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by

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ABSTRACT

Phonetic and Phonological Acquisition in Endangered Languages Learned by Adults:
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This dissertation compares the phonetic and phonological features of adult non-speakers' productions of words in an endangered Native American language, Oregon Northern Paiute (also known, and hereafter referred to, as Numu), to productions by fluent speakers. The purpose of this comparison is two-fold. The first purpose is to examine the differences in pronunciation that non-speakers bring to the language, which point to possible directions of future language change in a language that is no longer being learned as a first language by children. Changes brought to the language by second language learners are likely to occur due to transfer effects from English and processes of regularization, but may also occur due to the intensification of socially salient language features, or hypercorrection (see Wolfram, 2002). For this reason, two groups of non-speakers were included in the study: English speaking members of the community where Numu is spoken (Warm Springs, Oregon) and English speakers from outside the community. It was hypothesized that the latter group would only exhibit transfer effects or regularization, while the Warm Springs group would also exhibit hypercorrection of what they perceive to be salient features of Numu. By comparing the productions of the two non-speaker groups, specific aspects of potential change are identified and classified as transfer, regularization, or hypercorrection.

The second purpose of the comparison between speaker and non-speaker productions is to ascertain specific differences in pronunciation that result in perceivably accented speech. This research goal is achieved by examining fluent speakers' reactions to non-speakers' productions. It was hypothesized that not all features unique to non-speaker produced speech would result in a perceivable accent. Learners who wish to improve their pronunciation from the perspective of the Numu community could then focus particularly on the features that do contribute to a noticeable accent.

This research makes contributions to our understanding of phonetic and phonological change in endangered language contexts, both from a second language acquisition perspective and a socio-phonetic perspective. The theoretical framework for this research is described in Chapter 1, along with information about Numu and about the Warm Springs community. The second

chapter provides a phonetic sketch of Numu based on data from four fluent speakers of the language. This sketch forms the basis for comparison of non-speaker productions in later chapters, but also contributes a phonetic record of several features of Numu for future generations of learners and researchers. Chapter 3 repeats these phonetic measurements for non-speakers, and also examines a number of phonological features of non-speaker speech, finding that study participants from Warm Springs generally have a production advantage as compared to people from outside the community. It also finds that, in some cases, study participants from Warm Springs produce novel segments that are not present in the fluent speaker input, but that do exist in other geographically close Native American languages. Chapter 4 discusses these findings in terms of the possible changes that adult learners may bring to Numu. These changes are explored with regards to three theoretical proposals of endangered language change, including transfer effects from a dominant language, adoption of universal language features, and hypercorrection of socially salient language features. A fourth mechanism of endangered language change is proposed, based on findings that non-speakers incorporate phonological elements of other Native American languages, of which they are not speakers.

Chapter five presents and discusses results from a perception test in which fluent speakers provided ratings for non-speaker productions. These ratings are compared to the non-speaker features present in a given production in order to determine which features are linked to lower ratings. These features are hypothesized to contribute to a perceivable accent in the speech community. Finally, Chapter 6 concludes the dissertation with a discussion of wider implications for endangered language change, as well as implications for the use of electronic media in endangered language learning.

To Belén and Paula,
for whom nothing is impossible.

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CHAPTER 1

Introduction

1.1 Overview

For several decades, linguists have warned of the impending loss of the majority of the world's languages. This loss is felt strongly in North America, where Krauss (1996) estimates that fewer than 30 of the continent's remaining 210 indigenous languages are still learned by children and likely to continue as spoken languages into the next century. However, to avert this loss, many minority language communities are launching efforts to protect and revitalize their languages in a variety of ways, including language documentation, immersion lessons and school programs, language camps and classes, and the use of electronic resources to increase people's access to language materials (see Hinton, 2001a for an overview of language revitalization efforts in the United States).

As a result of these efforts, many languages are being learned by people who are past the age at which they are likely to learn the language with native-like fluency, especially at the phonological level. The implication of this trend is that the accented features of adult learner speech may become permanent features of the language (Hinton, 2001b). Indeed, rapid phonetic and phonological change is a pervasive characteristic of endangered languages (e.g., Campbell & Muntzel, 1989; Chang, 2007; Goodfellow, 2005; Yu, 2008) and is especially common when languages are primarily learned by adults (see Trudgill, 1989). A prevalent attitude among many people, including researchers, teachers, and community members is that these changes are detrimental to the languages. For example, Lipka (1994) reports that Yup'ik speakers in Manokotak, Alaska complain about the mixing of Yup'ik with English and the language's subsequent "deterioration." Carpenter (1997) reports the results of interviews with teachers and administrators at indigenous language programs throughout the United States, finding that one of their greatest concerns is "preserving the language in its original form" (p. 32). In addition, some researchers express the importance of "pure" language data (e.g., Evans, 2001; Mufwene, 1993). Social attitudes about language production are so strong that embarrassment about imperfect production can form a barrier to learning endangered languages or practicing them with fluent speakers (e.g., Basham & Fathman, 2008; Goodfellow, 2005).

Though some linguists have made a case for accepting change and variation in endangered language revitalization (Dorian, 1994b; Goodfellow, 2003), little effort has been made to understand community attitudes towards specific language changes. In fact, it is likely that some phonetic and phonological changes are highly conspicuous, while others go unnoticed. For example, Abrahamsson & Hyltenstam (2009) find that native Swedish speakers' perceptions of nativelikeness in late onset second language learners does not correspond with measurements of linguistic performance. In addition, some acoustic cues have also been found to be more salient than others in studies of dialect perception (Clopper & Pisoni, 2005). Furthermore, native-speakerhood is tied up in issues of identity and perception; whether or not an incorrect utterance is tolerated or even noticed may depend entirely on if the speaker is perceived to be part of the speech community or not (Davies, 2003).

This dissertation examines phonetic and phonological changes that adult learners may bring to the dialect of Oregon Northern Paiute (known by speakers, and hereafter referred to, as Numu) spoken in Warm Springs, Oregon. In this community, the majority of potential future speakers are learning the language as teenagers and adults, after the critical period of acquisition. The research therefore compares the productions of non-speakers repeating Numu words to the productions of fluent speakers in an effort to determine the types of changes that adult learners may bring to the language. However, these changes will not ultimately signal the language's demise if the language community continues to accept it as a viable marker of their culture. The second part of the research, therefore, examines fluent speakers' reactions to non-speakers' productions in order to identify which differences in pronunciation contribute to a perception of accented speech. These are the differences that must be addressed if learners wish to produce unaccented speech.

1.2 Language acquisition and language change

Though the mechanisms by which children and adults acquire phonology are still under debate (see, for example, Flege, 1987; Flege, 1992; Montrul, 2006), it is widely accepted that the majority of adults learn languages less perfectly than children. Adult-learned language may include illicit syllables, incorrect stress and intonation, mistimed or misapplied gestures, long or short phoneme duration, long or short voice onset time (VOT), and a number of other aspects that are noticeable to fluent speakers but difficult for the adult learners to control (Au et al., 2002; Davidson, 2006). Learner-produced language is described as *interlanguage*, a term introduced by Selinker (1969; 1972), which implies that the learner has not yet fully acquired the second language, but is speaking something that falls in between the first and second language. The term *transfer effects* refers to the use of linguistic structures from the first language in the production of a second language. Schachter (1993) treats transfer as a by-product of language hypothesis testing rather than its own distinct process. Under her model, adults formulate and test hypotheses about the new language's structures, which may be influenced by either what they know about the language, what they know about their first language, or a mixture of both. She notes that the implication of this model is that the first language will have the same amount of influence on the second language regardless of how related the two languages are, but the influence itself will differ.

This model is disputed by Corder (1993), who argues that the term *transfer* does not adequately describe the process by which an interlanguage is formed. Instead, he contends that learners speak a simplified form of language, more akin to a child's grammar or even a universal grammar than to their mother tongue. Stauble (1980) also discusses the language acquisition process in terms of universal grammatical simplification. Initially, the learner reduces the target language grammar for ease of use while still maintaining a minimum ability to communicate. Later, the learner elaborates on the simplified system with some grammatical elements of the language, but still exhibits features of the reduced system. Major (2001), however, incorporates both processes of simplification and transfer effects into his ontogeny phylogeny model (OPM) of second language phonological acquisition. This model proposes that a given interlanguage (IL) includes three interacting elements: the first language (L1), the second language (L2), and language universals (U). In the beginning stages, the interlanguage consists almost entirely of the first language (IL = L1). As the learner's ability in the second language increases, the role of the first language decreases, until the interlanguage reaches the idealized state IL = L2. During this process, the role of universal simplification increases and then decreases, so that at some midpoint, the interlanguage includes all three elements (IL = L1 + U + L2).

Ellis (1989) attributes even more complexity to interlanguage development, exploring it in terms of speakers' sociolinguistic roles. He states, "Instead of measuring interlanguage using the yardstick provided by the target language... we need to illuminate the inner logic of learner systems by examining how they operate in the 'pragmatic mode'" (p. 33). According to him, second language learners exhibit variation in their speech as a result of the conflict among natural simplifications and target norms, variation within the target language itself, and exposure to multiple varieties of the language. In his view, the learner tries out a new form, explores its potential communicative use in different contexts, and revises the interlanguage accordingly.

Corder (1993, p. 29) states, "Ultimately most, but not all, the incorrect items are eliminated in the course of further learning while the correct items are incorporated into the permanent structure of the interlanguage." However, adult learners tend not to reach this native-like endpoint, with their second language abilities instead undergoing *fossilization*, a term proposed by Selinker (1972) to describe the barrier to complete acquisition. Markham (1997) attributes fossilization to the creation of a closed-loop system, in which the learner relies on their own output as reinforcing input, thereby perpetuating any errors present in their own productions. Similarly, Flege & Liu (2001) argue that in order to move along the interlanguage continuum, substantial native-speaker input is essential. Furthermore, Lively, Logan, & Pisoni (1993) show that input from a diverse array of native speakers is required for learners to produce robust generalizations of sounds that are contrastive in the target language. Finally, feedback is required to achieve native-like speech, either directly (e.g., by being corrected) or indirectly (e.g., by not being understood). For example, Kowal & Swain (1997) find that in classroom situations where there are many learners and only a single teacher, students' productive skills do not match their receptive skills and errors are common, because they have few opportunities to receive feedback.

We might imagine therefore that the phenomenon of fossilization is highly pronounced for learners who have limited access to fluent speakers for input or feedback, which is often the case for learners of endangered languages. Indeed, the phenomena of interlanguage, fossilization, and transfer effects have been variously incorporated into explanations of change in endangered languages (e.g., Cook, 1995; Goodfellow, 2005; Trudgill, 1989). *Pidginization*, which likens endangered language change to the process of pidgin formation, has also been proposed (Dressler & Wodak-Leodolter, 1977; Hinton, 2001a). The factor that unites these theories is that as a language is spoken by fewer and fewer people, uncorrected "mistakes" become more prevalent, and eventually become part of the language's permanent structure.

1.3 The Numu language

This study examines the phenomena described above associated with language acquisition in Numu, an Uto-Aztecan language of the Western Numic branch. Dialects of Northern Paiute are spoken in scattered communities throughout Oregon, Nevada, and California, but this study is concerned primarily with the language as it is currently spoken on the Confederated Tribes of

Warm Springs Reservation in central Oregon. This section provides a brief history of the Numu people in Warm Springs, followed by information about the social context of language and language revitalization in this community.

1.3.1 Numu people in Warm Springs

Before the arrival of White settlers to the area in the early 19th century, the region in and around what is now the Confederated Tribes of Warm Springs Reservation was used by a number of mobile Native American bands for subsistence activities. During the summer, people traveled to the nearby Cascade Mountains, the Blue Mountains, and the Columbia Plateau to hunt game, pick berries, and dig for roots (see Figure 1). In the spring and fall, they traveled to the Columbia River for fishing and trading (Hirst, 1973). People belonging to the bands that lived in this way spoke Sahaptin (a Sahaptian language), while permanent dwellers along the Columbia River spoke Wasco (the easternmost Chinookan language). These two groups maintained an extensive system of contact. Speakers of Northern Paiute, on the other hand, lived far to the south and seldom came into contact with these two groups (CTWS, 1984).

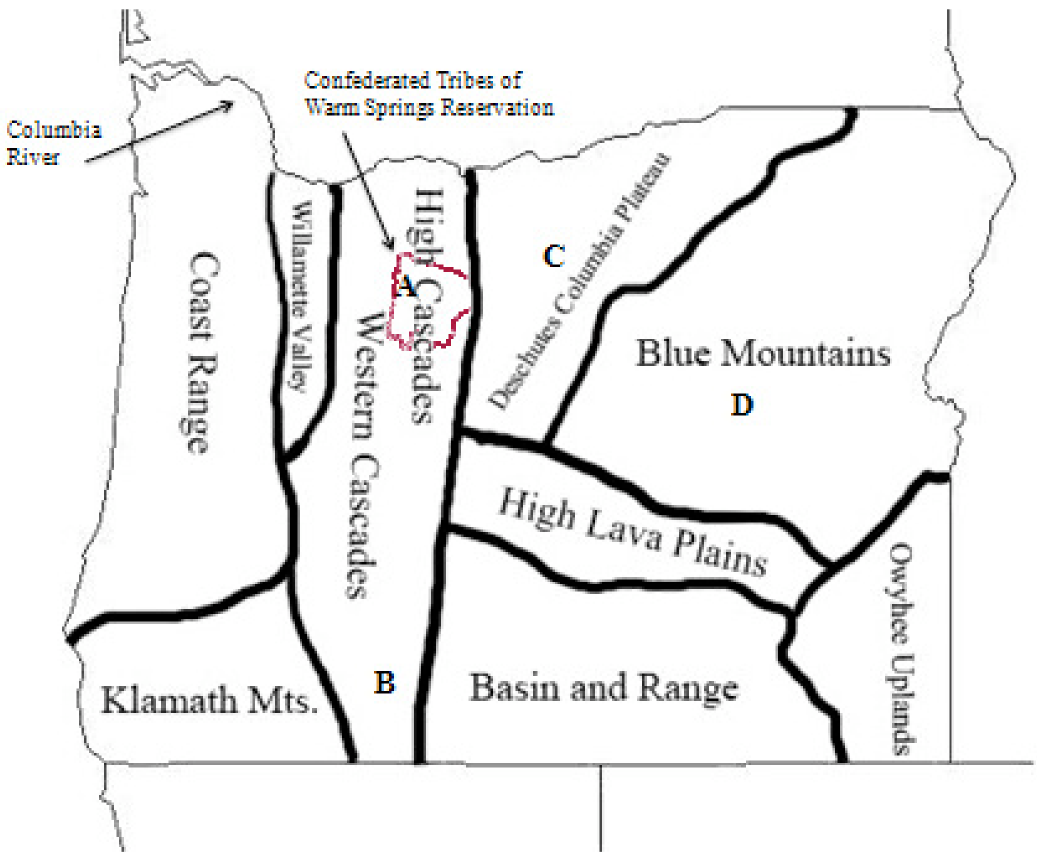

Figure 1. Map of Oregon showing the approximate location of the Confederated Tribes of Warm Springs Reservation (A), Cascade Mountains (B), the Columbia Plateau (C), and the Blue Mountains (D). The Columbia River forms Oregon's northern border.
Modified from http://oregonmag.com/OregonGeoMapNew.BMP

By the mid 1800s, thousands of settlers were entering and crossing the region every year. In 1855, Joel Palmer, the Superintendant for the Oregon Territory, received orders to remove Native Americans in the Columbia Basin from their land, which he achieved through the establishment of treaties with various groups. In 1855, a treaty was made to establish the Warm Springs Reservation, signed by the United States and by Warm Springs (Sahaptin) and Wasco bands. In exchange for a promise of protection and support from the U.S. government, including the rights to fish, hunt, and gather in traditional areas and the right to govern their own affairs, these bands gave up claims to more than ten million acres of traditionally occupied land for a reservation covering little more than 1000 square miles (CTWS, 1984).

Native American leaders, including members of the Walla Walla, Tygh, Wyam, Tenino, and John Day Bands (collectively known as the Warm Springs Tribe); and the Dalles and Dog (Hood) River bands (Wasco), were forced to accept the reservation sight unseen. Chief Mark, of The Dalles Band, stated, “The place that you have mentioned I have not seen. There are no Indians or white men there yet, and that is the reason I say I know nothing about that country. If there were Indians and white there, then I would think it was a good country” (quoted in CTWS, 1984, p. 24). Indeed, land on the reservation is considered generally poor for agriculture; the majority of the Tribes’ outside revenue comes from timber sales and from the tribally owned Kah-Nee-Ta Hot Springs Resort. These ventures became possible following the construction of U.S. Highway 26 in the 1930s and 1940s (Hirst, 1973).

Following the 1866-1868 military campaign of General Crook, several Northern Paiute bands who resided in southeastern Oregon were forced onto the Malheur Reservation, located in southeastern Oregon (see Figure 2). From there they were forced to move to the Yakima Reservation in south central Washington following the Bannock War of 1878 (the Malheur Reservation was then returned to the public domain). One small band settled on the Warm Springs Reservation (Hirst, 1973). In 1937, under the provisions of the 1934 Indian Reorganization Act, the three reservation tribes adopted a constitution and renamed themselves the Confederated Tribes of Warm Springs of Oregon. Currently, approximately 4000 tribal members live on the reservation.

Figure 2. 1879 map of the Malheur Reservation in southeastern Oregon (arrow added).
Oregon Historical Society, Map 132

1.3.2 The Warm Springs languages

The three indigenous languages spoken on the Confederated Tribes of Warm Springs Reservation are Numu, Ichishkin (a Sahaptian language), and Kiksht (a Chinookan language).[1] Numu and Ichishkin are still spoken by adults, but are not being transmitted inter-generationally on the reservation, putting them at Level 7 on Fishman's (1991) scale of endangerment (Level 8 being the most endangered). Kiksht is only spoken by one person who is over 90 years old, and is therefore a Level 8 language. Ichishkin is the most robust indigenous language in Warm Springs, though it has fewer than 50 fluent speakers. Numu has fewer than 10 speakers in Warm Springs, but dialects of the language are spoken in scattered communities throughout Oregon, California, and Nevada. Nonetheless, it is spoken by fewer than 500 people overall and is considered endangered (Thornes, 2003).

The current study deals with the future of one of these languages, Numu, but an examination of its historical trajectory in Warm Springs in conjunction with the other two languages is crucial to understanding its possible future outcomes. The next section therefore provides an overview of language loss and efforts for revitalization in Warm Springs, presented in the context of national, statewide, and local policies and practices. The discussion centers around education, because the primary means for language policy enactment in the United States has occurred through its education system, and because this education system has largely been blamed for the attempted eradication of Native American languages (Crawford, 1996; Gross, 2007). Interestingly, efforts to revitalize many Native American languages have also involved formal education systems (for better or for worse), and so the institution of education remains central to most discussions of North America's indigenous languages.

1.3.3 The Warm Springs language program

At the turn of the nineteenth century, the United States government began instituting policies aimed at "civilizing" Native American people, primarily through educating their children to conform to Western cultural norms. These policies began with the funding of missionary schools through the Civilization Fund Act of 1819, and continued with the establishment of boarding schools, which were specifically designed to separate Native American children from the influence of their parents and communities (Adams, 1995). Conditions in boarding schools were often deplorable. Children experienced intense homesickness, exposure to outbreaks of communicable diseases like typhoid and tuberculosis, physical and emotional abuse, and harsh punishments for speaking their mother tongue (Child, 1998). In 1880, regulations were issued that all instruction in schools serving Native American students, be they missionary or government boarding schools, must occur in English (Reyhner, 1993). This directive was reiterated in 1887 by J.D.C. Atkins, the Commissioner of Indian Affairs, who wrote, "The instruction of Indians in the vernacular is not only of no use to them, but is detrimental to the cause of their education and civilization, and it will not be permitted in any Indian school" (Prucha, 2000, p. 174).

In Oregon, the first Western schools were established by Christian missionaries, many of whom attempted to learn local languages and tolerated the use of Native American languages in classrooms (Gross, 2007). However, by the 1850s, federally run schools were beginning to

[1] Numu, Ichishkin, and Kiksht are the names of the Warm Springs languages in those respective languages. Northern Paiute, Sahaptin, and Wasco are the English names. Non-English names are used throughout this paper.

replace mission schools, including one in Warm Springs. The Treaty of 1855 that established the Confederated Tribes of Warm Spring's official relationship with the United States federal government stipulated that a school house, teacher, books, and supplies be provided to the tribes. However, Indian Agent William Logan reported that the school building that was eventually built was "not fit to keep school in during the fall and winter, too small, and not finished" (quoted in Clemmer, 1980, pg. 32). It was attended sporadically, mostly in the winter, due to children's participation in traditional sustenance activities with their parents during the rest of the year. Due to their low rates of attendance, in 1861 William H. Rector, Superintendant of Indian Affairs in Oregon, recommended the establishment of a boarding school. The boarding school became a reality in 1870, with a curricular focus on domestic chores and manual labor. Students who lived nearby still attended it as a day school. Another boarding school on the reservation was established in 1882 in Simnasho, and in 1880, a large boarding school in Forest Grove, more than 100 miles from Warm Springs, was established that was also attended by some students from Warm Springs (Clemmer, 1980).

Despite the presence of two boarding schools on the reservation, attendance continued to be sporadic. In his 1882-83 school report, Indian Agent John Smith stated, "It has been difficult to keep the children at this school. Their parents and friends do not fully appreciate the advantages of the [industrial] training we aim to give, and too often take the children's part, when they run off home, on account of having been corrected, or from getting homesick" (quoted in Clemmer, 1980, p. 108). Clemmer surmises that "being corrected" in the Warm Springs school was similar to customary discipline at Native American schools throughout the nation, and would have included harsh, demeaning, and abusive practices.

In 1897, the two reservation boarding schools were combined to form a single boarding school in Warm Springs (Clemmer, 1980). In another study I conducted in Warm Springs (Haynes, In Press), one woman who had attended this boarding school said:

> Before I went to the boarding school, I was speaking [Ichishkin], and all my sisters and brothers were speaking it. That's all we spoke, and then we got into boarding school and we were not allowed to speak. And I grew up believing that it was something very bad, because we got punished, or switched, and so they just kind of beat it out of me. My mother and father spoke it all the time and my grandmother who lived here spoke it all the time. But once we started going to school, my grandmother was forbidden even to speak in the house, especially at our table, because my parents were trying to get us ready for the new world... And so grandma could not talk to us, because that's all she spoke, was that language. That was a very sad time …That boarding school did bad stuff to us, and they took the most important thing, which was our language.

This woman's experience is typical of an institution aimed at the systematic assimilation of Native American people through eradication of their language and ties to older or more traditional family members. However, as early as the late 19th century, there was visible opposition to the way in which Native American children were being taught, from the oppression of their languages and cultures to the inferiority of instruction they received from ill-prepared and under-trained teachers (Reyhner, 1993). In 1928, the Meriam Report, commissioned by Secretary of the Interior Hubert Work and directed by Louis Meriam, strongly criticized the boarding school system and English-only policies. Not only did it admonish school officials to not separate young children from their families, it recommended an inclusive attitude towards Native American culture, stating, "The Indians have much to contribute to the dominant civilization, and the efforts should be made to secure this contribution" (quoted in Prucha, 2000, p. 220).

The rise of the Civil Rights movement in the United States yielded increasingly favorable mainstream attitudes about Native American cultures and languages and more critical examinations of Native American education. In 1969, Senator Robert F. Kennedy spearheaded the *Report on Indian Education*, the summary of which stated,

> We have concluded that our national policies for educating American Indians are a failure of major proportions. They have not offered Indian children—either in years past or today—an educational opportunity anywhere near equal to that offered the great bulk of American children (quoted in Prucha, 2000, p. 254).

The rising recognition of inequities in Native American education led to the passage of the Indian Education Act in 1972, which provided much needed funds for Native American education programs, created a new Office of Indian Education within the Office of Education, and created the National Advisory Council for Indian Education. The Advisory Council was to be made up entirely of representatives from Native American tribes, who would be responsible for advising congress on Native American education issues ("The Indian education act", 1975).

More recently, in 1990, congress passed the ground-breaking Native American Languages Act, which recognizes the special status of Native American languages in the United States and promotes and encourages their use in public school classrooms. Furthermore, it forbids the restriction of public use of Native American languages, including use in public school classrooms, and allows modification of teacher certification to make it easier for fluent speakers of Native American languages to teach in public schools (Native American Languages Act, 1990). Some states have taken advantage of this provision, including Oregon, where this study takes place. In 2001, at the urging of several of Oregon's tribes, Oregon's legislature passed Oregon Senate Bill 690, which allows speakers of Native American languages who don't hold teaching certificates to teach in public school classes with a regular classroom teacher present (Haynes, 2007).

Despite these advances, however, public education in the United States has largely remained a vehicle of Western culture, with curricula and materials that espouse Western historical narratives and cultural ideals (see Cummins, 1988). Teachers tend to favor Western modes of communication in classrooms with Native American students (St. Charles & Costantino, 2000; Philips, 1983). The introduction of Native American cultural and linguistic materials is often superficial or marginalized, even in schools with primarily Native American populations (e.g., Haynes, 2004; Greymorning, 2001; Suina, 2004; White, 2001). Lomawaima & McCarty (2006) provide a compelling explanation for such marginalization through their introduction of the *safety zone.* They argue that this zone demarcates "allowable cultural expression" for Native Americans within the nation's schools, fluctuating with the nation's general tolerance of non-Western cultures and peoples. Through the *safety zone*, the institution of United States education allows indigenous languages and cultures to be expressed only within the bounds of its broader program of homogenization and standardization.

The Confederated Tribes of Warm Springs represents a microcosm of these struggles between national homogenizing forces and local desires to preserve their linguistic and cultural heritage. Throughout the 1970s and 1980s, fluent speakers of the Tribes' languages (though primarily Ichishkin) taught sporadic language classes in local elementary schools and in the community. In 1979, the Warm Springs Culture and Heritage Committee was officially instated with the purpose, among other things, to review and approve curricular materials for teaching language and culture in local public schools, implying an intention to develop and use such materials. This intention was brought to fruition in 1994, when fluent speakers and language learners of all three Warm Springs languages attended the summer American Indian Language Development Institute (AILDI), where they received training in indigenous language education. Beginning the following fall, they began teaching the Warm Springs languages at Warm Springs Elementary School, a public school on the reservation serving a 98 percent Native American student population. The program began with an offering of Ichishkin classes, then added Kiksht and Numu in the following years. Due to this staggering of language classes, the first cohort of students was taught only Ichishkin, while subsequent cohorts received a combination of the three languages as each was incorporated into school.

But for a number of reasons, including federal and statewide pressure to produce improvement in student performance in English reading and math, the Jefferson County 509-J school district, of which Warm Springs Elementary School is part, elected to halt the language classes in 2003 (see Haynes, In Press for more information). Regardless of this setback, the Confederated Tribes of Warm Springs Culture and Heritage Department continues to pursue its stated goal: "With quality curriculum, materials and teachers, we will perpetuate and maintain the three languages of Warm Springs, thereby enhancing our abilities to protect our sovereignty, Tribal rights, and most importantly, our culture, values, and self-identity." Currently, tribal members can develop their Numu, Ichishkin, and/or Kiksht language skills through a variety of media. Weekly community language classes are held at the Language Program offices, as well as at a local site for after-school programs. Language teachers teach in pre-school classrooms several times a week and prepare lessons for the local radio station, which airs short daily language lessons in all three languages.[2] In addition, as part of this dissertation work, an on-line audio dictionary was developed that features Numu words, phrases, songs, and stories. The website is accessible to tribal members only, and there are plans to create similar dictionaries for the other two languages.

These teaching efforts are aimed at people whose first language is English, and rely heavily on electronic media. The use of radio and internet is in part to provide access to people who live far from the location of community classes, or whose schedules do not allow them to attend. While these are very useful tools for reaching a large number of people, it is unclear what effect they will have on people's pronunciation of Numu and the other languages. As discussed above, direct feedback is an important aspect of avoiding fossilization and achieving native-like speech. The question that therefore arises is, how will the Warm Springs languages be pronounced by

[2] The local radio station, KWSO, is currently reviewing plans to add a second digital station, which will be devoted exclusively to airing lessons, songs, and other language materials in all three of the Warm Springs languages.

people whose access to fluent speakers is limited, and how will the community of fluent speakers perceive this pronunciation? It is essential that these issues be understood and addressed to avoid a situation in which language teachers and learners feel that they have failed. As Littlebear (2007) emphasizes, perception of program failure may be a major setback for endangered language communities, and the time required to overcome these perceptions exhausts efforts of the remaining speakers that could have been put to more productive use. This research explores these issues in the Numu language.

