	0.600	488	2408	-0.710	0.885
ESP110CF2Q	f	2	C	East	ɛ	122.150	-0.677	579	2170	-0.538	0.782
ESP110CF2Q	f	2	C	East	æ	159.520	-0.058	959	1851	-0.035	0.627
ESP110CF2Q	f	2	C	East	ɑ	193.890	0.511	842	1190	-0.161	0.185
ESP110CF2Q	f	2	C	East	ɔ	228.160	1.078	887	1207	-0.110	0.200
ESP110CF2Q	f	2	C	East	o	169.380	0.105	454	1034	-0.781	0.044
ESP110CF2Q	f	2	C	East	ʊ	111.970	-0.846	528	1444	-0.641	0.370
ESP110CF2Q	f	2	C	East	u	120.100	-0.711	440	1406	-0.832	0.353
ESP70HF3Q	f	3	MA	East	i	157.290	-0.095	366	3143	-0.995	1.157
ESP70HF3Q	f	3	MA	East	ɪ	87.610	-1.249	427	2581	-0.840	0.959
ESP70HF3Q	f	3	MA	East	e	216.160	0.880	428	2735	-0.840	1.017
ESP70HF3Q	f	3	MA	East	ɛ	126.520	-0.605	554	2158	-0.583	0.779
ESP70HF3Q	f	3	MA	East	æ	188.980	0.429	759	1928	-0.269	0.667
ESP70HF3Q	f	3	MA	East	ɑ	234.250	1.179	766	1207	-0.256	0.199
ESP70HF3Q	f	3	MA	East	ɔ	251.810	1.470	746	1213	-0.282	0.205
ESP70HF3Q	f	3	MA	East	o	163.790	0.012	425	1163	-0.843	0.161
ESP70HF3Q	f	3	MA	East	ʊ	94.290	-1.139	436	1691	-0.820	0.537
ESP70HF3Q	f	3	MA	East	u	146.840	-0.268	341	1556	-1.069	0.447
ESP71HF2R	f	2	MA	East	i	118.650	-0.735	343	2864	-1.058	1.064
ESP71HF2R	f	2	MA	East	ɪ	65.850	-1.609	460	2298	-0.764	0.843
ESP71HF2R	f	2	MA	East	e	182.330	0.319	446	2552	-0.797	0.949
ESP71HF2R	f	2	MA	East	ɛ	110.590	-0.869	644	2056	-0.432	0.732
ESP71HF2R	f	2	MA	East	æ	156	-0.117	860	1850	-0.144	0.625
ESP71HF2R	f	2	MA	East	ɑ	187.050	0.398	777	1330	-0.242	0.296
ESP71HF2R	f	2	MA	East	ɔ	199.490	0.603	810	1338	-0.199	0.303
ESP71HF2R	f	2	MA	East	o	196.230	0.550	495	1227	-0.691	0.216
ESP71HF2R	f	2	MA	East	ʊ	78.150	-1.406	474	2132	-0.736	0.769
ESP71HF2R	f	2	MA	East	u	120.750	-0.700	346	1539	-1.050	0.440
ESP79SF1V	f	1	JA	East	i	159.230	-0.063	372	2731	-0.979	1.016

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ESP79SF1V	f	1	JA	East	ɪ	113.460	-0.821	474	2378	-0.734	0.877
ESP79SF1V	f	1	JA	East	e	176.130	0.217	434	2610	-0.825	0.971
ESP79SF1V	f	1	JA	East	ɛ	125.140	-0.628	567	2221	-0.562	0.809
ESP79SF1V	f	1	JA	East	æ	142.850	-0.334	704	2169	-0.342	0.784
ESP79SF1V	f	1	JA	East	ɑ	150.480	-0.208	726	1270	-0.309	0.251
ESP79SF1V	f	1	JA	East	ɔ	154.020	-0.149	709	1309	-0.332	0.278
ESP79SF1V	f	1	JA	East	o	210.550	0.787	542	1073	-0.607	0.081
ESP79SF1V	f	1	JA	East	ʊ	77.220	-1.421	480	1890	-0.722	0.648
ESP79SF1V	f	1	JA	East	u	143.720	-0.320	439	1734	-0.812	0.560
ESP80SF1W	f	1	JA	East	i	178.370	0.254	349	2773	-1.041	1.031
ESP80SF1W	f	1	JA	East	ɪ	125.200	-0.627	446	2376	-0.796	0.877
ESP80SF1W	f	1	JA	East	e	234.810	1.188	443	2674	-0.806	0.995
ESP80SF1W	f	1	JA	East	ɛ	145.910	-0.284	521	2385	-0.644	0.880
ESP80SF1W	f	1	JA	East	æ	205.240	0.699	731	2274	-0.305	0.833
ESP80SF1W	f	1	JA	East	ɑ	219.170	0.929	684	1161	-0.370	0.160
ESP80SF1W	f	1	JA	East	ɔ	237.340	1.230	699	1146	-0.347	0.148
ESP80SF1W	f	1	JA	East	o	208.980	0.761	418	1005	-0.860	0.016
ESP80SF1W	f	1	JA	East	ʊ	137.560	-0.422	450	1653	-0.786	0.514
ESP80SF1W	f	1	JA	East	u	220.080	0.944	376	1666	-0.995	0.522
ESP81AM3X	m	3	AA	East	i	131.880	-0.516	247	2596	-1.387	0.965
ESP81AM3X	m	3	AA	East	ɪ	71.900	-1.509	337	2074	-1.079	0.741
ESP81AM3X	m	3	AA	East	e	166.490	0.057	351	2313	-1.040	0.849
ESP81AM3X	m	3	AA	East	ɛ	95.150	-1.124	394	1896	-0.927	0.648
ESP81AM3X	m	3	AA	East	æ	152.930	-0.167	628	1720	-0.468	0.553
ESP81AM3X	m	3	AA	East	ɑ	168.880	0.097	477	1102	-0.730	0.109
ESP81AM3X	m	3	AA	East	ɔ	198.390	0.585	610	1162	-0.493	0.162
ESP81AM3X	m	3	AA	East	ʊ	85.970	-1.276	356	1322	-1.021	0.291
ESP81AM3X	m	3	AA	East	u	124.150	-0.644	253	1143	-1.364	0.142
ESP89SF2C	f	2	JA	East	i	106.340	-0.939	348	2890	-1.045	1.073
ESP89SF2C	f	2	JA	East	ɪ	68.440	-1.567	467	2066	-0.750	0.738
ESP89SF2C	f	2	JA	East	e	160.610	-0.040	436	2536	-0.822	0.941
ESP89SF2C	f	2	JA	East	ɛ	94.390	-1.137	556	2018	-0.580	0.714
ESP89SF2C	f	2	JA	East	æ	141.110	-0.363	663	1771	-0.413	0.582
ESP89SF2C	f	2	JA	East	ɑ	149.690	-0.221	729	1354	-0.307	0.315
ESP89SF2C	f	2	JA	East	ɔ	169.570	0.108	844	1389	-0.157	0.340
ESP89SF2C	f	2	JA	East	o	140.940	-0.366	432	1206	-0.829	0.198
ESP89SF2C	f	2	JA	East	ʊ	83.280	-1.321	466	1868	-0.754	0.634
ESP89SF2C	f	2	JA	East	u	133.240	-0.494	378	1895	-0.962	0.648
ESP99SM3H	m	3	JA	East	i	109.910	-0.880	315	2151	-1.145	0.778

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ESP99SM3H	m	3	JA	East	ɪ	65.600	-1.614	439	1886	-0.811	0.646
ESP99SM3H	m	3	JA	East	e	157.980	-0.084	447	1978	-0.797	0.693
ESP99SM3H	m	3	JA	East	ɛ	97.590	-1.084	557	1882	-0.576	0.642
ESP99SM3H	m	3	JA	East	æ	133.070	-0.496	667	1664	-0.394	0.519
ESP99SM3H	m	3	JA	East	ɑ	144.680	-0.304	665	1113	-0.396	0.119
ESP99SM3H	m	3	JA	East	ɔ	156.920	-0.101	673	1073	-0.384	0.080
ESP99SM3H	m	3	JA	East	o	112.870	-0.831	451	994	-0.785	-0.005
ESP99SM3H	m	3	JA	East	ʊ	76.970	-1.425	473	1707	-0.738	0.545
ESP99SM3H	m	3	JA	East	u	98.920	-1.062	356	2015	-1.021	0.711
ESV108CF3O	f	3	C	East	i	107.270	-0.924	328	2718	-1.111	1.011
ESV108CF3O	f	3	C	East	ɪ	86.810	-1.262	462	2324	-0.761	0.855
ESV108CF3O	f	3	C	East	e	153.920	-0.151	433	2508	-0.826	0.929
ESV108CF3O	f	3	C	East	ɛ	86.760	-1.263	544	1906	-0.599	0.654
ESV108CF3O	f	3	C	East	æ	147.150	-0.263	934	1680	-0.062	0.529
ESV108CF3O	f	3	C	East	ɑ	193.910	0.511	850	1262	-0.153	0.244
ESV108CF3O	f	3	C	East	ɔ	169.530	0.107	792	1265	-0.222	0.246
ESV108CF3O	f	3	C	East	o	125.060	-0.629	472	1280	-0.739	0.253
ESV108CF3O	f	3	C	East	ʊ	86.810	-1.262	496	1660	-0.690	0.519
ESV108CF3O	f	3	C	East	u	108.010	-0.911	363	1404	-1.006	0.349
ESV109CM3P	m	3	C	East	i	133.670	-0.486	291	2347	-1.222	0.865
ESV109CM3P	m	3	C	East	ɪ	80.220	-1.371	404	2005	-0.894	0.707
ESV109CM3P	m	3	C	East	e	186.940	0.396	389	2145	-0.933	0.775
ESV109CM3P	m	3	C	East	ɛ	113.060	-0.828	484	1739	-0.717	0.564
ESV109CM3P	m	3	C	East	æ	160.400	-0.044	663	1572	-0.407	0.463
ESV109CM3P	m	3	C	East	ɑ	181.100	0.299	625	1161	-0.459	0.161
ESV109CM3P	m	3	C	East	ɔ	208.810	0.758	617	1146	-0.473	0.148
ESV109CM3P	m	3	C	East	o	184.350	0.353	425	1059	-0.845	0.069
ESV109CM3P	m	3	C	East	ʊ	96.400	-1.103	426	1569	-0.844	0.461
ESV109CM3P	m	3	C	East	u	151.850	-0.185	345	1188	-1.053	0.183
ESV82SF3Y	f	3	JA	East	i	130.400	-0.541	390	2131	-0.932	0.768
ESV82SF3Y	f	3	JA	East	ɪ	93.860	-1.146	477	2198	-0.731	0.799
ESV82SF3Y	f	3	JA	East	e	224.780	1.022	415	2395	-0.870	0.885
ESV82SF3Y	f	3	JA	East	ɛ	124.780	-0.634	576	1972	-0.545	0.690
ESV82SF3Y	f	3	JA	East	æ	211.270	0.799	780	1852	-0.241	0.624
ESV82SF3Y	f	3	JA	East	ɑ	247.240	1.394	655	1041	-0.415	0.049
ESV82SF3Y	f	3	JA	East	ɔ	238.020	1.242	661	1010	-0.403	0.022
ESV82SF3Y	f	3	JA	East	o	180.460	0.288	447	912	-0.796	-0.082
ESV82SF3Y	f	3	JA	East	ʊ	95.340	-1.121	490	1826	-0.704	0.612
ESV82SF3Y	f	3	JA	East	u	126.680	-0.602	400	1343	-0.907	0.305

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SB69CF3P	f	3	C	West	i	121.970	-0.680	376	2578	-0.967	0.957
SB69CF3P	f	3	C	West	ɪ	100.380	-1.038	482	2265	-0.718	0.829
SB69CF3P	f	3	C	West	e	170.900	0.130	485	2378	-0.716	0.878
SB69CF3P	f	3	C	West	ɛ	98.710	-1.065	621	2072	-0.467	0.740
SB69CF3P	f	3	C	West	æ	166.490	0.057	888	1767	-0.108	0.580
SB69CF3P	f	3	C	West	ɑ	184.790	0.360	875	1432	-0.122	0.369
SB69CF3P	f	3	C	West	ɔ	210.280	0.782	852	1389	-0.148	0.339
SB69CF3P	f	3	C	West	o	123.040	-0.662	456	1342	-0.775	0.306
SB69CF3P	f	3	C	West	ʊ	76.440	-1.434	498	1916	-0.686	0.662
SB69CF3P	f	3	C	West	u	102.130	-1.009	420	1605	-0.855	0.483
SB93SM3D	m	3	JA	West	i	150.930	-0.201	276	2123	-1.278	0.764
SB93SM3D	m	3	JA	West	ɪ	99.050	-1.060	383	2125	-0.949	0.765
SB93SM3D	m	3	JA	West	e	197.560	0.572	413	2216	-0.873	0.806
SB93SM3D	m	3	JA	West	ɛ	121.370	-0.690	619	2079	-0.469	0.739
SB93SM3D	m	3	JA	West	æ	186.950	0.396	853	1957	-0.151	0.679
SB93SM3D	m	3	JA	West	ɑ	217.970	0.910	763	1032	-0.258	0.043
SB93SM3D	m	3	JA	West	ɔ	207.540	0.737	685	940	-0.367	-0.050
SB93SM3D	m	3	JA	West	o	181.370	0.304	400	920	-0.905	-0.072
SB93SM3D	m	3	JA	West	ʊ	110.980	-0.862	468	1964	-0.748	0.687
SB93SM3D	m	3	JA	West	u	158.410	-0.077	303	1055	-1.191	0.060
SBI94SM2E	m	2	JA	West	i	92.430	-1.169	247	2433	-1.397	0.901
SBI94SM2E	m	2	JA	West	ɪ	62.570	-1.664	397	2032	-0.913	0.721
SBI94SM2E	m	2	JA	West	e	172.560	0.158	417	2167	-0.864	0.784
SBI94SM2E	m	2	JA	West	ɛ	85.140	-1.290	495	1815	-0.695	0.608
SBI94SM2E	m	2	JA	West	æ	147.360	-0.260	720	1667	-0.319	0.522
SBI94SM2E	m	2	JA	West	ɑ	150.260	-0.212	673	924	-0.389	-0.067
SBI94SM2E	m	2	JA	West	ɔ	165.090	0.034	567	854	-0.557	-0.146
SBI94SM2E	m	2	JA	West	o	138.920	-0.399	409	981	-0.882	-0.009
SBI94SM2E	m	2	JA	West	ʊ	62.570	-1.664	380	1776	-0.957	0.585
SBI94SM2E	m	2	JA	West	u	138.880	-0.400	303	1624	-1.184	0.497
SC56SF1D	f	1	JA	West	i	139.090	-0.397	350	2763	-1.050	1.028
SC56SF1D	f	1	JA	West	ɪ	95.850	-1.113	419	2278	-0.861	0.835
SC56SF1D	f	1	JA	West	e	199.430	0.603	421	2483	-0.857	0.921
SC56SF1D	f	1	JA	West	ɛ	117.300	-0.757	513	2071	-0.659	0.740
SC56SF1D	f	1	JA	West	æ	179.170	0.267	625	1999	-0.461	0.704
SC56SF1D	f	1	JA	West	ɑ	186.170	0.383	704	1161	-0.339	0.160
SC56SF1D	f	1	JA	West	ɔ	224.880	1.024	700	1047	-0.345	0.058
SC56SF1D	f	1	JA	West	o	187.350	0.403	410	852	-0.881	-0.153
SC56SF1D	f	1	JA	West	ʊ	107.370	-0.922	521	1694	-0.641	0.539

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SC56SF1D	f	1	JA	West	u	145.900	-0.284	371	1108	-0.980	0.107
SC57SF2B	f	2	JA	West	i	107.310	-0.923	345	2675	-1.053	0.995
SC57SF2B	f	2	JA	West	ɪ	59.320	-1.718	448	2221	-0.792	0.809
SC57SF2B	f	2	JA	West	e	155.690	-0.122	421	2505	-0.855	0.930
SC57SF2B	f	2	JA	West	ɛ	96.360	-1.104	603	2118	-0.496	0.760
SC57SF2B	f	2	JA	West	æ	142.530	-0.340	731	1794	-0.304	0.591
SC57SF2B	f	2	JA	West	ɑ	154.190	-0.147	670	1373	-0.396	0.321
SC57SF2B	f	2	JA	West	ɔ	183.400	0.337	635	1321	-0.449	0.283
SC57SF2B	f	2	JA	West	o	118.890	-0.731	474	942	-0.735	-0.048
SC57SF2B	f	2	JA	West	ʊ	73.120	-1.489	491	2023	-0.700	0.716
SC57SF2B	f	2	JA	West	u	85.990	-1.276	360	1485	-1.011	0.406
SC61AF1K	f	1	AA	West	i	211.130	0.796	310	2596	-1.161	0.966
SC61AF1K	f	1	AA	West	ɪ	190.100	0.448	468	2185	-0.747	0.794
SC61AF1K	f	1	AA	West	e	326.110	2.700	437	2384	-0.820	0.880
SC61AF1K	f	1	AA	West	ɛ	196.990	0.562	538	2118	-0.612	0.762
SC61AF1K	f	1	AA	West	æ	271.720	1.800	731	2002	-0.309	0.705
SC61AF1K	f	1	AA	West	ɑ	296.590	2.211	740	1326	-0.289	0.294
SC61AF1K	f	1	AA	West	o	283.170	1.989	462	1031	-0.763	0.041
SC61AF1K	f	1	AA	West	ʊ	187.300	0.402	436	1590	-0.819	0.474
SC61AF1K	f	1	AA	West	u	287.880	2.067	376	1408	-0.972	0.349
SC62AF1L	f	1	AA	West	i	182.010	0.314	344	2859	-1.063	1.062
SC62AF1L	f	1	AA	West	ɪ	99.070	-1.059	416	2465	-0.868	0.911
SC62AF1L	f	1	AA	West	e	280.220	1.940	434	2577	-0.827	0.958
SC62AF1L	f	1	AA	West	ɛ	136.630	-0.437	489	2244	-0.708	0.819
SC62AF1L	f	1	AA	West	æ	219.820	0.940	644	2202	-0.435	0.798
SC62AF1L	f	1	AA	West	ɑ	226.920	1.058	670	1070	-0.390	0.076
SC62AF1L	f	1	AA	West	ɔ	312.450	2.474	638	981	-0.439	-0.008
SC62AF1L	f	1	AA	West	o	218.350	0.916	389	813	-0.934	-0.199
SC62AF1L	f	1	AA	West	ʊ	128.230	-0.576	403	1238	-0.902	0.214
SC62AF1L	f	1	AA	West	u	183.730	0.343	342	1007	-1.061	0.015
SC63AF1M	f	1	AA	West	i	130.930	-0.532	315	2876	-1.148	1.068
SC63AF1M	f	1	AA	West	ɪ	92.250	-1.172	405	2292	-0.892	0.841
SC63AF1M	f	1	AA	West	e	198.220	0.582	391	2650	-0.932	0.986
SC63AF1M	f	1	AA	West	ɛ	112.190	-0.842	512	2229	-0.658	0.813
SC63AF1M	f	1	AA	West	æ	158.510	-0.075	645	2108	-0.428	0.756
SC63AF1M	f	1	AA	West	ɑ	214.650	0.855	711	1202	-0.331	0.190
SC63AF1M	f	1	AA	West	ɔ	230.260	1.113	682	1112	-0.372	0.115
SC63AF1M	f	1	AA	West	o	133.480	-0.489	380	837	-0.959	-0.172
SC63AF1M	f	1	AA	West	ʊ	91.810	-1.180	414	1992	-0.872	0.699

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SC63AF1M	f	1	AA	West	u	130.560	-0.538	354	1242	-1.027	0.223
SC92CM3D	m	3	C	West	i	165.450	0.040	321	2151	-1.126	0.777
SC92CM3D	m	3	C	West	ɪ	102.580	-1.001	382	1886	-0.950	0.646
SC92CM3D	m	3	C	West	e	241.760	1.303	450	1859	-0.788	0.631
SC92CM3D	m	3	C	West	ɛ	121.600	-0.686	485	1665	-0.712	0.521
SC92CM3D	m	3	C	West	æ	206.990	0.728	650	1526	-0.421	0.432
SC92CM3D	m	3	C	West	ɑ	248.690	1.418	627	986	-0.455	-0.002
SC92CM3D	m	3	C	West	ɔ	264.300	1.677	576	922	-0.540	-0.069
SC92CM3D	m	3	C	West	o	169.330	0.104	434	1346	-0.825	0.309
SC92CM3D	m	3	C	West	ʊ	73.860	-1.477	407	1597	-0.890	0.478
SC92CM3D	m	3	C	West	u	150.110	-0.214	337	1749	-1.078	0.571
SD53SM1J	m	1	JA	West	i	153.630	-0.156	340	2342	-1.066	0.863
SD53SM1J	m	1	JA	West	ɪ	114.270	-0.808	418	1983	-0.861	0.696
SD53SM1J	m	1	JA	West	e	240.100	1.276	400	2110	-0.908	0.758
SD53SM1J	m	1	JA	West	ɛ	144.170	-0.313	477	1857	-0.731	0.629
SD53SM1J	m	1	JA	West	æ	199.940	0.611	599	1774	-0.503	0.582
SD53SM1J	m	1	JA	West	ɑ	206.340	0.717	522	882	-0.646	-0.116
SD53SM1J	m	1	JA	West	ɔ	218.850	0.924	576	843	-0.556	-0.158
SD53SM1J	m	1	JA	West	o	170.610	0.125	389	787	-0.938	-0.229
SD53SM1J	m	1	JA	West	ʊ	112.540	-0.836	449	1574	-0.791	0.463
SD53SM1J	m	1	JA	West	u	171.120	0.134	361	941	-1.006	-0.049
SD59SF2J	f	2	JA	West	i	127.200	-0.594	378	2774	-0.962	1.032
SD59SF2J	f	2	JA	West	ɪ	80.820	-1.362	481	2377	-0.720	0.877
SD59SF2J	f	2	JA	West	e	175.180	0.201	472	2545	-0.740	0.945
SD59SF2J	f	2	JA	West	ɛ	98.360	-1.071	565	2222	-0.560	0.810
SD59SF2J	f	2	JA	West	æ	155.240	-0.129	730	1935	-0.304	0.670
SD59SF2J	f	2	JA	West	ɑ	175.130	0.200	808	1496	-0.206	0.414
SD59SF2J	f	2	JA	West	ɔ	169.850	0.113	745	1486	-0.284	0.408
SD59SF2J	f	2	JA	West	o	142.780	-0.336	530	1558	-0.627	0.455
SD59SF2J	f	2	JA	West	ʊ	80.260	-1.371	505	2181	-0.673	0.792
SD59SF2J	f	2	JA	West	u	117.590	-0.753	410	2327	-0.881	0.856
SD88CF3B	f	3	C	West	i	259.040	1.590	415	2998	-0.868	1.110
SD88CF3B	f	3	C	West	ɪ	189.110	0.432	470	2379	-0.746	0.878
SD88CF3B	f	3	C	West	e	312.980	2.483	474	2456	-0.746	0.905
SD88CF3B	f	3	C	West	ɛ	171.600	0.142	724	2027	-0.314	0.715
SD88CF3B	f	3	C	West	æ	256.910	1.554	843	1961	-0.160	0.684
SD88CF3B	f	3	C	West	ɑ	354.180	3.165	813	1299	-0.195	0.273
SD88CF3B	f	3	C	West	ɔ	337.210	2.884	822	1232	-0.185	0.220
SD88CF3B	f	3	C	West	o	258.430	1.580	421	1178	-0.852	0.175