1.4 Overview of the research and methodology

This section provides a brief overview of methods and definitions used in this research. More detailed explanations will be provided at the beginning of each chapter.

1.4.1 Methods

Research for this study was conducted on the Confederated Tribes of Warm Springs Reservation in central Oregon and in the nearby town of Madras (see Figure 3). Participants included four adult fluent speakers of Numu who live in Warm Springs and twenty-five English speakers from central Oregon, fourteen of whom were Warm Springs community members, and eleven of whom were (non Native American) people from the nearby town of Madras, where Numu is not spoken. The second group served as a control group, under the hypothesis that previous exposure to the language could enhance production abilities (cf. Au et al., 2002 and Knightly et al., 2003 on Spanish; Oh, Au, & Jun, 2002 and Oh et al., 2003 on Korean; and Chang et. al., 2009 on Mandarin). The Warm Springs adults had had at least some passive exposure to Numu. They reported having heard the language from grandparents and elders when they were young or reported knowing a few nouns or adjectives. They had also had limited exposure to the language from short daily lessons that are broadcast on the local radio station, cultural events, and occasional evening language classes. People from Madras, on the other hand, reported no knowledge of Numu and had had no previous exposure that they were aware of. Their attempts to produce Numu words and phrases were therefore not affected by previous experiences with the language.

The first stage of this research included the collection of approximately 2600 words and 1550 phrases from four fluent speakers of Numu in Warm Springs. A subset of these data were analyzed to form the basis for a phonetic description of the language, which expands on Waterman's (1911) phonetic description. The phonetic analysis also serves as a basis of comparison to the productions of non-speakers in the second stage of research, in which non-speaker participants were presented with individual Numu words and asked to repeat each token into a microphone. The non-speaker productions were analyzed for phonological and phonetic features of Numu, which were then compared to results from the fluent speakers. Finally, a subset of the non-speaker productions were presented to two of the fluent Numu speakers, who rated them on a scale of 1 (foreign) to 5 (native-like). An analysis of their ratings reveals aspects of non-speaker speech that contribute to a perceivable accent in Numu.

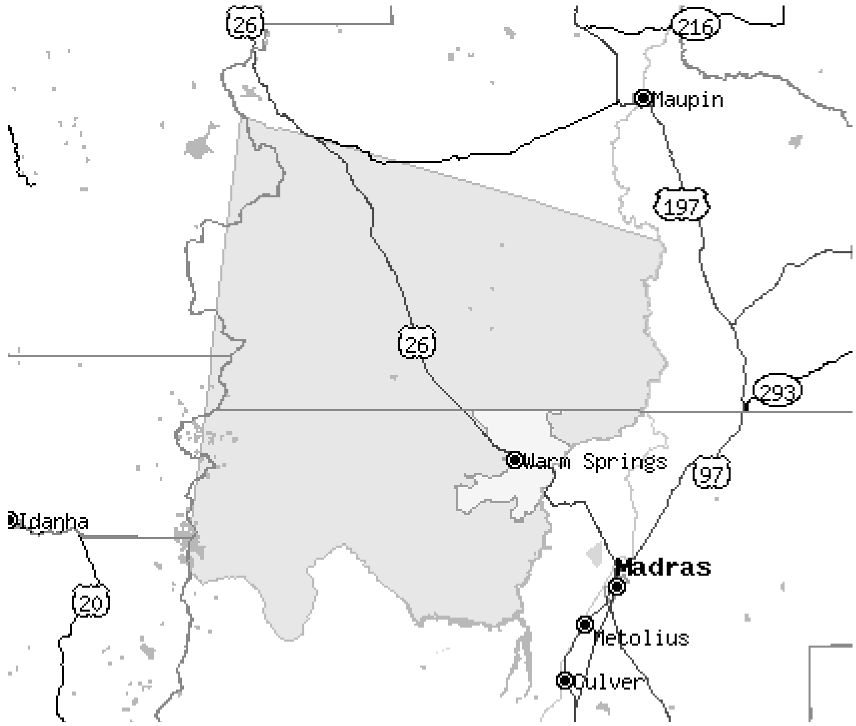

Figure 3. Map showing the towns of Warm Springs and Madras (the distance between the two towns is approximately 15 miles). The shaded portion depicts the Confederated Tribes of Warm Springs Reservation.
From http://en.wikipedia.org/wiki/File:Warm_Springs_map2.png

1.4.2 Research philosophy
As discussed above, the history of the people who live on the Confederated Tribes of Warm Springs reservation is a complex tale of loss and forced assimilation, as well as resistance, hope, and perseverance. Numu, Ichishkin, and Kiksht have remained important to the continuance of the Warm Springs cultural heritage. To the people of Warm Springs and people of Northern Paiute lineage, Numu (in addition to the other two languages) is therefore much more than just an "endangered language". It represents a way of life and a legacy of resistance to assimilation. In the course of this research, I have attempted to treat it as such, and though I believe this research has implications for other endangered languages, especially Native American languages, I have not ceased to view the Numu language as a unique entity that embodies the distinctive culture of the Numu community.

1.4.3 Non-speakers vs. learners
The majority of the participants in this research have not formally attempted to learn Numu, nor do they necessarily have plans to do so. Currently, language learning tends to be sporadic among adults in Warm Springs, and it was not practical to limit the study to active Numu learners.[3] It

[3] I believe that the lack of active learning is due largely to scheduling constraints rather than lack of interest. Over the course of several years, I have talked to many adults in Warm Springs who have emphasized the importance of their Tribal languages and have expressed interest in learning them. However, familial and work-related obligations make it difficult for many Tribal members to participate in regularly scheduled classes. It is for this reason that the

would therefore be inappropriate to refer to them as "learners," though I do draw heavily on language acquisition research throughout the study. For the purposes of this research, I have assumed that non-speaker participants represent *potential* learners, and that their productions represent the productions of people at early stages of learning who have not received a great deal of feedback. This may be a more accurate representation than anticipated; with the rising availability of electronic language materials, it is likely that at least some adults will begin (or have begun) practicing Numu words and phrases without direct access to a fluent speaker.

1.4.4 Phonetic vs. phonological change

In this study, several characteristics of the Numu sound system are examined in a comparison of fluent speaker and non-speaker productions. These can be divided into phonological and phonetic features, though the two categories are interrelated and the distinction is therefore often blurred in studies of speech acquisition. I have adopted a slightly modified version of Markham's (1997) dichotomy of phonetic and phonological acquisition. He defines phonological acquisition as the establishment of abstract categories for production and perception of the target language, including permissible variation within those categories. He defines phonetic acquisition as the establishment of surface production and perception of sounds in the target language, including the ability to relate perception to performance. Markham's description is restricted to the segment level, so I would also add the acquisition of syllable and word-level outputs that are not licensed in the first language to the phonological category. I would also add the establishment of sub-phonemic characteristics of the target language to the phonetic category (e.g., voice onset time, vowel duration, etc.) These distinctions are summarized in Table 1.

Table 1. The distinction between phonetic and phonological acquisition.

Phonological acquisition	abstract categories for production and perception permissible variation within categories rules governing syllable- and word-level outputs
Phonetic acquisition	surface production and perception of segments surface production and perception of sub-phonemic features

Because the majority of the participants in this research have not actively learned Numu, and because their productions are based on an imitation task, it is impossible to directly measure their phonological acquisition. However, it is possible to determine if non-speakers are able to ignore English phonological rules in order to correctly produce sounds and sound combinations that are licensed in Numu. Therefore, this research examines several phonological processes in Numu resulting in outputs that are not licensed in English. It also examines a number of sub-phonemic features to determine if English speakers achieve Numu phonetic targets.

1.5 Theoretical and practical contributions

This research makes contributions to our understanding of phonetic and phonological change in endangered language contexts from a socio-phonetic perspective. For linguists, all changes in

Warm Springs Language and Culture Department has worked on developing electronic media for language learning purposes.

language, including the minutest of sub-phonemic differences, offer a rich source of interesting study and debate. However, this type of interest cannot be assumed to be true for the speech communities in which the changes occur. Some language changes will be highly noticeable, and may even be associated with injurious stereotypes or otherwise negatively marked. Other changes will pass unnoticed. While this work examines an array of differences between speaker and non-speaker productions of Numu, it also examines speaker attitudes about these differences, thereby providing a unique perspective on endangered language change. Furthermore, it makes available a record of which features are the most saliently accented to some fluent speakers, providing the Warm Springs community a resource for intervention in learner speech (should they decide it is important).

In addition, this research makes predictions about the types of phonetic and phonological changes that may occur in Numu based on non-speaker produced speech, rather than examining the changes after the fact. Though the research cannot show definitively the future direction of language change in Numu, it provides the groundwork for long-term examinations of language change, based on a limited set of specific hypotheses that are laid out in Chapter 4.

Finally, this research contributes a phonetic record of several salient features of Numu for future generations of learners and researchers. While it is not comprehensive, it adds to Waterman's (1911) phonetic description of Oregon dialects of Numu, the only such published work to date. Due to limitations in equipment nearly a century ago, Waterman was able to provide only a small range of acoustic measurements of Numu. This research expands on his work with the aid of improved technology.

1.6 Organization of the dissertation

The next chapter, Chapter 2, provides a phonetic sketch of Numu based on data from four fluent speakers of the language. This sketch forms the basis for comparison of non-speaker productions in later chapters. Chapter 3 repeats these phonetic measurements for non-speakers, and also examines a number of phonological features of non-speaker speech, finding that study participants from Warm Springs generally have a production advantage as compared to people from outside the community. It also finds that, in some cases, study participants from Warm Springs are producing novel segments that are not present in the fluent speaker input, but that do exist in other geographically close Native American languages. Chapter 4 discusses these findings in terms of the possible changes that adult learners may bring to Numu. These changes are explored with regards to three theoretical proposals of endangered language change, including transfer effects from a dominant language, regression to universal language features, and intensification of socially salient language features. A fourth mechanism of endangered language change is proposed, based on findings that non-speakers incorporate phonological elements of other Native-American languages, of which they are not speakers.[4]

Chapter 5 presents and discusses results from a perception test in which fluent speakers provided ratings for non-speaker productions. These ratings are compared to the non-speaker features

[4] Predictions about change in non-endangered languages are beyond the scope of this work. However, as will be explored in greater detail in Chapter 4, endangered languages undergo processes that are familiar in all languages, albeit at an accelerated rate.

present in a given production in order to determine which features are linked to lower ratings. These features are considered significant elements of accented speech, and are compared to features that were emphasized in the productions of non-speakers from Warm Springs to determine if socially salient features for non-speakers correspond to salient features for fluent speakers. Implications for accent in speech produced by learners are discussed. Finally, Chapter 6 concludes the dissertation with a discussion of wider implications for endangered language change and the use of electronic media in endangered language learning.

CHAPTER 2

A Phonetic Sketch of Numu

2.1 Introduction

This chapter serves two purposes. The first is to form a basis for comparison to learner productions in later chapters. The second is to provide a phonetic record of several salient features of Numu segments for future generations of learners and researchers. As noted before, the only previous phonetic description of Numu was by Waterman (1911). While he provides a detailed account of relative duration and voicing of Numu segments, he is unable to supply absolute values of timing or information about spectral characteristics. Furthermore, his data were collected from a single consultant, a practice that is no longer considered sufficiently rigorous in phonetic description (see Ladefoged, 2003).[5] The current study seeks to add to his description using a wider range of measurements of sounds produced by a larger group of fluent speakers.

In their phonetic description of Montana Salish, Flemming, Ladefoged, & Thomason (2008) stress the importance of creating phonetic archives of endangered languages that include examples of the languages' distinctive features, not just features that are rare to the world's languages. The current description therefore focuses on features that are distinctive in Numu, including those that are common in the world's languages (e.g., vowel length distinctions). It attempts to provide acoustic details about Numu that have not been previously reported as well as those that have, in order to increase our general understanding of the language. One of the most distinctive features of Numu is its fortis/lenis distinction, for which a number of durational and qualitative acoustic measurements are presented here. The current sketch also includes descriptions of VOT in word initial obstruents and vowel quality and duration in short and long vowels. In addition, a spectral overlap assessment metric (SOAM) is applied to explore the relationship between spectral and temporal aspects of Numu vowels following the procedure described by Wassink (2006).

That said, I encourage the reader to consider this work as merely snapshot of all possible Numu productions. There is often a strong temptation to treat descriptions such as this as definitive of a language, despite the description's reliance on what Brody (2001, p. 7) describes as "the truly bizarre speech event of elicitation," in which the presence of the recording device, the presence of the person doing the recording, and the individual motives of both the recorder and the recordee create a unique context for language production that may or may not be similar to language produced in non-elicitation contexts. That is not to say that data collected in this way are without merit; we can learn much from documenting and analyzing any speech event, even one so "unnatural" as elicitation. Indeed, the phonetic context of speech elicitation is likely similar to the context in which people learn language formally from a teacher, a circumstance that is of great interest in endangered language research, as discussed in Chapter 1. However, the

[5] For example, though Waterman describes his language consultant as middle-aged in 1911, and we might therefore expect to observe some phonological changes in the language in the intervening century, it is not possible to draw significantly relevant conclusions about these changes, as we cannot realistically generalize phonetic data from a single speaker to all early 20th century Numu speakers.

danger is in accepting this text as a standard of Numu speech, as opposed what it is meant to be, namely a description of the language as it is produced by a small group of people in a particular context at a given time.

This danger is more pronounced insomuch as this description is not complete. It is derived primarily from acoustic measurements of segments, particularly vowels, nasals, word initial consonants, and the intervocalic fortis/lenis distinction. These types of segments are of particular interest because they are likely to show transfer effects from English in adult learner speech. A more complete account would also provide a detailed examination of contextual variation, but such a description would require a larger set of data than was available for this study. Another area for further study is direct measurements of articulatory gestures by Numu speakers. However, measurements of this kind, such as those produced in palatography, electroglottography, ultrasounds, and magnetic resonance imaging (MRI), are beyond the scope of the current work, which aims to provide a baseline description for current and future teaching and research.

We turn next to a description of the study methods in §2.2. Numu consonants are described in §2.3, including onset VOT, the fortis/lenis contrast, and nasal duration. Then, spectral and durational measures of vowels are explored in §2.4. The methodology and results of the SOAM procedure are described in §2.5. Next, variation in speaker productions are explored in §2.6, and the chapter concludes in §2.7.

2.2 Methods[6]

All data for this study are drawn from a set of recordings that were collected over the course of one year, from January 2008 to January 2009, for the purpose of creating an on-line audio dictionary of Numu. A total of four fluent speakers were recorded saying Numu words and phrases. Speakers included Speaker A, who was the head Paiute teacher for Warm Springs Language Program at the time of the recording; Speaker B, who lived in Warm Springs; and Speaker C and Speaker D, who were both teachers in the Program. Speaker A is originally from Burns, but has lived most of her adult life in Warm Springs. Speakers B, C, and D are all originally from McDermitt, Nevada (McDermitt is ten miles from the Oregon border). All four speak Numu similarly due to their long residence in Warm Springs, but individual variation among the speakers will be addressed in §2.6.

Recordings took place at the Culture and Heritage Department on the Confederated Tribes of Warm Springs Reservation in the quietest room possible, as no sound-proof room was available. All four speakers were recorded on either a Marantz PMD660 solid-state recorder with an AKG C420 head mounted condenser microphone, or an M-AUDIO Mobile-Pre USB preamp audio interface with an AKG C520 head mounted condenser microphone. All data were sampled at at least 44.1 kHz. All speakers except Speaker A produced each word a total of two times; Speaker A produced each word once. A total of 281 tokens representing 94 words were selected from these recordings for acoustic analysis. (See Appendix A for a complete list of words.) All analyses were carried out in PRAAT (Boersma & Weenink, 1992).

[6] All statistical analyses for this research were performed in R (R Development Core Team, 2009).

2.3 Consonants

Thornes (2003) proposes fourteen contrastive consonants in Numu, plus a final feature. I have adapted his inventory in Table 2 to include allophonic variation. I adopt this inventory and its theoretical implications in the current study because it aligns with my own observations of the language. Other descriptions of the language, including Snapp, Anderson, & Anderson (1982) and Waterman (1911), propose a larger number of contrastive segments for the language, which in this case have been attributed to allophony and/or the final feature. However, I concur with Nichols (1974), who presents historical and phonological evidence for marking abstract final features in Numic languages, most notably the wide but systematic range of phonetic variation that can be explained as a result of such marking.

Table 2. Numu segment inventory and allophones.

	Phone	Allophones
Obstruents	p	pp, b, β
	t	tt, d, ɾ
	k	kk, g, ɣ, q
	k^{w}	kk^{w},g^{w}, ɣ^{w}
	ʔ	
Nasals	m	mm, w̃
	n	nn
	ŋ	
Fricatives	s	ss, ʃ, ɕ, z, ʒ[7]
	h	x
Affricates	ts	tts, dz, z
	tʃ	dʒ
Approximates	w	k^{w}
	j	tʃ
Final Feature	′	

Numu syllables may be of the shape V, CV, and C_1C_2V, where C_1 is glottal and C_2 is a sonorant (Snapp, Anderson, & Anderson, 1982; Thornes, 2003). All consonants except /ŋ/ are licensed as onsets and as medial consonants in the dialect under study; /ŋ/ only appears medially, and does not participate in the fortis/lenis contrast. Thornes (2003) reports that the phoneme /tʃ/ cannot appear word-initially, but that [tʃ] does appear in that position as an allophone of /j/. Though the consonant inventory of Numu is very small, there is a tremendous amount of allophony that leads Thornes (2003, p. 18) to state, "postulating a set of contrastive consonantal phonemes is highly problematic in Northern Paiute." Some of this variation arises from the gradating effect of the final feature, which is described in the next section.

2.3.1 Fortis and lenis consonants

The feature of greatest theoretical interest in the Numu consonantal system is the phenomenon of final features and the resulting gradient properties of affected consonants. They are called final

[7] Note that I report a greater range of allophonic variation for this segment than does Thornes (2003).

features because they occur as a final element of a morpheme, affecting the following consonant. As such, these contrasts only occur word-medially; the distinction is neutralized in the onset position. Final features are a productive morphological phenomenon synchronically. Their effects are also seen morpheme-internally, a phenomenon that often (but not always) has a traceable diachronic explanation (Nichols, 1974).

The presence of final features affecting morphophonemic processes in the Numic languages was first proposed by Sapir (1930), who describes a three-way contrast of spirantization, gemination, and nasalization in Southern Paiute consonants. The southern dialects of Northern Paiute exhibit a three-way contrast between lenis, fortis, and voiced fortis series; the voiced fortis series appears as nasalized stops in Ute and Shoshone (Liljeblad, 1966). In the dialect examined here, however, there is only one final feature contrast: that of fortis and lenis consonants. Throughout this chapter, lenis consonants will be differentiated from fortis consonants by writing them as voiced stops (b, d, and g), though Thornes (2003) reports there is a great deal of gradation in natural speech, so that in careful speech, "a fortis consonant is ideally an unvoiced geminate stop, whereas a lenis consonant is ideally a voiced fricative" (p. 29).

Waterman (1911) reports on relative length of occlusion between lenis and fortis Numu obstruents, finding that the fortis sounds are approximately double the length of the lenis sounds. Babel (In Press) also examines closure duration, as well as release duration and percent voicing of the three-way lenis-fortis constrast in Mono Lake Northern Paiute and Carson Desert Northern Paiute (two southern dialects of Northern Paiute). Her findings are similar to those of Waterman, with fortis occlusion approximately double that of lenis occlusion. However, measures of duration may not fully address previously described differences between these Numu sound contrasts. Waterman (1911, p. 19) notes that a "vigorous explosion" accompanies the fortis articulations. Thornes (2003, p. 28) also reports that the fortis is "articulated with full and forceful occlusion of the articulatory mechanism." These observations are impressionistic, and little data is available about the phonetic correlates of the lenis/fortis contrast in this language. This study will address durational differences (VOT and closure), but will also explore other acoustic correlates of the "forceful" and "vigorous" nature of fortis obstruents, following the DiCanio's (2008) description of fortis and lenis consonants in San Martín Itunyoso Trique and Sundara's (2005) cross-linguistic study of coronal stops in Canadian French and English.

DiCanio (2008) attributes three acoustic and articulatory correlates to differences in articulatory strength between segments described as fortis and lenis: degree of articulatory constriction, amplitude of the burst, and speed of formant transitions. He uses these measures to determine if strength is a distinctive phonological feature in Trique (as opposed to a secondary correlates of another feature). I propose that the distinctiveness of strength is also important for the acquisition of a language's phonetic and phonological system, because learners must make appropriate decisions about the primary articulatory and acoustic correlates of a language's segments in order to perceive and produce the language correctly.

Due to limitations in data, only measurements of relative burst amplitude are possible in this study (measurements of formant trajectories would have required a larger number of non-preaspirated consonants than were available in the data set, and no articulatory measurements were taken). However, Sundara (2005) has found significant differences in four spectral measures of the burst of voiced and voiceless coronal obstruents in Canadian French. These measurements were therefore also made for the current data, both to provide another acoustic measure of lenis and fortis consonants, and to form a basis for comparison to non-native speakers in the next chapter.

Results from five acoustic measures of Numu lenis and fortis sounds are described in the following sections: VOT, duration, amplitude, intensity, and spectral moments. Sections 2.3.1.1 , 2.3.1.2, and 2.3.1.3 report VOT, obstruent duration, and nasal duration respectively. Section 2.3.1.4 examines measurements performed on the obstruent burst. Finally, §2.3.1.5 discusses which acoustic correlates of Numu lenis and fortis sounds appear to have primary importance.

2.3.1.1 Fortis and lenis obstruent VOT

Voice onset time was measured from the release of the closure to the onset of the first vocal pulse of the following vowel for /p/, /t/, and /k/. The VOT of fortis obstruents was measured in 31 tokens for /p/, 33 tokens for /t/, and 24 tokens for /k/. Mean values and standard deviations are presented in Table 3. Note that the VOT for the velar obstruent is nearly twice the length of the coronal and bilabial obstruents; this phenomenon of velar obstruents exhibiting longer VOTs is common, and is described by Maddieson (1997) as a phonetic universal.

Table 3. Mean VOT and standard deviation for fortis Numu obstruents.

	Mean VOT (ms)	SD (ms)
p	15.60	7.29
t	12.11	3.16
k	29.90	7.29
All	18.31	9.60

A total of 170 intervocalic lenis segments were included in the data set. In cases where consonants were lenited to the point of spirantization, no VOT measurement was taken, as VOT is defined from the consonant release.[8] Therefore, VOT for lenis obstruents was measured in 31 tokens for /b/, 26 tokens for /d/, and 25 tokens for /g/. Mean VOT and standard deviations for each place of articulation are presented in Table 4. Note that negative VOT indicates voicing through some portion of the closure.

Table 4. Mean VOT and standard deviation for lenis Numu obstruents.

	Mean VOT (ms)	SD (ms)
b	8.97	25.58
d	-26.69	35.78
g	-7.13	49.58
All	-7.45	39.95

[8] Measurements of VOT are sometimes employed in analyses of fricatives (e.g., Holton, 2001). However, in the current study, it would not be possible to provide a reliable comparison between fortis and lenis VOT if the lenis VOT measurements were performed differently (i.e., if the zero point were not always the point of release).

Figure 4 provides a comparison of mean VOT values for fortis and lenis consonants at all places of articulation. There is a much larger range of deviation for lenis obstruents, an indication that they exhibit more variation in pronunciation than fortis consonants. This is expected, as they range from voiceless singleton sounds to voiced fricatives (cf. Thornes, 2003). Though only obstruents were measured here, the onset of voicing ranged from the beginning of the consonant closure to the onset of the following vowel. A two-sample t-test shows mean fortis VOT is significantly longer than mean lenis VOT [$t(89)=5.63$, $p < 0.001$] by 25.76 ms, though there is no significant difference at the bilabial place of articulation. This result may be attributable to the fact that lenis bilabials tend to be either unvoiced or fully spirantized (and thus excluded from the current measurement), while there are a larger number of voiced obstruents in the coronal and velar lenis data.

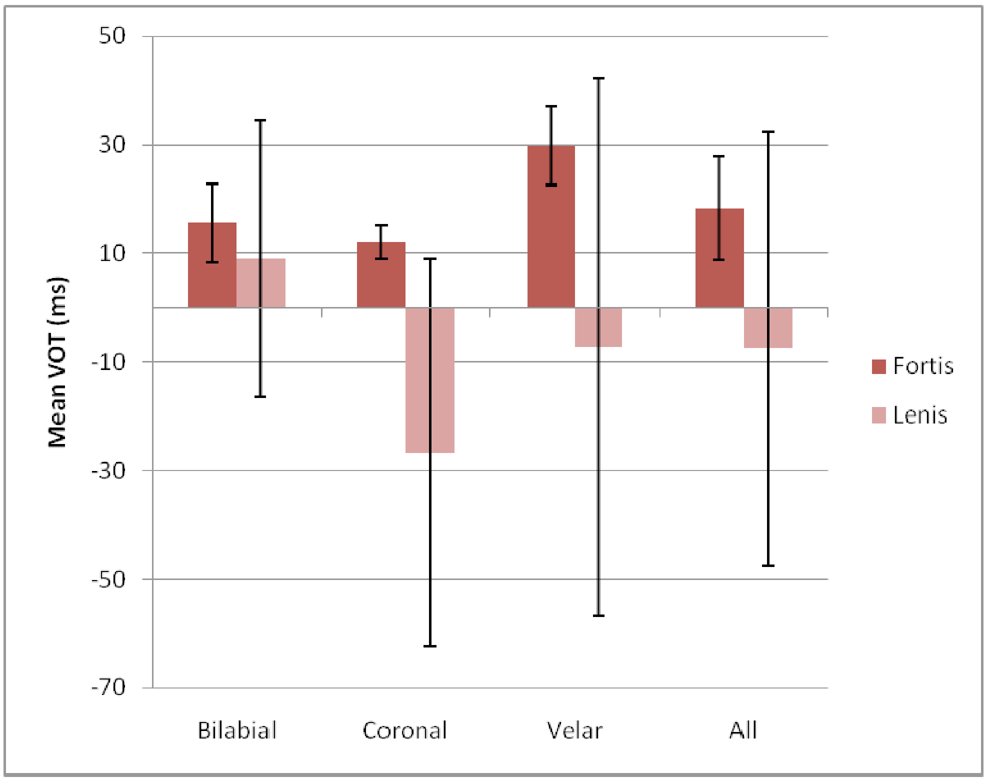

Figure 4. Mean VOT for fortis and lenis obstruents at bilabial, coronal, and velar places of articulation, and overall mean VOT for fortis and lenis obstruents.
(Error bars indicate ± one standard deviation.)

2.3.1.2 Fortis and lenis obstruent/fricative duration

Closure duration was measured from the closure of the articulators until the burst. Closure was determined by a sudden drop in spectral energy and reduced (or zero) amplitude. It was measured for 31 tokens of fortis /p/, 33 tokens of fortis /t/, and 24 tokens of fortis /k/. Table 5 presents mean closure durations and standard deviations for fortis obstruents.

Table 5. Mean closure duration and standard deviation for fortis obstruents.

	Mean Closure Duration (ms)	SD (ms)
p	199.19	32.97
t	191.73	29.40
k	177.34	26.83
All	190.44	30.95

Closure duration was measured for 97 tokens of lenis /b/, 31 tokens of lenis /d/, and 42 tokens of lenis /g/. For lenis obstruents, closure was measured from the closure of the articulators to the burst. For lenis fricatives, closure was measured from the beginning of frication to the first increased vocal fold pulse indicating the onset of the following vowel. Table 6 presents mean closure durations and standard deviations for lenis obstruents.

Table 6. Mean closure duration and standard deviation for lenis obstruents and fricatives.

	Mean Closure Duration (ms)	SD (ms)
b	98.82	48.46
d	50.87	19.01
g	79.41	33.83
All	88.25	44.40

As observed with VOT, lenis sounds have a greater range of durational variation. Numu fortis sounds are nonetheless more than double the length of Numu lenis sounds, a finding that is consistent with the findings of both Waterman (1911) and Babel (In Press). Duration ratios are provided in Table 7. Note that coronal sounds exhibit the largest mean fortis:lenis duration ratio, with fortis coronals more than three times as long as lenis coronals. This may be due to the frequent use of a coronal flap, which has short contact time, as a lenis coronal allophone.

Table 7. Mean closure duration ratios for fortis:lenis consonants.

POA	Fortis:Lenis Duration
bilabial	2.02
coronal	3.77
velar	2.23
All	2.16

Figure 5 shows a comparison of mean fortis and lenis duration, as well as the ratio of the difference between them. The overall difference in mean duration between fortis and lenis consonants is significant at the $p<0.001$ level in a two-sample t-test ($t(235)=22$).

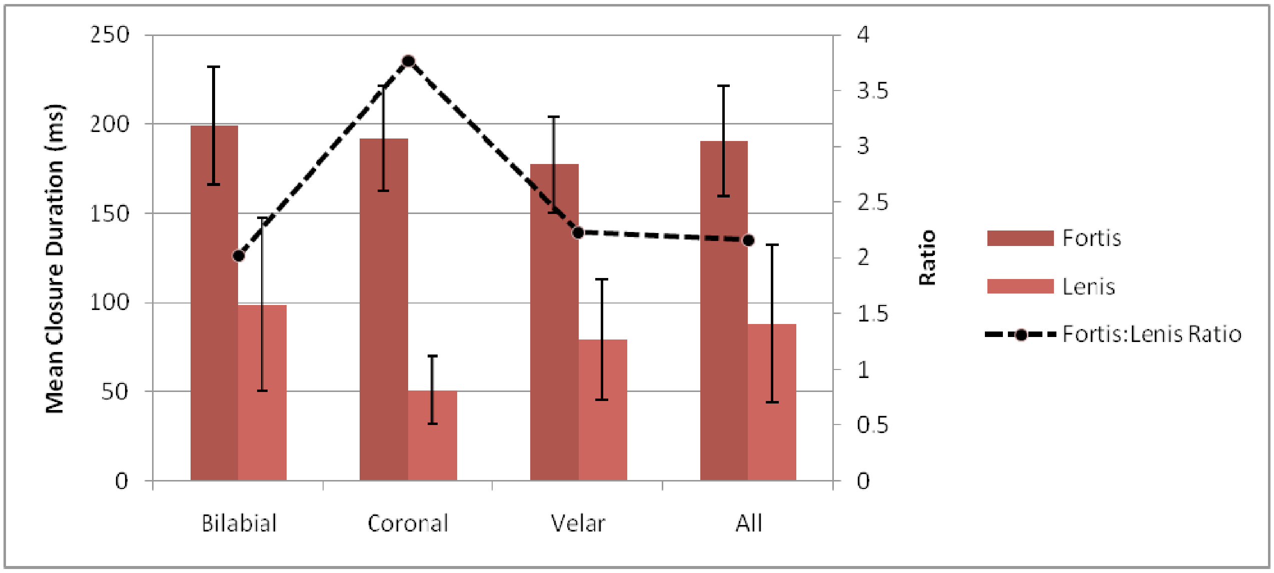

Figure 5. Mean closure duration for fortis and lenis consonants (bars) and the ratio of the difference between them (dotted line).
(Error bars indicate ± one standard deviation.)

2.3.1.3 Fortis and lenis nasal duration

Geminate nasal duration was measured in 38 tokens, onset nasal duration was measured in 63 tokens, and intervocalic singleton nasal duration was measured in 69 tokens. A two-sample t-test showed no significant difference between onset and intervocalic singleton nasals [t(106)=1.31, p=0.192], so no further distinction between singletons will be made here.

Table 8 shows mean duration and standard deviation in milliseconds for singleton and geminate nasals at bilabial, coronal, and velar places of articulation, as well as the overall mean durations.

Table 8. Mean duration and standard deviation for singleton and geminate nasals.

	Mean Singleton Duration (ms)	SD (ms)	Mean Geminate Duration (ms)	SD (ms)
m	77.70	31.90	146.93	39.67
n	83.27	35.08	159.02	28.15
ŋ	104.61	26.23	N/A[9]	
All	82.82	33.81	150.75	36.49

A two-sample t-test of the overall means indicates that singleton nasals differ significantly from geminate nasals in duration [t(56)=10.3, p<0.001]. Both bilabial and coronal singletons differ significantly from their geminate counterparts [bilabials: t(42)=7.7, p<0.001; coronals: t(17)=8.3,

[9] Recall that of Numu's three nasal sounds (/m/, /n/, and /ŋ/), only the bilabial and coronal nasals undergo the process of fortis gemination.

p<0.001]. Table 9 shows duration ratios for singleton and geminate nasals. Though geminate nasals are nearly twice as long as singleton nasals, the ratio between them is not as great as the ratio of fortis to lenis obstruents.

Table 9. Mean closure duration ratios for geminate:singleton nasals.

POA	Geminate:Singleton Duration
bilabial	1.89
coronal	1.91
velar	N/A
All	1.90

Figure 6 provides a comparison of fortis and lenis obstruents and nasals. Note that the velar singleton nasal is longer than the other singleton nasals by more than 20 ms. This finding is in opposition to the duration findings for obstruents and fricatives, where bilabial sounds have greater duration in both fortis and lenis contexts. It is likely that speakers keep bilabial and coronal singleton nasals short to preserve the distinction between singleton and geminate segments, which is unnecessary for velar nasals due to the gap in geminate nasals.

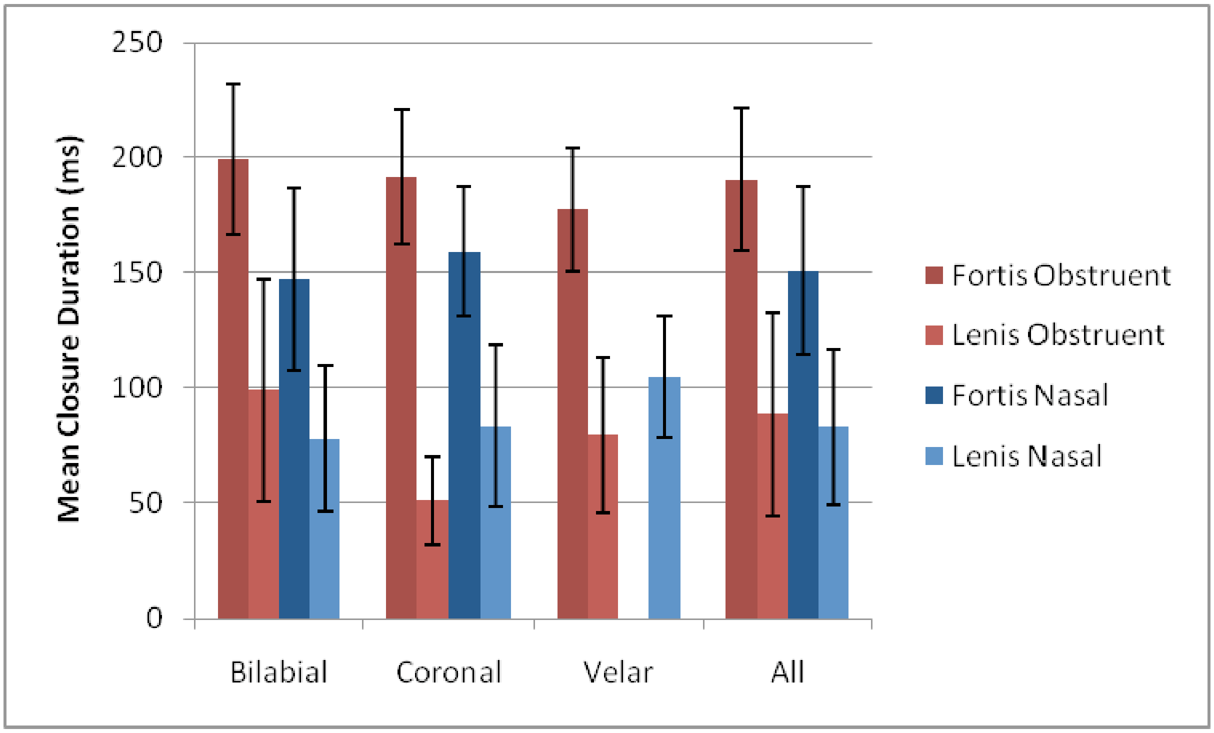

Figure 6. Mean closure duration for fortis and lenis obstruent and nasal consonants at all places of articulation.
(Error bars indicate ± one standard deviation.)

2.3.1.4 Acoustic measurements of the fortis and lenis burst

Three types of acoustic measures of the fortis and lenis obstruent burst were taken. The first was relative burst amplitude (A_R), which is adapted from DiCanio (2008, p. 108) in Equation 1, where A_{burst} is the maximum amplitude during the burst and A_{vowel} is the maximum amplitude over the duration of the following vowel. This normalization method and the use of a head-mounted microphone for all recordings made amplitude measurements feasible.

$$A_R = A_{vowel} - A_{burst} \qquad \text{(Equation 1)}$$

The second measure was burst intensity (I_R), which is calculated in Equation 2, where I_{burst} is the maximum intensity of the burst and $\bar{I}_a$ is the mean maximum intensity of the speaker's tokens of /a/. The mean maximum intensity of /a/ was used to mitigate the effect of the variation in vowel contexts for fortis and lenis obstruents in the data set.

$$I_R = \bar{I}_a - I_{burst} \qquad \text{(Equation 2)}$$

Four spectral measures of the burst were also made. These measures included, 1) *mean frequency*, or the average energy concentration over burst frequencies; 2) *standard deviation*, or the frequency spread around the mean; 3) *skewness*, or the symmetry of the frequency distribution; and 4) *kurtosis*, the degree of the peakedness. See the introduction in Sundara (2005) for a more detailed discussion of these measures.

A script was used to calculate all measures of the burst and the following vowel. Burst and vowel boundaries were hand-labeled. Following Sundara (2005), sounds were filtered using a 200 Hz high-pass filter before intensity and spectral measurements were taken to mitigate the effects of voicing, and bursts were pre-emphasized to increase the spectral slope by 6 dB/octave above 1000 Hz for spectral measurements. These measurements were only taken for intervocalic fortis and lenis obstruents that had a clear burst and preceded a voiced vowel. As a result, measurements were taken for 19 tokens of fortis /p/, 26 tokens of fortis /t/, and 20 tokens of fortis /k/, and for 25 tokens of lenis /b/, 19 tokens of lenis /d/, and 18 tokens of lenis /g/. Vowel contexts differed.

Table 10 compares mean relative burst amplitude for fortis and lenis consonants at each place of articulation. Generally, mean fortis burst amplitude is greater than mean lenis burst amplitude for all places of articulation. (See Figure 7.) However, an analysis of variance indicates that the main effects of Manner (fortis and lenis) and Place of Articulation (bilabial, coronal, and velar) are not significant at the $p<0.05$ level.

Table 10. Relative fortis and lenis burst amplitude (standard deviations in parentheses).

	Fortis Burst Amplitude (Pa)	Lenis Burst Amplitude (Pa)
bilabial	0.295 (0.14)	0.179 (0.12)
coronal	0.193 (0.16)	0.188 (0.15)
velar	0.212 (0.16)	0.196 (0.11)
All	0.229 (0.16)	0.187 (0.13)

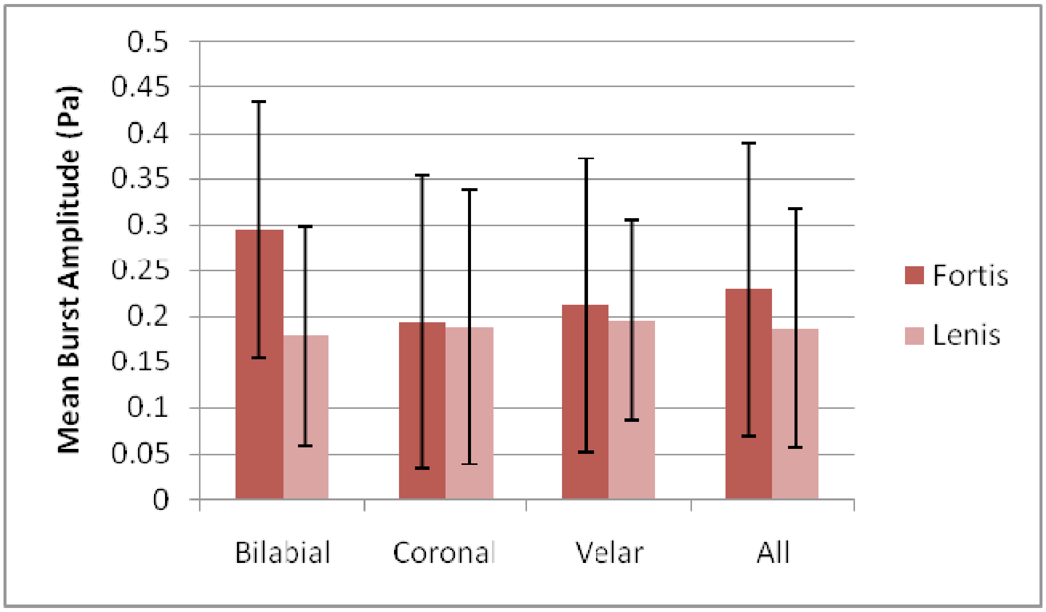

Figure 7. Mean burst amplitude for fortis and lenis obstruents at all places of articulation. (Error bars indicate $\pm$ one standard deviation)

For relative burst intensity, the main effects of Manner and Place of Articulation are both significant (F(1)=11.13, p<0.01; F(4)=3.92, p<0.01, respectively). Table 11 presents the mean relative burst intensity values for fortis and lenis consonants at all places of articulation. Note that in all cases, mean lenis burst intensity is higher than mean fortis intensity, indicating that fortis obstruents have softer bursts on this measure. (See Figure 8).

Table 11. Relative fortis and lenis burst intensity (standard deviations in parentheses).

	Fortis Burst Intensity(dB)	Lenis Burst Intensity (dB)
bilabial	17.87 (6.0)	22.61 (8.0)
coronal	15.64 (5.1)	17.66 (6.8)
velar	20.01 (3.3)	22.84 (5.0)
All	17.64 (5.2)	21.16 (7.2)

It is unclear what to make of this result based on Pickett's (1999) suggestion that the longer VOT and oral closure of voiceless stops is correlated with stronger bursts. As we have seen, Numu lenis consonants have shorter VOT and duration than their fortis counterparts. Nonetheless, softer burst intensity appears to be an acoustic characteristic that distinguishes fortis sounds from lenis sounds in Numu.

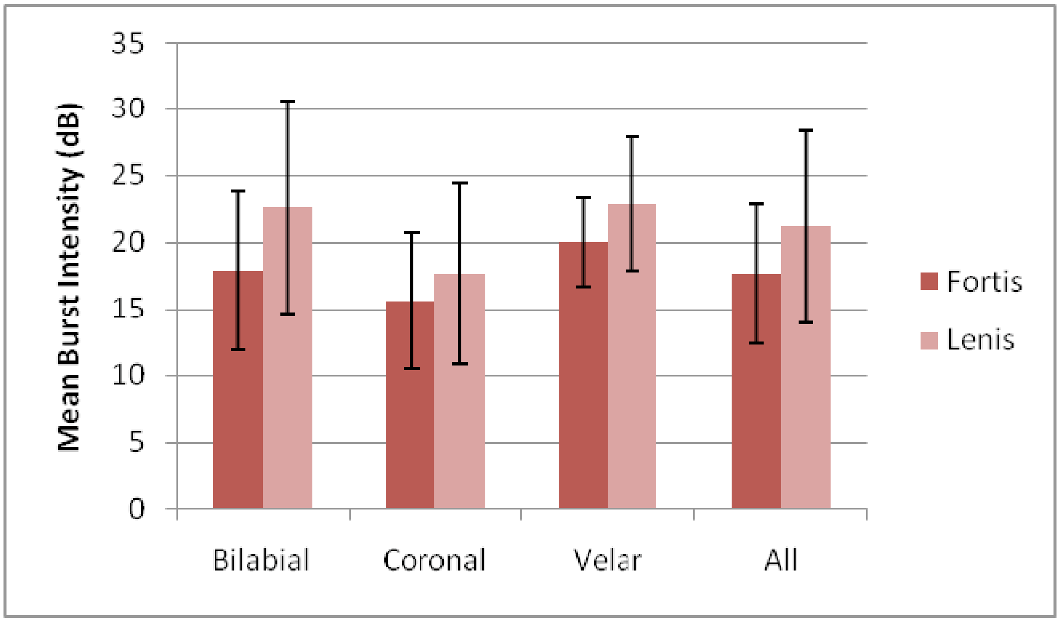

Figure 8. Relative fortis and lenis burst intensity (standard deviations in parentheses).
(Error bars indicate ± one standard deviation.)

Results of the spectral measures of fortis and lenis bursts are presented in Table 12 and Figure 9.

Table 12. Mean spectral measures for Numu fortis and lenis sounds at all places of articulation.
(Standard deviations in parentheses.)

	Mean Frequency (Hz)		**Standard Deviation (Hz)**		**Skewness**		**Kurtosis**	
	Fortis	***Lenis***	***Fortis***	***Lenis***	***Fortis***	***Lenis***	***Fortis***	***Lenis***
Bilabial	4319.03 (*1749.1*)	5142.75 (*2166.6*)	3804.37 (*1100.9*)[10]	4285.28 (*1248.8*)	1.57 (*1.1*)	1.47 (*1.0*)	4.22 (*6.1*)	2.99 (*4.4*)
Coronal	4207.90 (*1730.5*)	4296.74 (*1810.3*)	2321.44 (*777.3*)	2681.60 (*1154.6*)	2.25 (*1.7*)	3.12 (*2.3*)	14.43 (*16.2*)	19.94 (*26.0*)
Velar	3163.06 (*1516.0*)	3479.01 (*1314.7*)	3059.47 (*873.0*)	2747.15 (*1007.3*)	2.94 (*2.1*)	3.07 (*1.8*)	14.27 (*18.2*)	15.93 (*16.1*)
All	3918.89 (*1724.1*)	4403.03 (*1946.9*)	2982.00 (*1087.7*)	3351.37 (*1378.4*)	2.26 (*1.8*)	2.44 (*1.8*)	11.40 (*15.3*)	11.90 (*18.3*)

[10] It is perhaps confusing to report the standard deviation of the standard deviation for a given place of articulation. However, recall that *standard deviation* refers to a particular measurement of the frequency spread around the mean frequency; a summary of several of these measurements includes the mean measurement and the standard deviation of the measurement.

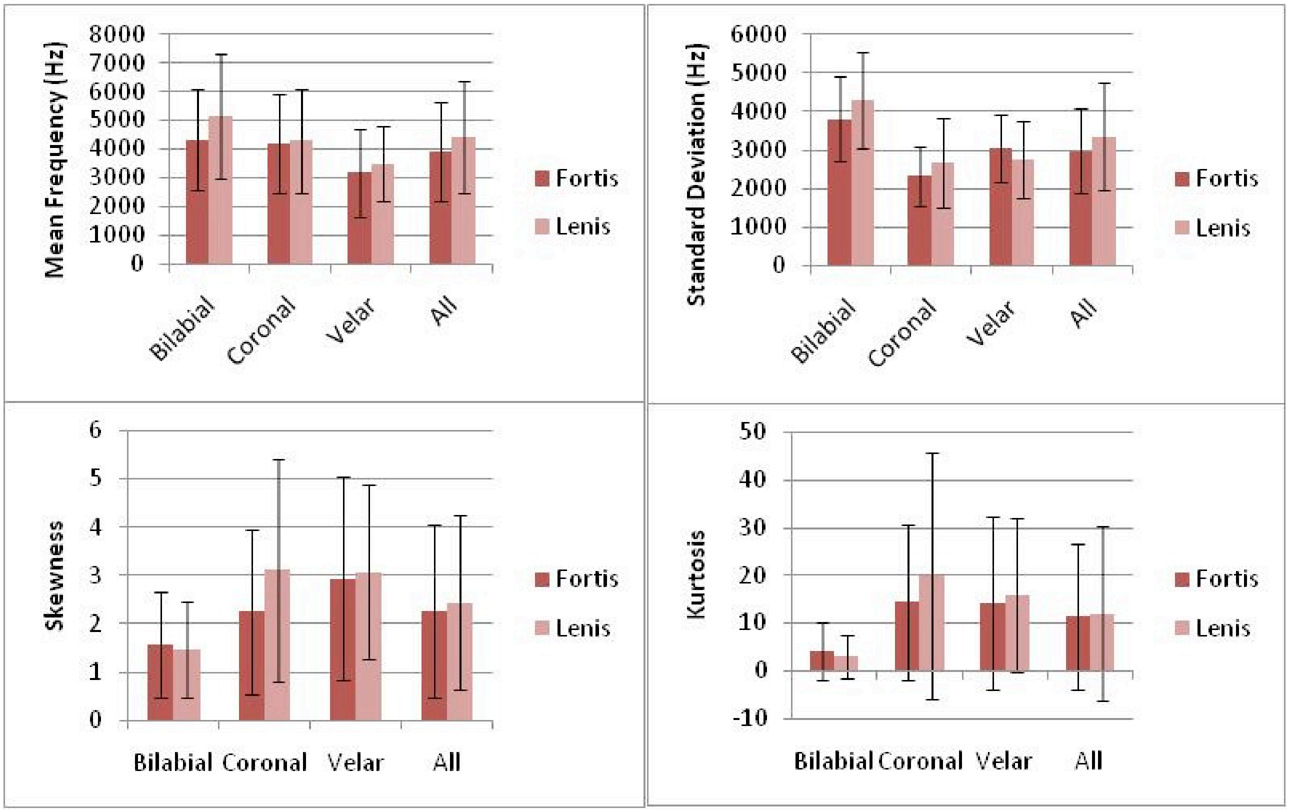

Figure 9. Average measurements of the mean frequency, standard deviation, skewness, and kurtosis of fortis and lenis bursts at all places of articulation.
(Error bars indicate ± one standard deviation.)

Analyses of variance on each of these spectral measures indicates that the main effect of Manner (fortis and lenis) is only significant for standard deviation [$F(1)=4.19$, $p<0.05$]. For standard deviation, lenis has higher values in all places of articulation except the velar position, where the opposite is true. This measure indicates that in most cases, fortis bursts tend to be more compact, with less spread of high-energy frequencies around the mean. The main effect of Place of Articulation (bilabial, coronal, and velar) is significant for standard deviation [$F(4)=15.02$, $p<0.001$], skewness [$F(4)=5.32$, $p<0.001$], and kurtosis [$F(4)=5.21$, $p<0.001$].

2.3.1.5 Acoustic correlates of the Numu lenis/fortis contrast

Numu fortis and lenis obstruents differ significantly in measures of VOT, duration, relative burst intensity, and spectral standard deviation, but not in burst amplitude, mean frequency of the burst, spectral skewness, or spectral kurtosis. These results provide us with an important basis for comparison to non-native productions, which have the potential to differ along any of these parameters. These results also expand upon previous characterizations of the Numu fortis/lenis distinction by including non-durational measures of the burst. However, further study is needed to determine if there are other acoustic correlates of this contrast, and also to determine possible articulatory correlates, such as place and degree of constriction, pulmonic force, and laryngeal configuration (see DiCanio, 2008).

2.3.2 Onset obstruents

As discussed above, the fortis/lenis distinction is neutralized in onset obstruents, which results in lack of distinction of manner of articulation in this position; onset obstruents are voiceless unaspirated singletons. Waterman (1911) reports that in these consonants, "the sonancy begins approximately at the same moment as the explosion" (p. 17), indicating a shorter VOT than found in English voiceless onset consonants.

In this study, VOT was measured in milliseconds from the obstruent burst to the beginning of the first vocalic glottal pulse for 32 tokens of onset /p/, 116 tokens of onset /t/, and 68 tokens of onset /k/. Table 13 shows mean VOT and standard deviation in milliseconds for onset obstruents. As we have seen with fortis obstruents, VOT is very similar for the bilabial and coronal consonants, but approximately double for the velar stop. This pattern is common; Maddieson (1997) reports that in most languages, stops that are articulated further back in the mouth have longer VOTs (though coronals vary widely depending on their place of articulation).

Table 13. Mean VOT and standard deviation for onset Numu obstruents.

	Mean VOT (ms)	SD (ms)
p	16.25	8.02
t	14.40	6.82
k	37.81	17.86
All	22.04	15.77

2.3.3 Comparison of VOT in onsets, fortis, and lenis obstruents

Table 14 provides an overview of mean VOT and standard deviation for each obstruent type examined in this study. We see that onset obstruents have the longest mean VOT, while intervocalic lenis obstruents have the shortest mean VOT. Figure 10 compares mean VOT values for onset, fortis, and lenis consonants at each place of articulation. VOT is longest for velar sounds and shortest for coronal sounds in all contexts except lenis, where bilabial sounds have the longest VOT. This pattern is likely due to the fact that bilabial lenis sounds in this data tend to either be unvoiced or fully spirantized (in which case VOT was not measured), whereas voiced coronal and velar lenis obstruents are more common.

Table 14. Mean VOT and standard deviation for onset, fortis, and lenis consonants.

	Mean VOT (ms)	SD (ms)
Onset	22.04	15.77
Fortis	18.31	9.60
Lenis	-7.45	39.95

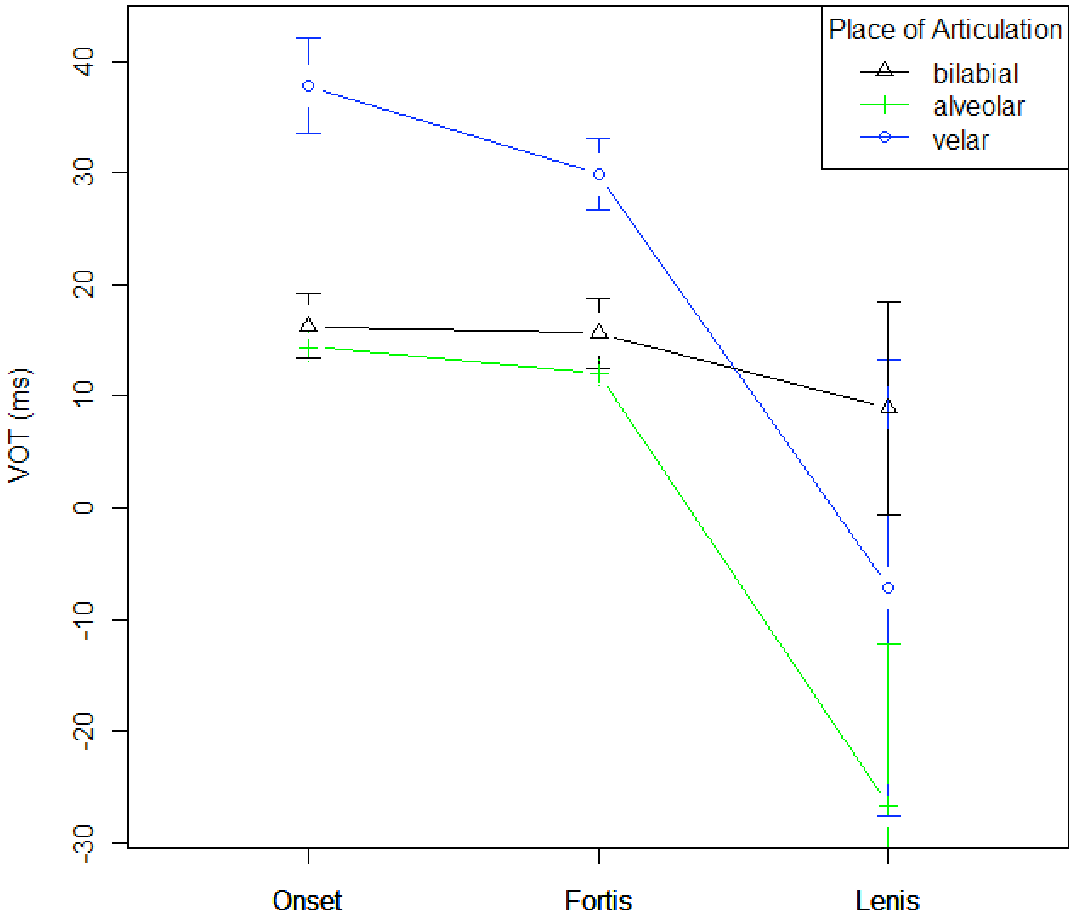

Figure 10. Mean VOT for onset, fortis, and lenis consonants.