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SD88CF3B	f	3	C	West	ʊ	145.130	-0.297	593	1816	-0.511	0.608
SD88CF3B	f	3	C	West	u	211.340	0.800	416	1453	-0.866	0.385
SE76CM2U	m	2	C	West	i	204.510	0.687	281	2276	-1.258	0.834
SE76CM2U	m	2	C	West	ɪ	127.430	-0.590	406	1915	-0.889	0.662
SE76CM2U	m	2	C	West	e	311.060	2.451	400	2130	-0.905	0.768
SE76CM2U	m	2	C	West	ɛ	160.270	-0.046	507	1908	-0.670	0.657
SE76CM2U	m	2	C	West	æ	263.720	1.667	608	1778	-0.489	0.585
SE76CM2U	m	2	C	West	ɑ	323.480	2.657	622	1071	-0.466	0.080
SE76CM2U	m	2	C	West	ɔ	376.340	3.532	619	873	-0.469	-0.134
SE76CM2U	m	2	C	West	o	201.490	0.637	408	962	-0.885	-0.028
SE76CM2U	m	2	C	West	ʊ	127.080	-0.595	429	1529	-0.835	0.433
SE76CM2U	m	2	C	West	u	173.640	0.176	302	1361	-1.185	0.320
SH18CF2K	f	2	C	West	i	107.370	-0.922	344	2749	-1.057	1.022
SH18CF2K	f	2	C	West	ɪ	62.980	-1.657	431	2428	-0.832	0.899
SH18CF2K	f	2	C	West	e	162.870	-0.003	440	2536	-0.812	0.942
SH18CF2K	f	2	C	West	ɛ	104.560	-0.968	532	2169	-0.622	0.785
SH18CF2K	f	2	C	West	æ	138.430	-0.408	721	1940	-0.325	0.672
SH18CF2K	f	2	C	West	ɑ	157.120	-0.098	635	1452	-0.446	0.383
SH18CF2K	f	2	C	West	ɔ	184.090	0.349	591	1211	-0.515	0.202
SH18CF2K	f	2	C	West	o	125.170	-0.627	424	1054	-0.846	0.060
SH18CF2K	f	2	C	West	ʊ	66.160	-1.604	423	1614	-0.848	0.487
SH18CF2K	f	2	C	West	u	106.740	-0.932	322	1227	-1.128	0.211
SK14CM2I	m	2	C	West	i	149.470	-0.225	304	2436	-1.179	0.902
SK14CM2I	m	2	C	West	ɪ	102.750	-0.998	428	1935	-0.837	0.672
SK14CM2I	m	2	C	West	e	214.630	0.854	406	2125	-0.890	0.765
SK14CM2I	m	2	C	West	ɛ	121.590	-0.686	506	1738	-0.671	0.564
SK14CM2I	m	2	C	West	æ	176.540	0.224	653	1652	-0.416	0.513
SK14CM2I	m	2	C	West	ɑ	242.980	1.324	607	1124	-0.487	0.128
SK14CM2I	m	2	C	West	ɔ	242.660	1.318	643	1152	-0.430	0.150
SK14CM2I	m	2	C	West	o	153.570	-0.157	404	774	-0.896	-0.253
SK14CM2I	m	2	C	West	ʊ	82.790	-1.329	415	1466	-0.870	0.395
SK14CM2I	m	2	C	West	u	129.240	-0.560	335	914	-1.084	-0.083
SKI90SM2C	m	2	JA	West	i	131.140	-0.528	225	2296	-1.486	0.843
SKI90SM2C	m	2	JA	West	ɪ	96.670	-1.099	367	1909	-0.993	0.658
SKI90SM2C	m	2	JA	West	e	216.960	0.893	327	2166	-1.124	0.784
SKI90SM2C	m	2	JA	West	ɛ	128.120	-0.578	382	1797	-0.985	0.597
SKI90SM2C	m	2	JA	West	æ	189.240	0.434	498	1744	-0.708	0.565
SKI90SM2C	m	2	JA	West	ɑ	341.860	2.961	611	1064	-0.481	0.074
SKI90SM2C	m	2	JA	West	ɔ	248.780	1.420	509	949	-0.666	-0.042

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SKI90SM2C	m	2	JA	West	o	159.470	-0.059	350	812	-1.045	-0.196
SKI90SM2C	m	2	JA	West	ʊ	138.740	-0.402	320	1477	-1.140	0.401
SKI90SM2C	m	2	JA	West	u	183.100	0.332	292	1497	-1.221	0.414
SKT68CM2O	m	2	C	West	i	142.410	-0.342	289	2406	-1.229	0.890
SKT68CM2O	m	2	C	West	ɪ	123.140	-0.661	407	1881	-0.887	0.644
SKT68CM2O	m	2	C	West	e	205.180	0.698	469	1942	-0.746	0.675
SKT68CM2O	m	2	C	West	ɛ	103.730	-0.982	550	1718	-0.587	0.550
SKT68CM2O	m	2	C	West	æ	175.950	0.214	650	1534	-0.420	0.438
SKT68CM2O	m	2	C	West	ɑ	235.360	1.198	634	936	-0.444	-0.054
SKT68CM2O	m	2	C	West	ɔ	219.440	0.934	674	912	-0.383	-0.080
SKT68CM2O	m	2	C	West	o	141.260	-0.361	426	861	-0.841	-0.138
SKT68CM2O	m	2	C	West	ʊ	77.800	-1.412	431	1296	-0.830	0.271
SKT68CM2O	m	2	C	West	u	126.770	-0.601	320	830	-1.128	-0.174
SN7CF2D	f	2	C	West	i	108.110	-0.910	316	2612	-1.142	0.972
SN7CF2D	f	2	C	West	ɪ	65.240	-1.619	390	2130	-0.932	0.768
SN7CF2D	f	2	C	West	e	148.090	-0.248	440	2368	-0.811	0.873
SN7CF2D	f	2	C	West	ɛ	90.130	-1.207	468	1844	-0.750	0.623
SN7CF2D	f	2	C	West	æ	141.990	-0.349	781	1734	-0.242	0.561
SN7CF2D	f	2	C	West	ɑ	179.930	0.280	682	1148	-0.373	0.148
SN7CF2D	f	2	C	West	ɔ	219.760	0.939	585	1110	-0.528	0.116
SN7CF2D	f	2	C	West	o	123.310	-0.658	377	1158	-0.965	0.155
SN7CF2D	f	2	C	West	ʊ	55.250	-1.785	374	1739	-0.972	0.565
SN7CF2D	f	2	C	West	u	133.110	-0.496	334	1179	-1.086	0.176
SO64CF2N	f	2	C	West	i	176.300	0.220	339	2635	-1.077	0.980
SO64CF2N	f	2	C	West	ɪ	148.670	-0.238	452	2054	-0.782	0.731
SO64CF2N	f	2	C	West	e	230.160	1.111	459	2245	-0.768	0.820
SO64CF2N	f	2	C	West	ɛ	126.690	-0.602	542	1890	-0.605	0.648
SO64CF2N	f	2	C	West	æ	197.720	0.574	730	1762	-0.308	0.577
SO64CF2N	f	2	C	West	ɑ	263.240	1.659	653	1187	-0.414	0.182
SO64CF2N	f	2	C	West	ɔ	291.390	2.125	593	1195	-0.520	0.189
SO64CF2N	f	2	C	West	o	151.590	-0.190	417	1194	-0.863	0.185
SO64CF2N	f	2	C	West	ʊ	82.790	-1.329	456	1703	-0.774	0.542
SO64CF2N	f	2	C	West	u	139.940	-0.383	351	1274	-1.035	0.252
SO65CF3N	f	3	C	West	i	142.870	-0.334	334	2827	-1.086	1.051
SO65CF3N	f	3	C	West	e	204.730	0.690	458	2526	-0.782	0.938
SO65CF3N	f	3	C	West	ɛ	116.010	-0.779	677	2086	-0.381	0.746
SO65CF3N	f	3	C	West	æ	196.620	0.556	867	1844	-0.138	0.619
SO65CF3N	f	3	C	West	ɑ	213.190	0.830	691	1160	-0.359	0.160
SO65CF3N	f	3	C	West	ɔ	222.190	0.979	690	1229	-0.361	0.218

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SO65CF3N	f	3	C	West	o	121.840	-0.682	379	1002	-0.958	0.014
SO65CF3N	f	3	C	West	ʊ	88.430	-1.236	390	1458	-0.932	0.388
SO65CF3N	f	3	C	West	u	150.990	-0.200	382	1123	-0.953	0.125
SO66CM2N	m	2	C	West	ɪ	89.250	-1.222	410	1892	-0.881	0.649
SO66CM2N	m	2	C	West	e	203.650	0.672	386	2143	-0.941	0.773
SO66CM2N	m	2	C	West	ɛ	119.650	-0.718	461	1801	-0.764	0.600
SO66CM2N	m	2	C	West	æ	175.830	0.212	573	1698	-0.547	0.540
SO66CM2N	m	2	C	West	ɑ	196.320	0.551	633	1217	-0.450	0.208
SO66CM2N	m	2	C	West	ʊ	97.730	-1.081	410	1606	-0.881	0.485
SO66CM2N	m	2	C	West	u	127.140	-0.594	316	1458	-1.140	0.388
SO67CM3N	m	3	C	West	i	199.160	0.598	244	2214	-1.400	0.806
SO67CM3N	m	3	C	West	ɪ	143.130	-0.330	350	1841	-1.046	0.622
SO67CM3N	m	3	C	West	e	285.730	2.032	421	1948	-0.863	0.678
SO67CM3N	m	3	C	West	ɛ	147.460	-0.258	484	1618	-0.719	0.492
SO67CM3N	m	3	C	West	æ	220.890	0.958	747	1539	-0.286	0.442
SO67CM3N	m	3	C	West	ɑ	291.020	2.119	585	994	-0.524	0.006
SO67CM3N	m	3	C	West	ɔ	294.090	2.170	646	1027	-0.426	0.036
SO67CM3N	m	3	C	West	ʊ	132.250	-0.510	431	1245	-0.830	0.228
SO67CM3N	m	3	C	West	u	164.700	0.028	261	1002	-1.331	0.014
SP55SM1D	m	1	JA	West	i	196.600	0.556	305	2008	-1.175	0.706
SP55SM1D	m	1	JA	West	ɪ	111.010	-0.862	413	1904	-0.873	0.656
SP55SM1D	m	1	JA	West	e	314.830	2.514	380	2016	-0.957	0.713
SP55SM1D	m	1	JA	West	ɛ	179.430	0.271	495	1769	-0.696	0.580
SP55SM1D	m	1	JA	West	æ	233.380	1.165	552	1716	-0.583	0.549
SP55SM1D	m	1	JA	West	ɑ	326.560	2.708	555	911	-0.579	-0.084
SP55SM1D	m	1	JA	West	ɔ	318.650	2.577	536	822	-0.613	-0.185
SP55SM1D	m	1	JA	West	o	232.600	1.152	351	771	-1.038	-0.263
SP55SM1D	m	1	JA	West	ʊ	122.460	-0.672	388	992	-0.935	0.003
SP55SM1D	m	1	JA	West	u	195.410	0.536	298	809	-1.200	-0.200
SQ73CF3S	f	3	C	West	i	120.070	-0.712	432	3175	-0.838	1.167
SQ73CF3S	f	3	C	West	ɪ	82.990	-1.326	518	2267	-0.645	0.830
SQ73CF3S	f	3	C	West	e	141.180	-0.362	511	2663	-0.664	0.991
SQ73CF3S	f	3	C	West	ɛ	87.110	-1.257	712	1991	-0.332	0.699
SQ73CF3S	f	3	C	West	æ	128.060	-0.579	957	1938	-0.035	0.672
SQ73CF3S	f	3	C	West	ɑ	168.280	0.087	947	1400	-0.043	0.347
SQ73CF3S	f	3	C	West	ɔ	159.980	-0.051	938	1318	-0.052	0.288
SQ73CF3S	f	3	C	West	o	97.850	-1.080	458	1378	-0.768	0.332
SQ73CF3S	f	3	C	West	ʊ	94.920	-1.128	578	1918	-0.537	0.662
SQ73CF3S	f	3	C	West	u	91.570	-1.183	360	1418	-1.010	0.360

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SR54SF2C	f	2	JA	West	i	149.880	-0.218	396	2760	-0.914	1.027
SR54SF2C	f	2	JA	West	ɪ	93.320	-1.154	481	2356	-0.722	0.868
SR54SF2C	f	2	JA	West	e	222.340	0.982	489	2556	-0.709	0.950
SR54SF2C	f	2	JA	West	ɛ	119.550	-0.720	558	2035	-0.574	0.722
SR54SF2C	f	2	JA	West	æ	192.390	0.486	650	1971	-0.423	0.688
SR54SF2C	f	2	JA	West	ɑ	221.620	0.970	665	1324	-0.396	0.292
SR54SF2C	f	2	JA	West	ɔ	232.650	1.153	654	1247	-0.414	0.231
SR54SF2C	f	2	JA	West	o	196.800	0.559	465	1044	-0.755	0.054
SR54SF2C	f	2	JA	West	ʊ	117.530	-0.754	455	1446	-0.781	0.380
SR54SF2C	f	2	JA	West	u	164.040	0.016	413	1332	-0.875	0.297
SR77CM3U	m	3	C	West	i	149.470	-0.225	284	2273	-1.248	0.832
SR77CM3U	m	3	C	West	ɪ	108.960	-0.895	363	1904	-1.003	0.655
SR77CM3U	m	3	C	West	e	176.450	0.222	328	2059	-1.107	0.733
SR77CM3U	m	3	C	West	ɛ	111.590	-0.852	412	1704	-0.888	0.543
SR77CM3U	m	3	C	West	æ	158.550	-0.074	639	1601	-0.445	0.481
SR77CM3U	m	3	C	West	ɑ	162.120	-0.015	595	1080	-0.516	0.087
SR77CM3U	m	3	C	West	ɔ	231.650	1.136	609	1086	-0.489	0.094
SR77CM3U	m	3	C	West	o	145.490	-0.291	337	1240	-1.079	0.227
SR77CM3U	m	3	C	West	ʊ	88.220	-1.239	353	1520	-1.031	0.430
SR77CM3U	m	3	C	West	u	121.780	-0.683	308	1518	-1.167	0.428
SR78CM2U	m	2	C	West	i	165.650	0.043	283	2268	-1.252	0.831
SR78CM2U	m	2	C	West	ɪ	113.720	-0.817	428	1994	-0.838	0.702
SR78CM2U	m	2	C	West	e	212.250	0.815	397	2123	-0.915	0.764
SR78CM2U	m	2	C	West	ɛ	126.260	-0.609	498	1913	-0.693	0.658
SR78CM2U	m	2	C	West	æ	193.460	0.504	671	1697	-0.387	0.538
SR78CM2U	m	2	C	West	ɑ	257.550	1.565	647	956	-0.426	-0.036
SR78CM2U	m	2	C	West	ɔ	257.240	1.560	639	965	-0.437	-0.030
SR78CM2U	m	2	C	West	o	173.060	0.166	396	841	-0.914	-0.163
SR78CM2U	m	2	C	West	ʊ	98.380	-1.071	390	1265	-0.929	0.245
SR78CM2U	m	2	C	West	u	111.060	-0.861	338	1387	-1.074	0.339
SRN85CF2A	f	2	C	West	i	141.960	-0.349	396	2696	-0.916	1.004
SRN85CF2A	f	2	C	West	ɪ	96.060	-1.109	525	2248	-0.637	0.821
SRN85CF2A	f	2	C	West	e	206.610	0.722	508	2365	-0.668	0.872
SRN85CF2A	f	2	C	West	ɛ	107.990	-0.912	611	2019	-0.485	0.715
SRN85CF2A	f	2	C	West	æ	172.870	0.163	773	1858	-0.250	0.630
SRN85CF2A	f	2	C	West	ɑ	205.270	0.699	663	1261	-0.401	0.243
SRN85CF2A	f	2	C	West	ɔ	237.070	1.226	691	1211	-0.365	0.203
SRN85CF2A	f	2	C	West	o	146.270	-0.278	473	1032	-0.742	0.042
SRN85CF2A	f	2	C	West	ʊ	83.900	-1.311	494	1631	-0.697	0.499

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SRN85CF2A	f	2	C	West	u	114.760	-0.799	424	1283	-0.869	0.259
SRN86CF3A	f	3	C	West	i	151.550	-0.190	406	2589	-0.891	0.962
SRN86CF3A	f	3	C	West	ɪ	92.830	-1.163	490	2053	-0.702	0.730
SRN86CF3A	f	3	C	West	e	193.090	0.498	490	2306	-0.704	0.846
SRN86CF3A	f	3	C	West	ɛ	110.350	-0.873	644	1940	-0.432	0.674
SRN86CF3A	f	3	C	West	æ	187.100	0.398	766	1742	-0.257	0.566
SRN86CF3A	f	3	C	West	ɑ	247.120	1.392	686	1250	-0.365	0.235
SRN86CF3A	f	3	C	West	ɔ	246.330	1.379	705	1282	-0.338	0.260
SRN86CF3A	f	3	C	West	o	151.010	-0.199	466	1253	-0.753	0.238
SRN86CF3A	f	3	C	West	ʊ	98.500	-1.069	545	1697	-0.594	0.541
SRN86CF3A	f	3	C	West	u	123.320	-0.658	402	1699	-0.900	0.541
SS27CM3O	m	3	C	West	i	118.880	-0.731	274	2348	-1.282	0.865
SS27CM3O	m	3	C	West	ɪ	80.930	-1.360	380	2051	-0.957	0.730
SS27CM3O	m	3	C	West	e	259.840	1.603	379	2134	-0.963	0.769
SS27CM3O	m	3	C	West	ɛ	110.660	-0.867	485	1735	-0.715	0.559
SS27CM3O	m	3	C	West	æ	186.020	0.380	616	1717	-0.476	0.549
SS27CM3O	m	3	C	West	ɑ	189.270	0.434	607	1002	-0.488	0.012
SS27CM3O	m	3	C	West	ɔ	216.630	0.887	532	952	-0.621	-0.038
SS27CM3O	m	3	C	West	o	173.500	0.173	426	1118	-0.845	0.122
SS27CM3O	m	3	C	West	ʊ	89.440	-1.219	395	1409	-0.918	0.355
SS27CM3O	m	3	C	West	u	103.360	-0.988	279	1251	-1.266	0.231
STA106AF3M	f	3	AA	West	i	145.480	-0.291	366	3140	-0.997	1.156
STA106AF3M	f	3	AA	West	ɪ	62.450	-1.666	455	2413	-0.779	0.893
STA106AF3M	f	3	AA	West	e	176.850	0.229	432	2700	-0.830	1.005
STA106AF3M	f	3	AA	West	ɛ	106.680	-0.933	571	2153	-0.552	0.777
STA106AF3M	f	3	AA	West	æ	163.330	0.005	720	1990	-0.324	0.698
STA106AF3M	f	3	AA	West	ɑ	182.360	0.320	654	1370	-0.414	0.327
STA106AF3M	f	3	AA	West	ɔ	180.050	0.282	716	1472	-0.325	0.394
STA106AF3M	f	3	AA	West	o	154.760	-0.137	441	1021	-0.807	0.030
STA106AF3M	f	3	AA	West	ʊ	106.280	-0.940	487	1886	-0.707	0.645
STA106AF3M	f	3	AA	West	u	134.470	-0.473	392	1455	-0.925	0.385
STA107AF3N	f	3	AA	West	i	142.140	-0.346	390	2621	-0.930	0.975
STA107AF3N	f	3	AA	West	ɪ	85.970	-1.276	430	2080	-0.831	0.744
STA107AF3N	f	3	AA	West	e	183.030	0.331	442	2250	-0.807	0.822
STA107AF3N	f	3	AA	West	ɛ	108.030	-0.911	570	1911	-0.551	0.659
STA107AF3N	f	3	AA	West	æ	178.100	0.249	784	1695	-0.234	0.540
STA107AF3N	f	3	AA	West	ɑ	197.290	0.567	764	1234	-0.257	0.221
STA107AF3N	f	3	AA	West	ɔ	197.980	0.579	759	1242	-0.265	0.228
STA107AF3N	f	3	AA	West	ʊ	102.820	-0.997	471	1722	-0.742	0.555

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
STA107AF3N	f	3	AA	West	u	112.500	-0.837	400	1672	-0.904	0.525
SU28CM3P	m	3	C	West	i	108.660	-0.901	283	2352	-1.250	0.867
SU28CM3P	m	3	C	West	ɪ	73.170	-1.488	424	1894	-0.846	0.650
SU28CM3P	m	3	C	West	e	188.290	0.418	402	2042	-0.903	0.726
SU28CM3P	m	3	C	West	ɛ	96.820	-1.096	504	1699	-0.674	0.540
SU28CM3P	m	3	C	West	æ	154.330	-0.144	698	1665	-0.352	0.519
SU28CM3P	m	3	C	West	ɑ	191.030	0.463	711	1047	-0.329	0.058
SU28CM3P	m	3	C	West	ɔ	169.550	0.108	671	1050	-0.389	0.060
SU28CM3P	m	3	C	West	o	120.380	-0.706	394	1011	-0.923	0.023
SU28CM3P	m	3	C	West	ʊ	58.150	-1.737	405	1439	-0.905	0.376
SU28CM3P	m	3	C	West	u	88.950	-1.227	293	1243	-1.217	0.229
SW58SF2B	f	2	JA	West	i	187.170	0.400	367	2970	-0.990	1.100
SW58SF2B	f	2	JA	West	ɪ	112.540	-0.836	417	2435	-0.863	0.902
SW58SF2B	f	2	JA	West	e	259.240	1.593	448	2682	-0.795	0.998
SW58SF2B	f	2	JA	West	ɛ	143.510	-0.323	599	2222	-0.503	0.809
SW58SF2B	f	2	JA	West	æ	234.780	1.188	688	2016	-0.363	0.710
SW58SF2B	f	2	JA	West	ɑ	248.280	1.411	637	1310	-0.440	0.277
SW58SF2B	f	2	JA	West	ɔ	283.060	1.987	678	1249	-0.377	0.234
SW58SF2B	f	2	JA	West	o	204.800	0.691	407	837	-0.889	-0.172
SW58SF2B	f	2	JA	West	ʊ	115.310	-0.790	463	1651	-0.760	0.513
SW58SF2B	f	2	JA	West	u	191.420	0.470	405	1540	-0.896	0.442
SW72CF2S	f	2	C	West	i	104.590	-0.968	336	2576	-1.081	0.957
SW72CF2S	f	2	C	West	ɪ	80.450	-1.368	475	2288	-0.735	0.839
SW72CF2S	f	2	C	West	e	158.200	-0.080	470	2286	-0.746	0.837
SW72CF2S	f	2	C	West	ɛ	89.980	-1.210	534	2061	-0.618	0.734
SW72CF2S	f	2	C	West	æ	135.930	-0.449	747	1821	-0.287	0.610
SW72CF2S	f	2	C	West	ɑ	166.810	0.062	771	1387	-0.252	0.338
SW72CF2S	f	2	C	West	ɔ	179.230	0.268	666	1291	-0.398	0.266
SW72CF2S	f	2	C	West	o	138.150	-0.412	472	1296	-0.739	0.271
SW72CF2S	f	2	C	West	ʊ	76.510	-1.433	495	1729	-0.692	0.558
SW72CF2S	f	2	C	West	u	75.950	-1.442	362	1588	-1.006	0.471
YH47HM3H	m	3	MA	Central	i	111	-0.862	289	2376	-1.229	0.877
YH47HM3H	m	3	MA	Central	ɪ	63.390	-1.650	365	1946	-0.997	0.677
YH47HM3H	m	3	MA	Central	e	158.860	-0.069	366	2163	-0.995	0.783
YH47HM3H	m	3	MA	Central	ɛ	86.150	-1.273	436	1820	-0.818	0.610
YH47HM3H	m	3	MA	Central	æ	128.460	-0.573	518	1715	-0.647	0.550
YH47HM3H	m	3	MA	Central	ɑ	162.370	-0.011	644	1132	-0.432	0.134
YH47HM3H	m	3	MA	Central	ɔ	162.630	-0.007	567	1070	-0.559	0.079
YH47HM3H	m	3	MA	Central	o	133.380	-0.491	425	1262	-0.844	0.245