2.4 Vowels

There are five monophthongs in Numu, as shown in Figure 11, and each is contrastive for length.

	Front	Central	Back
High	i	ɨ	u
Mid			ɔ
Low		a	

Figure 11. Numu monophthongs.

The phonemic vowel inventory of Numu is limited and assymetrical, with a concentration of high vowels, but limited low and front vowels. However, there is a great deal of allophony that makes increased use of the vowel space. Thornes (2003) notes that phonetic [e] or [ɛ] occur as allophones of /a/, and [o] occurs as an allophone of /u/ in a limited-domain process of height harmony. Phonetic [o] is also an allophone of the phoneme /ɔ/. Overall, there is a great deal of overlap in the pronunciation of Numu vowels (Nichols, 1974).

Previous descriptions of the great allophony of Numu vowels and their contrastive length make measurements of spectral and temporal aspects of Numu vowels particularly interesting. Waterman (1911) reports that the high vowels are distinguished by their duration, rounding, and place of articulation, with /i/ and /u/ noticeably shorter than /ɨ/, and /ɨ/ pronounced "with the lips in position for an i-sound and the tongue in position approximately for u" (p. 16). He describes both /ɔ/ and /a/ as shorter in duration than their English counterparts. Exact measurements of Numu vowels in this study allow for precise comparisons between vowels as well as between speakers of different fluency levels (see Chapter 3). For fluent speaker productions, spectral and temporal measurements were made on the following number of stressed vowel tokens: i -84, iː -10, ɨ -57, ɨː-36, u -22, uː -10, ɔ -50, ɔː -16, a -111, aː -35.

2.4.1. Vowel quality

First, second, and third formant measurements were taken by hand using LPC spectra over the middle portion of each stressed monophthong. Table 15 shows the mean values and standard deviations for the first three formants of each long and short Numu vowel. Figure 12 shows a plot of first and second formant values for all tokens, with the mean represented by a large character. Note that /ɨ/ appears to be directly in the center of the F2 vowel space between /i/ and /u/.

Table 15. Mean formant values for Numu vowels.

	F1 (Hz)		F2 (Hz)		F3(Hz)	
	mean	sd	mean	sd	mean	sd
i	409	63	2,352	279	2,855	151
iː	423	38	2,446	121	2,840	144
ɨ	512	105	1,625	290	2,771	212
ɨː	453	79	1,712	209	2,677	142
u	498	124	1,014	179	2,746	289
uː	427	60	1,056	181	2,740	60
ɔ	648	76	1,131	161	2,613	291
ɔː	638	166	1,072	183	2,584	368
a	760	81	1,514	177	2,688	209
aː	880	57	1,418	147	2,753	290

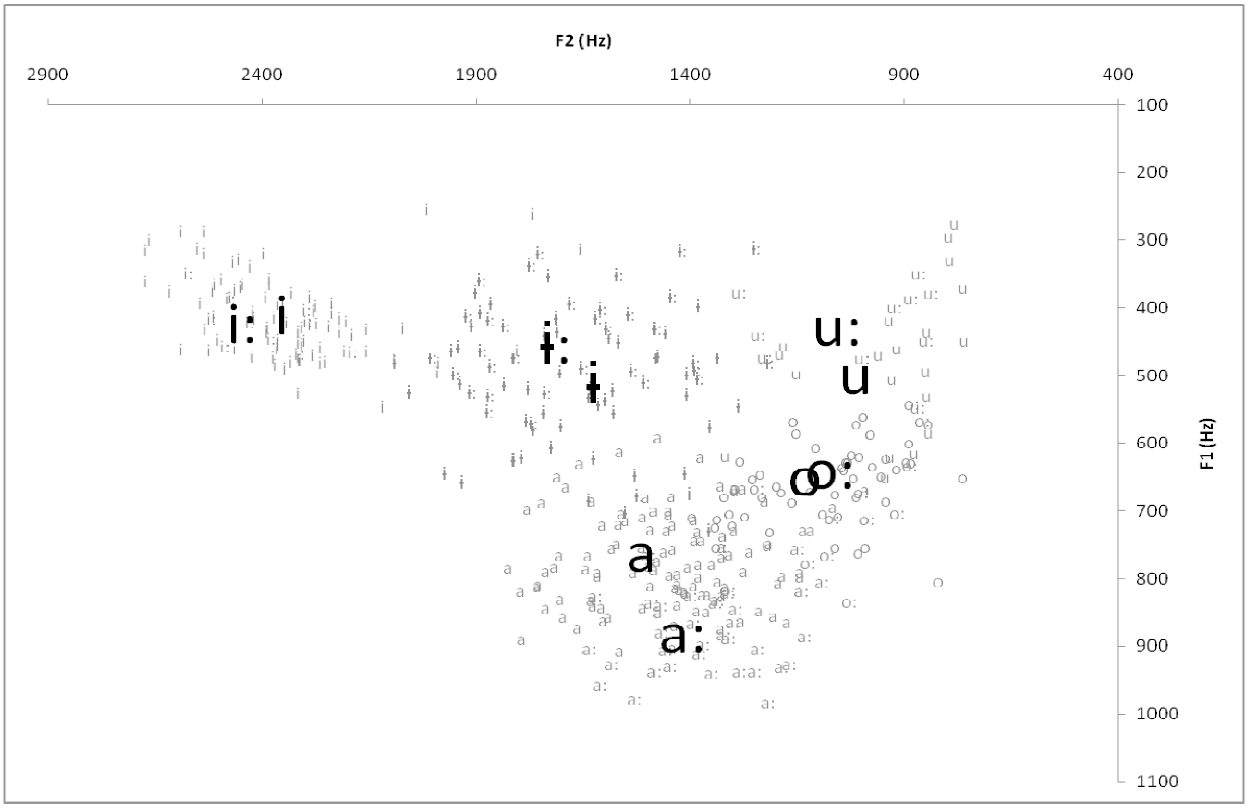

Figure 12. Scatterplot of F2 vs. F1 values for all Numu vowel tokens.
(Mean values are represented by large characters.)

Waterman (1911) also reports that Numu high vowels differ in their roundness. This is explored in Figure 13, which depicts F2 vs. F3 values for the three high vowels. The F3 values appear to be very similar for the three vowels, though an analysis of variance reveals that the high vowels do differ significantly in this measure [$F(5,213)=5.56$, $p<0.001$]. Post-hoc t-tests show that /i/ has significantly higher F3 values than /ɨ/ [$t(173)=4.7$, $p<0.001$] and /u/ [$t(39)=2.4$, $p<0.05$]. However, though the speakers significantly differentiate these vowels along the F3 dimension in production, the magnitude of the differences is very small, causing one to wonder if the differentiation is large enough to be perceptible. The difference between mean /i/ F3 values and mean /ɨ/ F3 values is 118 Hz, or 4.3% of the mean F3 value for /ɨ/, and the difference between mean /i/ F3 values and mean /u/ F3 values is 109 Hz, or 4.0% of the mean F3 value for /u/. Early research showed that the difference limens for formant frequencies in vowels are approximately 5% for adult hearers (Flanagan, 1955; Eguchi, 1976), suggesting that the Numu high vowels may be very difficult to differentiate perceptibly along the F3 dimension. But more recent work by Hawk (1994) reveals a substantially smaller difference limen of 1.42% for discrimination of multiple formant changes if the formants are shifted in the same direction (either increase or decrease). In the case of Numu high vowels, both mean F2 and F3 values decrease for successively further back vowels. Therefore, we can infer that both backness and roundness play a role in differentiating these vowels.

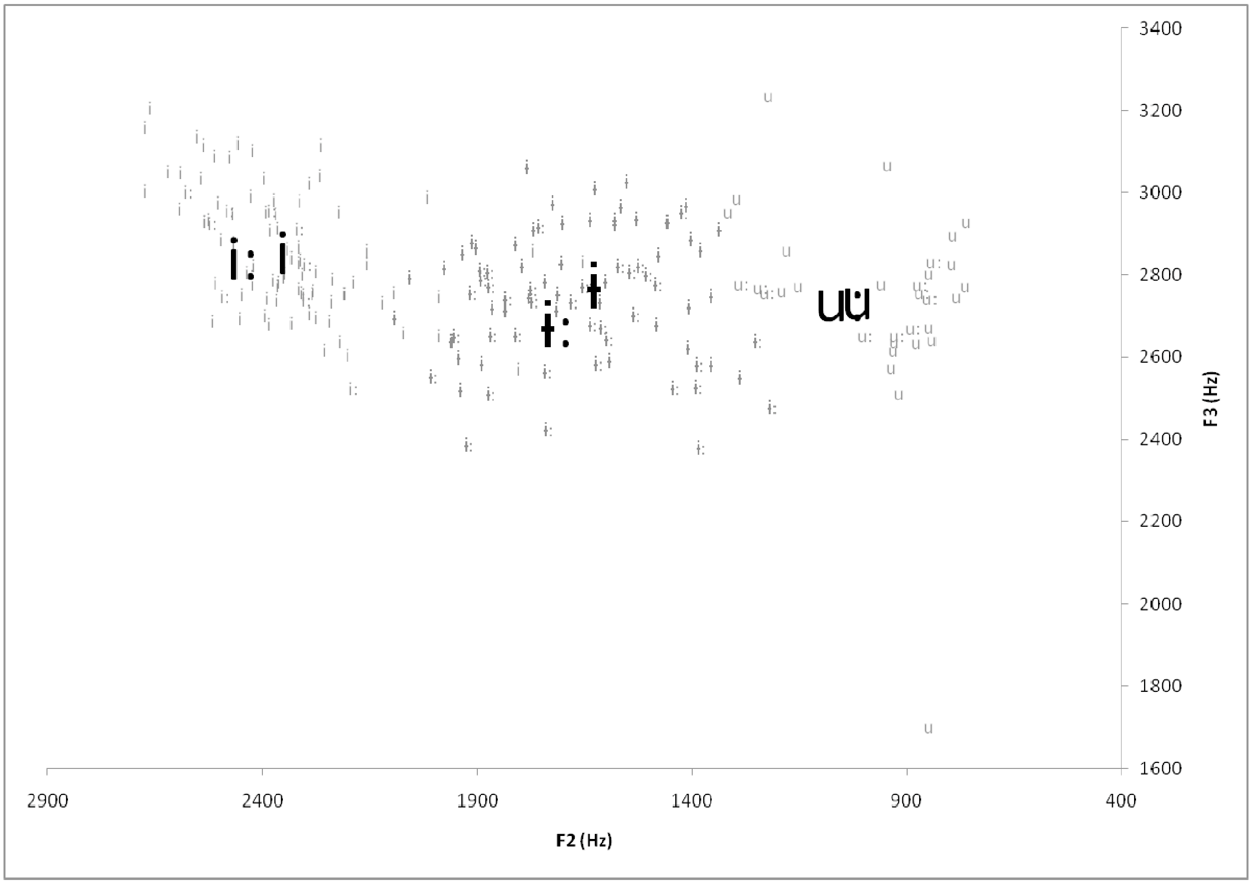

Figure 13. Scatterplot of F3 vs. F2 values for Numu high vowels.
(Mean values are represented by large characters.)

2.4.2 Vowel duration

Vowel duration was measured for stressed vowels from the start of the first vocalic glottal pulse to the end of the last vocalic glottal pulse. Word-final stressed vowels were found to be significantly longer than their word-internal counterparts ([$t(296)=9.02$, $p<0.001$] for short vowels and [$t(20)=5.35$, $p<0.001$] for long vowels), so means and standard deviations are presented for both word-internal and word-final short and long vowels in Table 16. This information is presented graphically in Figure 14.

This finding is the opposite of what is reported in Liljeblad (1966), who reports that Northern Paiute long vowels, "lose some of their phonetic length when they occur at the end of a word and gain length phonetically before a following consonant within the boundaries of a word" (p. 13). One possible explanation for why the current data are in contradiction to his description is that he was dealing with a different dialect than the one that is described here.[11] Another possibility is that the bilingual speakers whose productions are described in the current study have adopted English patterns for positional vowel duration. In a study using made-up words, Oller (1973)

[11] It is impossible to know if this option is true, as he does not provide information about the speakers he worked with.

finds that English speakers lengthen word-final syllables of all shapes, a strategy that may be adopted by these Numu speakers. However, word-final vowel lengthening has been reported in a large number of languages, and appears to be a universal phonetic tendency (see discussion of final vowel lengthening in Johnson & Martin, 2001).

Table 16. Mean duration in milliseconds for short and long vowels.
(Standard deviations are in parentheses.)

	Short Vowels		Long Vowels	
	Medial	Final	Medial	Final
i	118.46 (26.3)	167.96 (35.5)	214.12 (36.7)	349.04 (53.3)
ɨ	125.78 (34.4)	162.71 (38.3)	214.22 (50.6)	302.37 (57.2)
u	135.30 (11.2)	146.11 (34.7)	238.10 (60.4)	n/a
ɔ	124.02 (36.2)	163.40 (42.2)	274.17 (116.6)	315.80 (56.6)
a	133.28 (28.9)	158.25 (37.2)	230.41 (64.5)	n/a
All	126.03 (31.1) *n=172*	160.62 (37.1) *n=152*	231.89 (71.0) *n=93*	320.96 (55.9) *n=14*

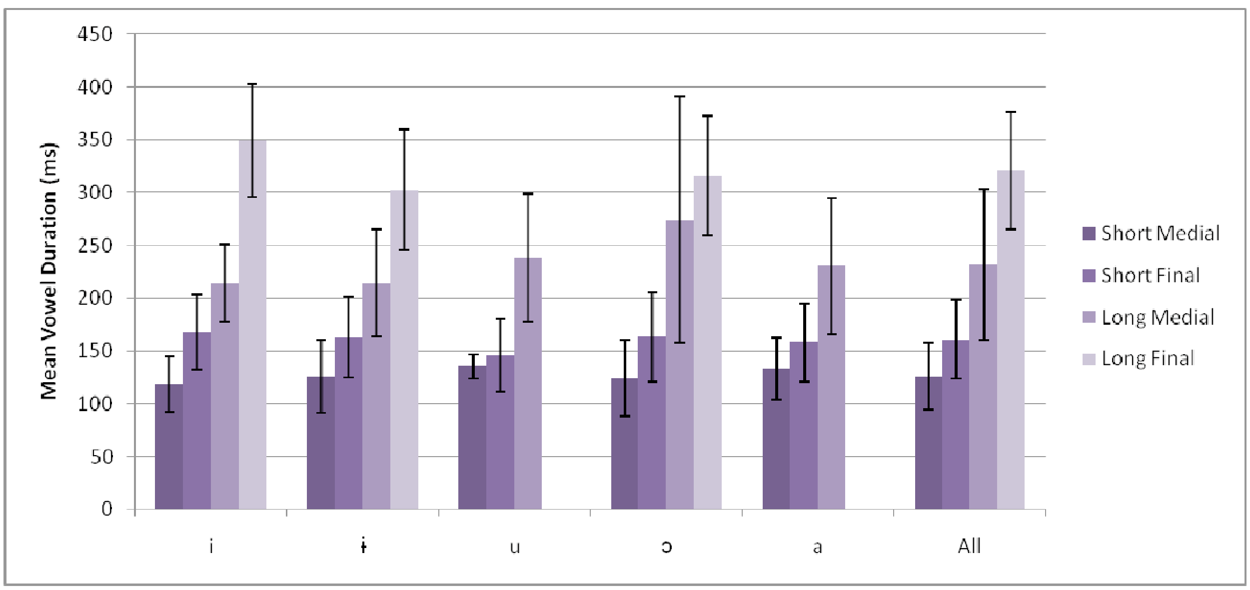

Figure 14. Mean duration for short medial, short final, long medial, and long final Numu vowels by vowel.
(Error bars indicate ± one standard deviation.)

Note that the standard deviation for long medial /ɔ/ is unusually large compared to other standard deviations. It is possible that this is due to a conflation of phonological /u/ and /ɔ/ with phonetic [o] in this chart. However, if that were the case, a similarly large standard deviation would be expected for the other cases of /ɔ/, but does not occur.[12] Another possibility is that this standard deviation reflects variation among speakers in their vowel productions; this possibility will be addressed in §2.6.

An analysis of variance does not show significant difference among durations for individual short vowels [$F(4,319)=1.22$, $p=0.30$], which is contradictory to Waterman's (1911) findings that /ɨ/ is longer in duration than other high vowels. It is unclear if this difference in findings is due to the fact that he analyzed the speech of only one speaker, that his tools of analysis were less sophisticated than the tools available today, or that there has been a change in speakers' productions of short vowels in the nearly 100 years since he conducted his study.

Ratios of long to short vowel durations are given in Table 17. For word-final stressed vowels, long vowels are twice as long as short vowels, and this is nearly the case for word-medial stressed vowels as well. These ratios are comparable to languages that are characterized as primary quantity languages (e.g., Thai, Icelandic), in which vowel duration plays a crucial role in segmental contrasts. However, as Lehiste (1970) cautions, a larger body of cross-linguistic evidence is necessary to determine the ratio at which duration may be considered distinctive. The issue of spectral versus temporal contrast will be explored in greater detail in §2.5.

Table 17. Long to short vowel duration ratios.

	Medial	Final
i	1.81	2.08
ɨ	1.70	1.85
u	1.76	n/a
ɔ	2.21	1.94
a	1.73	n/a
All	1.84	2.00

2.5 Spectral and temporal relations of Numu vowels

This study has included both spectral and durational measurements of vowel distinctions in Numu. We now turn to the spectral overlap assessment method (SOAM) described by Wassink (2006) to quantify the interactions of these features. This method will allow us to determine the degree to which quantity and quality differentiate vowels in Numu. This section will provide a brief description of the SOAM, but readers are referred to Wassink (2006) for further details.

The measurements of stressed vowel formants and duration described in §2.4.1 and §2.4.2 are used in this model. As will be discussed in further detail in §2.6, Speaker B's formant measurements varied greatly from the other speakers' productions, which threw off the SOAM model. Her measurements have therefore been excluded from the current analysis.

[12] There could also be greater allophony in the long medial vowels, but there is no phonological reason to believe this would be the case; the ɔ/u merger is governed by preceding velar or glottal consonants, or by vowel harmony, but never by the following consonant.

Vowel formant measurements were normalized using the log-mean normalization method given in Equation 3 (Nearey, 1977; Wassink, 1999), where f is the log-transformed formant for a particular token of a particular vowel produced by a particular speaker, $\overline{f}$ is the mean of all log-transformed tokens of that formant for that speaker, and F is the formant difference score.

$$F = f - \overline{f} \qquad \text{(Equation 3)}$$

Duration measurements were similarly normalized, but without log-transformations. The equation for duration normalization is given in Equation 4, where d is the duration of a particular vowel, $\overline{d}$ is the mean duration for all vowel categories for a particular speaker, and D is the duration difference score.

$$D = d - \overline{d} \qquad \text{(Equation 4)}$$

Normalized F1 and F2 frequencies were compared in a two-dimensional system for the vowel pairs i~iː, u~uː, and a~aː. These vowels were chosen because they define the periphery of the Numu vowel system, and because they allow for comparison to Wassink's (2006) results, which were based on the same vowel pairs in different languages (however, note that the normalization equations include measurements for all vowels in order to reduce physiological effects without suppressing linguistic variation; see Labov, 2001). Each pairing was plotted with a best-fit ellipsis, and the ellipses were analyzed for the percentage of tokens that fell within the overlapping regions of the ellipses, following Wasshink (2006). The overlap indicates to what degree the long-short vowel pairs are similar in spectral measures. Plots of the two dimensional overlaps are provided in Figure 15.

Next, duration was added to the model as a third dimension, and tokens were plotted with best-fit ellipsoids. In the measure of ellipsoid overlap fraction, I follow Wassink (2006), who calculates the overlap of each ellipsoid relative to the other and reports the larger of the two. This overlap indicates the degree to which the long and short vowel pairs are the same as a function of both spectral and durational measures. Plots of the three dimensional overlaps are provided in Figure 16.

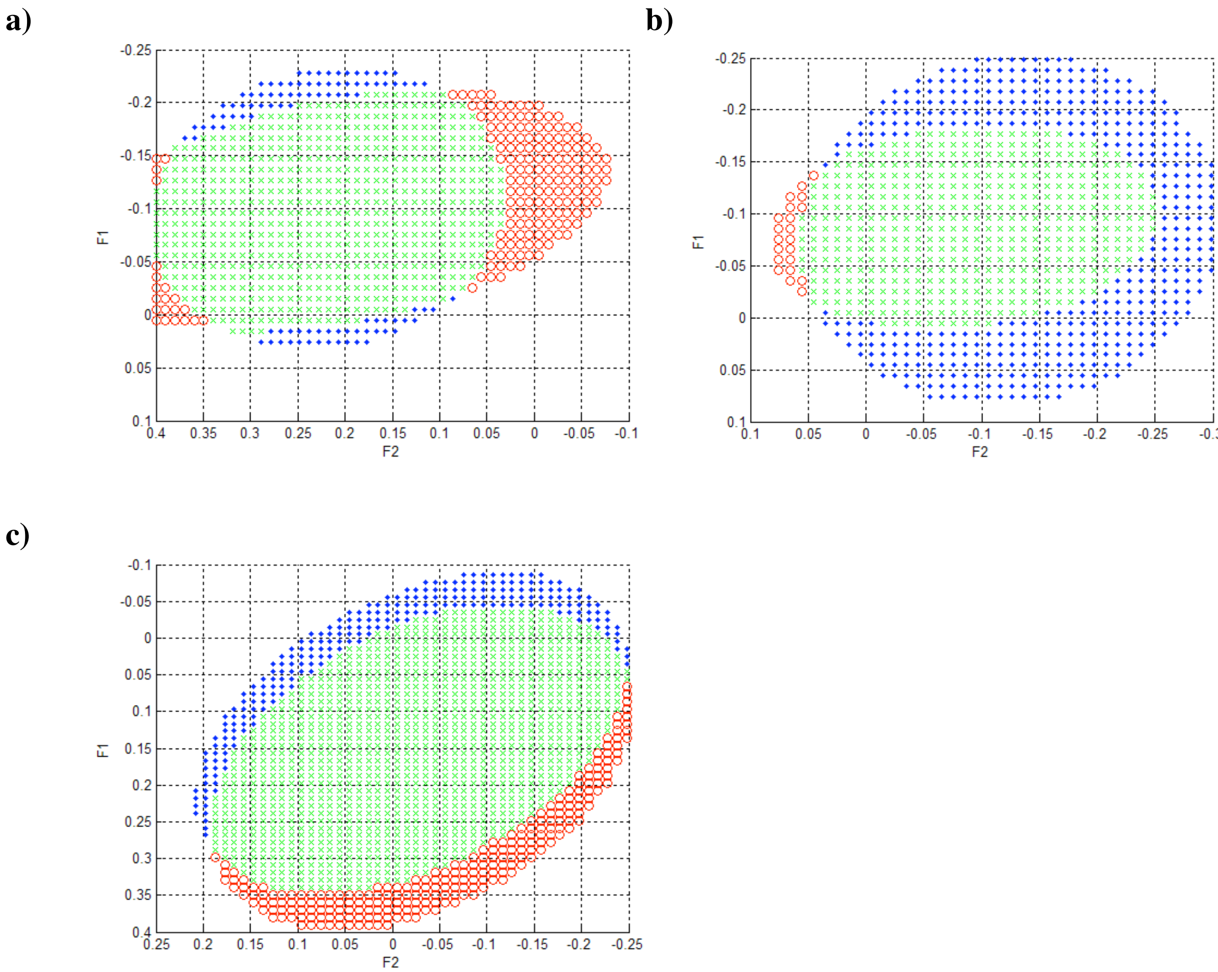

Figure 15. Two dimensional overlap figures of F2xF1 for a) i~iː, b) u~uː, and c) a~aː
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

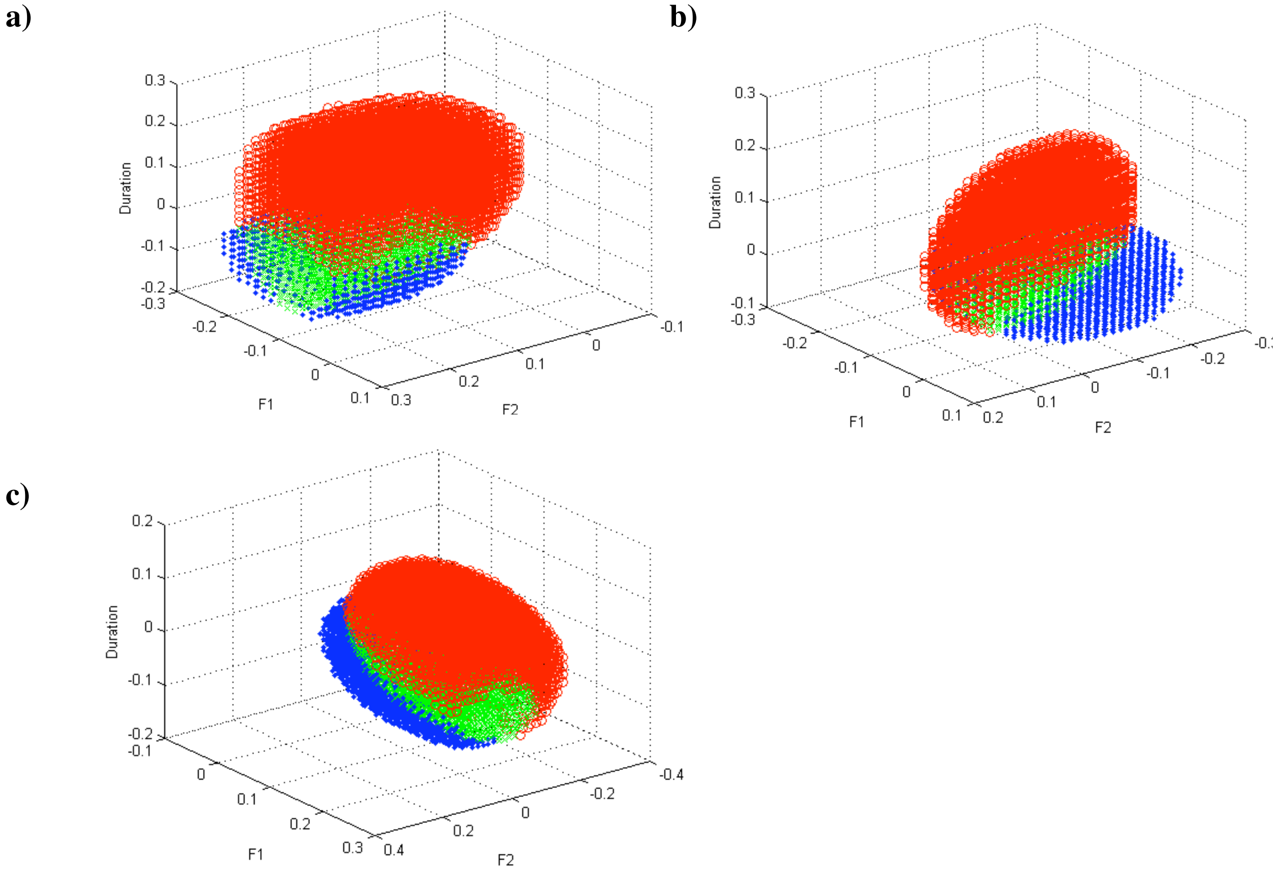

Figure 16. Three dimensional overlap figures of F2xF1xDuration for a) i~i:, b) u~u:, and c) a~a:
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

The two and three dimensional overlap percentages for each vowel pair are given in Table 18. An average is also provided for comparison to Wassink's (2006) results, but as she notes, this average is potentially problematic, as it may obscure internal variability in the vowel system. As expected for a language whose duration ratios would characterize it as a primary quantity language (see §2.4.2), there is a great deal of difference in the amount of overlap between the two dimensional model, which includes only spectral information, and the three dimensional model, which adds temporal information. Looking only at spectral measures, all three vowel pairs exhibit full overlap (>40%). In the three dimensional model, this overlap is reduced by 51%, 58%, and 52% for i~iː, u~uː, and a~aː, respectively.

Table 18. Two and three dimensional overlap percentages for i~i:, u~u:, and a~a:

	F2xF1	F2xF1xDur
i~iː	83%	32%
u~uː	59%	1%
a~aː	64%	12%
All	69%	15%

Under Wassink's (2006) proposed classification system, with a cutoff for no overlap at <20%, the i~i: pair would be classified as having partial overlap, and the other two vowels would be classified as having no overlap once temporal measures are taken into account. Note that though the i~i: pair has a similar reduction in overlap in the three dimensional model, its values are much more coextensive in the F2XF1 space than the other two vowel pairs. The small number of i: tokens may have skewed the results towards greater overlap in both models due to lack of variety, so we can posit that Numu is a full overlap system in the spectral domain and a no overlap system in the durational domain. To put it simply, Numu distinguishes long and short vowel pairs primarily by length, not by spectral differences.

2.6 Variation among speakers

Though there is a great deal of dialect variation within all of the Numic languages, Miller (1986) reports that the greatest variation within Northern Paiute is found at the southern extremes of the language's geographical range, with lesser variation in northern areas. He also notes that due to the high degree of mobility and intermarriage among speakers of different dialects, it can be difficult to determine dialect boundaries. Thus, though the four speakers in this study come from different regions originally (Burns, OR and McDermitt, NV), their long residence in Warm Springs and interactions with each other make it reasonable that they speak the language very similarly. However, some variation is expected. In addition to different dialectal and regional influences, the age of the speakers may be a factor; Speakers A and C are elders in the community, while both Speaker B and Speaker D are middle-aged.

Table 19 categorizes the four speakers according to age (columns) and region (rows). If these factors indeed contribute substantially to variation, we expect to see differences between Speaker A and Speakers B, C, and D (regional variation); or differences between Speakers B and D and Speakers A and C (age variation); or differences among Speakers B and D, Speaker A, and Speaker C (regional and age variation). It is likely, however, that other factors will be in effect. Dorian (1994a, p. 694) argues, "high levels of inter- and intraspeaker variation can both exist and persist within small, sharply-bounded populations." It is beyond the scope of this chapter to provide a prolonged discussion of sources of variability in the speakers' Numu productions beyond what is presented in Table 19.

Table 19. The age group (columns) and region of birth (rows) for the four Numu speakers.

	Middle-aged	***Elder***
Burns	—	Speaker A
McDermitt	Speaker B, Speaker D	Speaker C

Analyses of variance show that the main effect of Speaker is significant for all subphonemic measures performed in this chapter except fortis burst relative intensity, lenis burst standard deviation, geminate nasal duration, and long final vowel duration. Table 20 summarizes the significant results from Tukey post-hoc analyses of each of the measures performed on consonants, including the p-values for each difference. Age appears to be the largest contributing factor to variation in most of these measures, though region also has an effect, especially for lenis VOT. The reason for differences in fortis burst spectral standard deviation and singleton nasal duration cannot be determined from this information; Speaker B differs significantly from Speaker D in both measures, though they are in approximately from the same age group and originate from the same region (this is also true of measures of onset VOT and lenis burst relative intensity).

Table 20. Differences among fluent speakers in subphonemic measures of consonants.

Measure	***Speaker Differences***	***p-value***	***Contributing Factors***
Onset VOT	Speaker B/Speaker A	0.004	age/*unknown*
	Speaker B/Speaker C	0.000	
	Speaker B/Speaker D	0.000	
Fortis VOT	Speaker B/Speaker C	0.041	age (within McDermitt region)
Lenis VOT	Speaker A/Speaker B	0.019	region
	Speaker A/Speaker C	0.004	
Fortis Duration	Speaker C/Speaker B	0.027	age (within McDermitt region)
	Speaker C/Speaker D	0.000	
Lenis Duration	Speaker C/Speaker D	0.002	age (within McDermitt region)
Fortis Burst Relative Intensity	—	—	—
Lenis Burst Relative Intensity	Speaker B/Speaker A	0.000	age/*unknown*
	Speaker B/Speaker C	0.000	
	Speaker B/Speaker D	0.000	
Fortis Burst Standard Deviation	Speaker B/Speaker C	0.028	*unknown*
	Speaker B/Speaker D	0.003	
Lenis Burst Standard Deviation	—	—	—
Singleton Nasal Duration	Speaker D/Speaker B	0.000	*unknown*
	Speaker D/Speaker C	0.001	
Geminate Nasal Duration	—	—	—

Significant results from Tukey post-hoc analyses of each of the measures performed on vowels are presented in Table 21. There appears to be a great deal more variation in vowel measures than in consonant measures, with both age and region contributing to all differences in duration (long final vowel duration was the only duration measure that did not show significant variation among speakers). As noted above, Speaker B varies greatly from the other speakers in vocalic spectral measures; she is involved in two thirds of the spectral differences that are significant between speakers. It is possible that this variability can be accounted for by the fact that she is the only fluent speaker in this study who is not a fluent teacher in the language program, and may not interact with the other three speakers as much as a result.

It is worth emphasizing that age and region do not account for all of the variation among speakers reported here. Further study would be required to fully understand it, and it is likely due to individual factors that affect variation in speech in all languages. Though it cannot be accounted for, this variation is reported to provide a better insight into the variation that learners encounter, and to help account for some of the differences in fluent speaker perceptions of non-speaker accents discussed in Chapter 5.

Table 21. Differences among fluent speakers in subphonemic measures of vowels.

Measure	*Speaker Differences*	*p-value*	*Contributing Factors*
Short Medial Vowel Duration	Speaker A/Speaker C	0.008	age and region
	Speaker A/Speaker D	0.003	
	Speaker B/Speaker C	0.001	
	Speaker B/Speaker D	0.001	
	Speaker C/Speaker D	0.000	
Short Final Vowel Duration	Speaker A/Speaker B	0.001	age and region
	Speaker A/Speaker D	0.000	
	Speaker B/Speaker C	0.001	
	Speaker B/Speaker D	0.006	
	Speaker C/Speaker D	0.000	
Long Medial Vowel Duration	Speaker A/Speaker D	0.001	age and region
	Speaker B/Speaker C	0.005	
	Speaker C/Speaker D	0.000	
Long Final Vowel Duration	—	—	—
F1			
– i	Speaker B/Speaker C	0.000	age/*unknown*
	Speaker B/Speaker D	0.000	
– ɨ:	Speaker B/Speaker C	0.024	age
– u	Speaker B/Speaker A	0.000	*unknown*
	Speaker B/Speaker C	0.014	
	Speaker B/Speaker D	0.008	
– o:	Speaker B/Speaker C	0.000	*unknown*
	Speaker B/Speaker D	0.000	
– a	Speaker B/Speaker D	0.007	*unknown*
F2			
– ɨ	Speaker C/Speaker D	0.003	age
– ɨ:	Speaker C/Speaker D	0.005	age
– o	Speaker C/Speaker B	0.045	age
	Speaker C/Speaker D	0.009	
– a	Speaker C/Speaker B	0.007	age
	Speaker C/Speaker D	0.000	
F3			
– o	Speaker D/Speaker A	0.017	age/*unknown*
	Speaker D/Speaker B	0.000	
	Speaker D/Speaker C	0.003	
– a	Speaker A/Speaker D	0.010	age and region
	Speaker B/Speaker C	0.000	
	Speaker B/Speaker D	0.000	
– a:	Speaker A/Speaker D	0.001	age and region
	Speaker B/Speaker C	0.000	
	Speaker B/Speaker D	0.000	

2.7 Conclusion

This chapter has provided a sketch of several subphonemic features of Numu, including durational and spectral measures of the fortis/lenis distinction, onset VOT, and vowel quality and duration. It has also applied Wassink's (2006) SOAM to Numu vocalic data, concluding that Numu long and short vowels are distinguished primarily by length rather than formant values. In the next chapter, these measures are repeated for productions of Numu by people who do not speak the language in an effort to determine which types of production differences non-speakers bring to the language.

CHAPTER 3

Non-Speaker Production of Numu

3.1 Introduction

This chapter explores both phonological and subphonemic aspects of Numu words as produced by non-speakers of the language. It forms the basis for determining which aspects of learner speech contribute to a perceivable English accent in Numu. By comparing non-speaker productions to fluent speaker productions, we can determine which features of non-speaker speech are appreciably different from those of fluent speakers. The next step, described in Chapter 5, is to ask fluent speakers to rate the non-speaker productions, then use these ratings to link non-speaker features to perceptions of accented speech.

Another aspect of this portion of the research is a comparison of the speech produced by non-speakers from Warm Springs, who have had ambient exposure to the language and cultural norms associated with it, to speech produced by non-Native American people from the nearby town of Madras, who have no previous associations with the language. This comparison provides a means for determining which features of non-speaker speech are due primarily to transfer effects from English (those that occur in both sets of non-speakers), and which features have been affected by previous exposure to the language and cultural ideals (those that occur only in non-speakers from Warm Springs). These comparisons are discussed in Chapter 4.

Methods for the current study are described in the next section. Section 3.3 examines phonological contrasts, §3.4 describes consonantal phonetic contrasts, and §3.5 describes phonetic contrasts in vowels. This latter section includes an analysis of the relationship between vowel quality and vowel duration based on Wassink (2006), similar to the analysis made in Chapter 2. Section 3.6 concludes the chapter.

3.2 Methods

3.2.1 Background

This study makes use of an imitation task to collect data on non-speakers' productions of Numu sounds. In their review of methodological issues in adult cross-language perception studies, Beddor & Gottfried (1995) claim that imitation tasks confound perceptual and articulatory ability, but reduce subjects' memory load, remove the need for labels, and are a "natural way to elicit speech samples, especially in a language learning setting" (p. 221). In the case of this study, being able to distinguish perceptual from articulatory reasons for participants' productions is not as important as the productions themselves, and so the benefits of this type of task outweigh this drawback. Indeed, because many of the participants had reported never hearing the language before, most other kinds of tasks would have been impossible (e.g., recalling Numu words) or highly undesirable (e.g., reading Numu words). Furthermore, this task is similar to the experience a learner would have if they were attempting to learn the language from an electronic source, such as a CD or a computer program, a scenario that has become common in endangered language learning.

Another potential drawback of using an imitation task is pointed out by Markham (1997), who notes that productions in such a task are likely to exceed actual competence. In his proposed model of phonetic fossilization, attention to external input rather than internal (memorized) input results in fewer errors in pronunciation. Again, this phenomenon will not detract from the current study, in that if differences from fluent speakers' productions are detected in participants' productions when they are performing at the highest possible level, the differences can be considered robust.

3.2.2 Study participants

Participants in this portion of the study included twenty-five English speakers from central Oregon, fourteen of whom were Warm Springs community members, and eleven of whom were (non-Native American) people from the nearby town of Madras. All study participants had been born and lived a significant portion of their lives in Oregon. The second group served as a control group, under the hypothesis that socially salient features of the language would be enhanced by members of the Warm Springs community, while non-socially salient features would show similar effects in both groups. All participants were paid for their participation, and Warm Springs participants were given a CD of the tokens used in the experiment (Madras participants were not given a CD due to language sensitivity issues, and also because they had no interest in learning the language).

Tables 22 and 23 provide demographic and language background information for each participant. Twenty females and five males participated in the study. Their ages ranged from 14 years to 71 years, with a median age of 47. All participants from Warm Springs reported some previous exposure to Numu, ranging from ambient community exposure (e.g., hearing it spoken on the local radio station, during religious ceremonies, or occasionally spoken by older relatives) to prolonged exposure among family and Warm Springs Language Program classes. Only one Madras participant reported previous exposure, having heard it occasionally on the local radio station.

Because it has been shown in research on other languages that previous exposure to a language provides a phonetic advantage in the perception and production of that language (e.g., Au et al., 2002 and Knightly et al., 2003 on Spanish; Oh, Au, & Jun 2002 and Oh et al., 2003 on Korean; and Chang et. al., In Press on Mandarin), participants in this study were divided into three groups. The first group was the group from Madras, which consisted of people with no significant previous exposure to Numu. The second group included people from Warm Springs who had had ambient exposure to Numu in the community (Warm Springs 1), and the final group consisted of people from Warm Springs who had had direct exposure to the language through family members or classes (Warm Springs 2).

Table 22. Warm Springs participants' demographic information and language backgrounds.

Warm Springs Participants						
Participant	**Gender**	**Age**	**First Language(s)**	**Reported Previous Exposure To Numu**	**Group**	**Other Languages**
WS1	Female	45	English	Ambient community/ language program exposure	Warm Springs 1	Some Kiksht
WS2	Male	20	English	Mother speaks some Numu	Warm Springs 2	None
WS3	Female	18	English	Two months of language classes; mother-in-law speaks some Numu	Warm Springs 2	None
WS4	Female	71	Ichishkin, English	Ambient community/ language program exposure	Warm Springs 1	Fluent Ichishkin
WS5	Female	59	English	Some classes; older family members spoke Numu	Warm Springs 2	None
WS6	Female	47	English	Grandmother spoke Numu	Warm Springs 2	None
WS7	Female	46	English	Ambient community exposure	Warm Springs 1	Some Spanish
WS8	Female	42	English	Grandmother spoke Numu	Warm Springs 2	None
WS9	Female	43	English	Older relatives spoke Numu; involvement with Numu classes	Warm Springs 2	Fluent Spanish
WS10	Female	35	English	Ambient community/ language program exposure	Warm Springs 1	Some Spanish & Ichishkin
WS11	Male	50	English	Ambient community exposure	Warm Springs 1	Some Ichishkin
WS12	Female	18	English	Ambient community exposure	Warm Springs 1	Some Spanish & Nez Perce
WS13	Male	20	English	Ambient community exposure	Warm Springs 1	None
WS14	Female	46	English	Ambient community/ language program exposure	Warm Springs 1	L2 Kiksht

Table 23. Madras participants' demographic information and language backgrounds.

Madras Participants						
Participant	**Gender**	**Age**	**First Language(s)**	**Reported Previous Exposure To Numu**	**Group**	**Other Languages**
M1	Female	59	English	None	Madras	Some Spanish
M2	Female	62	English	None	Madras	None
M3	Female	53	English	None	Madras	Some Spanish
M4	Male	14	English	None	Madras	None
M5	Female	17	English	None	Madras	None
M6	Female	66	English	None	Madras	None
M7	Female	50	English	None	Madras	None
M8	Female	61	English	None	Madras	None
M9	Male	64	English	Occasionally on radio	Madras	None
M10	Female	55	English	None	Madras	None
M11	Female	49	English	None	Madras	None

3.2.2.1 Other language experience

Ten participants reported knowledge of at least one other language besides Numu. Six participants, including 2 Madras participants and 4 Warm Springs participants, reported limited to advanced knowledge of Spanish. It is likely that most or all people in the study have had some exposure to Spanish, either in classes, the Madras school environment (where 30% of the student population is Hispanic), or in the greater community, as Spanish is very pervasive in this region of Oregon. Previous exposure to Spanish is unlikely to systematically affect Numu production, either positively or negatively. Spanish phonology is very similar to English phonology, and segments that it does not share with English (e.g., ɲ, j̰) are also not shared with Numu, with the exception of the velar fricative /x/. This segment is not examined in the current study.

Six of the Warm Springs participants also reported knowledge of a Native American language, though none were languages that are known to be phylogenetically related to Numu. It is likely that all Warm Springs participants have had at least ambient exposure to Ichishkin and Kiksht, the tribes' other two indigenous languages, through local radio station programs, religious ceremonies, and other occasional public uses of these languages. One participant in the study is a fluent speaker of Ichishkin. However, exposure to Ichishkin or Kiksht is not likely to greatly affect Numu production, as it shares very few phonological features with Numu that are not also shared with English. Table 24 provides the segment inventories for both languages. Shaded regions indicate segments that are shared with Numu, but not with English. These include uvular stops (/q/ and/or /ɢ/), the affricate /ts/, a voiceless velar fricative (/x/), and the long vowel series. The possible contribution of previous Ichishkin and Kiksht exposure will be explored for each of these features (with the exception of /x/, which is not examined here).

Table 24. Segment inventories for Ichishkin and Kiksht.
Shaded regions indicate sounds that are shared with Numu, but not with English.

	Ichishkin		**Kiksht**	
Consonants	*plain*	*glottalized*	*plain*	*glottalized*
Obstruents	p	p’	p, b	p’
	t	t’	t, d	t’
	k	k’	k, g	k’
	k^w	k^{w}’	k^w, g^w	k^{w}’
	q	q’	q, ɢ	q’
	q^w	q^{w}’	q^w, $ɢ^w$	q^{w}’
	ʔ		ʔ	
Nasals	m		m	
	n		n	
Fricatives	s		s	
	ʃ		ʃ	
	ɬ		ɬ	
			ç	
			$ç^w$	
	x		x	
	x^w		x^w	
	h		h	
Affricates	ʦ	ʦ’	ʦ	ʦ’
	ʧ	ʧ’	ʧ	ʧ’
	tɬ	tɬ’	tɬ	tɬ’
Approximates	l		l	
	j		j	
	w		w	
Vowels	*short*	*long*	*short*	*long*
High	i	iː	i	iː
	u	uː	u	uː
Mid			ə	
				oː
Low	a	aː	a	aː

3.2.2.2 American Indian English

One possible confounding factor in this study is the fact that though all participants were born and raised in a similar geographic location, Native American people from Warm Springs generally speak American Indian English (AIE) in addition to the variety of Standard American English (SAE) spoken in the Central Oregon region. Impressionistically, AIE as it is spoken in Warm Springs differs from SAE largely at a lexical and discourse level, not phonetically. Leap (1993), who provides a detailed description of AIE, also does not report a great deal of phonetic variation from SAE in different varieties of AIE, stating, "Sound systems of Indian English rearrange sound contrasts found in standard English usage, but contain very few sound segments that are completely alien to standard English phonology" (p. 45).

Furthermore, if AIE as it is spoken in Warm Springs has been influenced by the indigenous languages spoken there, it will have been influenced by all three of the indigenous languages, with no particular advantage given to Numu. As we have seen in the previous section, Ichishkin and Kiksht provide very few advantages to speaking Numu, with the possible exception of vowel lengthening. Indeed, phonological vowel lengthening has been observed in some varieties of AIE as a result of influence from local indigenous languages (Leap, 1993). This aspect of non-speaker productions will therefore have to be analyzed with some caution.

3.2.3 Stimuli

Stimuli for this experiment included 281 Numu tokens produced by four fluent speakers. Tokens had been recorded in a quiet room at the Warm Springs Culture and Heritage Department with an M-AUDIO pre-amp and AKG C520 head-mounted condenser microphone, as described in Chapter 2. The words were produced during general language elicitation sessions, and as a result, not every token selected for this experiment was produced by all four speakers. However, most tokens were produced by at least two of the fluent speakers.

A total of 94 separate words were included in the data set. (See Appendix A for a complete list of words and the number of tokens of each.) Words were selected to maximize the number of contrastive Numu features that were represented, while at the same time minimizing the total number of words that would be presented to study participants.

3.2.4 Study procedure

Participants completed the experiment individually in a quiet room either in the Warm Springs Culture and Heritage Department, or at a private house or small office in Madras. Tokens were presented in blocks by speakers at a comfortable volume over open-air digital headphones with a frequency range of 20-20,000 Hz, sensitivity of 105 dB/1 mW, and impedance of 32 ohms $\pm$ 10%. Open-air headphones were used in order to simulate the same level of outside noise that language learners might experience should they ever attempt to learn Numu, either in a class or using a home computer, though outside noise was minimal in the experiment environs.

The experiment interface was designed using Praat's Multiple Forced Choice (MFC) listening experiment function (Boersma & Weenink, 2008). At the beginning of the experiment, each participant was given a practice test with five English tokens repeated three times, or until the participant indicated that they were comfortable with the procedure. At the beginning of the procedure and preceding each speaker block, participants were presented with a screen that read, "Repeat each word you hear into the microphone, then push NEXT. Click to start." Upon clicking the screen with a mouse, they heard a single token. They were presented with a "repeat" button that allowed the token to be repeated a single time. After hearing each token, participants said the word into a microphone and pushed the "next" button to hear the next word. Their repetitions were recorded using an M-AUDIO pre-amp with an AKG C520 head-mounted condenser microphone. Participants were allowed a break between each speaker block.

Acoustic measurements of study participants' productions were completed in Praat (Boersma & Weenink, 2008). Participants' productions were measured for the same subphonemic details that fluent speaker productions were measured for (see Chapter 2 for details), and results from these measurements are presented in §3.4 and §3.5. In addition, the study participants' tokens were analyzed for the production of a variety of Numu phonological features. These features are described in the next section.

3.3 Phonological contrasts

Recall from Chapter 1 that phonological acquisition is distinguished from phonetic acquisition in the establishment of abstract categories and rules that govern syllable- and word-level outputs, rather than in the surface production of sounds. Due to the nature of the current study, in which participants were asked to repeat words rather than produce them from memory (the second option would not have been possible, as most participants have not actively learned the language), it is difficult to distinguish participants' abilities to imitate surface phonetic forms from their establishment of separate phonological categories and rules. In most cases, it is likely that we are observing the former; in his study of the acquisition of the three-way Korean laryngeal contrast, for example, Chang (2009) found that novice learners attend to a phonetically detailed representation of the sounds without forming abstract sound categories.

However, we can nonetheless observe if participants were able to eschew the phonological rules of their primary language (English) in order to correctly produce Numu syllables and words. As transfer effects essentially consist of the use of the linguistic structures from a formerly established language in the production of a second language, the ability to avoid these structures is an important step in the establishment of new categories and rules (see Major, 2001). We can also observe if Numu phonological rules are adopted, but overapplied or applied incorrectly.

Participants' productions were therefore examined for sounds and sound sequences that occur in Numu, but that are not licensed in English. If participants do not correctly produce the Numu sounds and sound sequences, we can conclude that this is a result of transfer effects from English (in the event that they use sounds and sound sequences licensed in English), or of overapplication of the Numu rule (in the event that they overuse sounds and sound sequences licensed in Numu). (A third possibility, that non-speakers adopt universal language features, is examined in Chapter 4). The following sections describe the results of phonological examinations of the production of word-initial /ts/, uvularization of velar consonants before low back vowels, the devoicing of word-final unstressed vowels, ejective consonants, and suprasegmental features.

3.3.1 Word-initial /ts/

The English phonological system does not include the affricate /ts/, a sound that is licensed in all consonantal positions in Numu. Though it is expected that English speakers will produce this affricate correctly word-internally due to phonological rules in English that allow sequences of the consonants /t/ and /s/ across syllables (e.g. 'we**t.s**uit') or morphological boundaries (e.g. 'we**ts**'), participants who fully transfer English phonological rules to Numu words will not produce the sound word-initially.[13]

Word-initial /ts/ occurred in 19 of the tokens presented to participants. Their productions of this sound were examined and individual results are presented in Figure 17. This figure includes the percentage of total words correctly produced with /ts/, percentage of productions of other affricates that are licensed word-initially in English[14] (i.e., /tʃ/ and /ʤ/), percentage of productions of /s/, and percentage of productions of /t/, also licensed word-initially in English. In cases where the total does not reach 100%, other sounds were produced or the word was not produced at all. This figure indicates that participants from Warm Springs were more likely to produce word-initial /ts/, though some individual participants from Madras produced the sound frequently (e.g., M7, a 50-year-old female with no previous Numu experience).

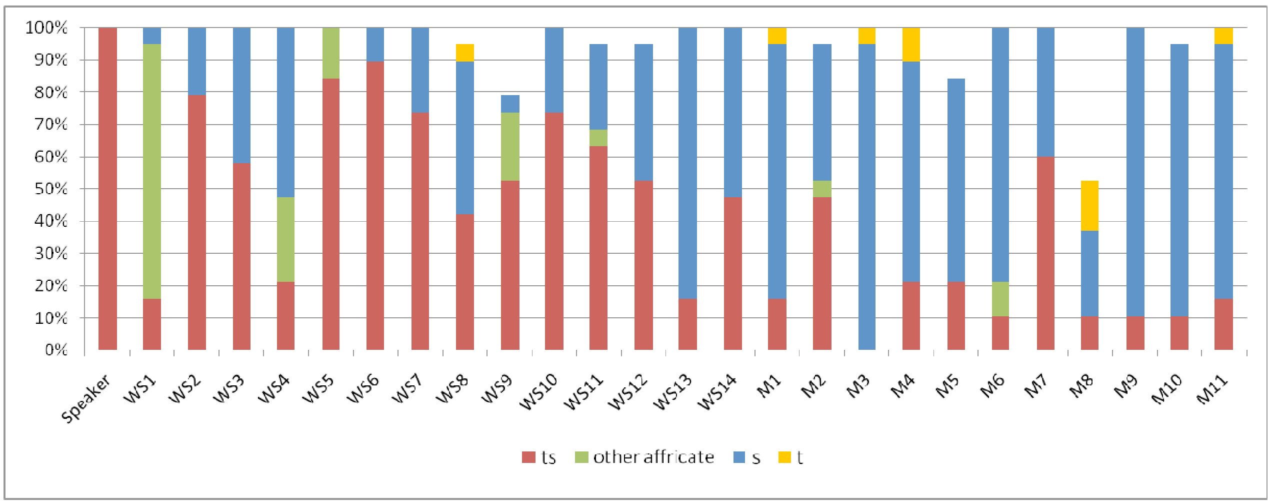

Figure 17. Percentage of word-initial tokens of /ts/ produced as /ts/, another affricate, /s/, or /t/, by participant.

Some advantage in onset /ts/ production may be expected of people who know or have learned Ichishkin or Kiksht, languages that license this affricate word-initially.[15] This possibility is explored in Figure 18, which shows a comparison of word-initial /ts/ production by people in the Warm Springs 1 group who have had exposure to Ichishkin or Kiksht, people in the Warm Springs 1 group who reported no previous exposure to these languages, and the Warm Springs 2 group. In fact, there appears to be no advantage to having some knowledge of Ichishkin or

[13] Similarly, in borrowings from other languages, English speakers produce /ts/ word-internally or word-finally (e.g., the German surname *Katz*), but not word-initially (e.g., the Japanese word *tsunami* is frequently pronounced with a word-initial /s/).
[14] In the case of some Warm Springs participants, the "other affricate" category also included some productions of ejective /ts'/. These cases will be examined in more detail in § 3.3.4.
[15] No advantage is expected for people who speak or have learned Spanish because, like English, it does not license word-initial /ts/.

Kikesht; this group's production of word-initial /ts/ was lower than the productions of the other two groups.

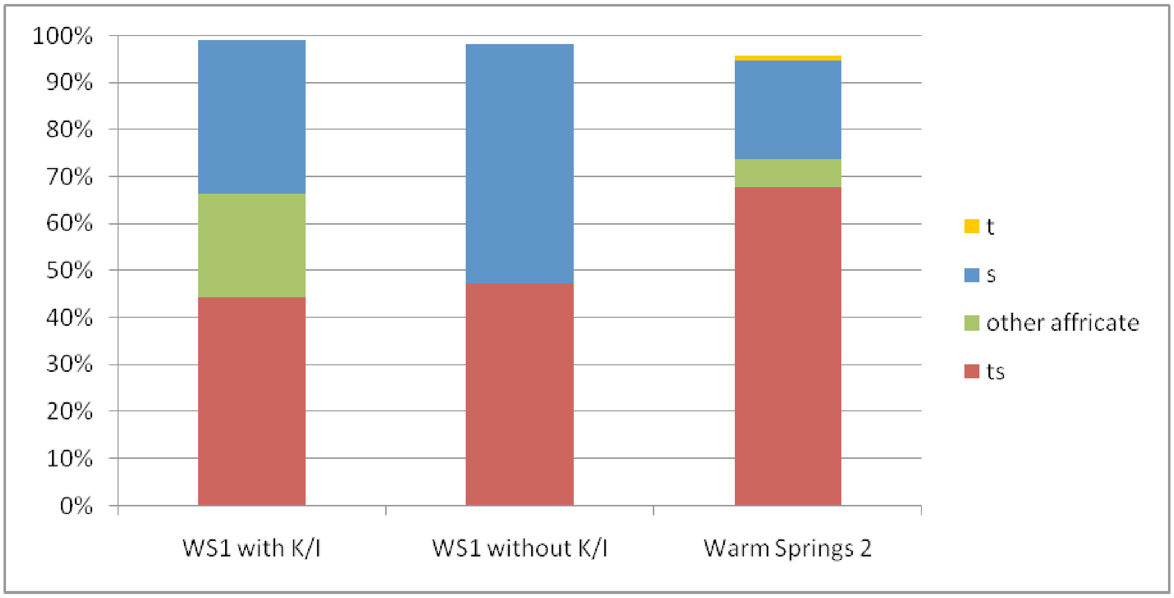

Figure 18. Percentage of word-initial tokens of /ts/ produced as /ts/, another affricate, /s/, or /t/ by members of the Warm Springs 1 group with previous exposure to Ichishkin or Kiksht, members of the Warm Springs 1 group with no previous exposure to these languages, and members of the Warm Springs 2 group.