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YH47HM3H	m	3	MA	Central	ʊ	77.800	-1.412	412	1615	-0.879	0.491
YH47HM3H	m	3	MA	Central	u	131.390	-0.524	329	1384	-1.099	0.335
YH48HF3H	f	3	MA	Central	i	73.060	-1.490	382	2775	-0.950	1.032
YH48HF3H	f	3	MA	Central	ɪ	81.160	-1.356	478	2220	-0.728	0.809
YH48HF3H	f	3	MA	Central	e	139.690	-0.387	457	2505	-0.772	0.929
YH48HF3H	f	3	MA	Central	ɛ	91.840	-1.179	542	2019	-0.602	0.714
YH48HF3H	f	3	MA	Central	æ	111.720	-0.850	648	1903	-0.425	0.652
YH48HF3H	f	3	MA	Central	ɑ	156.400	-0.110	546	1131	-0.598	0.134
YH48HF3H	f	3	MA	Central	o	145.050	-0.298	509	1213	-0.663	0.205
YH48HF3H	f	3	MA	Central	ʊ	98.320	-1.072	504	1835	-0.674	0.619
YH48HF3H	f	3	MA	Central	u	106.080	-0.943	424	1540	-0.847	0.440
YM37HF2C	f	2	MA	Central	i	144.600	-0.305	357	2721	-1.023	1.013
YM37HF2C	f	2	MA	Central	ɪ	100.110	-1.042	440	2418	-0.809	0.894
YM37HF2C	f	2	MA	Central	e	218.760	0.923	429	2548	-0.837	0.947
YM37HF2C	f	2	MA	Central	ɛ	140.570	-0.372	553	2153	-0.584	0.775
YM37HF2C	f	2	MA	Central	æ	181.470	0.305	844	1718	-0.158	0.552
YM37HF2C	f	2	MA	Central	ɑ	206.900	0.726	852	1264	-0.148	0.246
YM37HF2C	f	2	MA	Central	ɔ	252.100	1.475	832	1242	-0.174	0.228
YM37HF2C	f	2	MA	Central	o	235.830	1.205	436	904	-0.818	-0.089
YM37HF2C	f	2	MA	Central	ʊ	102.870	-0.996	423	1363	-0.848	0.319
YM37HF2C	f	2	MA	Central	u	170.010	0.115	360	1039	-1.021	0.050
YS44NF2G	f	2	YN	Central	i	226.240	1.046	305	2722	-1.177	1.013
YS44NF2G	f	2	YN	Central	ɪ	97.570	-1.084	368	2391	-0.990	0.883
YS44NF2G	f	2	YN	Central	e	236.080	1.209	360	2621	-1.012	0.975
YS44NF2G	f	2	YN	Central	ɛ	127.230	-0.593	445	2167	-0.803	0.783
YS44NF2G	f	2	YN	Central	æ	190.780	0.459	536	2018	-0.617	0.712
YS44NF2G	f	2	YN	Central	ɑ	208.310	0.750	504	1318	-0.674	0.288
YS44NF2G	f	2	YN	Central	ɔ	255.570	1.532	484	1243	-0.717	0.228
YS44NF2G	f	2	YN	Central	o	260.720	1.617	328	1027	-1.117	0.036
YS44NF2G	f	2	YN	Central	ʊ	88.330	-1.237	412	1895	-0.877	0.651
YS44NF2G	f	2	YN	Central	u	190.170	0.449	321	1365	-1.123	0.323
YS45NF2G	f	2	YN	Central	i	216.260	0.881	324	2162	-1.115	0.783
YS45NF2G	f	2	YN	Central	ɪ	75.080	-1.457	379	2313	-0.959	0.849
YS45NF2G	f	2	YN	Central	e	252.710	1.485	401	2268	-0.907	0.825
YS45NF2G	f	2	YN	Central	ɛ	129.640	-0.553	459	2182	-0.770	0.791
YS45NF2G	f	2	YN	Central	æ	190.710	0.458	639	1852	-0.443	0.626
YS45NF2G	f	2	YN	Central	ɑ	203.930	0.677	588	1133	-0.519	0.136
YS45NF2G	f	2	YN	Central	ʊ	96.940	-1.095	400	1496	-0.905	0.412
YS45NF2G	f	2	YN	Central	u	190.940	0.462	363	1484	-1.001	0.406

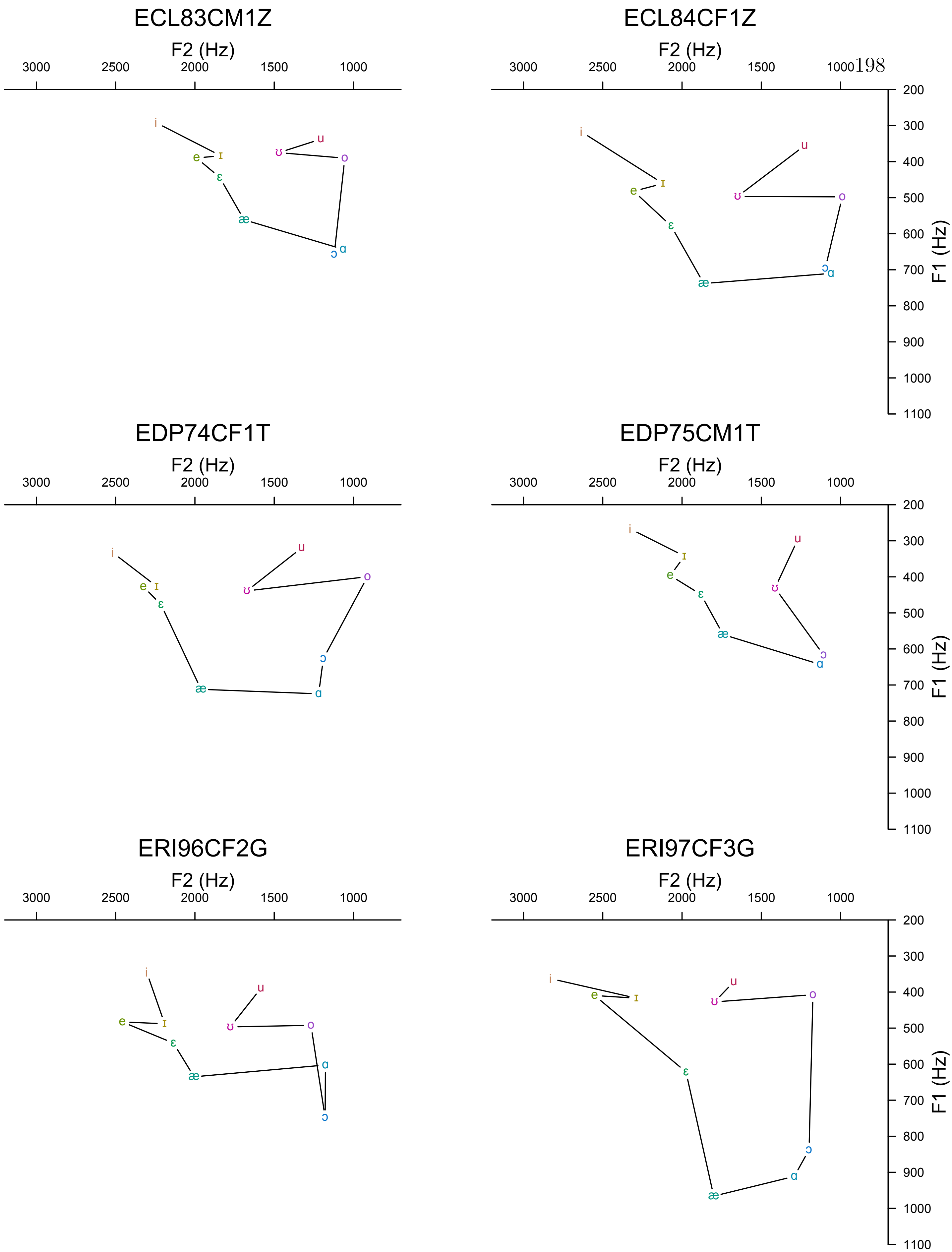
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YS46NF3G	f	3	YN	Central	i	123.940	-0.647	376	2371	-0.966	0.874
YS46NF3G	f	3	YN	Central	ɪ	89.530	-1.217	414	2240	-0.874	0.818
YS46NF3G	f	3	YN	Central	e	199.310	0.601	427	2273	-0.840	0.832
YS46NF3G	f	3	YN	Central	ɛ	103.860	-0.980	457	1943	-0.775	0.675
YS46NF3G	f	3	YN	Central	æ	153.460	-0.159	613	1722	-0.487	0.554
YS46NF3G	f	3	YN	Central	ɑ	172.680	0.160	597	1291	-0.504	0.267
YS46NF3G	f	3	YN	Central	ɔ	158.840	-0.070	700	1190	-0.345	0.184
YS46NF3G	f	3	YN	Central	o	168.110	0.084	446	1176	-0.797	0.173
YS46NF3G	f	3	YN	Central	ʊ	92.890	-1.162	424	1686	-0.848	0.534
YS46NF3G	f	3	YN	Central	u	146.550	-0.273	350	1523	-1.037	0.433
YT49NM2E	m	2	YN	Central	i	209.880	0.776	286	2012	-1.241	0.710
YT49NM2E	m	2	YN	Central	ɪ	125.280	-0.625	387	1884	-0.942	0.644
YT49NM2E	m	2	YN	Central	e	272.040	1.805	361	1864	-1.014	0.632
YT49NM2E	m	2	YN	Central	ɛ	166.200	0.052	461	1730	-0.770	0.558
YT49NM2E	m	2	YN	Central	æ	219.620	0.937	613	1512	-0.479	0.424
YT49NM2E	m	2	YN	Central	ɑ	268.080	1.739	607	972	-0.487	-0.017
YT49NM2E	m	2	YN	Central	ɔ	265.780	1.701	601	977	-0.497	-0.011
YT49NM2E	m	2	YN	Central	o	259.030	1.590	400	799	-0.904	-0.212
YT49NM2E	m	2	YN	Central	ʊ	121.170	-0.693	405	1228	-0.892	0.218
YT49NM2E	m	2	YN	Central	u	214.850	0.858	305	954	-1.177	-0.035
YU51NM2E	m	2	YN	Central	i	146.060	-0.281	312	2399	-1.157	0.887
YU51NM2E	m	2	YN	Central	ɪ	102.630	-1	373	2136	-0.981	0.770
YU51NM2E	m	2	YN	Central	e	226.960	1.058	353	2211	-1.035	0.805
YU51NM2E	m	2	YN	Central	ɛ	119.030	-0.729	450	2050	-0.790	0.725
YU51NM2E	m	2	YN	Central	æ	170.200	0.119	603	1945	-0.496	0.675
YU51NM2E	m	2	YN	Central	ɑ	237.740	1.237	656	952	-0.413	-0.049
YU51NM2E	m	2	YN	Central	ɔ	170.450	0.123	658	1010	-0.407	0.021
YU51NM2E	m	2	YN	Central	o	187.200	0.400	376	867	-0.968	-0.137
YU51NM2E	m	2	YN	Central	ʊ	100.100	-1.042	412	1753	-0.874	0.573
YU51NM2E	m	2	YN	Central	u	152.050	-0.182	286	1848	-1.242	0.623
YW41NM3F	m	3	YN	Central	i	255.120	1.525	276	2395	-1.278	0.883
YW41NM3F	m	3	YN	Central	ɪ	134.180	-0.478	377	1996	-0.963	0.703
YW41NM3F	m	3	YN	Central	e	320.470	2.607	417	2077	-0.870	0.742
YW41NM3F	m	3	YN	Central	ɛ	170.660	0.126	528	1798	-0.628	0.598
YW41NM3F	m	3	YN	Central	æ	247.200	1.394	645	1673	-0.426	0.525
YW41NM3F	m	3	YN	Central	ɑ	271.400	1.794	632	1015	-0.447	0.021
YW41NM3F	m	3	YN	Central	ɔ	271.890	1.802	643	709	-0.430	-0.332
YW41NM3F	m	3	YN	Central	o	216.250	0.881	362	783	-1.003	-0.234
YW41NM3F	m	3	YN	Central	ʊ	177.480	0.239	370	1318	-0.984	0.285

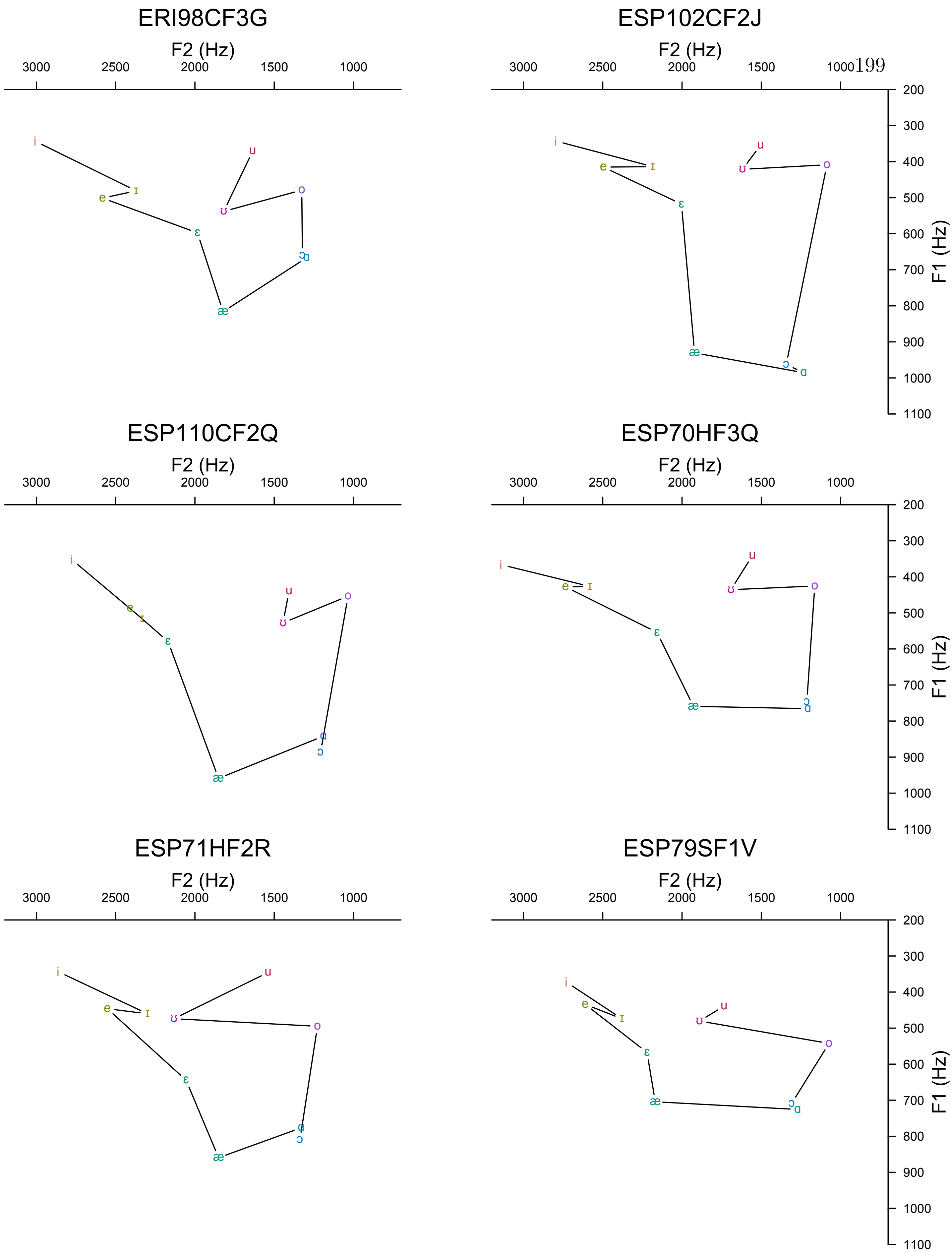
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YW41NM3F	m	3	YN	Central	u	222.300	0.981	304	1069	-1.180	0.074
YW42NM3G	m	3	YN	Central	i	139.770	-0.385	283	2287	-1.251	0.839
YW42NM3G	m	3	YN	Central	ɪ	100.040	-1.043	413	1886	-0.873	0.646
YW42NM3G	m	3	YN	Central	e	206.110	0.713	404	2018	-0.897	0.711
YW42NM3G	m	3	YN	Central	ɛ	112.050	-0.844	466	1672	-0.756	0.526
YW42NM3G	m	3	YN	Central	æ	167.430	0.073	646	1616	-0.432	0.490
YW42NM3G	m	3	YN	Central	ɑ	191.610	0.473	649	1119	-0.426	0.125
YW42NM3G	m	3	YN	Central	ɔ	200.950	0.628	736	1089	-0.302	0.097
YW42NM3G	m	3	YN	Central	o	179.240	0.268	403	893	-0.899	-0.102
YW42NM3G	m	3	YN	Central	ʊ	106.630	-0.934	417	1374	-0.862	0.329
YW42NM3G	m	3	YN	Central	u	142.350	-0.343	334	1188	-1.084	0.184
YW43HM3H	m	3	MA	Central	i	122.520	-0.671	268	2211	-1.306	0.805
YW43HM3H	m	3	MA	Central	ɪ	127.110	-0.595	372	1840	-0.979	0.622
YW43HM3H	m	3	MA	Central	e	174.430	0.189	396	1927	-0.919	0.668
YW43HM3H	m	3	MA	Central	ɛ	120.600	-0.703	465	1690	-0.756	0.536
YW43HM3H	m	3	MA	Central	æ	163.850	0.013	599	1620	-0.502	0.491
YW43HM3H	m	3	MA	Central	ɑ	124.680	-0.635	614	1070	-0.476	0.077
YW43HM3H	m	3	MA	Central	ɔ	155.580	-0.124	590	1004	-0.516	0.015
YW43HM3H	m	3	MA	Central	o	159.140	-0.065	370	970	-0.984	-0.020
YW43HM3H	m	3	MA	Central	ʊ	118.090	-0.744	379	1402	-0.959	0.347
YW43HM3H	m	3	MA	Central	u	143.990	-0.315	292	1332	-1.223	0.293
YY35HF3A	f	3	MA	Central	i	110.970	-0.862	384	2930	-0.944	1.087
YY35HF3A	f	3	MA	Central	ɪ	70.840	-1.527	425	2231	-0.845	0.814
YY35HF3A	f	3	MA	Central	e	191.890	0.478	408	2577	-0.891	0.956
YY35HF3A	f	3	MA	Central	ɛ	99.650	-1.050	560	1979	-0.572	0.694
YY35HF3A	f	3	MA	Central	æ	162.290	-0.012	834	1802	-0.177	0.600
YY35HF3A	f	3	MA	Central	ɑ	195.750	0.542	798	1235	-0.219	0.221
YY35HF3A	f	3	MA	Central	ɔ	166.670	0.060	705	1220	-0.341	0.207
YY35HF3A	f	3	MA	Central	o	157.960	-0.084	448	1186	-0.795	0.182
YY35HF3A	f	3	MA	Central	ʊ	81.220	-1.355	494	1708	-0.698	0.547
YY35HF3A	f	3	MA	Central	u	132.690	-0.503	386	1423	-0.939	0.365
YY36HF3B	f	3	MA	Central	i	144.450	-0.308	337	2993	-1.077	1.108
YY36HF3B	f	3	MA	Central	ɪ	82.050	-1.341	465	2485	-0.754	0.922
YY36HF3B	f	3	MA	Central	e	181.710	0.309	441	2746	-0.811	1.021
YY36HF3B	f	3	MA	Central	ɛ	122.540	-0.671	585	2265	-0.529	0.829
YY36HF3B	f	3	MA	Central	æ	165.460	0.040	833	1969	-0.173	0.686
YY36HF3B	f	3	MA	Central	ɑ	179.710	0.276	761	1261	-0.262	0.243
YY36HF3B	f	3	MA	Central	ɔ	209.160	0.764	821	1358	-0.185	0.316
YY36HF3B	f	3	MA	Central	o	175.220	0.202	478	1100	-0.732	0.103

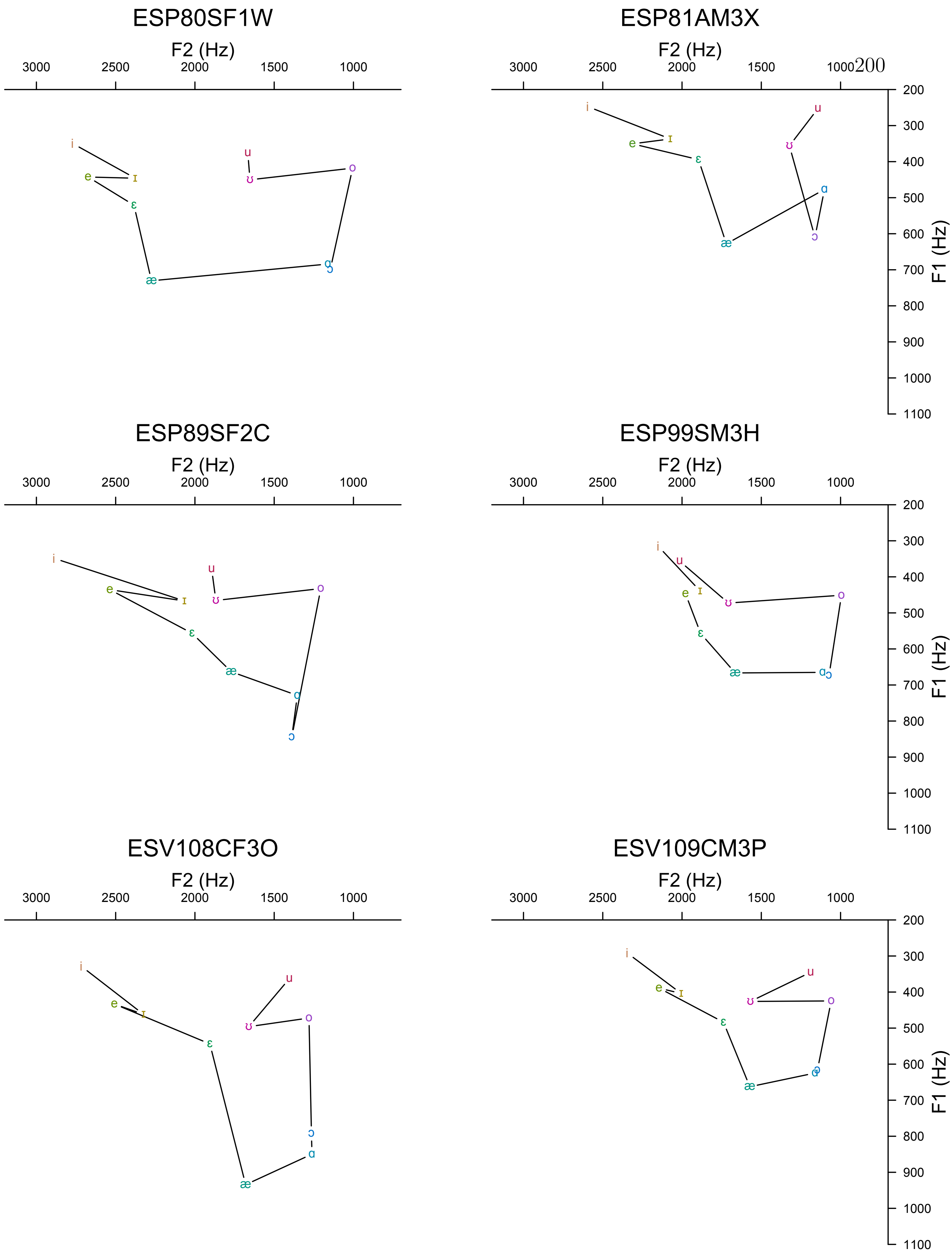
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YY36HF3B	f	3	MA	Central	ʊ	95.030	-1.126	512	1806	-0.660	0.598
YY36HF3B	f	3	MA	Central	u	113.830	-0.815	402	1448	-0.900	0.378
YY39HF3D	f	3	MA	Central	i	130.140	-0.545	415	2373	-0.868	0.876
YY39HF3D	f	3	MA	Central	ɪ	80.390	-1.369	510	2408	-0.662	0.890
YY39HF3D	f	3	MA	Central	e	167.150	0.068	453	2619	-0.782	0.974
YY39HF3D	f	3	MA	Central	ɛ	111.100	-0.860	622	2128	-0.467	0.767
YY39HF3D	f	3	MA	Central	æ	153.390	-0.160	772	1962	-0.249	0.685
YY39HF3D	f	3	MA	Central	ɑ	179.250	0.268	839	1375	-0.165	0.329
YY39HF3D	f	3	MA	Central	ɔ	198.190	0.582	760	1318	-0.265	0.287
YY39HF3D	f	3	MA	Central	o	186.220	0.384	448	1160	-0.791	0.160
YY39HF3D	f	3	MA	Central	ʊ	98.060	-1.076	586	1990	-0.526	0.699
YY39HF3D	f	3	MA	Central	u	122.400	-0.673	478	1655	-0.727	0.513
YY52HF3I	f	3	MA	Central	i	120.210	-0.709	318	2954	-1.132	1.094
YY52HF3I	f	3	MA	Central	ɪ	113.560	-0.819	482	2376	-0.717	0.877
YY52HF3I	f	3	MA	Central	e	207.240	0.732	436	2562	-0.821	0.951
YY52HF3I	f	3	MA	Central	ɛ	126.350	-0.608	608	2144	-0.489	0.774
YY52HF3I	f	3	MA	Central	æ	189.340	0.435	788	1802	-0.238	0.598
YY52HF3I	f	3	MA	Central	ɑ	217.530	0.902	845	1205	-0.156	0.195
YY52HF3I	f	3	MA	Central	ɔ	233.270	1.163	848	1258	-0.153	0.241
YY52HF3I	f	3	MA	Central	o	181.250	0.302	496	964	-0.691	-0.025
YY52HF3I	f	3	MA	Central	ʊ	174.080	0.183	455	1482	-0.776	0.405
YY52HF3I	f	3	MA	Central	u	163.820	0.013	366	1578	-0.995	0.466
YY60HF2I	f	2	MA	Central	i	119.320	-0.724	281	2872	-1.262	1.067
YY60HF2I	f	2	MA	Central	ɪ	80.140	-1.373	500	2364	-0.682	0.871
YY60HF2I	f	2	MA	Central	e	199.600	0.605	445	2582	-0.800	0.960
YY60HF2I	f	2	MA	Central	ɛ	118.860	-0.732	679	2092	-0.378	0.750
YY60HF2I	f	2	MA	Central	æ	186.540	0.389	1063	1808	0.069	0.604
YY60HF2I	f	2	MA	Central	ɑ	224.770	1.022	1008	1242	0.019	0.227
YY60HF2I	f	2	MA	Central	ɔ	214.740	0.856	1023	1192	0.034	0.187
YY60HF2I	f	2	MA	Central	o	157.080	-0.099	464	992	-0.757	0.003
YY60HF2I	f	2	MA	Central	ʊ	116.850	-0.765	521	1530	-0.641	0.436
YY60HF2I	f	2	MA	Central	u	181.530	0.306	354	1121	-1.030	0.125
YZ40NF2E	f	2	YN	Central	i	124.680	-0.635	289	2879	-1.231	1.069
YZ40NF2E	f	2	YN	Central	ɪ	93.880	-1.145	437	2402	-0.816	0.888
YZ40NF2E	f	2	YN	Central	e	192.770	0.492	417	2658	-0.866	0.988
YZ40NF2E	f	2	YN	Central	ɛ	119.560	-0.720	565	2128	-0.563	0.767
YZ40NF2E	f	2	YN	Central	æ	178.430	0.255	875	1854	-0.122	0.627
YZ40NF2E	f	2	YN	Central	ɑ	170.190	0.118	879	1280	-0.117	0.259
YZ40NF2E	f	2	YN	Central	ɔ	204.060	0.679	907	1253	-0.087	0.233