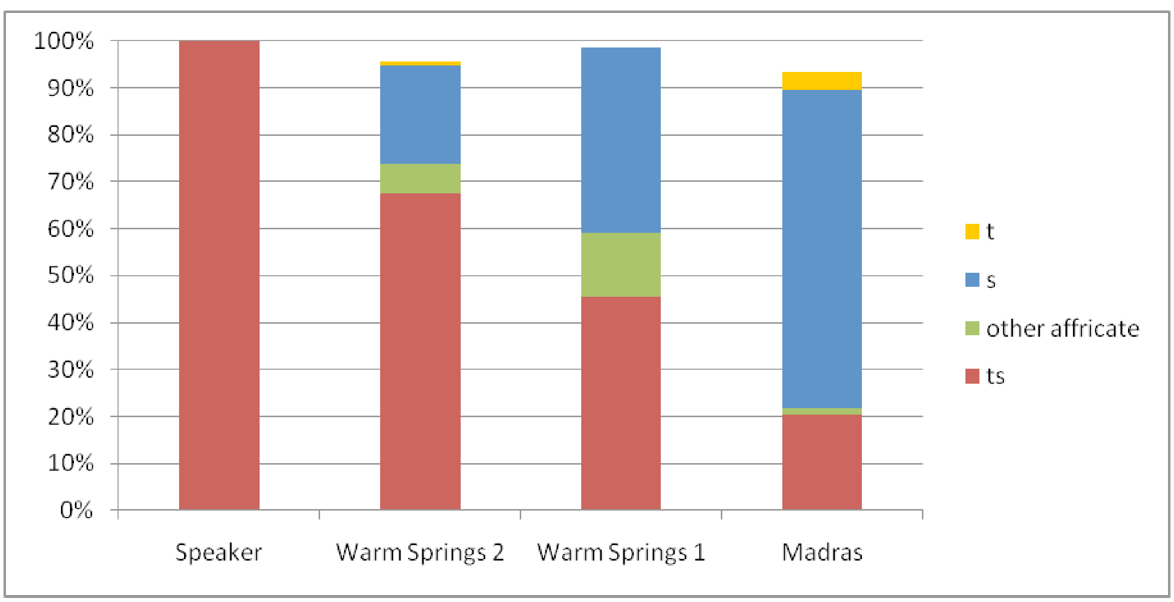

Figure 19. Percentage of word-initial tokens of /ts/ produced as /ts/, another affricate, /s/, or /t/, by group.

Figure 19 shows word-initial /ts/ production by participant group. Here, we see that the percentage of correct productions of word-initial /ts/ follow the pattern of amount of exposure to Numu, with the percentage of Warm Springs 2 productions > Warm Springs 1 productions > Madras productions. A chi-square test of the frequency of /ts/ production reveals that the three non-speaker groups differ significantly from each other and from the Fluent Speaker group [χ^2 (3)=107, p<0.001].

3.3.2 Uvularization

Thornes (2003) describes a phonological rule by which Numu velar consonants are realized as uvulars preceding /ɔ/ and /a/. This rule presents a situation in which study participants may produce uvular consonants not as a response to the rule, but as a direct phonetic imitation of the sounds they hear in the target words. However, adherence to English rules of phonology will lead to the production of velar sounds in Numu uvular contexts, despite the presence of uvularization in the input. Therefore, though we cannot assume adoption of the Numu rule by those who produce uvular consonants, we can observe which participants transfer English phonological rules to Numu through the production of velar consonants.

In my own data, I have observed that for some fluent speakers, the uvularization process is neutralized (or nearly neutralized) in velar sounds preceding /a/ if the following consonant has labial involvement (e.g., /p/, /b/, or /w/). For example, there are several tokens of [kappa] "*bed*" rather than the expected [qappa], [kammɨ] *"rabbit"* rather than [qammɨ], or [kaʔwɔtsḁ] *"back of head or neck"* rather than [qaʔwɔtsḁ]. This neutralization never occurs if the vowel context is /ɔ/ (e.g., I have never heard [qɔpiʔi] *"coffee"* produced as [kɔpiʔi]). Words with an /a/ followed by a [+labial] consonant have therefore been excluded from the current examination, in order to ensure that the input received by study participants was fully uvularized.

The production of uvulars in 25 tokens was examined for all study participants. As with word-initial /ts/, participants who have had training in Ichishkin or Kiksht are likely to be at an advantage in the production of uvular sounds, as both of these languages have uvular consonants in their inventories. People with previous exposure to Spanish have no such advantage. Results by individual participant are presented in Figure 20, where the percentage of production of uvular sounds is compared to the percentage of production of velar sounds or other sounds in the same context (in cases where the total percentage is not 100%, no word was produced, or the word produced was completely different from the word given as input). In most cases, a larger percentage of the words were produced with velar sounds than with uvular sounds, though most participants produced at least some uvular sounds.

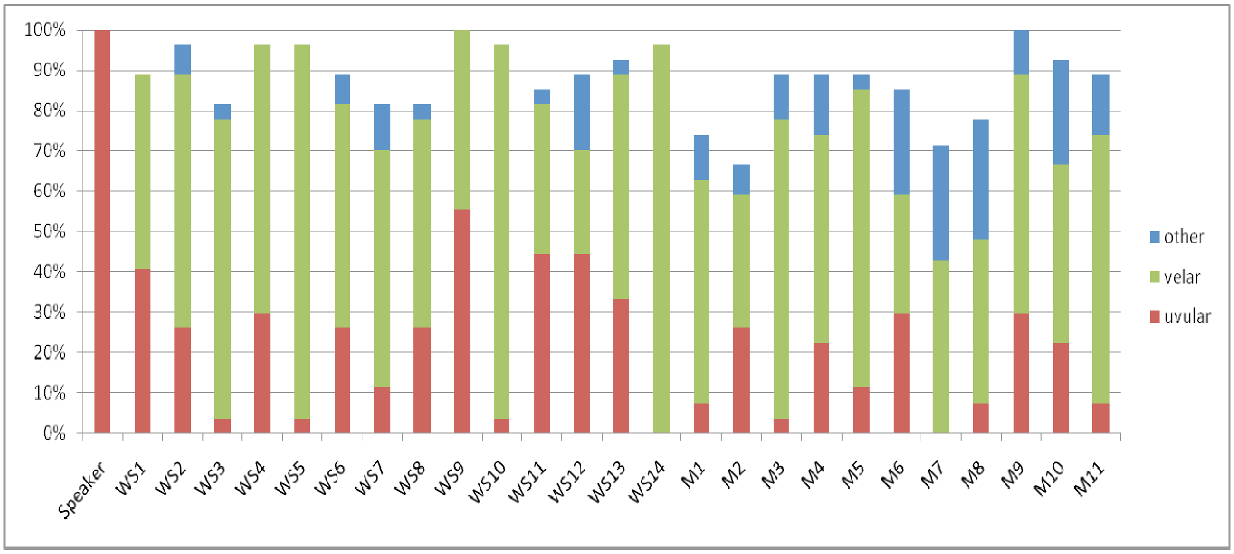

Figure 20. Percentage of uvular sounds, velar sounds, and other sounds produced in Numu uvular contexts, by individual.

Figure 21 shows the percentage of production of uvular sounds by group. A chi-square test of frequency of uvular productions confirms a significant difference between fluent speakers and the non-speaker groups [χ^2 (3)=67, p<0.001]. However, no significant difference is found among the non-speaker groups.

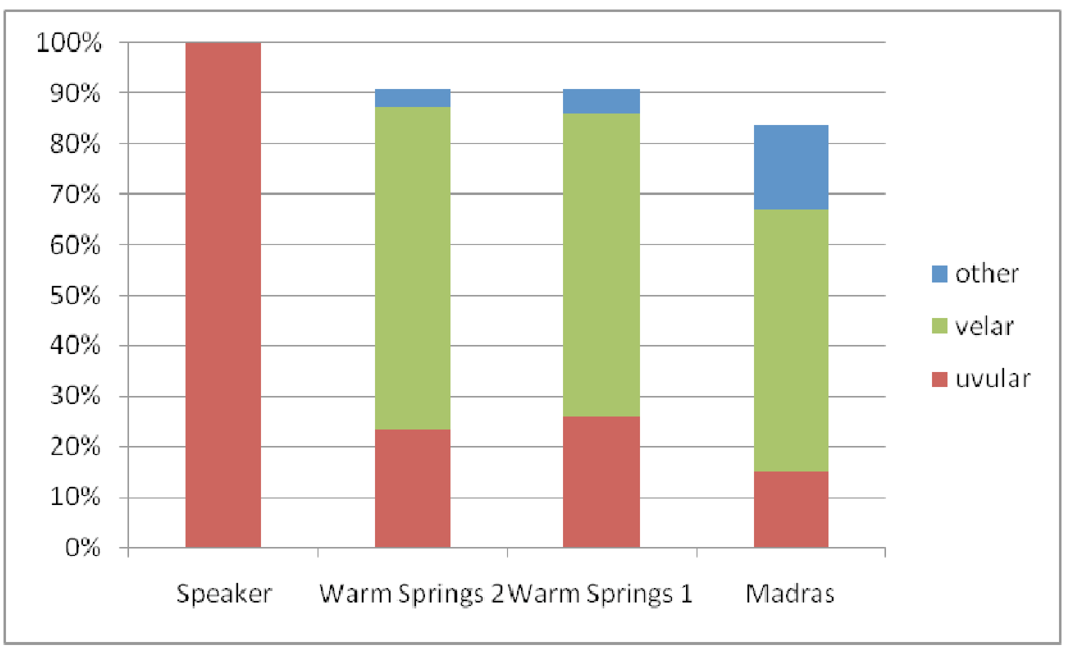

Figure 21. Percentage of uvular sounds, velar sounds, and other sounds produced in Numu uvular contexts, by group.

Interestingly, previous exposure to Ichishkin or Kiksht also does not confer an advantage in terms of uvular production (see Figure 22), despite the fact that uvular consonants are in the inventories of both of these languages.

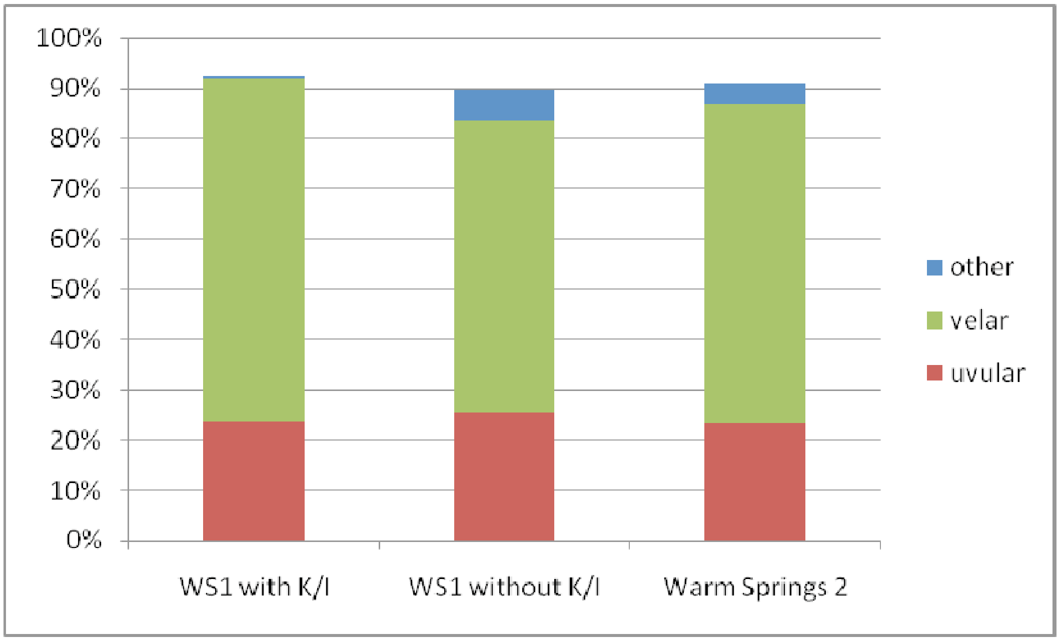

Figure 22. Percentage of uvular sounds, velar sounds, and other sounds produced in Numu uvular contexts, by members of the Warm Springs 1 group with previous exposure to Ichishkin or Kiksht, members of the Warm Springs 1 group with no previous exposure to these languages, and members of the Warm Springs 2 group.

3.3.3 Voiceless vowels

One particularly interesting phonological process in Numu is the devoicing of word-final unstressed vowels. Thornes (2003) notes that devoicing occurs in the final syllable of the word, and may spread left as far as the word's stressed syllable. This process appears to be both gradient and optional; Liljeblad (1966, p. 14) reports that "an unstressed vowel at the end of an utterance tends to become reduced… varying from a weak articulation of the vowel to complete apocope."

All input productions by fluent speakers were examined for final vowel devoicing, and the results were compared to the study participants' productions. Cases of devoicing were divided between devoicing in response to the input and spontaneous devoicing, in which a final vowel was devoiced in a study participant's production that had not been devoiced in the input. These results are presented in Figure 23: the red bars represent the total number of tokens that included a devoiced vowel, and the yellow triangles represent the number of those tokens that were devoiced spontaneously. A percentage is provided above the yellow triangles. The Madras group is presented first, from left to right, followed by the Warm Springs 1 group (WS1 through WS14), and ending with the Warm Springs 2 group (WS2 through WS9). Note that only participants from Warm Springs produced spontaneous devoicing, and nearly all of them did it 8% of the time or more. In cases where the input was devoiced, many of the non-speakers from all three groups used the strategy of fully aspirating the final consonant, especially voiceless obstruents, in order to imitate the voiceless vowel they had heard.

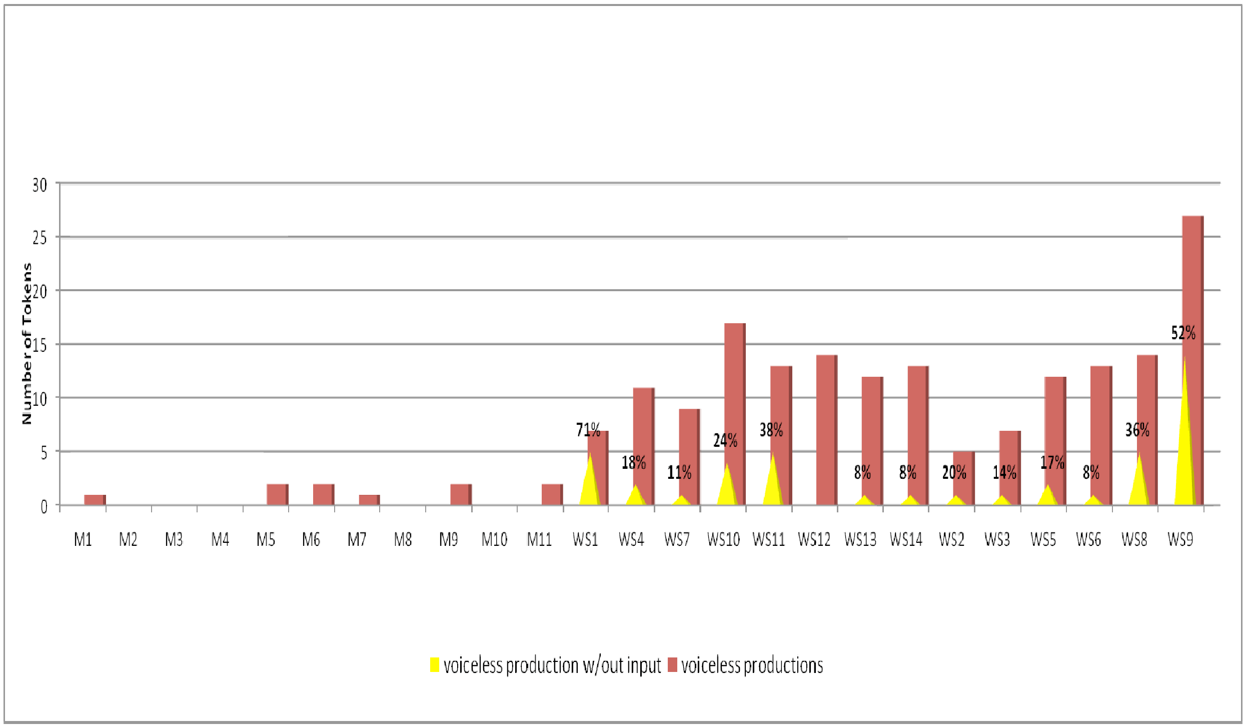

Figure 23. Number and percentage of spontaneously devoiced productions (triangles) as compared to the total number of devoiced productions (rectangles), by participant.

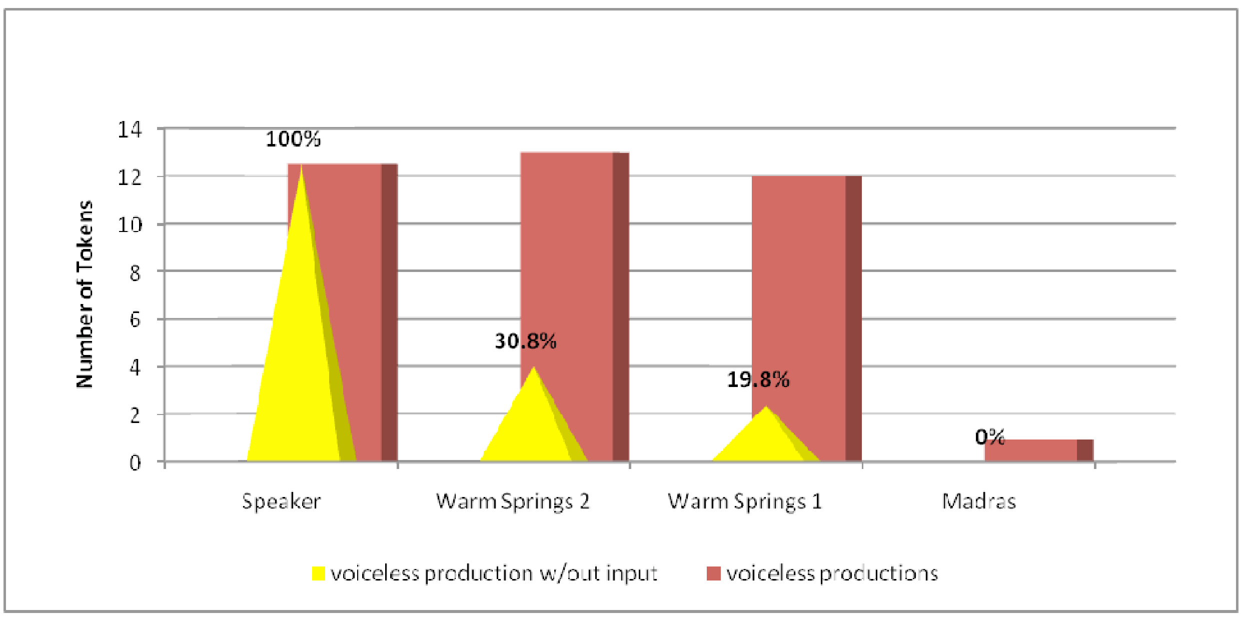

Figure 24. Number and percentage of spontaneously devoiced productions (triangles) as compared to the total number of devoiced productions (rectangles), by group.

Figure 24 presents the vowel devoicing data by group. Here, the average number of devoiced tokens per group member is represented by the red bars, and the average number of spontaneously devoiced tokens per group member is represented by the yellow triangles. Overall, more devoicing was found in productions by Warm Springs participants, and all Warm Springs participants devoiced vowels in several tokens. Surprisingly, members of the Warm Springs 2 group produced more devoiced tokens on average than the Fluent Speaker group. Members of the Warm Springs 2 group also produced more tokens of spontaneous devoicing than the other non-speaker groups. These average are presented in Table 25. A chi-square analysis reveals that the four groups differ significantly in average voiceless productions [χ^2 (3)=280, p<0.000]

Table 25. Average number of voiceless productions per participant, by group.

Group	***Average Voiceless Productions***
Speaker	12.5
Warm Springs 2	13
Warm Springs 1	12
Madras	0.9

Another surprising result of the analysis of non-speaker devoicing was the fact that two of the participants, one from the Warm Springs 1 group and the other from the Warm Springs 2 group, devoiced stressed vowels at the end of two-syllable words, an unlicensed realization of devoicing in Numu. One such devoicing occurred on a stressed vowel following a nasal, a double violation, as devoicing is not licensed following sonorants (Thornes, 2003). As word-final vowel devoicing is not a feature of English, Spanish, Ichishkin, or Kiksht, the devoicing of word-final stressed vowels must be analyzed as overapplication of the Numu devoicing rule, a phenomenon that will be discussed in greater detail in Chapter 4.

3.3.4 Ejectives

Though ejective consonants are a common areal feature of Pacific Northwest indigenous languages (Jacobs, 1954), they are not a feature of Numu. Therefore, none of the tokens presented to study participants contained ejective sounds. Surprisingly, however, productions of ejectives were found in the data of eight of the participants from Warm Springs. Five of these participants were in the Warm Springs 2 group, and three were in the Warm Springs 1 group. They produced between 1-19 ejectives each, and productions included [p'], [t'], [ts'], [tʃ'], and [k']. The majority (37) of the ejectives occurred word-initially, with 10 of those being ejective velars in Numu uvular contexts. Another 13 ejectives occurred in place of intervocalic fortis consonants, and the remaining 10 occurred in place of intervocalic lenis consonants.

Table 26 provides a summary of the participants who produced ejectives, their group, the total number of ejectives they produced in the dataset, and the types of ejectives they produced. Figure 25 is the waveform and spectrogram of /k'a/ produced by participant WS5 at the beginning of the word [kaʔwɔtsḁ] *"back of head or neck."* Arrow (a) points to the oral release and arrow (b) points to the glottal release. This participant also exhibits a short period of creaky voicing in the following vowel (arrow c), a secondary feature of some ejective productions (see Ladefoged & Maddieson, 1996).

Table 26. Ejective production by Warm Springs participants.

Participant	**WS1**	**WS2**	**WS3**	**WS5**	**WS6**	**WS9**	**WS11**	**WS14**
Warm Springs Group	1	2	2	2	2	2	1	1
Total ejectives produced	19	1	1	16	1	2	8	12
Types of ejectives produced	t' ts' tʃ'	ts'	k'	t' ts' k'	ts'	t' ts'	p' t' ts' k'	p' t' ts' tʃ' k'

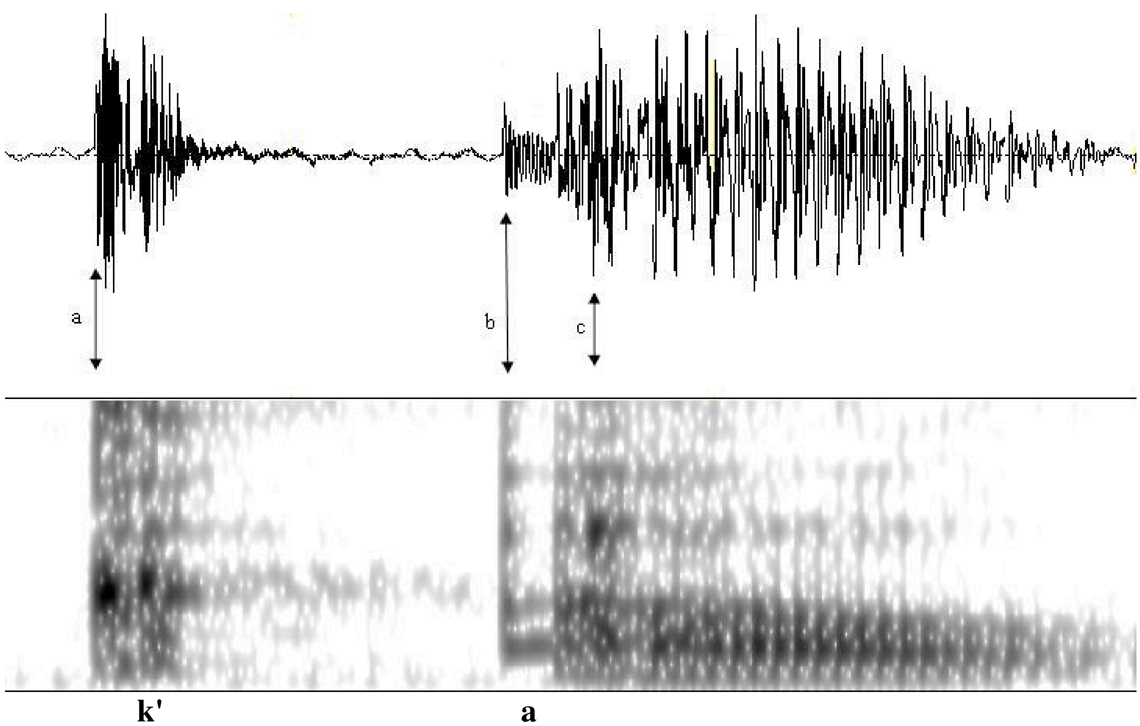

Figure 25. Waveform and spectrogram of /k'a/ produced by WS5. Arrow (a) indicates the oral release, arrow (b) indicates the glottal release, and arrow (c) indicates creaky voicing.

Both of the participants who have had exposure to Kiksht (WS1 and WS14) and one of the participants who has had exposure to Ichishkin (WS11) produced ejectives. This is not surprising, as both Kiksht and Ichishkin have an extensive inventory of ejective consonants, including obstruent ejectives and affricate ejectives. The fluent speaker of Ichishkin did not produce ejectives, and it is likely that her fluency in Ichishkin allowed her to recognize the absence of ejectives in the Numu input. However, five of the participants who produced ejectives reported no previous exposure to Ichishkin or Kiksht.

This phenomenon will be explored in detail in Chapter 4, but it is likely due to general cultural knowledge about the languages in Warm Springs and a resulting phonological generalization among some non-speakers that Native American languages have ejectives. It may also reflect a subconscious ideological desire to pronounce Numu words as differently from English as possible. A possible result is the eventual spread of ejectives to Numu, a incident that is well within the historio-cultural tradition of Pacific Northwest indigenous tribes, as is evident by the large amount of historical areal spread in the region.

3.3.5 Suprasegmental features

Prosody is a very important aspect of language learning and use (Major, 2001; Trofimovich & Baker, 2007). However, major differences in speaker and non-speaker stress placement is not expected for a number of reasons. Firstly, stress in Numu is regular, generally falling on the second mora of the prosodic word, which was the case for all words used in this experiment. Second, because stress is variable and contrastive in English, it is expected that English speakers will pay more careful attention to stress placement in any language. Finally, because this is an imitation study, it is expected that participants' online memory will allow them to remember and repeat the stress placement as they heard it (this would not necessarily be the case if participants repeated words from memory).

Indeed, in examining the data, few major discrepancies in stress in non-speakers' productions of Numu were observed. No non-speaker exhibited less than 94% accuracy in stress placement. Figure 26 shows the mean percentage of accurate productions by group; differences among the groups were not significant at the $p < 0.05$ level.

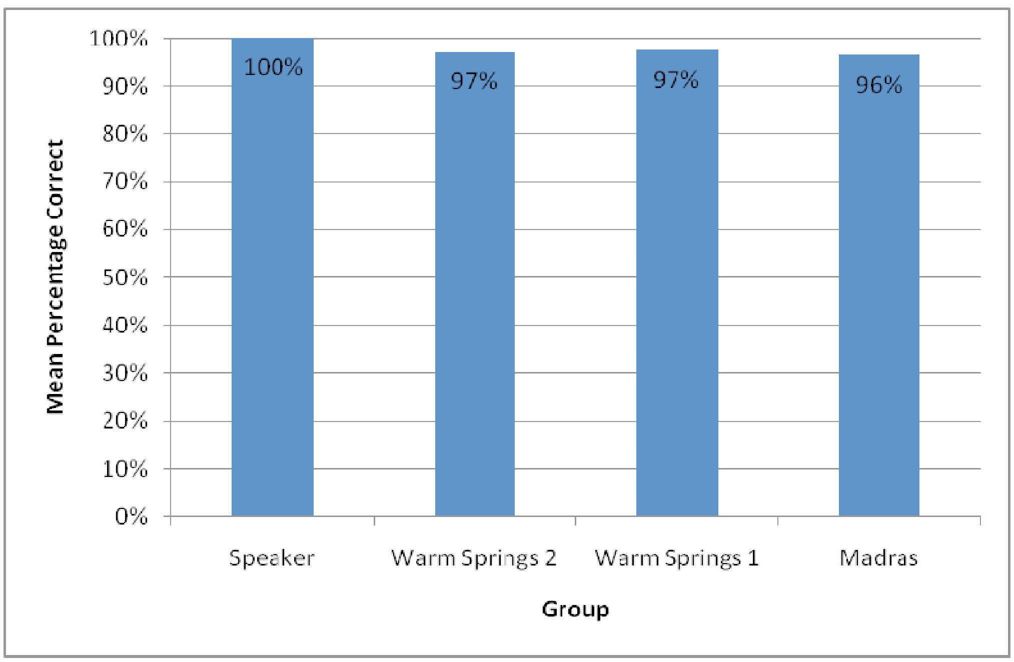

Figure 26. Mean percentage of accurate stress production by group.