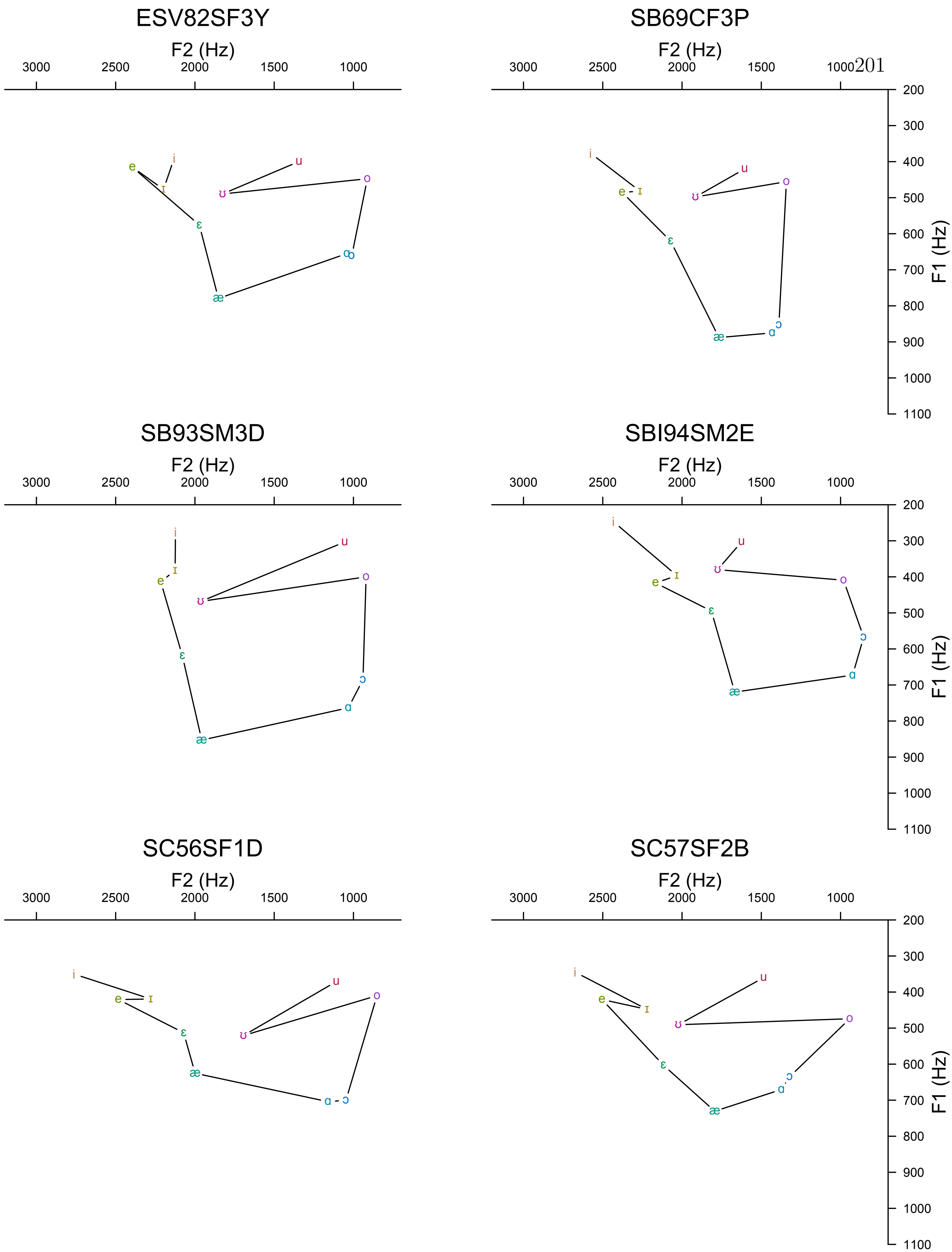
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YZ40NF2E	f	2	YN	Central	o	142.860	-0.334	407	914	-0.890	-0.078
YZ40NF2E	f	2	YN	Central	ʊ	94.370	-1.137	479	1615	-0.728	0.486
YZ40NF2E	f	2	YN	Central	u	128.620	-0.570	322	1388	-1.125	0.339

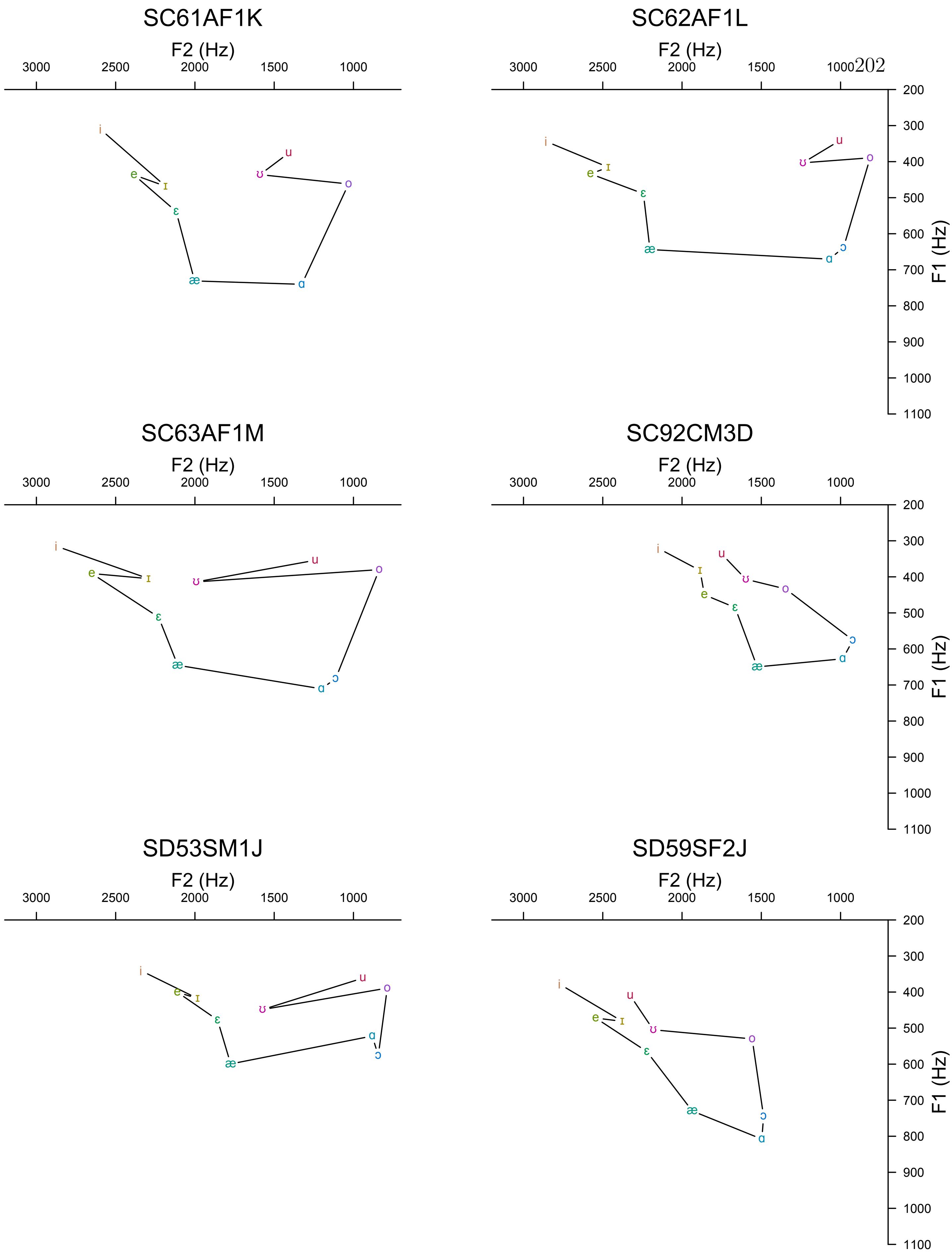
APPENDIX G: INDIVIDUAL VOWEL PLOTS

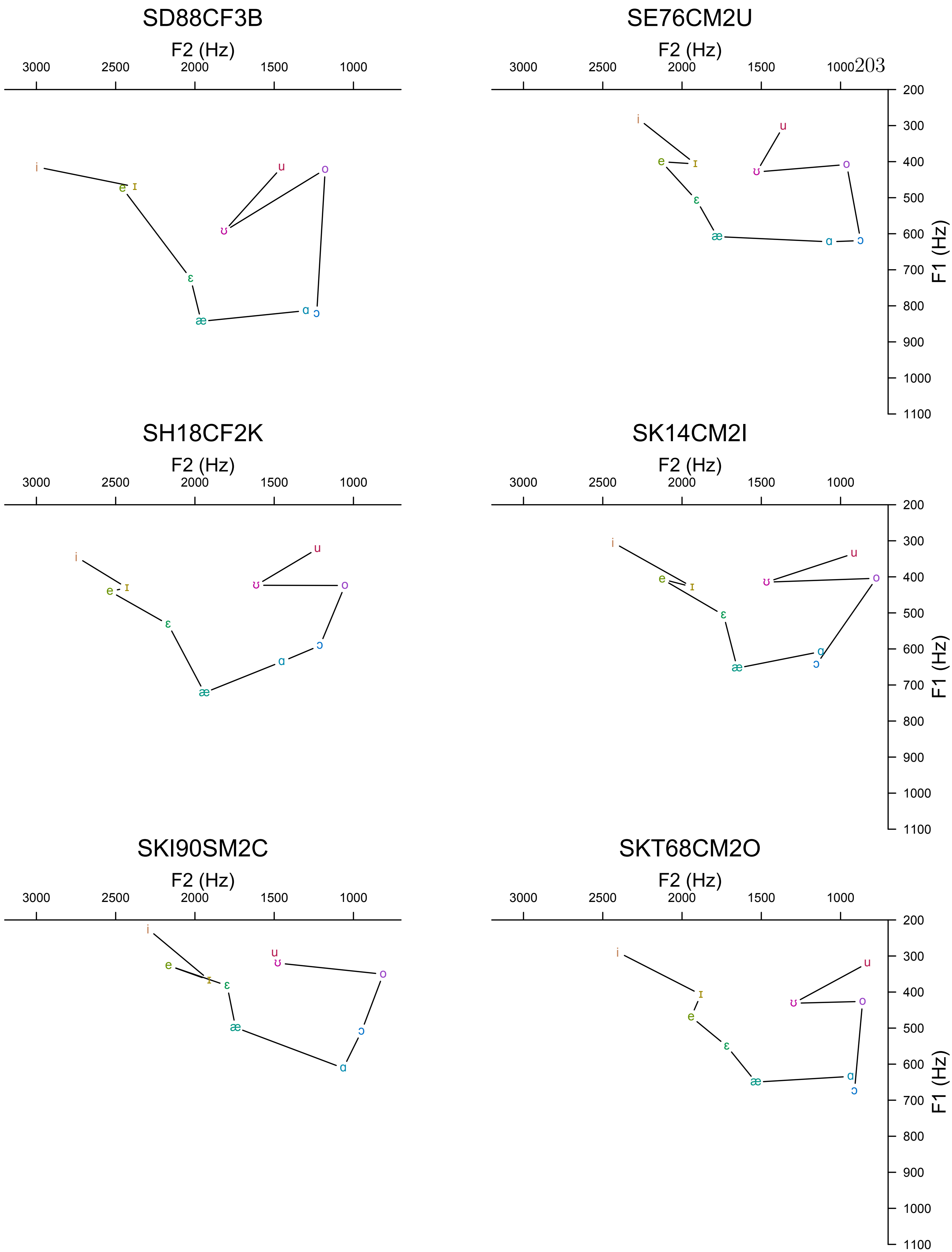

ECL83CM1Z
F2 (Hz)
3000 2500 2000 1500 1000
i ɪ e ɛ æ u ʊ o ɔ ɑ
ECL84CF1Z
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)
i ɪ e ɛ æ u ʊ o ɔ ɑ
EDP74CF1T
F2 (Hz)
3000 2500 2000 1500 1000
i e ɪ ɛ æ u ʊ o ɔ ɑ
EDP75CM1T
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)
i ɪ e ɛ æ u ʊ ɔ ɑ
ERI96CF2G
F2 (Hz)
3000 2500 2000 1500 1000
i e ɪ ɛ æ u ʊ o ɑ ɔ
ERI97CF3G
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)
i e ɪ ɛ æ u ʊ o ɔ ɑ

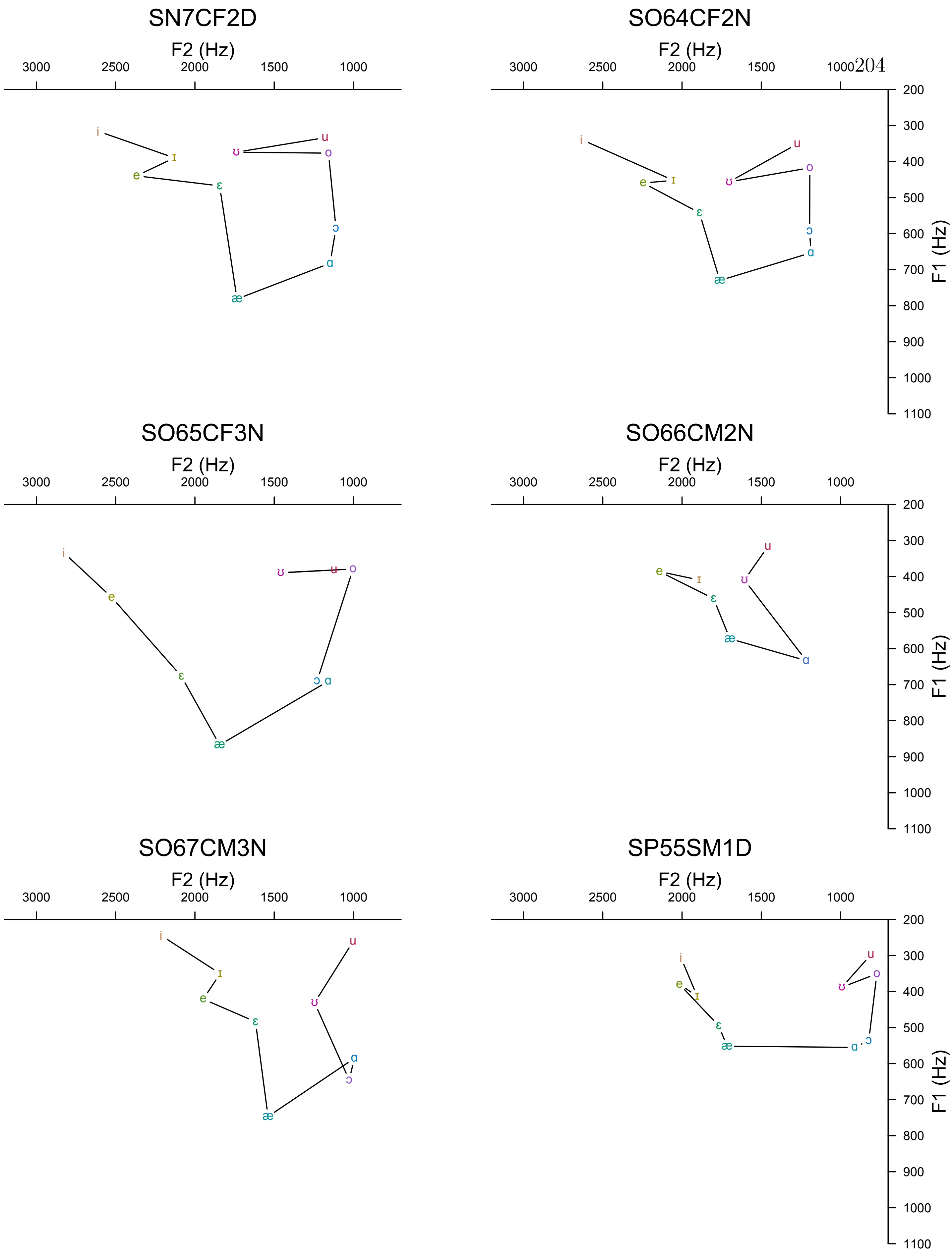

ERI98CF3G
F2 (Hz)
3000 2500 2000 1500 1000
i ɪ e ɛ æ ɑ ɔ o ʊ u
ESP102CF2J
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
i ɪ e ɛ æ ɑ ɔ o ʊ u
ESP110CF2Q
F2 (Hz)
3000 2500 2000 1500 1000
i e ɪ ɛ æ ɑ ɔ o ʊ u
ESP70HF3Q
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
i e ɪ ɛ æ ɑ ɔ o ʊ u
ESP71HF2R
F2 (Hz)
3000 2500 2000 1500 1000
i e ɪ ɛ æ ɑ ɔ o ʊ u
ESP79SF1V
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
i e ɪ ɛ æ ɑ ɔ o ʊ u

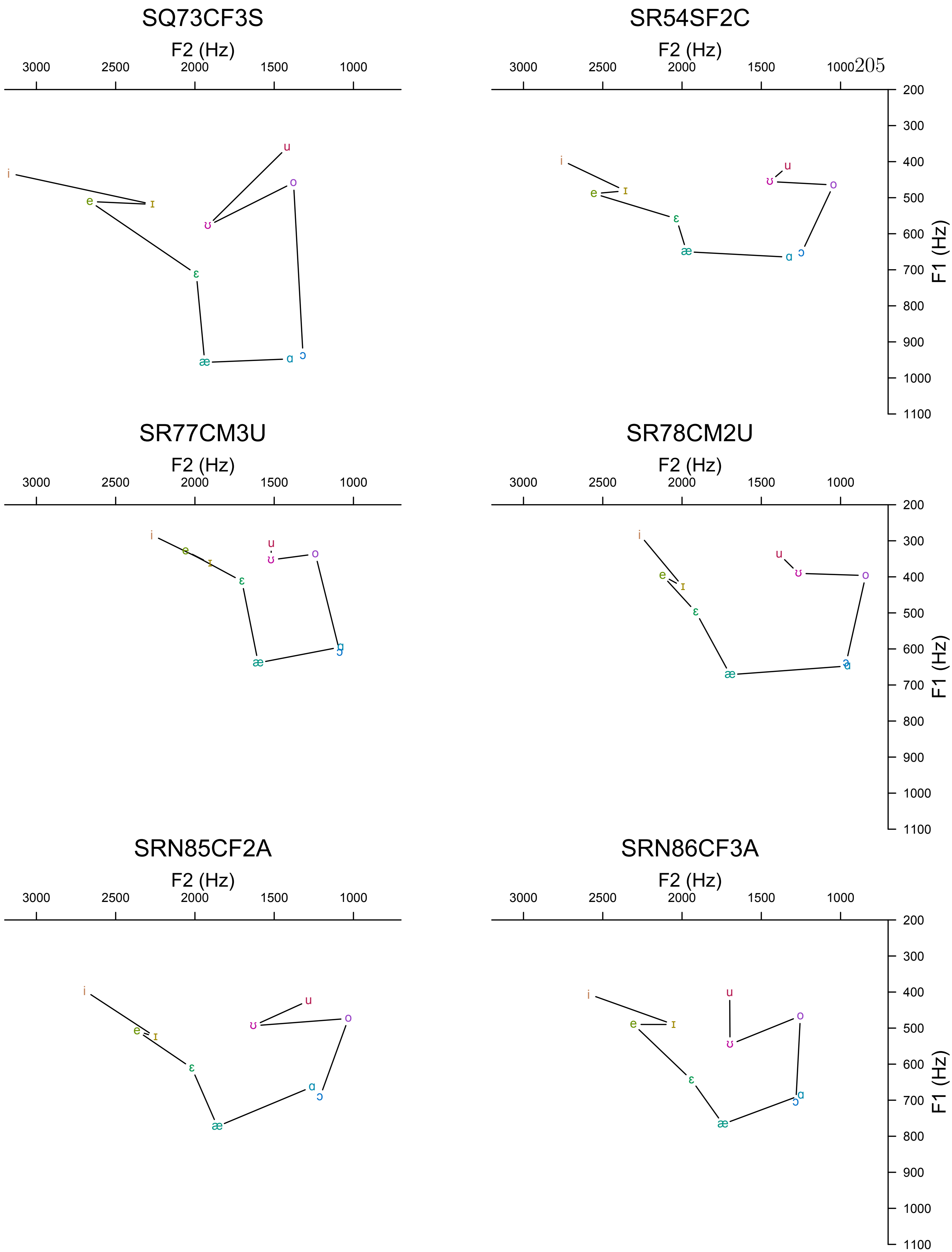

ESP80SF1W
F2 (Hz)
3000
2500
2000
1500
1000
i
ɪ
e
ɛ
æ
u
ʊ
o
ɑ
ɔ
ESP81AM3X
F2 (Hz)
3000
2500
2000
1500
1000
200
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
i
ɪ
e
ɛ
æ
u
ʊ
ɑ
ɔ
ESP89SF2C
F2 (Hz)
3000
2500
2000
1500
1000
i
e
ɪ
u
ʊ
o
ɛ
æ
ɑ
ɔ
ESP99SM3H
F2 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
i
u
e
ɪ
ʊ
o
ɛ
æ
ɑ
ɔ
ESV108CF3O
F2 (Hz)
3000
2500
2000
1500
1000
i
e
ɪ
u
ʊ
o
ɛ
ɔ
ɑ
æ
ESV109CM3P
F2 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
i
e
ɪ
u
ʊ
o
ɛ
ɔ
ɑ
æ

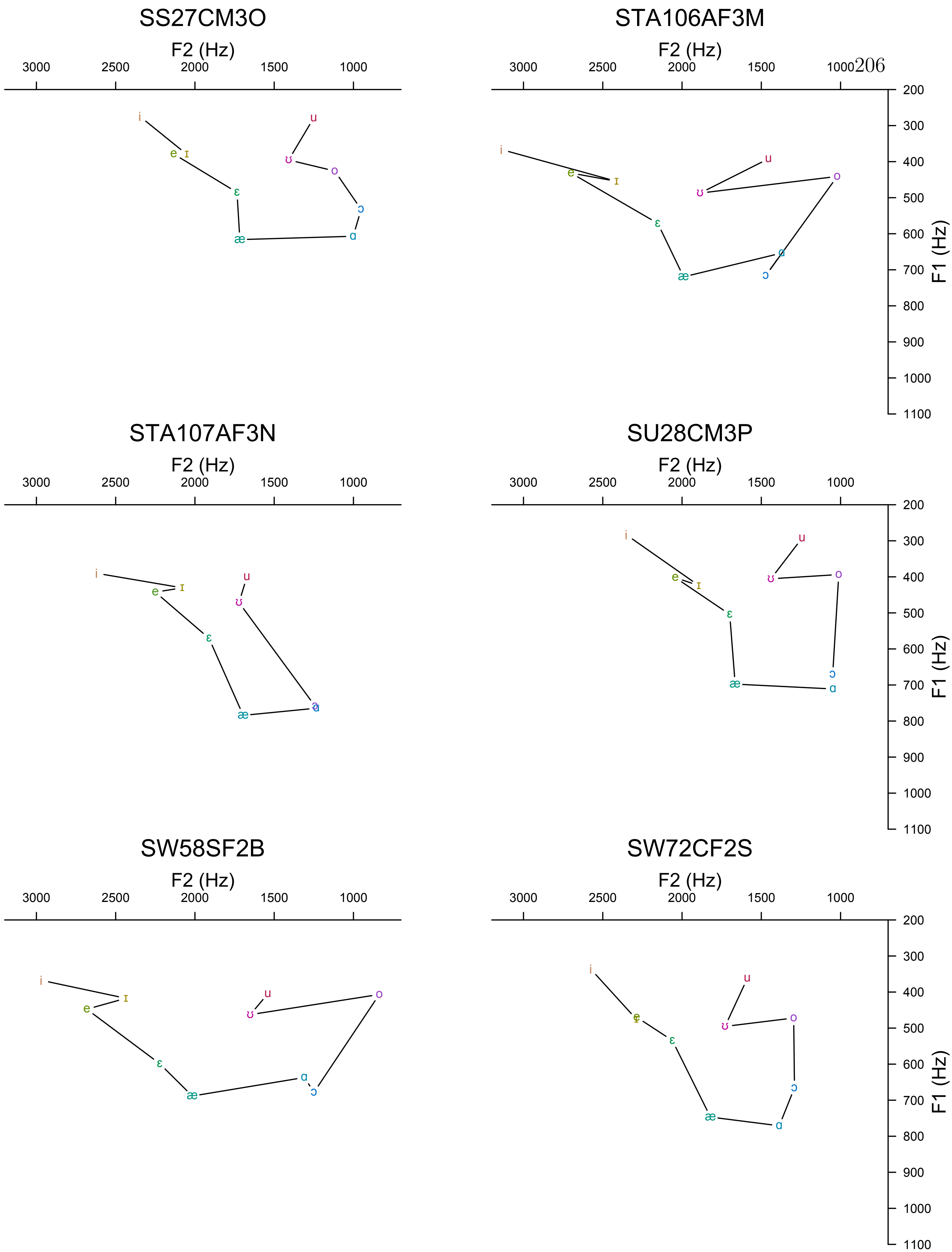

ESV82SF3Y
F2 (Hz)
3000
2500
2000
1500
1000
SB69CF3P
F2 (Hz)
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
SB93SM3D
SBI94SM2E
SC56SF1D
SC57SF2B
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u

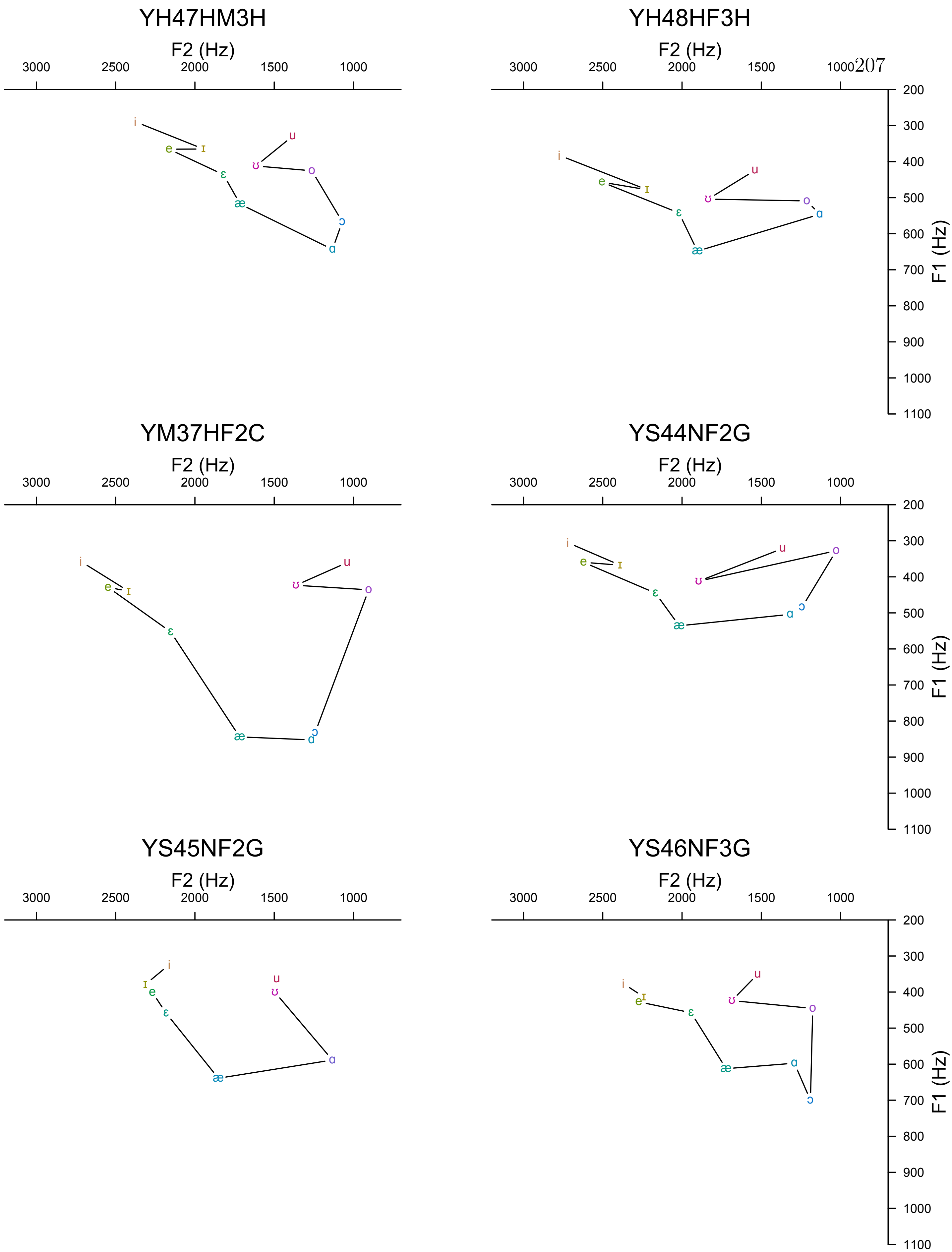

SC61AF1K
SC62AF1L
SC63AF1M
SC92CM3D
SD53SM1J
SD59SF2J
F2 (Hz)
3000
2500
2000
1500
1000
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u


SD88CF3B
F2 (Hz)
3000
2500
2000
1500
1000
SE76CM2U
F2 (Hz)
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
SH18CF2K
SK14CM2I
SKI90SM2C
SKT68CM2O
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u

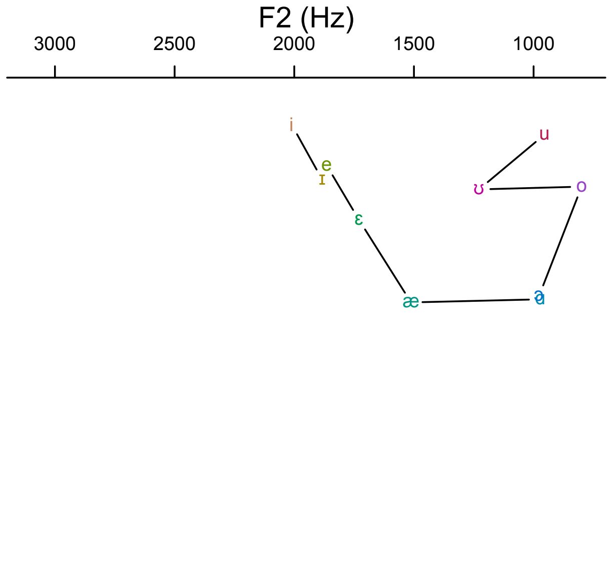

SN7CF2D
F2 (Hz)
3000 2500 2000 1500 1000
SO64CF2N
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)
SO65CF3N
F2 (Hz)
3000 2500 2000 1500 1000
SO66CM2N
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)
SO67CM3N
F2 (Hz)
3000 2500 2000 1500 1000
SP55SM1D
F2 (Hz)
3000 2500 2000 1500 1000
200 300 400 500 600 700 800 900 1000 1100
F1 (Hz)


SQ73CF3S
F2 (Hz)
SR54SF2C
F2 (Hz)
F1 (Hz)
SR77CM3U
F2 (Hz)
SR78CM2U
F2 (Hz)
F1 (Hz)
SRN85CF2A
F2 (Hz)
SRN86CF3A
F2 (Hz)
F1 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u

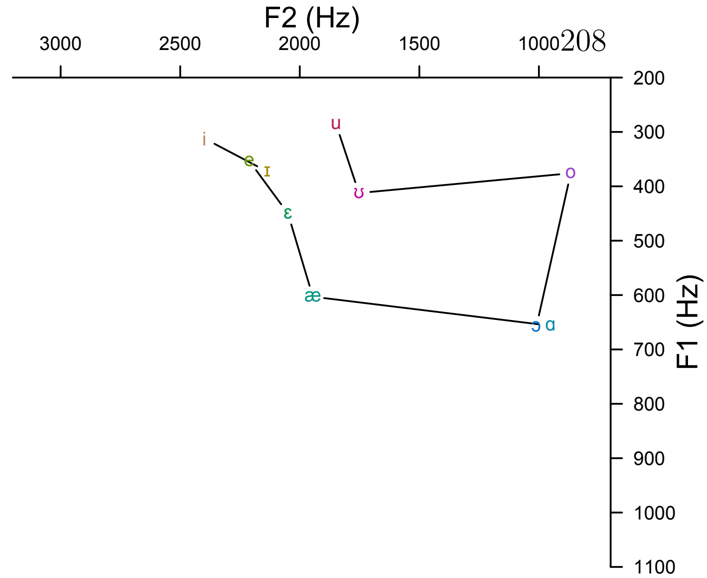

SS27CM3O
STA106AF3M
STA107AF3N
SU28CM3P
SW58SF2B
SW72CF2S
F2 (Hz)
3000
2500
2000
1500
1000
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u


YH47HM3H
YH48HF3H
YM37HF2C
YS44NF2G
YS45NF2G
YS46NF3G
F2 (Hz)
3000
2500
2000
1500
1000
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u

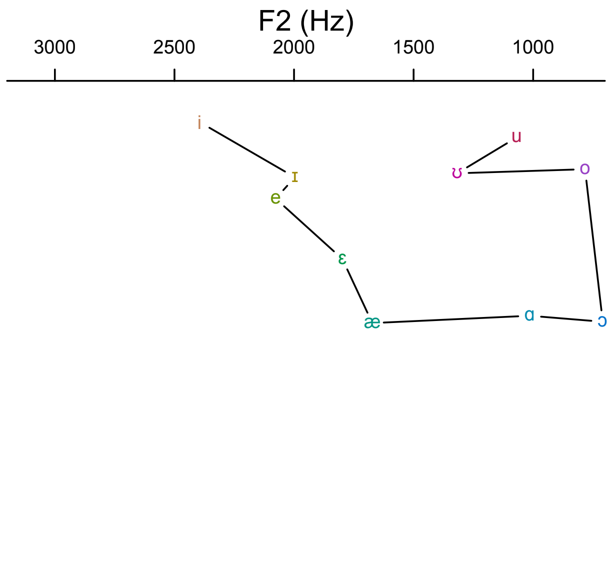
YT49NM2E



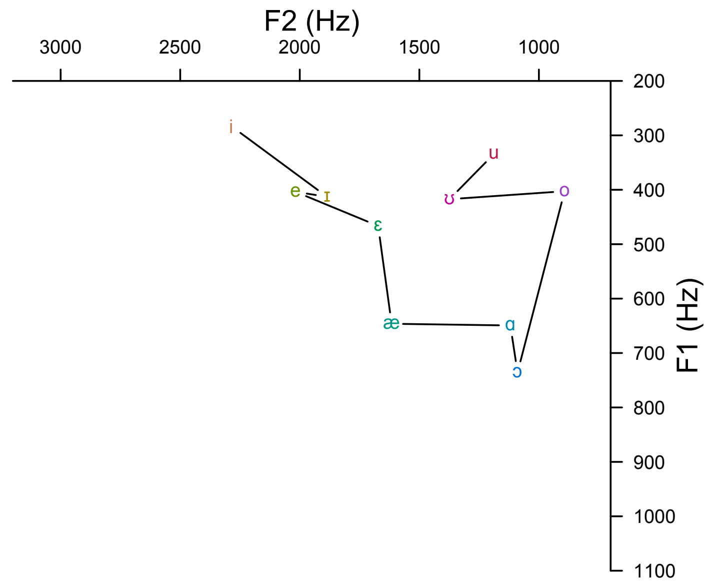
YU51NM2E



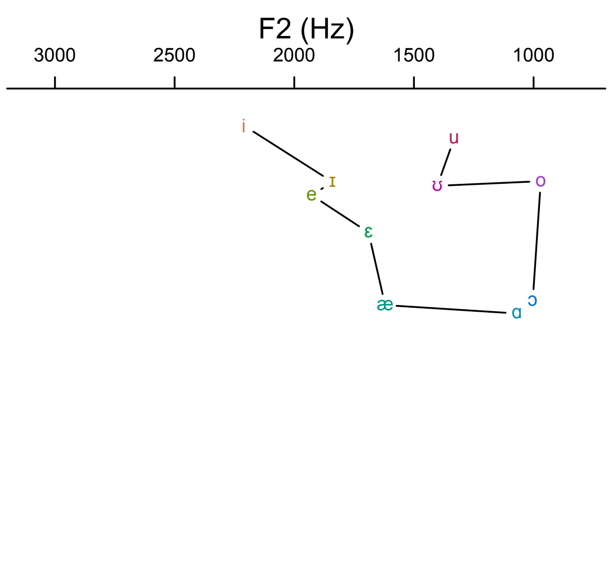
YW41NM3F



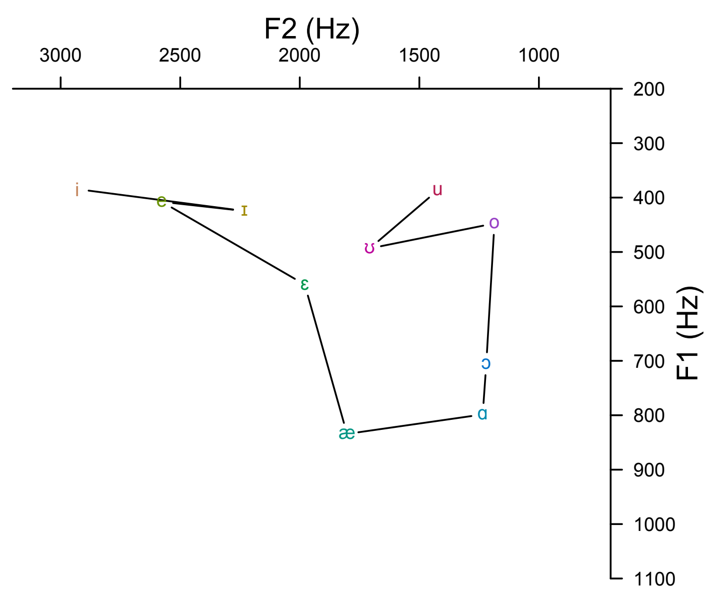
YW42NM3G

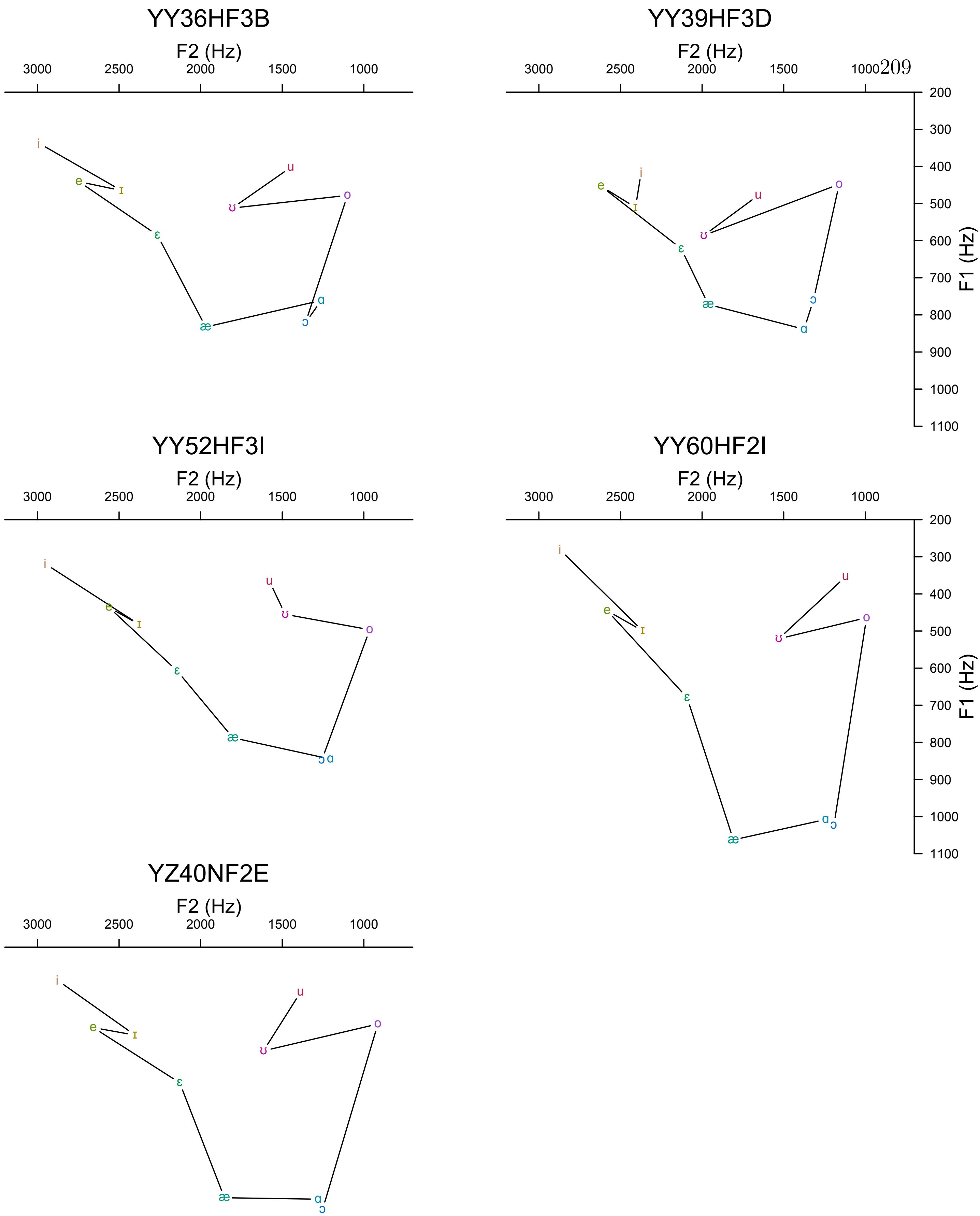


YW43HM3H



YY35HF3A




YY36HF3B
F2 (Hz)
3000
2500
2000
1500
1000
YY39HF3D
F2 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
YY52HF3I
F2 (Hz)
3000
2500
2000
1500
1000
YY60HF2I
F2 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
YZ40NF2E
F2 (Hz)
3000
2500
2000
1500
1000
i
ɪ
e
ɛ
æ
ɑ
ɔ
o
ʊ
u

APPENDIX H: VOWEL MEANS BY SPEAKER (PRE-VELAR)

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ECL83CM1Z	m	1	C	East	e	C	227.540	1.068	390	1990	-0.932	0.700
ECL83CM1Z	m	1	C	East	e	g	167.330	0.071	437	1837	-0.817	0.620
ECL83CM1Z	m	1	C	East	ɛ	C	150.510	-0.208	444	1844	-0.803	0.621
ECL83CM1Z	m	1	C	East	ɛ	g	155.060	-0.132	438	1814	-0.815	0.606
ECL83CM1Z	m	1	C	East	æ	C	199.010	0.596	561	1690	-0.571	0.534
ECL83CM1Z	m	1	C	East	æ	g	197.130	0.564	536	1733	-0.612	0.561
ECL84CF1Z	f	1	C	East	e	C	253.240	1.494	482	2305	-0.719	0.846
ECL84CF1Z	f	1	C	East	e	g	166.990	0.065	532	2114	-0.623	0.759
ECL84CF1Z	f	1	C	East	ɛ	C	150.690	-0.204	578	2069	-0.538	0.738
ECL84CF1Z	f	1	C	East	ɛ	g	151.050	-0.199	551	2087	-0.587	0.746
ECL84CF1Z	f	1	C	East	æ	C	223.150	0.995	738	1863	-0.293	0.633
ECL84CF1Z	f	1	C	East	æ	g	185.600	0.373	678	1940	-0.378	0.673
EDP74CF1T	f	1	C	East	e	C	219.690	0.938	427	2325	-0.841	0.855
EDP74CF1T	f	1	C	East	e	g	158.190	-0.080	523	2137	-0.637	0.771
EDP74CF1T	f	1	C	East	ɛ	C	138.040	-0.414	477	2214	-0.738	0.806
EDP74CF1T	f	1	C	East	ɛ	g	139.510	-0.390	507	2145	-0.668	0.774
EDP74CF1T	f	1	C	East	æ	C	198.130	0.581	712	1962	-0.339	0.683
EDP74CF1T	f	1	C	East	æ	g	192.130	0.482	609	2062	-0.492	0.734
EDP75CM1T	m	1	C	East	e	C	268.040	1.739	396	2074	-0.919	0.739
EDP75CM1T	m	1	C	East	e	g	186.420	0.387	407	1926	-0.889	0.666
EDP75CM1T	m	1	C	East	ɛ	C	147.210	-0.262	449	1881	-0.790	0.643
EDP75CM1T	m	1	C	East	ɛ	g	166.170	0.052	422	1921	-0.853	0.664
EDP75CM1T	m	1	C	East	æ	C	216.370	0.883	560	1741	-0.572	0.564
EDP75CM1T	m	1	C	East	æ	g	204.780	0.691	513	1850	-0.658	0.626
ERI96CF2G	f	2	C	East	e	C	259.750	1.601	483	2458	-0.717	0.910
ERI96CF2G	f	2	C	East	e	g	182.230	0.318	491	2362	-0.701	0.870
ERI96CF2G	f	2	C	East	ɛ	C	144.570	-0.306	542	2135	-0.606	0.767
ERI96CF2G	f	2	C	East	ɛ	g	157.620	-0.090	541	2208	-0.608	0.802
ERI96CF2G	f	2	C	East	æ	C	219.720	0.939	635	2005	-0.451	0.706
ERI96CF2G	f	2	C	East	æ	g	201.750	0.641	624	2065	-0.463	0.734
ERI97CF3G	f	3	C	East	e	C	156.250	-0.113	410	2551	-0.886	0.948
ERI97CF3G	f	3	C	East	e	g	126.520	-0.605	490	2331	-0.706	0.857