Phrase level prosody was not examined in the current study, as none of the study participant productions exceeded the length of a word.

3.3.6 Conclusion

In an examination of the realization of Numu phonological rules by native speakers of English, it was found that those who had had previous exposure to the language and who live in the Warm Springs community are more successful at eschewing English rules of phonology to correctly produce Numu sounds and sequences than those who did not report previous exposure and who do not live in the community. Participants in the Warm Springs groups produced significantly more tokens of the word-initial affricate /ts/ and also produced more tokens of devoicing and spontaneous devoicing than participants in the Madras group. However, this was found not to be the case for the Numu rule of uvularization of velar consonants before low back vowels, where all three non-speaker groups performed equally. Of particular interest are the instances of overapplication of phonological rules that occurred within the Warm Springs groups, both in the case of devoicing stressed vowels and in the case of producing ejective consonants. These cases will be explored in further detail in Chapter 4.

3.4 Phonetic contrasts: Consonants

This section explores non-speakers' productions of subphonemic contrasts in Numu consonants. It has been previously found that differences at the segment level are easier for adult second language learners to overcome than subphonemic differences (Flege & Port, 1981; Mitlieb, 1983). Nonetheless, participants from the Warm Springs groups are expected to outperform their Madras counterparts, more successfully meeting native speaker targets. This is in part due to their previous exposure to the language. Knightly et al. (2003) find that people who overheard Spanish as a child, but who were not spoken to directly and did not use the language, nonetheless have an advantage over people who attempt to learn the language as adults in terms of phoneme production. If this generalization holds for other languages, we would expect people who grew up in Warm Springs, where Numu is occasionally played on the radio, used in religious events and ceremonies, and spoken by some elders, to have a phonemic advantage over people who did not have ambient exposure to the language. We would also expect people who had greater exposure to the language, including direct instruction and/or family members who spoke to them, to have an even greater advantage.

Celce-Murcia, Brinton, & Goodwin (1996) report that motivation is a significant factor in successful second language pronunciation. People in the Warm Springs community generally view their heritage indigenous languages as important and integral parts of Warm Springs history and culture and are anxious that they continue to be spoken (Haynes, 2004; Haynes, 2007). Furthermore, it is generally believed in Warm Springs that people from Warm Springs have a closer cultural connection to their languages. They are therefore expected to have greater motivation to speak the language correctly.

The features that are examined in this section are the same as those described for fluent speakers in Chapter 2, and include fortis and lenis VOT, duration, and measurements of the burst; nasal duration; onset VOT; vowel quality; and vowel duration. If the predictions described above hold true, we expect phonemic measurements to follow a pattern in which the Warm Springs 2 group's productions are closest to fluent speaker targets, followed by productions by the Warm Springs 1 group, and with productions by the Madras group the furthest from fluent speaker targets.

3.4.1 Fortis and lenis

For non-speaker productions, measurements were made for fortis and lenis VOT, duration, and burst intensity, amplitude, and mean frequency. All 25 participants were presented with 19 tokens of fortis /p/, 19 tokens of fortis /t/, and 14 tokens of fortis /k/, as well as 57 tokens of lenis /b/, 15 tokens of lenis /d/, and 30 tokens of lenis /g/. Cases where they incorrectly repeated the word, producing a sound at a different place of articulation, or where they failed to repeat the word entirely have not been included in the following analysis.

3.4.1.1. Fortis and lenis obstruent VOT

As with the fluent speaker productions, VOT was measured in non-speaker productions from the release of the closure to the onset of the first vocal pulse of the following vowel for fortis and lenis bilabial, coronal, and velar obstruents. Mean values and standard deviations of fortis VOT for the three groups of non-speakers are presented in Table 27. A fourth column presents fluent speaker values for comparison. Both mean VOT and the standard deviation generally decrease across the three non-speaker groups, with values for the Warm Springs 2 group more closely approximating fluent speaker values than the other groups. Figure 27 presents this trend graphically.

An analysis of variance shows that the main effects of Group (Madras, Warm Springs 1, Warm Springs 2, and Fluent Speakers) and Consonant (p, t, and k) are both highly significant [Group: $F(3)=13.35$, $p < 0.001$; Consonant: $F(2) = 55.73$, $p <0.001$], with no significant interaction. Post-hoc Tukey pairwise comparisons by Group show that all groups differ from one another significantly except the Madras and Warm Springs 1 and the Warm Springs 2 and Fluent Speaker groups, which did not differ significantly for fortis VOT. This result indicates that the more experienced Warm Springs 2 group patterns with fluent speakers, while the less experienced Warm Springs 1 group patterns with people who have no previous Numu experience.

Table 27. Mean VOT for fortis Numu obstruents.
(Standard deviations are in parentheses.)

	Madras VOT (ms)	Warm Springs 1 VOT (ms)	Warm Springs 2 VOT (ms)	Fluent Speaker VOT (ms)
p	22.71 (35.0)	23.65 (36.2)	19.82 (13.6)	15.60 (7.29)
t	33.31 (28.9)	27.67 (29.3)	20.51 (15.7)	12.11 (3.16)
k	46.10 (17.6)	42.39 (16.5)	36.56 (15.3)	29.90 (7.29)
All	34.10 (29.4)	30.90 (29.5)	25.07 (16.7)	18.31 (9.60)

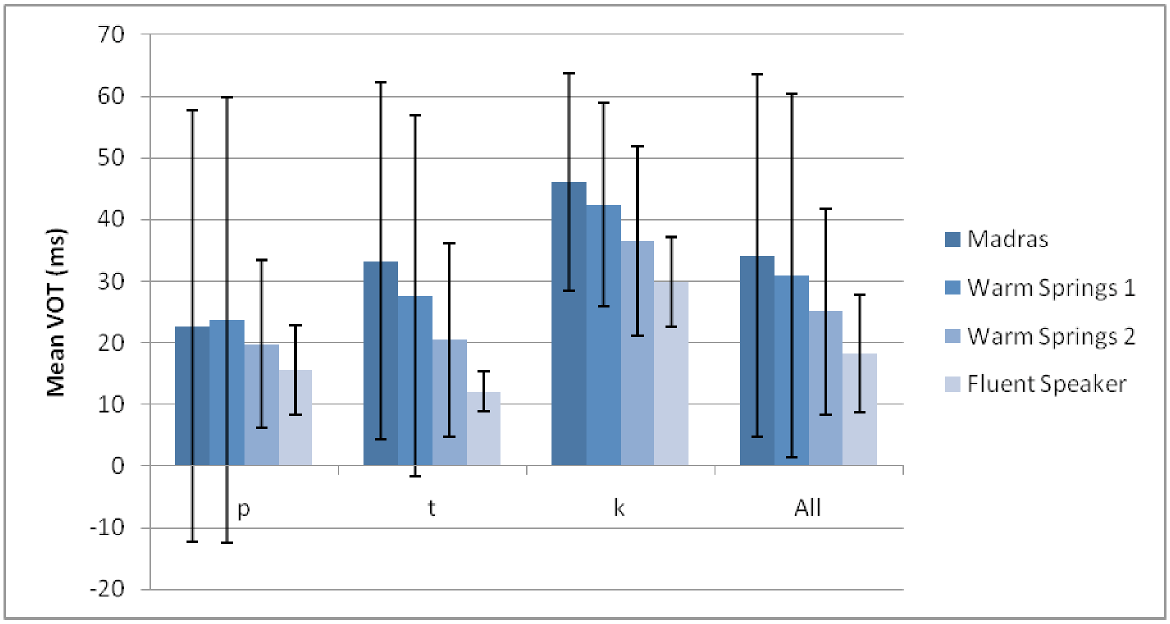

Figure 27. Mean fortis VOT across groups by consonant.
(Error bars indicate ∓ one standard deviation from the mean.)

For lenis sounds, VOT was measured only in obstruents, as discussed in Chapter 2. Table 28 presents mean values and standard deviations of lenis VOT for both groups of non-speakers and fluent speakers. An analysis of variance shows no significant effect of Group, though the main effect of Consonant (b, d, and g) is significant [F(2)=59.7, p<0.001], and there is a marginally significant interaction of Group by Consonant [F(4)=2.5, p<0.05].

Table 28. Mean VOT for lenis Numu obstruents.
(Standard deviations are in parentheses.)

	Madras VOT (ms)	Warm Springs 1 VOT (ms)	Warm Springs 2 VOT (ms)	Fluent Speaker VOT (ms)
b	-3.53 (52.4)	-2.24 (54.1)	-12.59 (53.4)	8.97 (25.6)
d	-42.64 (52.9)	-44.33 (50.0)	-44.75 (44.3)	-26.69 (35.8)
g	-10.24 (60.6)	-3.27 (59.9)	4.82 (54.7)	-7.13 (49.6)
All	-13.85 (57.4)	-12.04 (57.8)	-13.28 (54.7)	-7.45 (40.0)

A comparison of the durational distinction made by each group for fortis and lenis VOT is provided in Table 29. Note that all groups make a highly significant (p<0.001) distinction, with the magnitude of the difference increasing with a decrease in Numu experience (see Figure 28). This indicates that groups with the least Numu experience place the greatest emphasis on VOT distinctions between the two types of sounds.

Table 29. Difference between fortis and lenis VOT by group.

	Difference (ms)
Madras	47.94***
Warm Springs 1	42.93***
Warm Springs 2	38.35***
Fluent Speaker	25.76***

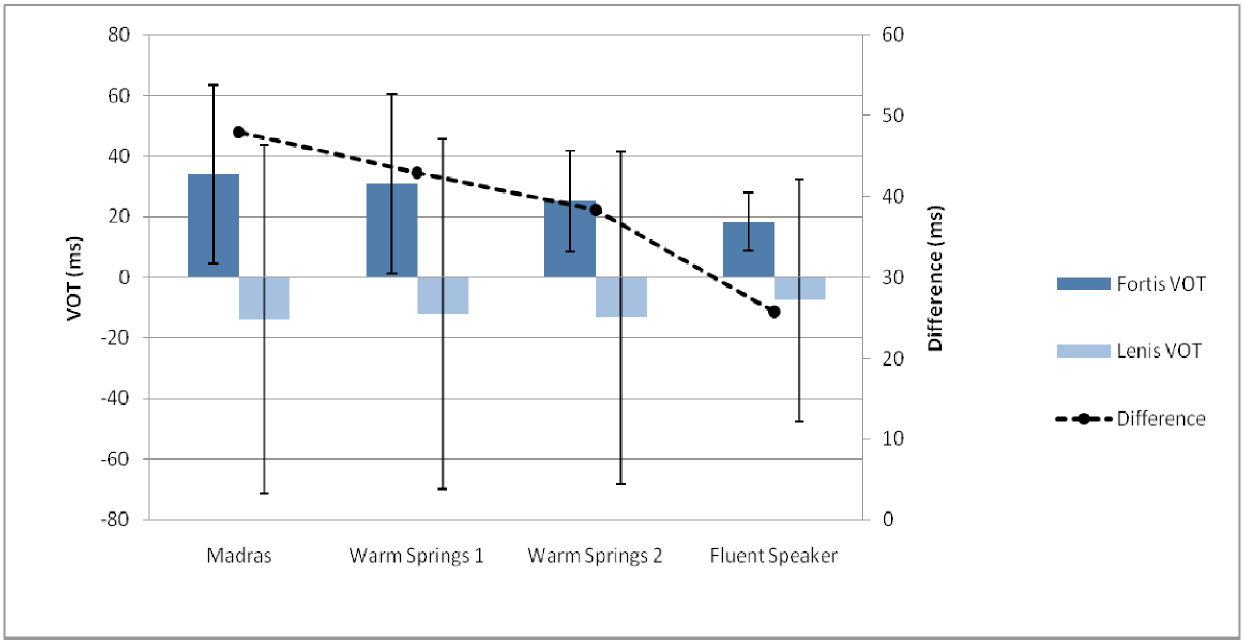

Figure 28. Fortis and lenis VOT (bars) and the difference between fortis and lenis VOT (line), by group. (Error bars indicate ∓ one standard deviation.)

3.4.1.2 Fortis and lenis obstruent/fricative duration

Closure duration was measured in all fortis and lenis productions from the closure (or approximate closure) of the articulators to the beginning of the first vocal pulse in the following vowel. Results for fortis sounds are given in Table 30. Fluent speakers have the longest closure duration for all places of articulation, followed by Warm Springs 2 participants, Warm Springs 1 participants, and Madras participants. An analysis of variance shows that the main effects of Group and Consonant (p, t, and k) are significant [Group: $F(3)=11.6$, $p<0.001$; Consonant: $F(2)=16.7$, $p<0.001$], with no significant interaction of Group by Consonant. However, only the Madras group shows significant differences from the other groups in post-hoc Tukey t-tests, indicating that both of the Warm Springs groups pattern with the fluent speaker group in fortis duration.

Table 30. Mean closure duration for fortis Numu consonants by group.
(Standard deviations are in parentheses.)

	Madras Closure Duration (ms)	Warm Springs 1 Closure Duration (ms)	Warm Springs 2 Closure Duration (ms)	Fluent Speaker Closure Duration (ms)
p	165.23 (66.3)	184.41 (67.6)	192.20 (61.0)	199.19 (33.0)
t	168.65 (51.2)	175.76 (46.1)	178.31 (45.3)	191.73 (29.4)
k	147.84 (44.0)	160.09 (53.3)	167.19 (53.3)	177.34 (26.8)
All	161.93 (55.9)	174.43 (57.1)	180.22 (54.3)	190.44 (31.0)

Table 31 reports duration results for lenis consonants. Note that the pattern here is different than fortis duration, with the Fluent Speaker group showing the shortest duration, followed by the Madras group, then the two Warm Spring groups. For lenis sounds, the main effects of Group and Consonant (b, d, and g) are significant (Group: $F(3)=7.4$, $p<0.001$; Consonant: $F(2)=92.0$, $p<0.001$), and there is no significant interaction of Group by Consonant. Post-hoc Tukey pairwise comparisons show that only the two Warm Springs groups do not differ significantly in lenis duration.

Table 31. Mean closure duration for lenis Numu consonants by group.
(Standard deviations are in parentheses.)

	Madras Closure Duration (ms)	Warm Springs 1 Closure Duration (ms)	Warm Springs 2 Closure Duration (ms)	Fluent Speaker Closure Duration (ms)
b	104.10 (50.0)	109.54 (46.2)	108.13 (53.6)	98.82 (48.5)
d	77.28 (32.0)	77.43 (27.5)	72.48 (29.6)	50.87 (19.0)
g	87.85 (31.3)	96.34 (31.7)	94.92 (34.5)	79.41 (33.8)
All	95.53 (44.3)	101.04 (41.8)	99.25 (47.6)	88.25 (44.4)

Mean fortis to lenis closure duration ratios are given in Table 32. Following the predicted pattern, duration ratios are proportional to experience: the Fluent Speaker group exhibits the largest closure ratio, followed by the Warm Springs 2 group, the Warm Springs 1 group, and the Madras group. However, all four groups make a highly significant ($p<0.001$) distinction between lenis and fortis closure duration. This relationship is shown graphically in Figure 29.

Table 32. Mean closure duration ratios for fortis:lenis sounds by group.

POA	Madras Fortis:Lenis Duration	Warm Springs 1 Fortis:Lenis Duration	Warm Springs 2 Fortis:Lenis Duration	Fluent Speaker Fortis:Lenis Duration
bilabial	1.59	1.68	1.78	2.02
coronal	2.18	2.27	2.46	3.77
velar	1.68	1.66	1.76	2.23
All	1.70***	1.73***	1.82***	2.16***

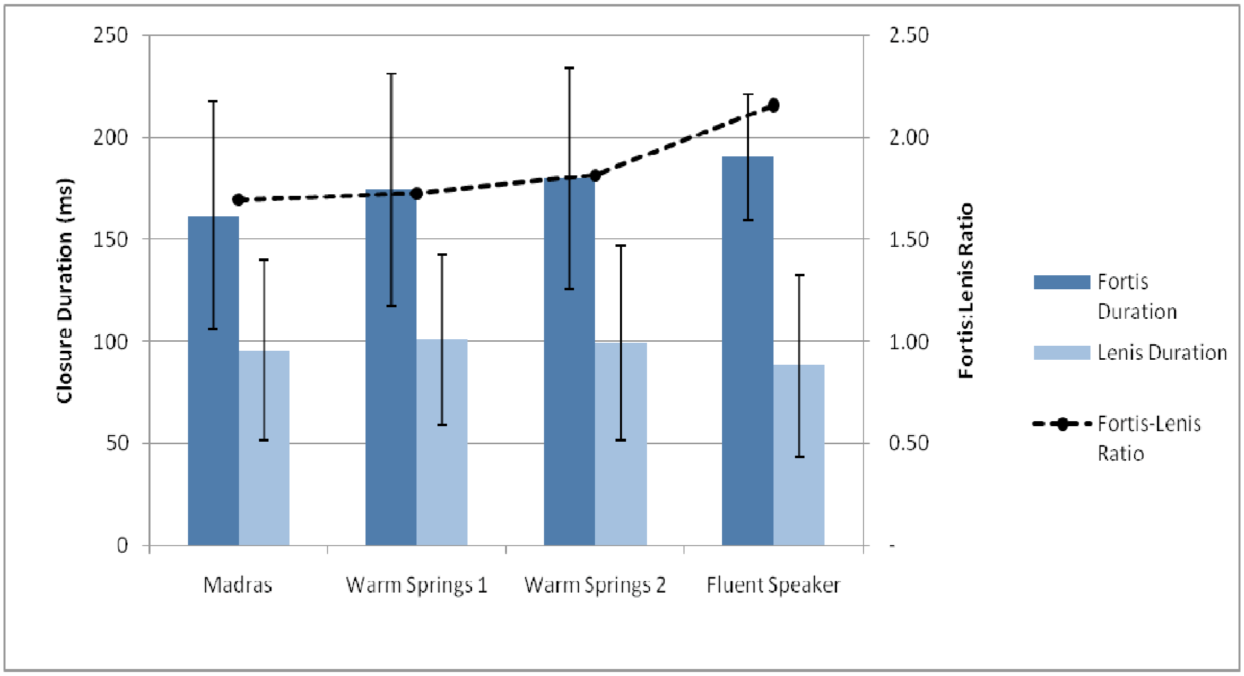

Figure 29. Mean fortis and lenis duration (bars) and fortis to lenis ratio (line) by group. (Error bars indicate ∓ one standard deviation.)

Comparing these results to fortis and lenis VOT results, it appears that while all groups make significant distinctions between fortis and lenis sounds using both VOT and duration, non-speakers tend to place greater importance on differences in VOT, while fluent speakers place greater importance on differences in duration.

3.4.1.3 The fortis and lenis burst

Measurements of the burst for study participants' fortis and lenis productions were the same as those performed on fluent speaker productions and included the relative burst amplitude (A_R), the relative burst intensity (I_R), and the four spectral measures of the burst. (See Chapter 2 for further details about these measures.) Measurements were taken for all intervocalic fortis and lenis obstruents that exhibited a clear burst. Vowel contexts differed. As with the fluent speakers, a script was used to calculate the burst measures for non-speaker productions, based on hand-labeled boundaries for the burst and following vowel. I_R was measured using the mean maximum intensity of each participant's tokens of /a/, and sounds were filtered using a 200 Hz high-pass filter before intensity and spectral measurements were taken. Bursts were pre-emphasized for spectral measures to increase the spectral slope by 6 dB/octave above 1000 Hz. This section makes a comparison of fortis and lenis sounds on each of these measures for each group. The goal is to determine whether non-speakers distinguish fortis and lenis sounds along the same acoustic parameters as fluent speakers.

For relative burst amplitude, an analysis of variance shows a highly significant interaction of Type (lenis or fortis) by Group (Fluent Speaker, Warm Springs 2, Warm Springs 1, and Madras) [$F(3) = 11$, $p < 0.000$]. Table 33 presents the results for mean relative burst amplitude by group for fortis and lenis sounds. The final column shows whether or not the difference between the mean fortis and lenis burst amplitude is significant, based on post-hoc Tukey t-tests.

Table 33. Mean relative burst amplitude for Numu obstruents by group.
(Standard deviations are in parentheses.)

	Mean Fortis Burst Amplitude (Pa)	Mean Lenis Burst Amplitude (Pa)	Difference	Significance of Difference
Fluent Speaker	0.229 (0.16)	0.185 (0.12)	0.044	—
Warm Springs 2	0.163 (0.16)	0.244 (0.15)	-0.081	$p < 0.000$
Warm Springs 1	0.185 (0.14)	0.186 (0.12)	-0.001	—
Madras	0.174 (0.13)	0.210 (0.12)	-0.036	$p < 0.01$

Though fluent speakers do not significantly distinguish fortis and lenis sounds by relative burst amplitude, both the Madras and Warm Springs 2 groups do. Interestingly, the lenis relative burst amplitude is higher than the fortis relative burst amplitude for both of these groups, indicating a higher degree of pressure present in the release of the lenis consonants. It is unclear why these two groups exhibit this pattern, especially as the difference is not significant for the third non-speaker group, Warm Springs 1. It is possible that participants in the Warm Springs 2 group are aware that Numu has fortis and lenis sounds, but do not distinguish them in the way that fluent speakers do. However, this does not explain why the Madras group patterns in the same way. Furthermore, because this measure is acoustic and not articulatory, it is impossible to determine if it is directly correlated to intentional differences in production.

One measure on which fluent speakers did significantly differentiate lenis and fortis sounds was that of relative burst intensity. Again, an analysis of variance shows a significant interaction of Type by Group. Table 34 shows mean relative burst intensity for fortis and lenis sounds by group with results of Tukey post-hoc pairwise comparisons. Only the Fluent Speaker and Warm Springs 2 groups distinguish fortis and lenis sounds significantly by relative burst intensity, with fluent speakers showing the highest magnitude of difference between the two types of sounds.

Table 34. Mean relative burst intensity for Numu obstruents by group.
(Standard deviations are in parentheses.)

	Mean Fortis Burst Intensity (dB)	Mean Lenis Burst Intensity (dB)	Difference	Significance of Difference
Fluent Speaker	17.64 (5.2)	21.16 (7.2)	-3.52	$p < 0.01$
Warm Springs 2	13.77 (5.3)	16.35 (6.4)	-2.58	$p < 0.000$
Warm Springs 1	15.84 (5.2)	17.18 (5.9)	-1.34	—
Madras	15.35 (4.8)	16.15 (5.0)	-0.80	—

Table 35 shows the mean values for measurements of the burst intensity at the coronal place of articulation. Numu coronals are described by Waterman (1911) as dental, and Jongman, Blumstein, & Lahiri (1985) have found a correlation between high relative burst intensity values and dental coronal obstruents in comparison to the relative burst intensity of alveolar coronal obstruents. Indeed, an analysis of variance shows a main effect of Group on relative burst intensity for fortis coronal sounds [$F(3) = 4.5$, $p < 0.01$] and for lenis coronal sounds [$F(3) = 4.6$, $p < 0.01$]. Post-hoc Tukey t-tests reveal that for fortis sounds, the Warm Springs 2 group differs significantly from both the Madras group ($p < 0.05$) and the Fluent Speaker group ($p < 0.05$), and for lenis sounds, the Fluent Speaker group differs significantly from all three non-speaker groups (Madras: $p < 0.05$; Warm Springs 1: $p < 0.05$; Warm Springs 2: $p < 0.01$).

Table 35. Mean relative burst intensity for Numu coronals by group.
(Standard deviations are in parentheses.)

	Madras Burst Intensity (dB)	Warm Springs 1 Burst Intensity (dB)	Warm Springs 2 Burst Intensity (dB)	Fluent Speaker Burst Intensity (dB)
t	14.52 (3.2)	14.37 (4.5)	12.99 (4.5)	15.64 (5.1)
d	13.85 (4.6)	13.80 (4.5)	12.41 (6.1)	17.66 (6.8)

The Fluent Speaker group has higher relative intensity values for coronal sounds than the other non-speaker groups, so we might take this to mean that for lenis sounds, they produce coronals in a more forward (i.e., dental) position than the other groups. For fortis sounds, the coronals of both the Fluent Speaker and the Madras groups are further forward than the coronals of the Warm Springs 2 group. However, some caution is required in interpreting this result. Jongman, Blumstein, & Lahiri (1985) found their most robust results in a comparison of the relative burst intensity of dental and alveolar obstruents that are contrastive in the same language (Malayalam); they found that the procedure is less reliable in languages that have only one coronal obstruent series such as English and Dutch (and in our case, Numu). Furthermore, the effect of vowel context has not been examined here.

The other measures of the burst were spectral and included mean frequency, standard deviation, skewness, and kurtosis. Table 36 shows the mean values for burst mean frequency for each group. An analysis of variance shows a significant interaction of Type by Group [$F(3) = 2.7$, $p < 0.05$] for burst mean frequency, but post-hoc Tukey t-tests reveal that the only group that significantly distinguishes fortis and lenis sounds by mean frequency of the burst is the Madras group, with a 586 Hz difference between fortis and lenis sounds.

Table 36. Mean frequency of the burst for Numu obstruents by group.
(Standard deviations are in parentheses.)

	Mean Fortis Mean Frequency (Hz)	Mean Lenis Mean Frequency (Hz)	Difference	Significance of Difference
Fluent Speaker	3919 (1724)	4402 (1990)	-483	—
Warm Springs 2	4475 (2146)	4126 (2224)	349	—
Warm Springs 1	4406 (2079)	4295 (2053)	111	—
Madras	4881 (2378)	4295 (2457)	586	p < 0.01

For the standard deviation of the burst, only the Fluent Speaker group distinguishes fortis and lenis sounds significantly (see Table 37), a result discussed in Chapter 2.

Table 37. Mean standard deviation of the burst for Numu obstruents by group. (Standard deviations are in parentheses.)

	Mean Fortis Burst SD (Hz)	Mean Lenis Burst SD (Hz)	Difference	Significance of Difference
Fluent Speaker	2982 (1088)	3351 (1378)	-369	p < 0.01
Warm Springs 2	3440 (1024)	3556 (1044)	-116	—
Warm Springs 1	3570 (992)	3487 (996)	83	—
Madras	3612 (1013)	3510 (1109)	102	—

There were no significant interactions of Type by Group for skewness of the burst or for kurtosis of the burst, indicating that none of the groups distinguish fortis and lenis sounds along these acoustic parameters. Table 38 summarizes the measures by which the four groups distinguished fortis and lenis sounds.

Table 38. Acoustic correlates of the fortis v. lenis distinction, by group.

Group	Acoustic fortis v. lenis distinction
Fluent Speakers	Duration VOT Burst Relative Intensity Burst Standard Deviation
Warm Springs 2	Duration VOT Burst Relative Amplitude Burst Relative Intensity
Warm Springs 1	Duration VOT
Madras	Duration VOT Burst Relative Amplitude Burst Mean Frequency

3.4.2 Singleton and geminate nasal duration

All study participants were presented with 28 tokens of singleton /m/, 43 tokens of singleton /n/, and 8 tokens of /ŋ/. They were also presented with 15 tokens of geminate /mm/ and 7 tokens of geminate /nn/. Unlike fluent speakers, the non-speaker groups distinguish onset nasal duration from intervocalic nasal duration [$t(1778)=-11.2$, $p<0.001$]. Therefore, onset duration is presented here separately from intervocalic singleton duration, with measurements of fluent speaker onset and intervocalic singleton nasal duration presented for comparison.