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ERI97CF3G	f	3	C	East	ɛ	C	81.080	-1.357	622	1975	-0.472	0.692
ERI97CF3G	f	3	C	East	ɛ	g	101.200	-1.024	561	2070	-0.587	0.738
ERI97CF3G	f	3	C	East	æ	C	127.560	-0.588	966	1800	-0.025	0.598
ERI97CF3G	f	3	C	East	æ	g	135.300	-0.459	979	1827	-0.011	0.614
ERI98CF3G	f	3	C	East	e	C	198.840	0.593	501	2583	-0.683	0.959
ERI98CF3G	f	3	C	East	e	g	155.600	-0.123	537	2398	-0.614	0.882
ERI98CF3G	f	3	C	East	ɛ	C	102.290	-1.006	598	1984	-0.509	0.696
ERI98CF3G	f	3	C	East	ɛ	g	128.060	-0.579	573	2144	-0.548	0.772
ERI98CF3G	f	3	C	East	æ	C	151.720	-0.187	816	1823	-0.195	0.611
ERI98CF3G	f	3	C	East	æ	g	167.200	0.069	743	1869	-0.292	0.636
ESP102CF2J	f	2	C	East	e	C	195.370	0.535	415	2496	-0.874	0.924
ESP102CF2J	f	2	C	East	e	g	155.440	-0.126	488	2092	-0.712	0.748
ESP102CF2J	f	2	C	East	ɛ	C	111.320	-0.856	518	2003	-0.650	0.706
ESP102CF2J	f	2	C	East	ɛ	g	125.820	-0.616	480	2032	-0.728	0.719
ESP102CF2J	f	2	C	East	æ	C	159.480	-0.059	930	1921	-0.063	0.663
ESP102CF2J	f	2	C	East	æ	g	158.130	-0.081	596	2026	-0.542	0.715
ESP110CF2Q	f	2	C	East	e	C	199.250	0.600	488	2408	-0.710	0.885
ESP110CF2Q	f	2	C	East	e	g	152.190	-0.180	572	2035	-0.548	0.719
ESP110CF2Q	f	2	C	East	ɛ	C	122.150	-0.677	579	2170	-0.538	0.782
ESP110CF2Q	f	2	C	East	ɛ	g	131.940	-0.515	586	2228	-0.526	0.810
ESP110CF2Q	f	2	C	East	æ	C	159.520	-0.058	959	1851	-0.035	0.627
ESP110CF2Q	f	2	C	East	æ	g	144.350	-0.310	722	2057	-0.321	0.731
ESP70HF3Q	f	3	MA	East	e	C	216.160	0.880	428	2735	-0.840	1.017
ESP70HF3Q	f	3	MA	East	e	g	160.400	-0.044	502	2510	-0.686	0.929
ESP70HF3Q	f	3	MA	East	ɛ	C	126.520	-0.605	554	2158	-0.583	0.779
ESP70HF3Q	f	3	MA	East	ɛ	g	132.480	-0.506	540	2348	-0.608	0.860
ESP70HF3Q	f	3	MA	East	æ	C	188.980	0.429	759	1928	-0.269	0.667
ESP70HF3Q	f	3	MA	East	æ	g	185.800	0.377	684	2034	-0.374	0.720
ESP71HF2R	f	2	MA	East	e	C	182.330	0.319	446	2552	-0.797	0.949
ESP71HF2R	f	2	MA	East	e	g	152.760	-0.170	490	2402	-0.705	0.887
ESP71HF2R	f	2	MA	East	ɛ	C	110.590	-0.869	644	2056	-0.432	0.732
ESP71HF2R	f	2	MA	East	ɛ	g	154.120	-0.148	490	2395	-0.705	0.884
ESP71HF2R	f	2	MA	East	æ	C	156	-0.117	860	1850	-0.144	0.625
ESP71HF2R	f	2	MA	East	æ	g	160.640	-0.040	850	1894	-0.157	0.649
ESP79SF1V	f	1	JA	East	e	C	176.130	0.217	434	2610	-0.825	0.971
ESP79SF1V	f	1	JA	East	e	g	149.520	-0.224	474	2549	-0.737	0.947
ESP79SF1V	f	1	JA	East	ɛ	C	125.140	-0.628	567	2221	-0.562	0.809
ESP79SF1V	f	1	JA	East	ɛ	g	122.980	-0.663	546	2364	-0.597	0.871
ESP79SF1V	f	1	JA	East	æ	C	142.850	-0.334	704	2169	-0.342	0.784

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ESP79SF1V	f	1	JA	East	æ	g	142.270	-0.344	673	2181	-0.386	0.790
ESP80SF1W	f	1	JA	East	e	C	234.810	1.188	443	2674	-0.806	0.995
ESP80SF1W	f	1	JA	East	e	g	167.250	0.070	455	2581	-0.779	0.959
ESP80SF1W	f	1	JA	East	ɛ	C	145.910	-0.284	521	2385	-0.644	0.880
ESP80SF1W	f	1	JA	East	ɛ	g	148.400	-0.242	514	2453	-0.655	0.909
ESP80SF1W	f	1	JA	East	æ	C	205.240	0.699	731	2274	-0.305	0.833
ESP80SF1W	f	1	JA	East	æ	g	200.640	0.623	707	2259	-0.335	0.826
ESP81AM3X	m	3	AA	East	e	C	166.490	0.057	351	2313	-1.040	0.849
ESP81AM3X	m	3	AA	East	e	g	117.550	-0.753	385	2079	-0.951	0.742
ESP81AM3X	m	3	AA	East	ɛ	C	95.150	-1.124	394	1896	-0.927	0.648
ESP81AM3X	m	3	AA	East	ɛ	g	110.680	-0.867	390	1942	-0.932	0.670
ESP81AM3X	m	3	AA	East	æ	C	152.930	-0.167	628	1720	-0.468	0.553
ESP81AM3X	m	3	AA	East	æ	g	141.840	-0.351	538	1723	-0.632	0.554
ESP89SF2C	f	2	JA	East	e	C	160.610	-0.040	436	2536	-0.822	0.941
ESP89SF2C	f	2	JA	East	e	g	118.190	-0.743	494	2276	-0.696	0.833
ESP89SF2C	f	2	JA	East	ɛ	C	94.390	-1.137	556	2018	-0.580	0.714
ESP89SF2C	f	2	JA	East	ɛ	g	106.530	-0.936	490	2318	-0.704	0.849
ESP89SF2C	f	2	JA	East	æ	C	141.110	-0.363	663	1771	-0.413	0.582
ESP89SF2C	f	2	JA	East	æ	g	123.390	-0.657	491	2286	-0.713	0.836
ESP99SM3H	m	3	JA	East	e	C	157.980	-0.084	447	1978	-0.797	0.693
ESP99SM3H	m	3	JA	East	e	g	110.050	-0.878	494	1863	-0.693	0.634
ESP99SM3H	m	3	JA	East	ɛ	C	97.590	-1.084	557	1882	-0.576	0.642
ESP99SM3H	m	3	JA	East	ɛ	g	112.410	-0.838	476	1950	-0.732	0.679
ESP99SM3H	m	3	JA	East	æ	C	133.070	-0.496	667	1664	-0.394	0.519
ESP99SM3H	m	3	JA	East	æ	g	131.600	-0.521	587	1826	-0.525	0.613
ESV108CF3O	f	3	C	East	e	C	153.920	-0.151	433	2508	-0.826	0.929
ESV108CF3O	f	3	C	East	e	g	128.600	-0.570	502	2133	-0.684	0.761
ESV108CF3O	f	3	C	East	ɛ	C	86.760	-1.263	544	1906	-0.599	0.654
ESV108CF3O	f	3	C	East	ɛ	g	119.080	-0.728	538	2182	-0.613	0.786
ESV108CF3O	f	3	C	East	æ	C	147.150	-0.263	934	1680	-0.062	0.529
ESV108CF3O	f	3	C	East	æ	g	153.090	-0.165	952	1668	-0.044	0.522
ESV109CM3P	m	3	C	East	e	C	186.940	0.396	389	2145	-0.933	0.775
ESV109CM3P	m	3	C	East	e	g	138.860	-0.400	411	2033	-0.878	0.721
ESV109CM3P	m	3	C	East	ɛ	C	113.060	-0.828	484	1739	-0.717	0.564
ESV109CM3P	m	3	C	East	ɛ	g	136.970	-0.432	425	1961	-0.848	0.683
ESV109CM3P	m	3	C	East	æ	C	160.400	-0.044	663	1572	-0.407	0.463
ESV109CM3P	m	3	C	East	æ	g	162.760	-0.005	570	1656	-0.559	0.513
ESV82SF3Y	f	3	JA	East	e	C	224.780	1.022	415	2395	-0.870	0.885
ESV82SF3Y	f	3	JA	East	e	g	147.290	-0.261	478	2253	-0.733	0.822

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
ESV82SF3Y	f	3	JA	East	ɛ	C	124.780	-0.634	576	1972	-0.545	0.690
ESV82SF3Y	f	3	JA	East	ɛ	g	140.040	-0.381	483	2204	-0.720	0.801
ESV82SF3Y	f	3	JA	East	æ	C	211.270	0.799	780	1852	-0.241	0.624
ESV82SF3Y	f	3	JA	East	æ	g	168.980	0.098	521	2100	-0.648	0.746
SB69CF3P	f	3	C	West	e	C	170.900	0.130	485	2378	-0.716	0.878
SB69CF3P	f	3	C	West	e	g	143.230	-0.328	514	2310	-0.658	0.848
SB69CF3P	f	3	C	West	ɛ	C	98.710	-1.065	621	2072	-0.467	0.740
SB69CF3P	f	3	C	West	ɛ	g	106.950	-0.929	565	2176	-0.568	0.787
SB69CF3P	f	3	C	West	æ	C	166.490	0.057	888	1767	-0.108	0.580
SB69CF3P	f	3	C	West	æ	g	146.950	-0.266	879	1801	-0.119	0.600
SB93SM3D	m	3	JA	West	e	C	197.560	0.572	413	2216	-0.873	0.806
SB93SM3D	m	3	JA	West	e	g	151.930	-0.184	445	2206	-0.801	0.802
SB93SM3D	m	3	JA	West	ɛ	C	121.370	-0.690	619	2079	-0.469	0.739
SB93SM3D	m	3	JA	West	ɛ	g	129.330	-0.558	571	2107	-0.553	0.755
SB93SM3D	m	3	JA	West	æ	C	186.950	0.396	853	1957	-0.151	0.679
SB93SM3D	m	3	JA	West	æ	g	172.750	0.161	773	2002	-0.248	0.704
SBI94SM2E	m	2	JA	West	e	C	172.560	0.158	417	2167	-0.864	0.784
SBI94SM2E	m	2	JA	West	e	g	129.820	-0.550	461	2013	-0.763	0.711
SBI94SM2E	m	2	JA	West	ɛ	C	85.140	-1.290	495	1815	-0.695	0.608
SBI94SM2E	m	2	JA	West	ɛ	g	93.530	-1.151	522	1854	-0.643	0.626
SBI94SM2E	m	2	JA	West	æ	C	147.360	-0.260	720	1667	-0.319	0.522
SBI94SM2E	m	2	JA	West	æ	g	145.680	-0.287	641	1792	-0.439	0.593
SC56SF1D	f	1	JA	West	e	C	199.430	0.603	421	2483	-0.857	0.921
SC56SF1D	f	1	JA	West	e	g	185.640	0.374	451	2378	-0.785	0.878
SC56SF1D	f	1	JA	West	ɛ	C	117.300	-0.757	513	2071	-0.659	0.740
SC56SF1D	f	1	JA	West	ɛ	g	137.890	-0.417	517	2125	-0.652	0.765
SC56SF1D	f	1	JA	West	æ	C	179.170	0.267	625	1999	-0.461	0.704
SC56SF1D	f	1	JA	West	æ	g	185.070	0.365	586	2078	-0.533	0.741
SC57SF2B	f	2	JA	West	e	C	155.690	-0.122	421	2505	-0.855	0.930
SC57SF2B	f	2	JA	West	e	g	133.020	-0.497	536	2250	-0.614	0.822
SC57SF2B	f	2	JA	West	ɛ	C	96.360	-1.104	603	2118	-0.496	0.760
SC57SF2B	f	2	JA	West	ɛ	g	119.160	-0.727	524	2302	-0.641	0.845
SC57SF2B	f	2	JA	West	æ	C	142.530	-0.340	731	1794	-0.304	0.591
SC57SF2B	f	2	JA	West	æ	g	115.750	-0.783	595	2158	-0.515	0.779
SC61AF1K	f	1	AA	West	e	C	326.110	2.700	437	2384	-0.820	0.880
SC61AF1K	f	1	AA	West	e	g	225.450	1.033	512	2221	-0.663	0.809
SC61AF1K	f	1	AA	West	ɛ	C	196.990	0.562	538	2118	-0.612	0.762
SC61AF1K	f	1	AA	West	ɛ	g	177.070	0.232	538	2186	-0.613	0.793
SC61AF1K	f	1	AA	West	æ	C	271.720	1.800	731	2002	-0.309	0.705

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SC61AF1K	f	1	AA	West	æ	g	267.890	1.736	678	2047	-0.379	0.728
SC62AF1L	f	1	AA	West	e	C	280.220	1.940	434	2577	-0.827	0.958
SC62AF1L	f	1	AA	West	e	g	185.090	0.365	471	2452	-0.743	0.907
SC62AF1L	f	1	AA	West	ε	C	136.630	-0.437	489	2244	-0.708	0.819
SC62AF1L	f	1	AA	West	ε	g	152.460	-0.175	510	2354	-0.667	0.865
SC62AF1L	f	1	AA	West	æ	C	219.820	0.940	644	2202	-0.435	0.798
SC62AF1L	f	1	AA	West	æ	g	204.100	0.680	608	2248	-0.488	0.820
SC63AF1M	f	1	AA	West	e	C	198.220	0.582	391	2650	-0.932	0.986
SC63AF1M	f	1	AA	West	e	g	124.880	-0.632	445	2325	-0.802	0.851
SC63AF1M	f	1	AA	West	ε	C	112.190	-0.842	512	2229	-0.658	0.813
SC63AF1M	f	1	AA	West	ε	g	104.200	-0.974	487	2288	-0.713	0.835
SC63AF1M	f	1	AA	West	æ	C	158.510	-0.075	645	2108	-0.428	0.756
SC63AF1M	f	1	AA	West	æ	g	148.030	-0.249	601	2159	-0.500	0.780
SC92CM3D	m	3	C	West	e	C	241.760	1.303	450	1859	-0.788	0.631
SC92CM3D	m	3	C	West	e	g	175.840	0.212	488	1744	-0.706	0.568
SC92CM3D	m	3	C	West	ε	C	121.600	-0.686	485	1665	-0.712	0.521
SC92CM3D	m	3	C	West	ε	g	139.060	-0.397	479	1773	-0.726	0.584
SC92CM3D	m	3	C	West	æ	C	206.990	0.728	650	1526	-0.421	0.432
SC92CM3D	m	3	C	West	æ	g	184.190	0.350	616	1602	-0.475	0.482
SD53SM1J	m	1	JA	West	e	C	240.100	1.276	400	2110	-0.908	0.758
SD53SM1J	m	1	JA	West	e	g	185.340	0.369	428	2007	-0.838	0.707
SD53SM1J	m	1	JA	West	ε	C	144.170	-0.313	477	1857	-0.731	0.629
SD53SM1J	m	1	JA	West	ε	g	163.010	-0.001	451	1858	-0.789	0.628
SD53SM1J	m	1	JA	West	æ	C	199.940	0.611	599	1774	-0.503	0.582
SD53SM1J	m	1	JA	West	æ	g	217.870	0.908	546	1843	-0.598	0.621
SD59SF2J	f	2	JA	West	e	C	175.180	0.201	472	2545	-0.740	0.945
SD59SF2J	f	2	JA	West	e	g	124.950	-0.631	555	2299	-0.579	0.842
SD59SF2J	f	2	JA	West	ε	C	98.360	-1.071	565	2222	-0.560	0.810
SD59SF2J	f	2	JA	West	ε	g	110.320	-0.873	550	2331	-0.589	0.855
SD59SF2J	f	2	JA	West	æ	C	155.240	-0.129	730	1935	-0.304	0.670
SD59SF2J	f	2	JA	West	æ	g	140.490	-0.373	628	2178	-0.455	0.789
SD88CF3B	f	3	C	West	e	C	312.980	2.483	474	2456	-0.746	0.905
SD88CF3B	f	3	C	West	e	g	218.830	0.924	602	2398	-0.499	0.886
SD88CF3B	f	3	C	West	ε	C	171.600	0.142	724	2027	-0.314	0.715
SD88CF3B	f	3	C	West	ε	g	196.410	0.553	597	2309	-0.516	0.846
SD88CF3B	f	3	C	West	æ	C	256.910	1.554	843	1961	-0.160	0.684
SD88CF3B	f	3	C	West	æ	g	252.350	1.479	776	2130	-0.243	0.767
SE76CM2U	m	2	C	West	e	C	311.060	2.451	400	2130	-0.905	0.768
SE76CM2U	m	2	C	West	e	g	219.380	0.933	478	1941	-0.728	0.675

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SE76CM2U	m	2	C	West	ε	C	160.270	-0.046	507	1908	-0.670	0.657
SE76CM2U	m	2	C	West	ε	g	184.790	0.360	473	1979	-0.740	0.694
SE76CM2U	m	2	C	West	æ	C	263.720	1.667	608	1778	-0.489	0.585
SE76CM2U	m	2	C	West	æ	g	201.460	0.636	467	1985	-0.751	0.697
SH18CF2K	f	2	C	West	e	C	162.870	-0.003	440	2536	-0.812	0.942
SH18CF2K	f	2	C	West	e	g	120.100	-0.711	478	2401	-0.729	0.887
SH18CF2K	f	2	C	West	ε	C	104.560	-0.968	532	2169	-0.622	0.785
SH18CF2K	f	2	C	West	ε	g	98.320	-1.072	496	2222	-0.694	0.808
SH18CF2K	f	2	C	West	æ	C	138.430	-0.408	721	1940	-0.325	0.672
SH18CF2K	f	2	C	West	æ	g	116.890	-0.764	666	1925	-0.401	0.666
SK14CM2I	m	2	C	West	e	C	214.630	0.854	406	2125	-0.890	0.765
SK14CM2I	m	2	C	West	e	g	169.460	0.106	471	2014	-0.743	0.711
SK14CM2I	m	2	C	West	ε	C	121.590	-0.686	506	1738	-0.671	0.564
SK14CM2I	m	2	C	West	ε	g	134.170	-0.478	485	1910	-0.716	0.658
SK14CM2I	m	2	C	West	æ	C	176.540	0.224	653	1652	-0.416	0.513
SK14CM2I	m	2	C	West	æ	g	161.690	-0.022	568	1912	-0.557	0.660
SKI90SM2C	m	2	JA	West	e	C	216.960	0.893	327	2166	-1.124	0.784
SKI90SM2C	m	2	JA	West	e	g	177.340	0.237	355	2092	-1.036	0.750
SKI90SM2C	m	2	JA	West	ε	C	128.120	-0.578	382	1797	-0.985	0.597
SKI90SM2C	m	2	JA	West	ε	g	132.190	-0.511	365	1969	-1.027	0.687
SKI90SM2C	m	2	JA	West	æ	C	189.240	0.434	498	1744	-0.708	0.565
SKI90SM2C	m	2	JA	West	æ	g	173.540	0.174	388	2051	-0.952	0.730
SKT68CM2O	m	2	C	West	e	C	205.180	0.698	469	1942	-0.746	0.675
SKT68CM2O	m	2	C	West	e	g	146.560	-0.273	516	1754	-0.650	0.573
SKT68CM2O	m	2	C	West	ε	C	103.730	-0.982	550	1718	-0.587	0.550
SKT68CM2O	m	2	C	West	ε	g	122.480	-0.672	523	1779	-0.640	0.586
SKT68CM2O	m	2	C	West	æ	C	175.950	0.214	650	1534	-0.420	0.438
SKT68CM2O	m	2	C	West	æ	g	129.470	-0.556	616	1613	-0.474	0.489
SN7CF2D	f	2	C	West	e	C	148.090	-0.248	440	2368	-0.811	0.873
SN7CF2D	f	2	C	West	e	g	116.770	-0.766	557	2120	-0.576	0.763
SN7CF2D	f	2	C	West	ε	C	90.130	-1.207	468	1844	-0.750	0.623
SN7CF2D	f	2	C	West	ε	g	95.570	-1.117	476	2148	-0.736	0.775
SN7CF2D	f	2	C	West	æ	C	141.990	-0.349	781	1734	-0.242	0.561
SN7CF2D	f	2	C	West	æ	g	100.500	-1.036	560	2003	-0.574	0.705
SO64CF2N	f	2	C	West	e	C	230.160	1.111	459	2245	-0.768	0.820
SO64CF2N	f	2	C	West	e	g	175.290	0.203	525	2072	-0.635	0.740
SO64CF2N	f	2	C	West	ε	C	126.690	-0.602	542	1890	-0.605	0.648
SO64CF2N	f	2	C	West	ε	g	140.270	-0.377	512	2027	-0.661	0.718
SO64CF2N	f	2	C	West	æ	C	197.720	0.574	730	1762	-0.308	0.577

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SO64CF2N	f	2	C	West	æ	g	166.660	0.060	571	2017	-0.553	0.713
SO65CF3N	f	3	C	West	e	C	204.730	0.690	458	2526	-0.782	0.938
SO65CF3N	f	3	C	West	e	g	152.220	-0.179	628	2293	-0.474	0.840
SO65CF3N	f	3	C	West	ε	C	116.010	-0.779	677	2086	-0.381	0.746
SO65CF3N	f	3	C	West	ε	g	148.500	-0.241	567	2305	-0.579	0.845
SO65CF3N	f	3	C	West	æ	C	196.620	0.556	867	1844	-0.138	0.619
SO65CF3N	f	3	C	West	æ	g	155.010	-0.133	632	2230	-0.455	0.813
SO66CM2N	m	2	C	West	e	C	203.650	0.672	386	2143	-0.941	0.773
SO66CM2N	m	2	C	West	e	g	133.680	-0.486	440	1971	-0.810	0.690
SO66CM2N	m	2	C	West	ε	C	119.650	-0.718	461	1801	-0.764	0.600
SO66CM2N	m	2	C	West	ε	g	112.750	-0.833	429	1961	-0.836	0.685
SO66CM2N	m	2	C	West	æ	C	175.830	0.212	573	1698	-0.547	0.540
SO66CM2N	m	2	C	West	æ	g	114.220	-0.808	456	1929	-0.775	0.668
SO67CM3N	m	3	C	West	e	C	285.730	2.032	421	1948	-0.863	0.678
SO67CM3N	m	3	C	West	e	g	186.890	0.395	537	1698	-0.613	0.541
SO67CM3N	m	3	C	West	ε	C	147.460	-0.258	484	1618	-0.719	0.492
SO67CM3N	m	3	C	West	ε	g	169.560	0.108	502	1785	-0.683	0.591
SO67CM3N	m	3	C	West	æ	C	220.890	0.958	747	1539	-0.286	0.442
SO67CM3N	m	3	C	West	æ	g	168.450	0.090	533	1710	-0.621	0.548
SP55SM1D	m	1	JA	West	e	C	314.830	2.514	380	2016	-0.957	0.713
SP55SM1D	m	1	JA	West	e	g	219.350	0.932	413	1948	-0.874	0.678
SP55SM1D	m	1	JA	West	ε	C	179.430	0.271	495	1769	-0.696	0.580
SP55SM1D	m	1	JA	West	ε	g	163.780	0.012	468	1796	-0.751	0.594
SP55SM1D	m	1	JA	West	æ	C	233.380	1.165	552	1716	-0.583	0.549
SP55SM1D	m	1	JA	West	æ	g	258.940	1.588	529	1711	-0.627	0.547
SQ73CF3S	f	3	C	West	e	C	141.180	-0.362	511	2663	-0.664	0.991
SQ73CF3S	f	3	C	West	e	g	97.460	-1.086	570	2387	-0.558	0.880
SQ73CF3S	f	3	C	West	ε	C	87.110	-1.257	712	1991	-0.332	0.699
SQ73CF3S	f	3	C	West	ε	g	78.130	-1.406	578	2425	-0.544	0.897
SQ73CF3S	f	3	C	West	æ	C	128.060	-0.579	957	1938	-0.035	0.672
SQ73CF3S	f	3	C	West	æ	g	97.630	-1.083	905	2082	-0.095	0.744
SR54SF2C	f	2	JA	West	e	C	222.340	0.982	489	2556	-0.709	0.950
SR54SF2C	f	2	JA	West	e	g	179.700	0.276	567	2349	-0.556	0.864
SR54SF2C	f	2	JA	West	ε	C	119.550	-0.720	558	2035	-0.574	0.722
SR54SF2C	f	2	JA	West	ε	g	139.100	-0.396	563	2099	-0.566	0.750
SR54SF2C	f	2	JA	West	æ	C	192.390	0.486	650	1971	-0.423	0.688
SR54SF2C	f	2	JA	West	æ	g	190.010	0.447	575	2131	-0.543	0.767
SR77CM3U	m	3	C	West	e	C	176.450	0.222	328	2059	-1.107	0.733
SR77CM3U	m	3	C	West	e	g	139.220	-0.395	366	1982	-0.999	0.696

Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
SR77CM3U	m	3	C	West	ɛ	C	111.590	-0.852	412	1704	-0.888	0.543
SR77CM3U	m	3	C	West	ɛ	g	116.040	-0.778	341	1949	-1.072	0.677
SR77CM3U	m	3	C	West	æ	C	158.550	-0.074	639	1601	-0.445	0.481
SR77CM3U	m	3	C	West	æ	g	138.380	-0.408	561	1708	-0.586	0.546
SR78CM2U	m	2	C	West	e	C	212.250	0.815	397	2123	-0.915	0.764
SR78CM2U	m	2	C	West	e	g	163.860	0.014	508	1870	-0.667	0.637
SR78CM2U	m	2	C	West	ɛ	C	126.260	-0.609	498	1913	-0.693	0.658
SR78CM2U	m	2	C	West	ɛ	g	125.360	-0.624	486	1963	-0.712	0.685
SR78CM2U	m	2	C	West	æ	C	193.460	0.504	671	1697	-0.387	0.538
SR78CM2U	m	2	C	West	æ	g	145.790	-0.286	561	1864	-0.568	0.634
SRN85CF2A	f	2	C	West	e	C	206.610	0.722	508	2365	-0.668	0.872
SRN85CF2A	f	2	C	West	e	g	137.200	-0.428	559	2196	-0.575	0.798
SRN85CF2A	f	2	C	West	ɛ	C	107.990	-0.912	611	2019	-0.485	0.715
SRN85CF2A	f	2	C	West	ɛ	g	121.370	-0.690	565	2203	-0.562	0.801
SRN85CF2A	f	2	C	West	æ	C	172.870	0.163	773	1858	-0.250	0.630
SRN85CF2A	f	2	C	West	æ	g	121.500	-0.688	601	2104	-0.502	0.755
SRN86CF3A	f	3	C	West	e	C	193.090	0.498	490	2306	-0.704	0.846
SRN86CF3A	f	3	C	West	e	g	132.600	-0.504	599	2115	-0.503	0.760
SRN86CF3A	f	3	C	West	ɛ	C	110.350	-0.873	644	1940	-0.432	0.674
SRN86CF3A	f	3	C	West	ɛ	g	112.320	-0.840	590	2126	-0.519	0.766
SRN86CF3A	f	3	C	West	æ	C	187.100	0.398	766	1742	-0.257	0.566
SRN86CF3A	f	3	C	West	æ	g	127.820	-0.583	707	1945	-0.337	0.677
SS27CM3O	m	3	C	West	e	C	259.840	1.603	379	2134	-0.963	0.769
SS27CM3O	m	3	C	West	e	g	239.330	1.263	434	1966	-0.825	0.687
SS27CM3O	m	3	C	West	ɛ	C	110.660	-0.867	485	1735	-0.715	0.559
SS27CM3O	m	3	C	West	ɛ	g	151.940	-0.184	423	1992	-0.852	0.699
SS27CM3O	m	3	C	West	æ	C	186.020	0.380	616	1717	-0.476	0.549
SS27CM3O	m	3	C	West	æ	g	218.400	0.917	578	1725	-0.545	0.556
STA106AF3M	f	3	AA	West	e	C	176.850	0.229	432	2700	-0.830	1.005
STA106AF3M	f	3	AA	West	e	g	142.150	-0.346	488	2442	-0.709	0.903
STA106AF3M	f	3	AA	West	ɛ	C	106.680	-0.933	571	2153	-0.552	0.777
STA106AF3M	f	3	AA	West	ɛ	g	115.750	-0.783	538	2337	-0.614	0.858
STA106AF3M	f	3	AA	West	æ	C	163.330	0.005	720	1990	-0.324	0.698
STA106AF3M	f	3	AA	West	æ	g	159.320	-0.062	681	2024	-0.381	0.716
STA107AF3N	f	3	AA	West	e	C	183.030	0.331	442	2250	-0.807	0.822
STA107AF3N	f	3	AA	West	e	g	145.080	-0.297	518	2070	-0.649	0.737
STA107AF3N	f	3	AA	West	ɛ	C	108.030	-0.911	570	1911	-0.551	0.659
STA107AF3N	f	3	AA	West	ɛ	g	116.090	-0.777	561	1910	-0.567	0.657
STA107AF3N	f	3	AA	West	æ	C	178.100	0.249	784	1695	-0.234	0.540

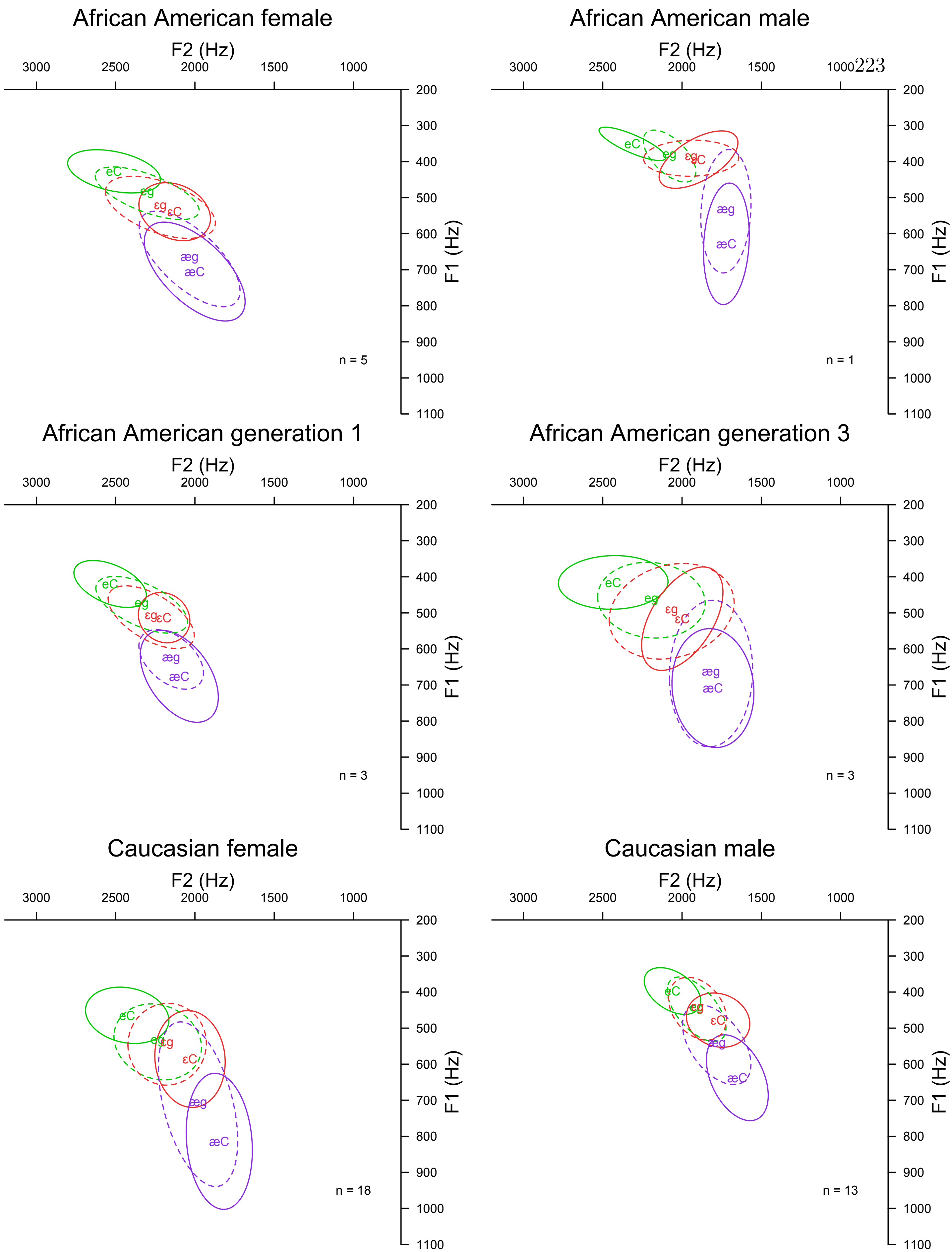
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
STA107AF3N	f	3	AA	West	æ	g	182.350	0.320	780	1700	-0.240	0.542
SU28CM3P	m	3	C	West	e	C	188.290	0.418	402	2042	-0.903	0.726
SU28CM3P	m	3	C	West	e	g	128.910	-0.565	368	1977	-0.988	0.693
SU28CM3P	m	3	C	West	ε	C	96.820	-1.096	504	1699	-0.674	0.540
SU28CM3P	m	3	C	West	ε	g	102.350	-1.005	423	1862	-0.855	0.632
SU28CM3P	m	3	C	West	æ	C	154.330	-0.144	698	1665	-0.352	0.519
SU28CM3P	m	3	C	West	æ	g	126.900	-0.599	575	1748	-0.555	0.570
SW58SF2B	f	2	JA	West	e	C	259.240	1.593	448	2682	-0.795	0.998
SW58SF2B	f	2	JA	West	e	g	199.940	0.611	518	2399	-0.646	0.885
SW58SF2B	f	2	JA	West	ε	C	143.510	-0.323	599	2222	-0.503	0.809
SW58SF2B	f	2	JA	West	ε	g	167.200	0.069	521	2371	-0.643	0.871
SW58SF2B	f	2	JA	West	æ	C	234.780	1.188	688	2016	-0.363	0.710
SW58SF2B	f	2	JA	West	æ	g	227.750	1.071	623	2223	-0.464	0.806
SW72CF2S	f	2	C	West	e	C	158.200	-0.080	470	2286	-0.746	0.837
SW72CF2S	f	2	C	West	e	g	111.730	-0.850	520	2236	-0.646	0.816
SW72CF2S	f	2	C	West	ε	C	89.980	-1.210	534	2061	-0.618	0.734
SW72CF2S	f	2	C	West	ε	g	109.720	-0.883	527	2180	-0.638	0.790
SW72CF2S	f	2	C	West	æ	C	135.930	-0.449	747	1821	-0.287	0.610
SW72CF2S	f	2	C	West	æ	g	131.240	-0.527	653	1933	-0.424	0.670
YH47HM3H	m	3	MA	Central	e	C	158.860	-0.069	366	2163	-0.995	0.783
YH47HM3H	m	3	MA	Central	e	g	124.890	-0.632	402	2037	-0.899	0.723
YH47HM3H	m	3	MA	Central	ε	C	86.150	-1.273	436	1820	-0.818	0.610
YH47HM3H	m	3	MA	Central	ε	g	113.750	-0.816	430	1882	-0.832	0.643
YH47HM3H	m	3	MA	Central	æ	C	128.460	-0.573	518	1715	-0.647	0.550
YH47HM3H	m	3	MA	Central	æ	g	135.700	-0.453	534	1796	-0.621	0.597
YH48HF3H	f	3	MA	Central	e	C	139.690	-0.387	457	2505	-0.772	0.929
YH48HF3H	f	3	MA	Central	e	g	122.790	-0.666	533	2255	-0.626	0.822
YH48HF3H	f	3	MA	Central	ε	C	91.840	-1.179	542	2019	-0.602	0.714
YH48HF3H	f	3	MA	Central	ε	g	112.650	-0.835	491	2273	-0.704	0.829
YH48HF3H	f	3	MA	Central	æ	C	111.720	-0.850	648	1903	-0.425	0.652
YH48HF3H	f	3	MA	Central	æ	g	154.730	-0.138	670	1944	-0.393	0.676
YM37HF2C	f	2	MA	Central	e	C	218.760	0.923	429	2548	-0.837	0.947
YM37HF2C	f	2	MA	Central	e	g	194.840	0.527	508	2330	-0.669	0.855
YM37HF2C	f	2	MA	Central	ε	C	140.570	-0.372	553	2153	-0.584	0.775
YM37HF2C	f	2	MA	Central	ε	g	157.590	-0.090	512	2295	-0.660	0.840
YM37HF2C	f	2	MA	Central	æ	C	181.470	0.305	844	1718	-0.158	0.552
YM37HF2C	f	2	MA	Central	æ	g	203.850	0.676	738	1962	-0.296	0.678
YS44NF2G	f	2	YN	Central	e	C	236.080	1.209	360	2621	-1.012	0.975
YS44NF2G	f	2	YN	Central	e	g	199.050	0.596	397	2292	-0.917	0.838

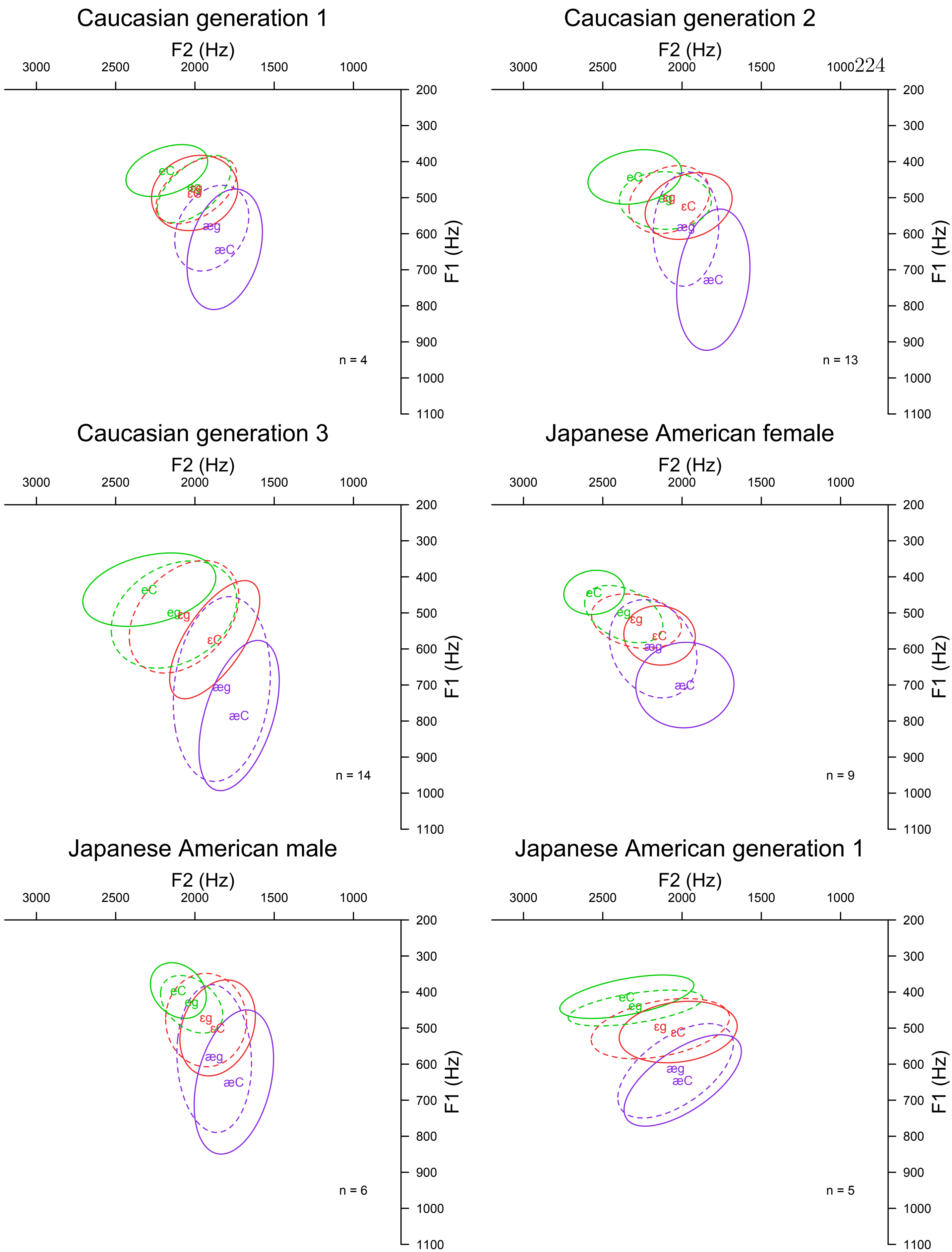
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YS44NF2G	f	2	YN	Central	ɛ	C	127.230	-0.593	445	2167	-0.803	0.783
YS44NF2G	f	2	YN	Central	ɛ	g	154.620	-0.139	430	2294	-0.838	0.838
YS44NF2G	f	2	YN	Central	æ	C	190.780	0.459	536	2018	-0.617	0.712
YS44NF2G	f	2	YN	Central	æ	g	239.120	1.260	516	2034	-0.658	0.721
YS45NF2G	f	2	YN	Central	e	C	252.710	1.485	401	2268	-0.907	0.825
YS45NF2G	f	2	YN	Central	e	g	180.680	0.292	418	2334	-0.864	0.858
YS45NF2G	f	2	YN	Central	ɛ	C	129.640	-0.553	459	2182	-0.770	0.791
YS45NF2G	f	2	YN	Central	ɛ	g	145.190	-0.296	442	2277	-0.807	0.832
YS45NF2G	f	2	YN	Central	æ	C	190.710	0.458	639	1852	-0.443	0.626
YS45NF2G	f	2	YN	Central	æ	g	219.330	0.932	546	2218	-0.604	0.808
YS46NF3G	f	3	YN	Central	e	C	199.310	0.601	427	2273	-0.840	0.832
YS46NF3G	f	3	YN	Central	e	g	129.780	-0.551	438	2325	-0.815	0.856
YS46NF3G	f	3	YN	Central	ɛ	C	103.860	-0.980	457	1943	-0.775	0.675
YS46NF3G	f	3	YN	Central	ɛ	g	137.770	-0.419	435	2106	-0.822	0.752
YS46NF3G	f	3	YN	Central	æ	C	153.460	-0.159	613	1722	-0.487	0.554
YS46NF3G	f	3	YN	Central	æ	g	174.150	0.184	572	1765	-0.560	0.577
YT49NM2E	m	2	YN	Central	e	C	272.040	1.805	361	1864	-1.014	0.632
YT49NM2E	m	2	YN	Central	e	g	205.820	0.708	413	1753	-0.876	0.570
YT49NM2E	m	2	YN	Central	ɛ	C	166.200	0.052	461	1730	-0.770	0.558
YT49NM2E	m	2	YN	Central	ɛ	g	194.590	0.522	429	1764	-0.841	0.575
YT49NM2E	m	2	YN	Central	æ	C	219.620	0.937	613	1512	-0.479	0.424
YT49NM2E	m	2	YN	Central	æ	g	233.850	1.172	529	1561	-0.635	0.454
YU51NM2E	m	2	YN	Central	e	C	226.960	1.058	353	2211	-1.035	0.805
YU51NM2E	m	2	YN	Central	e	g	141.120	-0.363	390	2192	-0.931	0.794
YU51NM2E	m	2	YN	Central	ɛ	C	119.030	-0.729	450	2050	-0.790	0.725
YU51NM2E	m	2	YN	Central	ɛ	g	129.660	-0.553	383	2123	-0.957	0.763
YU51NM2E	m	2	YN	Central	æ	C	170.200	0.119	603	1945	-0.496	0.675
YU51NM2E	m	2	YN	Central	æ	g	178.770	0.260	566	1869	-0.563	0.635
YW41NM3F	m	3	YN	Central	e	C	320.470	2.607	417	2077	-0.870	0.742
YW41NM3F	m	3	YN	Central	e	g	211.220	0.798	479	1968	-0.728	0.688
YW41NM3F	m	3	YN	Central	ɛ	C	170.660	0.126	528	1798	-0.628	0.598
YW41NM3F	m	3	YN	Central	ɛ	g	181.650	0.308	461	1939	-0.764	0.673
YW41NM3F	m	3	YN	Central	æ	C	247.200	1.394	645	1673	-0.426	0.525
YW41NM3F	m	3	YN	Central	æ	g	246.850	1.388	624	1714	-0.465	0.549
YW42NM3G	m	3	YN	Central	e	C	206.110	0.713	404	2018	-0.897	0.711
YW42NM3G	m	3	YN	Central	e	g	170.930	0.131	451	1803	-0.784	0.601
YW42NM3G	m	3	YN	Central	ɛ	C	112.050	-0.844	466	1672	-0.756	0.526
YW42NM3G	m	3	YN	Central	ɛ	g	122.180	-0.677	468	1747	-0.751	0.566
YW42NM3G	m	3	YN	Central	æ	C	167.430	0.073	646	1616	-0.432	0.490

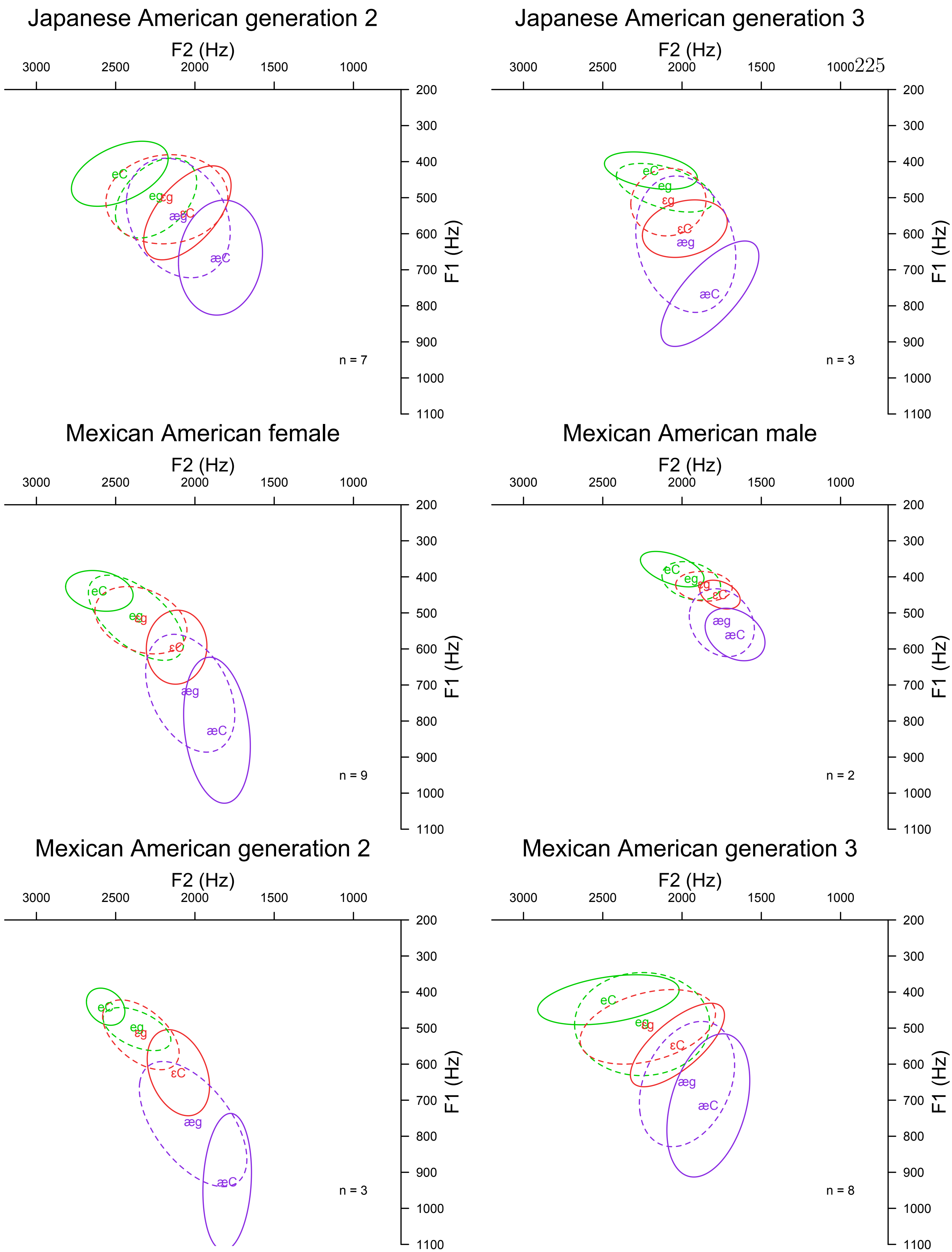
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YW42NM3G	m	3	YN	Central	æ	g	167.460	0.073	646	1616	-0.444	0.492
YW43HM3H	m	3	MA	Central	e	C	174.430	0.189	396	1927	-0.919	0.668
YW43HM3H	m	3	MA	Central	e	g	139.150	-0.396	419	1854	-0.863	0.629
YW43HM3H	m	3	MA	Central	ɛ	C	120.600	-0.703	465	1690	-0.756	0.536
YW43HM3H	m	3	MA	Central	ɛ	g	140.900	-0.367	422	1841	-0.855	0.620
YW43HM3H	m	3	MA	Central	æ	C	163.850	0.013	599	1620	-0.502	0.491
YW43HM3H	m	3	MA	Central	æ	g	171.330	0.137	520	1692	-0.654	0.533
YY35HF3A	f	3	MA	Central	e	C	191.890	0.478	408	2577	-0.891	0.956
YY35HF3A	f	3	MA	Central	e	g	137.710	-0.419	416	2524	-0.868	0.937
YY35HF3A	f	3	MA	Central	ɛ	C	99.650	-1.050	560	1979	-0.572	0.694
YY35HF3A	f	3	MA	Central	ɛ	g	113.480	-0.821	461	2312	-0.769	0.848
YY35HF3A	f	3	MA	Central	æ	C	162.290	-0.012	834	1802	-0.177	0.600
YY35HF3A	f	3	MA	Central	æ	g	170.830	0.129	737	1826	-0.300	0.613
YY36HF3B	f	3	MA	Central	e	C	181.710	0.309	441	2746	-0.811	1.021
YY36HF3B	f	3	MA	Central	e	g	157.050	-0.099	609	2338	-0.506	0.847
YY36HF3B	f	3	MA	Central	ɛ	C	122.540	-0.671	585	2265	-0.529	0.829
YY36HF3B	f	3	MA	Central	ɛ	g	133.850	-0.483	549	2480	-0.592	0.916
YY36HF3B	f	3	MA	Central	æ	C	165.460	0.040	833	1969	-0.173	0.686
YY36HF3B	f	3	MA	Central	æ	g	177.140	0.233	760	2135	-0.270	0.767
YY39HF3D	f	3	MA	Central	e	C	167.150	0.068	453	2619	-0.782	0.974
YY39HF3D	f	3	MA	Central	e	g	146.070	-0.281	537	2350	-0.612	0.866
YY39HF3D	f	3	MA	Central	ɛ	C	111.100	-0.860	622	2128	-0.467	0.767
YY39HF3D	f	3	MA	Central	ɛ	g	124.700	-0.635	558	2347	-0.574	0.864
YY39HF3D	f	3	MA	Central	æ	C	153.390	-0.160	772	1962	-0.249	0.685
YY39HF3D	f	3	MA	Central	æ	g	135.890	-0.450	709	2103	-0.346	0.754
YY52HF3I	f	3	MA	Central	e	C	207.240	0.732	436	2562	-0.821	0.951
YY52HF3I	f	3	MA	Central	e	g	141.420	-0.358	500	2295	-0.688	0.841
YY52HF3I	f	3	MA	Central	ɛ	C	126.350	-0.608	608	2144	-0.489	0.774
YY52HF3I	f	3	MA	Central	ɛ	g	130.350	-0.541	528	2275	-0.635	0.831
YY52HF3I	f	3	MA	Central	æ	C	189.340	0.435	788	1802	-0.238	0.598
YY52HF3I	f	3	MA	Central	æ	g	175.330	0.204	640	2089	-0.443	0.746
YY60HF2I	f	2	MA	Central	e	C	199.600	0.605	445	2582	-0.800	0.960
YY60HF2I	f	2	MA	Central	e	g	161.920	-0.019	511	2364	-0.663	0.871
YY60HF2I	f	2	MA	Central	ɛ	C	118.860	-0.732	679	2092	-0.378	0.750
YY60HF2I	f	2	MA	Central	ɛ	g	136.230	-0.444	553	2328	-0.592	0.854
YY60HF2I	f	2	MA	Central	æ	C	186.540	0.389	1063	1808	0.069	0.604
YY60HF2I	f	2	MA	Central	æ	g	158.540	-0.074	686	2205	-0.375	0.800
YZ40NF2E	f	2	YN	Central	e	C	192.770	0.492	417	2658	-0.866	0.988
YZ40NF2E	f	2	YN	Central	e	g	131.030	-0.530	478	2246	-0.729	0.818

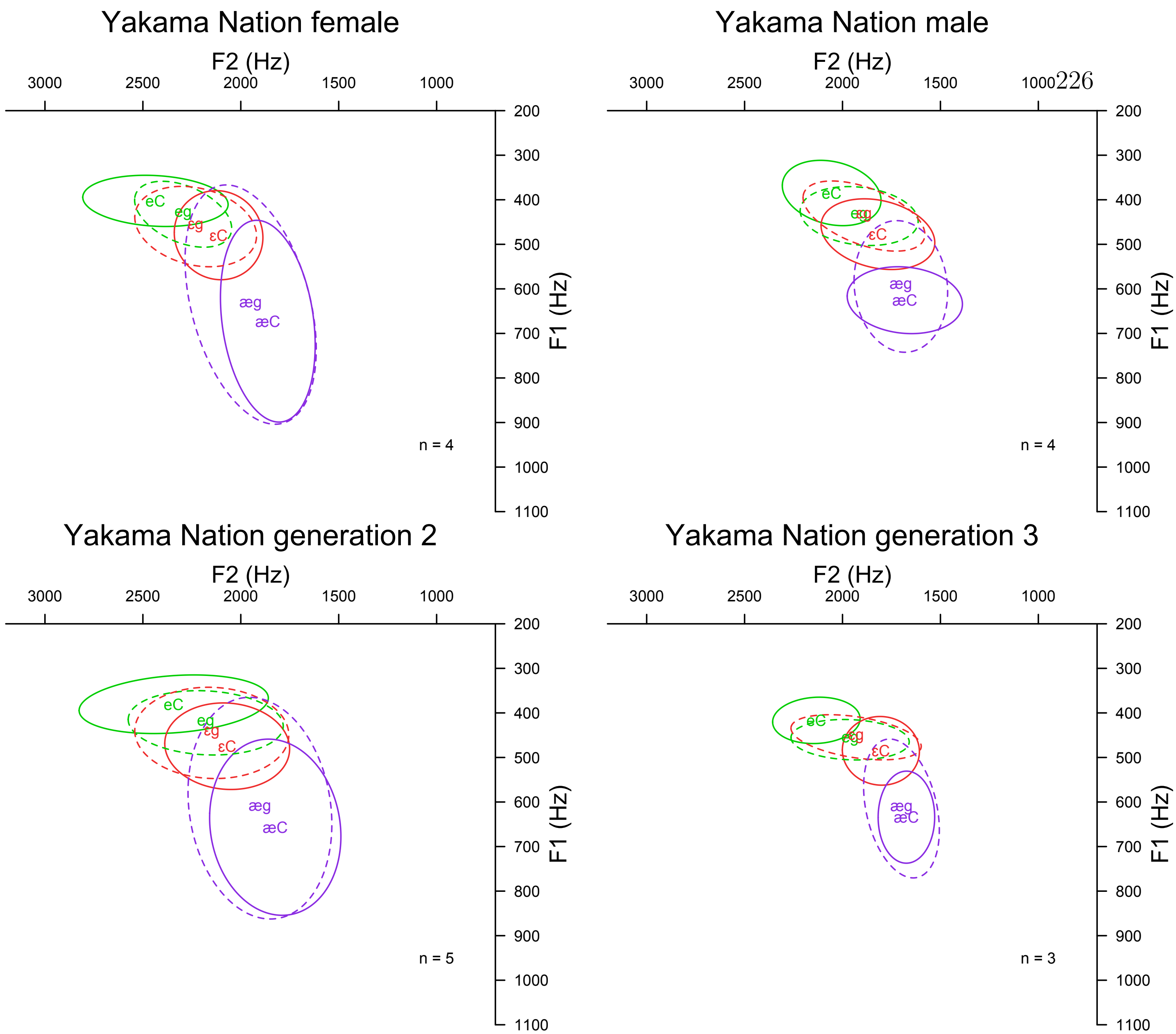
Speaker	Gender	Generation	Ethnicity	Region	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
YZ40NF2E	f	2	YN	Central	ε	C	119.560	-0.720	565	2128	-0.563	0.767
YZ40NF2E	f	2	YN	Central	ε	g	121.280	-0.692	533	2245	-0.621	0.817
YZ40NF2E	f	2	YN	Central	æ	C	178.430	0.255	875	1854	-0.122	0.627
YZ40NF2E	f	2	YN	Central	æ	g	164.680	0.027	844	1870	-0.179	0.633

APPENDIX I: GROUP PLOTS (RAW)


African American female
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 5
African American male
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 1
African American generation 1
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 3
African American generation 3
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 3
Caucasian female
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 18
Caucasian male
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
ɛg
ɛC
æg
æC
n = 13


Caucasian generation 1
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 4
Caucasian generation 2
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 13
Caucasian generation 3
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 14
Japanese American female
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 9
Japanese American male
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 6
Japanese American generation 1
F2 (Hz)
3000 2500 2000 1500 1000
F1 (Hz)
200 300 400 500 600 700 800 900 1000 1100
eC
eg
εg
εC
æg
æC
n = 5


Japanese American generation 2
F2 (Hz)
3000
2500
2000
1500
1000
F1 (Hz)
200
300
400
500
600
700
800
900
1000
1100
eC
eg
ɛg
ɛC
æg
æC
n = 7
Japanese American generation 3
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 3
Mexican American female
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 9
Mexican American male
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 2
Mexican American generation 2
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 3
Mexican American generation 3
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 8


Yakama Nation female
F2 (Hz)
3000
2500
2000
1500
1000
200
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 4
Yakama Nation male
F2 (Hz)
eC
eg
ɛC
æg
æC
n = 4
Yakama Nation generation 2
F2 (Hz)
eC
eg
ɛg
ɛC
æg
æC
n = 5
Yakama Nation generation 3
F2 (Hz)
eC
eg
ɛC
æg
æC
n = 3

APPENDIX J: VOWEL MEANS BY GENDER (PRE-VELAR)

Gender	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1 (SD)	Norm. F2 (SD)
f	e	C	203.360	0.668	443	2501	-0.807 (0.108)	0.926 (0.076)
f	e	g	153.480	-0.158	512	2300	-0.667 (0.133)	0.841 (0.085)
f	ɛ	C	117.590	-0.753	566	2091	-0.567 (0.143)	0.747 (0.072)
f	ɛ	g	130.760	-0.535	526	2239	-0.639 (0.131)	0.814 (0.088)
f	æ	C	176.450	0.222	769	1896	-0.265 (0.172)	0.647 (0.092)
f	æ	g	166.330	0.054	682	2032	-0.391 (0.199)	0.716 (0.098)
m	e	C	225.100	1.028	392	2077	-0.933 (0.121)	0.741 (0.066)
m	e	g	165.230	0.036	437	1946	-0.824 (0.13)	0.675 (0.076)
m	ɛ	C	126.950	-0.598	478	1805	-0.737 (0.143)	0.599 (0.082)
m	ɛ	g	138.400	-0.408	448	1905	-0.801 (0.152)	0.653 (0.08)
m	æ	C	186.010	0.380	632	1685	-0.457 (0.148)	0.529 (0.09)
m	æ	g	172.360	0.154	559	1791	-0.584 (0.179)	0.591 (0.087)

APPENDIX K: VOWEL MEANS BY GENERATION (PRE-VELAR)

Generation	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1 (SD)	Norm. F2 (SD)
1	e	C	245.090	1.359	418	2337	-0.866 (0.104)	0.855 (0.112)
1	e	g	177.580	0.241	463	2212	-0.764 (0.107)	0.799 (0.12)
1	ɛ	C	146.620	-0.272	504	2054	-0.68 (0.117)	0.726 (0.106)
1	ɛ	g	148.010	-0.249	497	2124	-0.695 (0.12)	0.758 (0.12)
1	æ	C	204.060	0.679	652	1962	-0.425 (0.142)	0.679 (0.118)
1	æ	g	198.910	0.594	609	2018	-0.492 (0.131)	0.708 (0.106)
2	e	C	209.860	0.775	426	2385	-0.849 (0.136)	0.876 (0.105)
2	e	g	158	-0.084	490	2185	-0.712 (0.141)	0.789 (0.1)
2	ɛ	C	119.610	-0.719	529	2023	-0.637 (0.164)	0.712 (0.094)
2	ɛ	g	132.580	-0.504	496	2145	-0.701 (0.157)	0.77 (0.105)
2	æ	C	177.790	0.244	721	1815	-0.335 (0.201)	0.604 (0.093)
2	æ	g	159.260	-0.063	602	2001	-0.519 (0.216)	0.701 (0.098)
3	e	C	199.210	0.599	427	2323	-0.848 (0.128)	0.847 (0.122)
3	e	g	149.310	-0.227	490	2151	-0.717 (0.173)	0.77 (0.123)
3	ɛ	C	112.170	-0.842	552	1932	-0.598 (0.174)	0.665 (0.104)
3	ɛ	g	128.770	-0.567	500	2093	-0.695 (0.174)	0.743 (0.12)
3	æ	C	172.080	0.150	745	1764	-0.299 (0.18)	0.575 (0.1)
3	æ	g	164.350	0.022	679	1863	-0.4 (0.223)	0.628 (0.111)

APPENDIX L: VOWEL MEANS BY ETHNICITY (PRE-VELAR)

Ethnicity	Vowel	Following Class	Duration	Norm. Duration	F1	F2	Norm. F1	Norm. F2
AA	e	C	223.400	1	418	2486	-0.867 (0.113)	0.92 (0.08)
AA	e	g	158.640	-0.073	471	2266	-0.749 (0.135)	0.825 (0.097)
AA	ε	C	125.740	-0.618	515	2089	-0.664 (0.159)	0.745 (0.086)
AA	ε	g	129.480	-0.556	504	2172	-0.685 (0.154)	0.781 (0.115)
AA	æ	C	191.640	0.474	692	1954	-0.366 (0.145)	0.675 (0.113)
AA	æ	g	184.080	0.348	649	1983	-0.435 (0.172)	0.69 (0.117)
C	e	C	211.980	0.810	437	2277	-0.825 (0.135)	0.83 (0.104)
C	e	g	155.590	-0.123	502	2105	-0.689 (0.156)	0.751 (0.108)
C	ε	C	118.270	-0.741	542	1926	-0.615 (0.167)	0.663 (0.099)
C	ε	g	131.970	-0.514	504	2064	-0.686 (0.168)	0.732 (0.096)
C	æ	C	180.950	0.296	742	1767	-0.303 (0.186)	0.577 (0.094)
C	æ	g	159.320	-0.062	643	1899	-0.454 (0.221)	0.648 (0.097)
JA	e	C	209.560	0.770	425	2382	-0.851 (0.127)	0.874 (0.108)
JA	e	g	158.320	-0.078	477	2234	-0.738 (0.138)	0.811 (0.102)
JA	ε	C	123.060	-0.662	538	2029	-0.62 (0.163)	0.714 (0.102)
JA	ε	g	131.660	-0.520	505	2145	-0.682 (0.156)	0.768 (0.119)
JA	æ	C	179.650	0.275	680	1890	-0.387 (0.167)	0.642 (0.116)
JA	æ	g	170.740	0.127	593	2054	-0.53 (0.204)	0.726 (0.113)
MA	e	C	184.210	0.350	426	2490	-0.846 (0.103)	0.918 (0.111)
MA	e	g	149.690	-0.221	493	2285	-0.708 (0.157)	0.832 (0.116)
MA	ε	C	114.310	-0.807	568	2050	-0.565 (0.15)	0.726 (0.092)
MA	ε	g	132.050	-0.513	503	2251	-0.685 (0.135)	0.816 (0.118)
MA	æ	C	162.650	-0.006	775	1823	-0.265 (0.211)	0.609 (0.086)
MA	æ	g	167.090	0.067	690	1982	-0.377 (0.189)	0.691 (0.105)
YN	e	C	237.240	1.229	394	2262	-0.925 (0.114)	0.82 (0.127)
YN	e	g	174.670	0.193	434	2109	-0.827 (0.107)	0.75 (0.127)
YN	ε	C	130.640	-0.536	478	1975	-0.733 (0.125)	0.686 (0.114)
YN	ε	g	148.030	-0.249	449	2065	-0.798 (0.128)	0.728 (0.132)
YN	æ	C	190.780	0.459	648	1770	-0.435 (0.165)	0.577 (0.112)
YN	æ	g	200.890	0.627	614	1821	-0.5 (0.219)	0.604 (0.122)

APPENDIX M: SPEAKER DEMOGRAPHIC DATA AND OVERLAP FRACTIONS

Speaker	City	Region	Gender	Ethnicity	Gen.	Regionality	NSS	æg∼ɛg	æg∼eg	æg∼e	ɛg∼eg	ɛg∼e	eg∼e	Approximation
ECL83CM1Z	Clayton	E	M	C	1	2	8	0.10	0.06	0	1	0	0	0.70
ECL84CF1Z	Clayton	E	F	C	1	2.5	7.5	0.02	0.13	0	0.46	0	0	0.49
EDP74CF1T	Deer Park	E	F	C	1	2	12.5	0.32	0.43	0.05	0.33	0.01	0.07	0.53
EDP75CM1T	Deer Park	E	M	C	1	2.5	11	0.08	0.08	0	0.73	0.15	0.30	0.50
ERI96CF2G	Richland	E	F	C	2	2	6.5	0.45	0.07	0	0.75	0.19	0.28	0.64
ERI97CF3G	Richland	E	F	C	3	2	7	0.11	0	0	0.48	0	0.10	0.49
ERI98CF3G	Richland	E	F	C	3	1	10	0.14	0.14	0.03	0.39	0.16	0.42	0.37
ESP102CF2J	Spokane	E	F	C	2	2.5	11	0.51	0.51	0.14	0.45	0.06	0.25	0.57
ESP110CF2Q	Spokane	E	F	C	2	1	12	0.23	0.12	0	0.48	0.21	0.39	0.44
ESP70HF3Q	Spokane	E	F	MA	3	2.5	7.5	0.27	0.19	0.16	0.64	0.04	0.22	0.56
ESP71HF2R	Spokane	E	F	MA	2	2.5	6.5	0	0	0	0.53	0.57	0.30	0.41
ESP79SF1V	Spokane	E	F	JA	1	2.5	8.5	0.14	0	0	0.27	0	0.16	0.42
ESP80SF1W	Spokane	E	F	JA	1	2.5	9	0	0	0	0.24	0	0	0.41
ESP81AM3X	Spokane	E	M	AA	3	2.5	13	0.41	0.20	0	0.51	0	0	0.64
ESP89SF2C	Spokane	E	F	JA	2	1	6	0.48	0.75	0.80	0.54	0.15	0.17	0.62
ESP99SM3H	Spokane	E	M	JA	3	2.5	7.5	0.24	0.20	0	0.86	0.08	0	0.70
ESV108CF3O	Spokane Val.	E	F	C	3	2	11.5	0	0	0	0.78	0.24	0.48	0.43
ESV109CM3P	Spokane Val.	E	M	C	3	1	11	0.26	0.30	0	0.77	0.28	0.18	0.62
ESV82SF3Y	Spokane Val.	E	F	JA	3	2	12.5	0.73	0.93	0.26	0.80	0.05	0.08	0.82
SB69CF3P	Seattle	W	F	C	3	2	11.5	0	0.06	0	0.30	0.17	0.58	0.24
SB93SM3D	Seattle	W	M	JA	3	2.5	4.5	0.05	0	0	0.19	0	0.24	0.34
SBI94SM2E	Bainbridge Isl.	W	M	JA	2	1	10	0.13	0	0	0.43	0	0.10	0.48
SC56SF1D	Seattle	W	F	JA	1	2.5	7	0.31	0.27	0.28	0.06	0.03	0.46	0.30
SC57SF2B	Seattle	W	F	JA	2	1	7	0.80	0.78	0.11	0.61	0.13	0	0.80
SC61AF1K	Seattle	W	F	AA	1	2.5	6	0.01	0.08	0	0.59	0.02	0.10	0.50
SC62AF1L	Seattle	W	F	AA	1	2	9	0.46	0	0	0.96	0.03	0	0.81
SC63AF1M	Seattle	W	F	AA	1	2	8.5	0.20	0.23	0	0.88	0	0.22	0.62
SC92CM3D	Seattle	W	M	C	3	2.5	9	0	0	0	0.63	0	0.06	0.52
SD53SM1J	Seattle	W	M	JA	1	2.5	8.5	0.21	0.16	0.01	0.83	0.12	0.23	0.61
SD59SF2J	Seattle	W	F	JA	2	1	9	0.17	0.27	0	0.73	0	0.06	0.61
SD88CF3B	Seattle	W	F	C	3	2.5	10	0.34	0	0	1	0.02	0	0.78

Speaker	City	Region	Gender	Ethnicity	Gen.	Regionality	NSS	æg~ɛg	æg~eg	æg~e	ɛg~eg	ɛg~e	eg~e	Approximation
SE76CM2U	Seattle	W	M	C	2	2	9	0.80	0.61	0	0.48	0	0	0.76
SH18CF2K	Seattle	W	F	C	2	1	11	0.13	0	0	0.65	0.10	0.44	0.44
SK14CM2I	Kirkland	W	M	C	2	1	16	0.56	0.15	0	0.84	0	0.01	0.79
SKI90SM2C	Kingston	W	M	JA	2	2.5	7	0.53	0.62	0.26	0.60	0.08	0.39	0.58
SKT68CM2O	Kent	W	M	C	2	2	5.5	0.20	0.16	0	0.99	0.43	0.40	0.60
SN7CF2D	Seattle	W	F	C	2	1	14.5	0.49	0.46	0	0.34	0.10	0	0.61
SO64CF2N	Shoreline	W	F	C	2	1	12.5	0.39	0.33	0.02	0.31	0.01	0.08	0.54
SO65CF3N	Shoreline	W	F	C	3	1	11.5	0.68	0.68	0	0.93	0.73	0.24	0.79
SO66CM2N	Shoreline	W	M	C	2	2	10.5	0.70	0.63	0.04	0.68	0.14	0.23	0.72
SO67CM3N	Shoreline	W	M	C	3	1	11	0.46	0.93	0.08	0.72	0.11	0.06	0.70
SP55SM1D	Portland	W	M	JA	1	2.5	NA	0.28	0	0	0.35	0	0.13	0.50
SQ73CF3S	Seattle	W	F	C	3	2	8.5	0	0.13	0	0.56	0	0.57	0.33
SR54SF2C	Seattle	W	F	JA	2	1	10	0.38	0.50	0.11	0.48	0.02	0.25	0.54
SR77CM3U	Seattle	W	M	C	3	3	7	0.09	0.37	0.01	0.49	0.40	0.29	0.43
SR78CM2U	Seattle	W	M	C	2	2	9	0.30	0.36	0	0.72	0	0	0.67
SRN85CF2A	Renton	W	F	C	2	2	11	0.60	0.78	0.05	0.71	0.10	0.04	0.76
SRN86CF3A	Renton	W	F	C	3	2	8	0.35	0.19	0	0.33	0.28	0.07	0.54
SS27CM3O	Seattle	W	M	C	3	1	9.5	0.12	0.15	0	0.42	0.01	0.28	0.42
STA106AF3M	Tacoma	W	F	AA	3	2	10.5	0.08	0.09	0	0.56	0.13	0.32	0.44
STA107AF3N	Tacoma	W	F	AA	3	2.5	6	0	0	0	0.34	0	0	0.45
SU28CM3P	Seattle	W	M	C	3	3	8.5	0.37	0.55	0.22	0.81	0.19	0.32	0.62
SW58SF2B	Seattle	W	F	JA	2	1	9	0.16	0.10	0	0.45	0	0.01	0.53
SW72CF2S	Seattle	W	F	C	2	2	9.5	0.27	0.32	0.19	0.91	0.65	0.36	0.60
YH47HM3H	Harrah	C	M	MA	3	2	6	0.20	0.15	0	0.23	0	0.12	0.44
YH48HF3H	Harrah	C	F	MA	3	2.5	4	0.15	0.28	0	0.60	0.82	0.86	0.29
YM37HF2C	Mabton	C	F	MA	2	3	8	0	0.01	0	0.54	0	0.12	0.47
YS44NF2G	White Swan	C	F	YN	2	1	5.5	0.12	0.27	0	0.59	0.05	0.44	0.42
YS45NF2G	White Swan	C	F	YN	2	1	14.5	0.34	0.20	0.26	0.50	0.22	0.31	0.51
YS46NF3G	White Swan	C	F	YN	3	1	6	0.26	0.04	0.03	0.61	0.48	0.18	0.56
YT49NM2E	Toppenish	C	M	YN	2	1	10.5	0.39	0.16	0.11	0.97	0.31	0.21	0.72
YU51NM2E	Sunnyside	C	M	YN	2	2	10	0.03	0	0	0.81	0	0	0.61
YW41NM3F	Wapato	C	M	YN	3	1	9.5	0.11	0.19	0	0.51	0.04	0.15	0.49
YW42NM3G	Wapato	C	M	YN	3	1	9.5	0.25	0.46	0.30	0.41	0.12	0.42	0.41
YW43HM3H	Wapato	C	M	MA	3	2.5	7	0.25	0.28	0.51	0.63	0.36	0.25	0.54
YY35HF3A	Yakima	C	F	MA	3	2.5	7	0	0	0	0.34	0.11	0.22	0.37
YY36HF3B	Yakima	C	F	MA	3	2.5	6.5	0.07	0.40	0.07	0.59	0.10	0.52	0.38
YY39HF3D	Yakima	C	F	MA	3	2.5	10	0.34	0.46	0.03	0.72	0.06	0.14	0.64
YY52HF3I	Yakima	C	F	MA	3	2.5	10	0.25	0.27	0	0.73	0.04	0.24	0.58
YY60HF2I	Yakima	C	F	MA	2	2.5	8	0.65	0.59	0.08	0.36	0.04	0.10	0.64

Speaker	City	Region	Gender	Ethnicity	Gen.	Regionality	NSS	æg∼ɛg	æg∼eg	æg∼e	ɛg∼eg	ɛg∼e	eg∼e	Approximation
YZ40NF2E	Zillah	C	F	YN	2	2	4	0.05	0	0.11	0.70	0	0	0.58