Table 39 shows duration for onset nasals, which are always singletons, by group. We find that the two Warm Springs non-speaker groups have the longest onset nasal duration, followed by the Fluent Speaker group and the Madras group. The main effects of Group and Nasal (m and n) are highly significant by an analysis of variance [Group: $F(3)=16.9$, $p < 0.001$; Nasal: $F(1)=48.5$, $p<0.001$], with no significant interaction of Group by Nasal. However, post-hoc Tukey t-tests reveal that the only significant differences are between the Madras group and the two Warm Springs groups; no non-speaker group differs significantly from the Fluent Speaker group.

Table 39. Mean duration for onset nasals by group.
(Standard deviations are in parentheses.)

	Madras Nasal Duration (ms)	Warm Springs 1 Nasal Duration (ms)	Warm Springs 2 Nasal Duration (ms)	Fluent Speaker Nasal Duration (ms)
m	62.79 (39.5)	82.08 (36.6)	91.39 (39.5)	75.52 (33.9)
n	85.15 (47.5)	103.37 (53.3)	105.73 (50.9)	100.93 (43.6)
All	72.92 (44.7)	91.61 (46.0)	97.77 (45.4)	87.00 (40.4)

Mean durations for intervocalic singleton nasals are shown in Table 40. Note that for the non-speaker groups, these are substantially longer than onset singleton nasals. They are also much longer than the Fluent Speaker group for all nasals. This result is expected for /m/ and /n/, as Waterman (1911) describes these consonants as having a shorter duration in Numu than in English. Thus, transfer effects from English would cause non-speakers to produce longer bilabial and coronal nasals in Numu. However, it is a surprising result for Numu /ŋ/, as Waterman (1911) describes Numu /ŋ/ as longer than its English counterpart. Note that like the fluent speakers, all non-speaker groups produce longer mean duration for singleton /ŋ/ than for the other two singleton nasals.

Table 40. Mean duration for intervocalic singleton nasals by group.
(Standard deviations are in parentheses.)

	Madras Nasal Duration (ms)	Warm Springs 1 Nasal Duration (ms)	Warm Springs 2 Nasal Duration (ms)	Fluent Speaker Nasal Duration (ms)
m	109.49 (66.5)	117.07 (27.7)	134.70 (36.8)	82.65 (27.2)
n	101.24 (49.2)	100.83 (38.6)	112.62 (35.8)	72.28 (22.9)
ŋ	131.09 (75.2)	131.10 (36.1)	127.91 (47.3)	104.61 (26.2)
All	107.11 (57.8)	107.64 (38.0)	118.93 (38.7)	79.12 (26.5)

An analysis of variance in the intervocalic singleton nasal duration data shows that there is a significant main effect of both Group and Nasal (m, n, and ŋ) [Group: $F(3)=14.2$, $p < 0.001$; Nasal: $F(2)=23.8$, $p<0.001$], with no significant interaction. Post-hoc Tukey pairwise comparisons show that the Fluent Speaker and Warm Springs 2 groups are significantly different from each other and all other groups, while the Warm Springs 1 and Madras groups are not significantly different from each other.

Table 41 provides the mean durations for geminate nasals by group. Here, as with the other nasals, the Warm Springs 2 group exhibits the longest duration. However, the difference between the Warm Springs 2 group and the Fluent Speaker group is not significant. The only significant difference among the groups is between the Warm Springs 2 and Madras groups.

Table 41. Mean duration for geminate nasals by group.
(Standard deviations are in parentheses.)

	Madras Nasal Duration (ms)	Warm Springs 1 Nasal Duration (ms)	Warm Springs 2 Nasal Duration (ms)	Fluent Speaker Nasal Duration (ms)
mm	132.26 (45.2)	144.89 (34.6)	151.13 (48.2)	146.93 (39.7)
nn	149.69 (57.8)	141.74 (42.0)	158.04 (27.5)	159.02 (28.2)
All	137.78 (50.1)	143.91 (36.9)	153.29 (42.8)	150.75 (36.5)

If we compare the ratios of intervocalic singleton to geminate nasals for all groups (see Table 42), we find that the fluent speakers make the greatest distinction, though all groups make a highly significant ($p<0.001$) distinction between the two. Note that these ratios are not as high as the mean closure duration ratios for fortis to lenis obstruents in any group. This is likely an artifact of the fact that fortis and lenis obstruents differ in voicing in addition to phonological length; voiceless stops tend to have longer closure duration than voiced stops (Pickett, 1999). Numu singleton and geminate nasal consonants, on the other hand, do not differ in voicing.

Table 42. Mean duration ratios for intervocalic long:short nasal duration by group.
(*** indicates significance at the $p<0.001$ level)

	Madras Nasal Ratio	Warm Springs 1 Nasal Ratio	Warm Springs 2 Nasal Ratio	Fluent Speaker Nasal Ratio
bilabial	1.21	1.24	1.12	1.78
coronal	1.48	1.41	1.40	2.20
All	1.29***	1.34***	1.29***	1.91***

Figure 30 represents the difference between mean onset, intervocalic singleton, and geminate nasal duration for each group. The Warm Springs 2 group consistently has the longest nasal duration, which perhaps reflects both the effect of transfer from English for singleton nasals (as seen in the other non-speaker groups) and the effect of hypercorrection in all nasal series, due to a general knowledge that Numu has geminate nasals. However, as we have seen, the Warm Springs 2 group is not always significantly different from the other groups, and the resulting difference between their mean intervocalic long and short nasal durations is comparable to the other non-speaker groups.

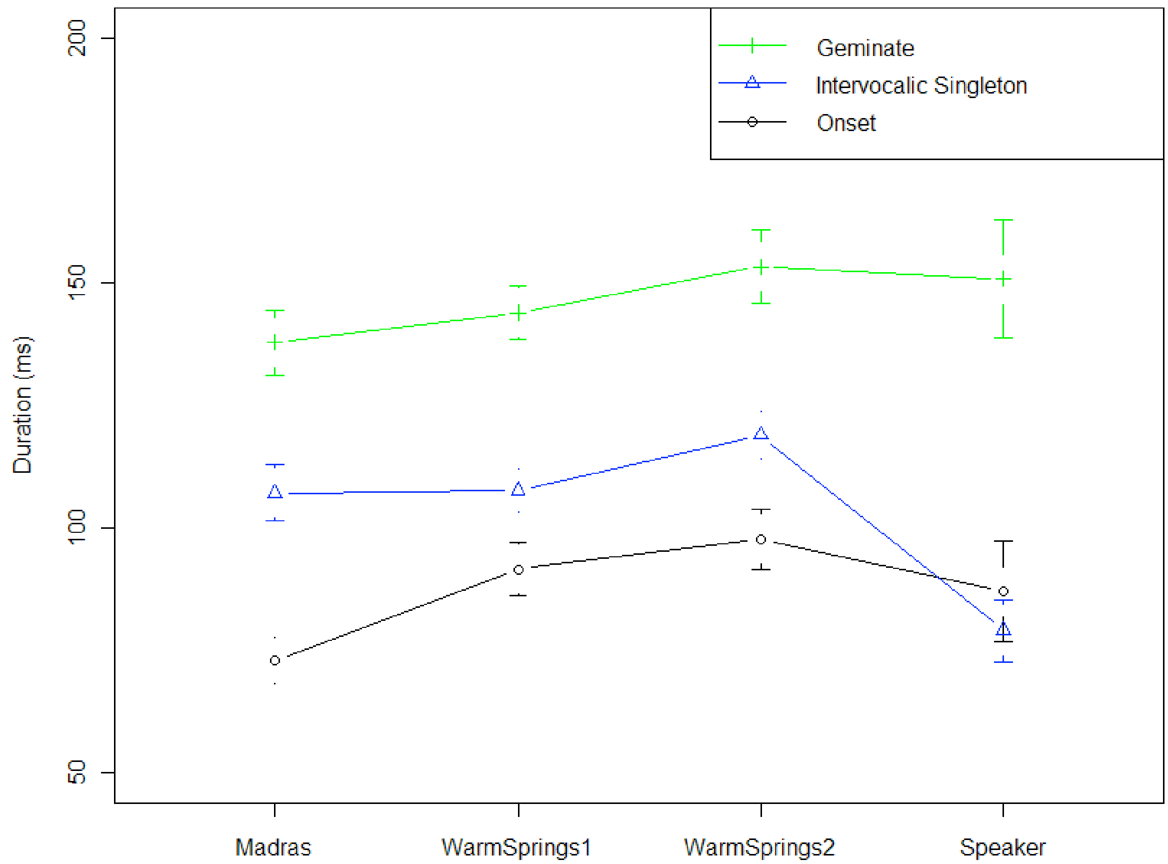

Figure 30. Mean nasal duration for each nasal type by group.
(Error bars indicate the 95% confidence interval.)

3.4.3 Onset VOT

Onset VOT was examined in 19 tokens of /p/, 68 tokens of /t/, and 41 tokens of /k/ for each participant. Results are show in Table 43, where we see the longest mean VOT in the Fluent Speaker group.

Table 43. Mean onset obstruent VOT by group.
(Standard deviations are in parentheses.)

	Madras Onset VOT (ms)	Warm Springs 1 Onset VOT (ms)	Warm Springs 2 Onset VOT (ms)	Fluent Speaker Onset VOT (ms)
p	13.92 (48.0)	-2.32 (55.5)	19.73 (32.2)	16.25 (8.0)
t	7.21 (51.1)	-9.84 (56.4)	8.51 (46.1)	14.40 (6.8)
k	35.70 (48.5)	29.86 (54.9)	35.61 (48.7)	37.81 (17.9)
All	16.59 (51.4)	3.74 (58.6)	18.58 (46.8)	22.04 (15.8)

However, the only mean VOT that shows significant differences from the other means is that of the Warm Springs 1 group. This group had several members who produced a substantial number of pre-voiced tokens, as is especially evident for /p/ and /t/ in Figure 31, resulting in lower mean scores overall. Study participants in the other two non-speaker groups produced occasional pre-voiced tokens as well, which accounts for their generally lower mean VOT values than those of the Fluent Speaker group, who produced no pre-voiced tokens.

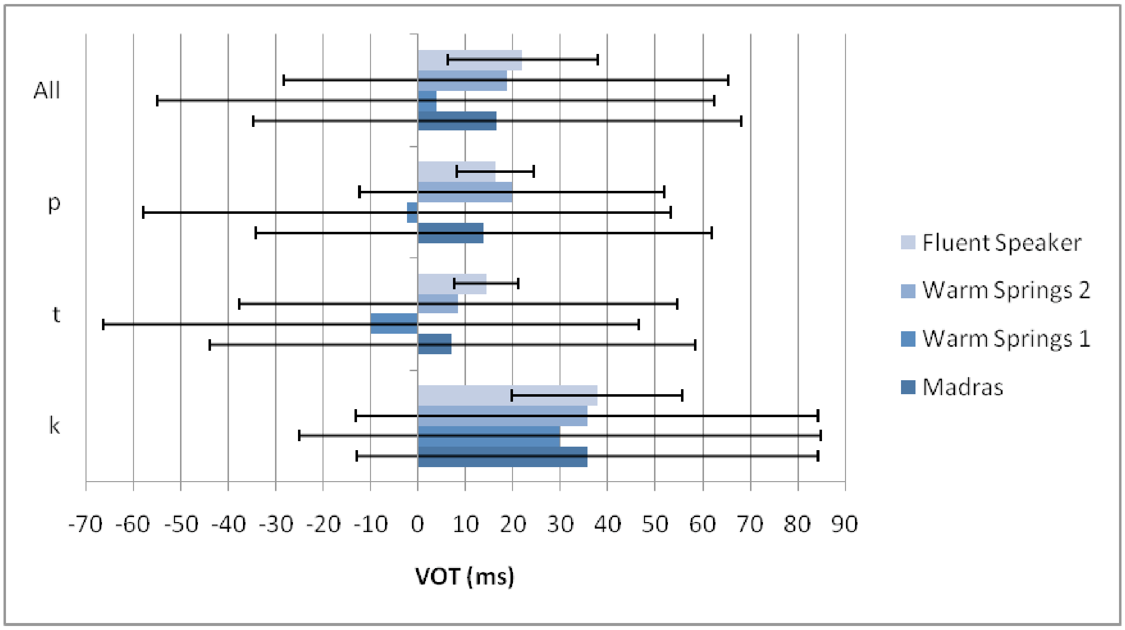

Figure 31. Mean VOT for Numu onsets produced by each group, by consonant. (Error bars indicate ∓ one standard deviation.)

Standard deviations are substantially larger (sometime by a factor of as much as 8) in the non-speaker groups than in the Fluent Speaker group, indicating a great deal of fluctuation between long VOTs and short VOTs for non-speakers. It is possible that non-speakers perceived voiced onset obstruents rather than the Numu voiceless unaspirated obstruents, as the latter are unlicensed in onset position in English. As a result, non-speakers sometimes produced onsets with negative or very short VOT values, and when they perceived voiceless onsets, they produced them with aspiration as in English, resulting in long VOT values. This hypothesis is supported by the presence of a great many negative VOT values in the non-speakers' dataset.

3.4.4 Conclusion

The predicted pattern Madras < Warm Springs 1 < Warm Springs 2 < Fluent Speakers (or vice versa) held true for some, but not all, subphonemic measures of consonants. Fortis VOT decreases with Numu experience, as does the difference between fortis and lenis VOT. Similarly, fortis duration increases with Numu experience, and the ratio of fortis to lenis duration increases with experience as well. However, the Warm Springs groups threw off the pattern for lenis VOT, duration, and measures of the burst. The Warm Springs 2 group also consistently had the highest nasal durations (though the difference between that group and other groups was not always significant), and the Warm Springs 1 group had the lowest onset obstruent VOT values. One hypothesis that will be explored in further detail in Chapter 4 is that the Warm Springs groups may exhibit effects of hypercorrection due to their exposure to social norms associated with this and other Native American languages. These effects of hypercorrection may also interact with transfer effects from English.

3.5 Phonetic contrasts: Vowels

This section explores duration and qualitative measures of Numu stressed vowels as produced by non-native speakers in comparison to vocalic productions by fluent speakers. As with the consonants, it is expected that productions will follow a pattern of experience, with the Warm Springs 2 group producing vowels that are most like fluent speaker vowels, followed by the Warm Springs 1 group, and finally the Madras group.

All study participants were presented with 50 tokens of short /i/, 6 tokens of long /iː/, 32 tokens of short /ɨ/, 23 tokens of long /ɨː/, 14 tokens of short /u/, 6 tokens of long /uː/, 30 tokens of short /ɔ/, 9 tokens of long /ɔː/, 64 tokens of short /a/, and 20 tokens of long /aː/. Measurements made on participants' productions were categorized according to the input regardless of output in order to compare their Numu vowel space to that of fluent speakers. For example, if the input was /ɨ/, but the participant produced /u/, it was still categorized as /ɨ/ so that the lower F2 values would be reflected in that participant's data for /ɨ/.

Vowel quality is examined first in the next section, followed by long and short stressed vowel duration. Finally, an analysis comparing these two descriptive dimensions of vowel production is presented in §3.5.3.

3.5.1 Vowel quality

Mean first, second, and third formant values were measured by hand in Praat (Boersma & Weenink, 2008) for all study tokens. The measurements were made over the middle section of each stressed vowel in order to mitigate the effects of preceding and following consonants. Results for each vowel are given in Table 44. The mean F2 and F1 values are also plotted in Figure 32. Though it appears that the non-speaker groups have lower F1 and F2 values for all vowels, this is not a valid comparison, as there are male participants in the non-speaker groups, but no male fluent speakers. Indeed, an analysis of variance reveals a significant effect of Gender on both F1 [$F(1) = 140$, $p<0.001$] and F2 [$F(1) = 121$, $p<0.001$].

Table 44. Mean F1, F2, and F3 values for each Numu vowel by group.
(Values given in Hertz; standard deviations are in parentheses.)

	Madras			Warm Springs 1			Warm Springs 2			Fluent Speaker		
	F1	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*
i	337	2330	2988	343	2247	2904	357	2466	3030	409	2352	2855
	(64)	*(413)*	*(323)*	*(52)*	*(342)*	*(352)*	*(61)*	*(320)*	*(246)*	*(63)*	*(279)*	*(151)*
iː	341	2303	3029	338	2398	3056	332	2606	3155	423	2446	2840
	(63)	*(542)*	*(297)*	*(50)*	*(332)*	*(396)*	*(59)*	*(268)*	*(307)*	*(38)*	*(121)*	*(144)*
ɨ	407	1458	2603	399	1381	2744	412	1417	2847	512	1625	2771
	(133)	*(462)*	*(479)*	*(90)*	*(354)*	*(413)*	*(118)*	*(406)*	*(369)*	*(105)*	*(290)*	*(212)*
ɨː	370	1466	2608	361	1452	2691	371	1482	2850	453	1712	2677
	(79)	*(357)*	*(394)*	*(65)*	*(329)*	*(352)*	*(74)*	*(292)*	*(298)*	*(79)*	*(209)*	*(142)*
u	352	1036	2608	360	1104	2691	357	1073	2855	498	1014	2746
	(92)	*(216)*	*(446)*	*(80)*	*(243)*	*(435)*	*(100)*	*(178)*	*(324)*	*(124)*	*(179)*	*(289)*
uː	345	1153	2612	332	1226	2702	339	1091	2839	427	1056	2740
	(44)	*(208)*	*(358)*	*(43)*	*(256)*	*(281)*	*(51)*	*(205)*	*(214)*	*(60)*	*(181)*	*(60)*
ɔ	483	1144	2614	453	1138	2719	478	1090	2834	648	1131	2613
	(131)	*(235)*	*(389)*	*(99)*	*(202)*	*(320)*	*(125)*	*(211)*	*(365)*	*(76)*	*(161)*	*(291)*
ɔː	503	1063	2603	458	1029	2842	430	974	2851	638	1072	2584
	(149)	*(196)*	*(403)*	*(117)*	*(152)*	*(434)*	*(122)*	*(142)*	*(373)*	*(166)*	*(183)*	*(368)*
a	575	1311	2562	579	1358	2731	621	1393	2759	760	1514	2688
	(166)	*(261)*	*(481)*	*(140)*	*(228)*	*(481)*	*(195)*	*(253)*	*(418)*	*(81)*	*(177)*	*(209)*
aː	644	1286	2603	633	1334	2795	632	1340	2827	880	1418	2753
	(183)	*(219)*	*(461)*	*(171)*	*(226)*	*(580)*	*(234)*	*(194)*	*(471)*	*(57)*	*(147)*	*(290)*

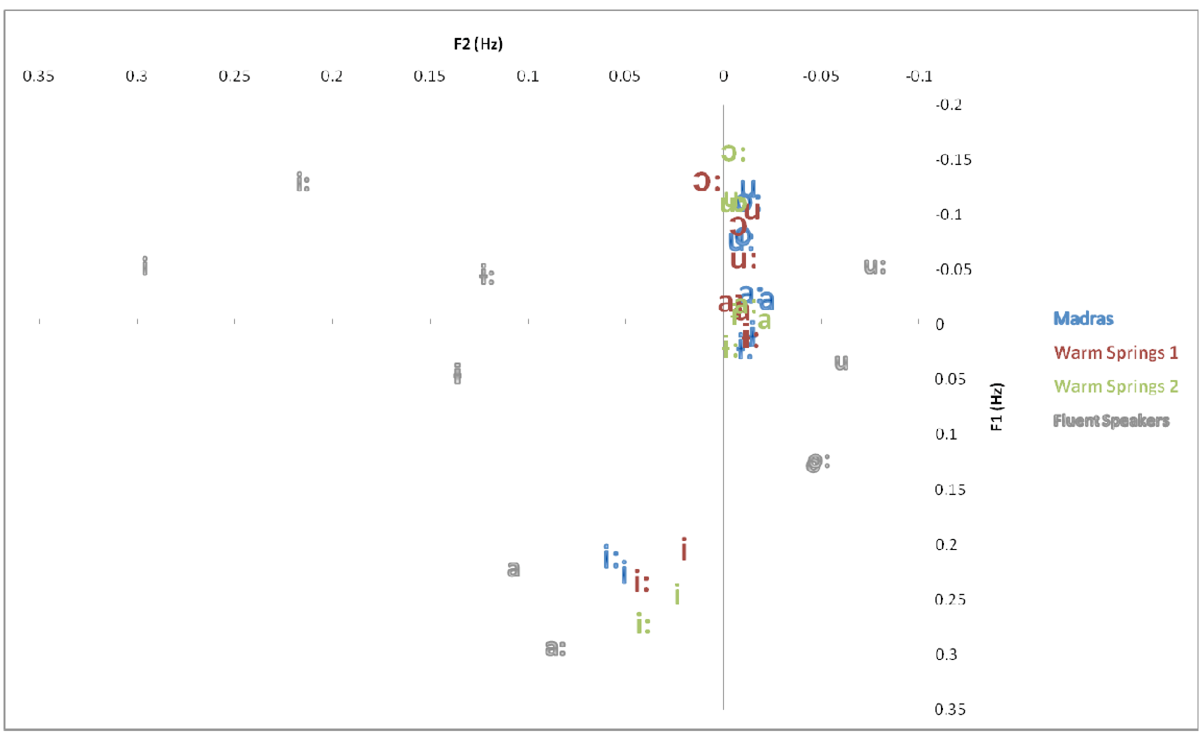

Figure 32. Mean F2 and F1 values for all groups.
(Vowel symbol corresponds to mean values.)

To address the issue of gender disparities in the data set, all F1, F2, and F3 values were normalized using the log-mean normalization method described in Chapter 2 for the SOAM (see Equation 3). Similarity differences among all four groups along the F1, F2, and F3 dimensions were calculated and a multi-dimensional scaling analysis was employed using R (R Development Core Team, 2009). Comparisons were made for the most crowded areas of the vowel space, namely high vowels and back vowels, as well as a summary comparison of all vowels. The first two dimensions of the multi-dimensional analysis are plotted in Figure 33 for high vowels, Figure 34 for back vowels, and Figure 35 for all vowels. Dashed blue lines encircle fluent speaker vowels and vowel clusters, and solid red lines encircle non-speaker vowels and vowel clusters. Each of these figures is accompanied by a second figure showing results of hierarchical clustering of the data (Figures 36 for high vowels, 37 for back vowels, and 38 for all vowels), which more clearly represents the distances between vowels.

In Figure 33, it appears that fluent speaker and non-speaker /i/s are highly distinct, which is supported by the cluster analysis in Figure 36. The cluster analysis also shows that Speaker /ɨ/ and /ɨː/ are distinct from non-speaker /ɨ/, with non-speaker /ɨ/s closer to speaker /u/; indeed, all non-speaker productions of long and short /ɨ/ and /u/ are closer to speaker /u/ than to speaker /ɨ/. This is an expected result, as /ɨ/ is not a distinct phoneme in English, and is therefore predicted to be re-categorized as /u/ for English speakers. Membership in either of the Warm Springs groups does not appear to confer an advantage in this case. However, non-speakers maintain at least some distinction between their productions of /ɨ/, /ɨː/, /u/, and /uː/.

For the back vowels, it appears in Figure 34 and in Figure 37 that non-speaker /a/ and /aː/ are very distinct from speaker /a/ and /aː/, instead clustering with other non-speaker productions of /u/ and /ɔ/ (for short /a/) and /uː/ and /ɔː/ (for long /aː/). It is possible that non-speakers misinterpret phonetic [ɔ] as [a] or [u]. Some of the most clustered non-speaker groups for the back vowels contain both /ɔ/ and /u/, indicating a general lack of distinction between these vowels for non-speakers. But note that the closest cluster to speaker /u/ is a cluster of speaker /ɔ/ and /ɔː/, indicating closeness for the fluent speakers as well. None of the non-speaker groups are distinguished from other non-speaker groups.

The most striking aspect of the final scatterplot figure, Figure 35, is that while speaker vowels are very spread out (with the exception perhaps of /ɨ/ and /i/), indicating that they are distinct from each other along F1, F2, and F3 dimensions, non-speaker vowels are clustered into three distinct areas: /i/ and /iː/, /a/ and /ɨ/, and /u/ and /ɔ/. The latter two clusters are very close. These observations are confirmed in the hierarchical cluster analysis presented in Figure 38, which shows three clusters of non-speaker /i/ and /iː/, /a/ and /ɨ/, and /u/ and /ɔ/. It appears that participants in the non-speaker groups frequently confuse back and central vowels, an observation that is confirmed in listening to their productions. Again, there is no apparent advantage to being in either of the Warm Springs non-speaker groups.

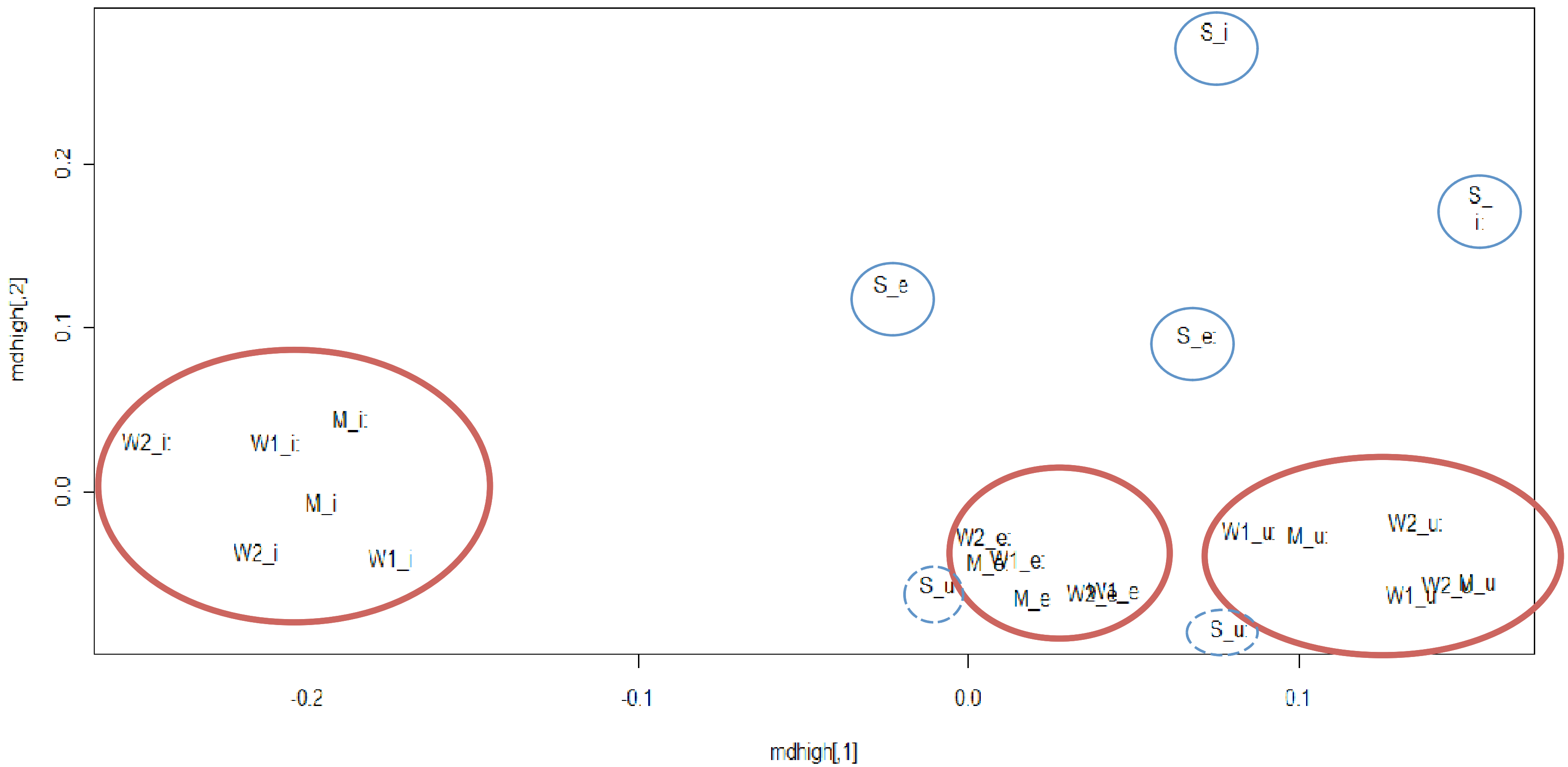

Figure 33. Summary plot of dimension 1 (horizontal) and dimension 2 (vertical) of the multi-dimensional scaling similarity distances of Numu high vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, e = ɨ, e: = ɨ:*)

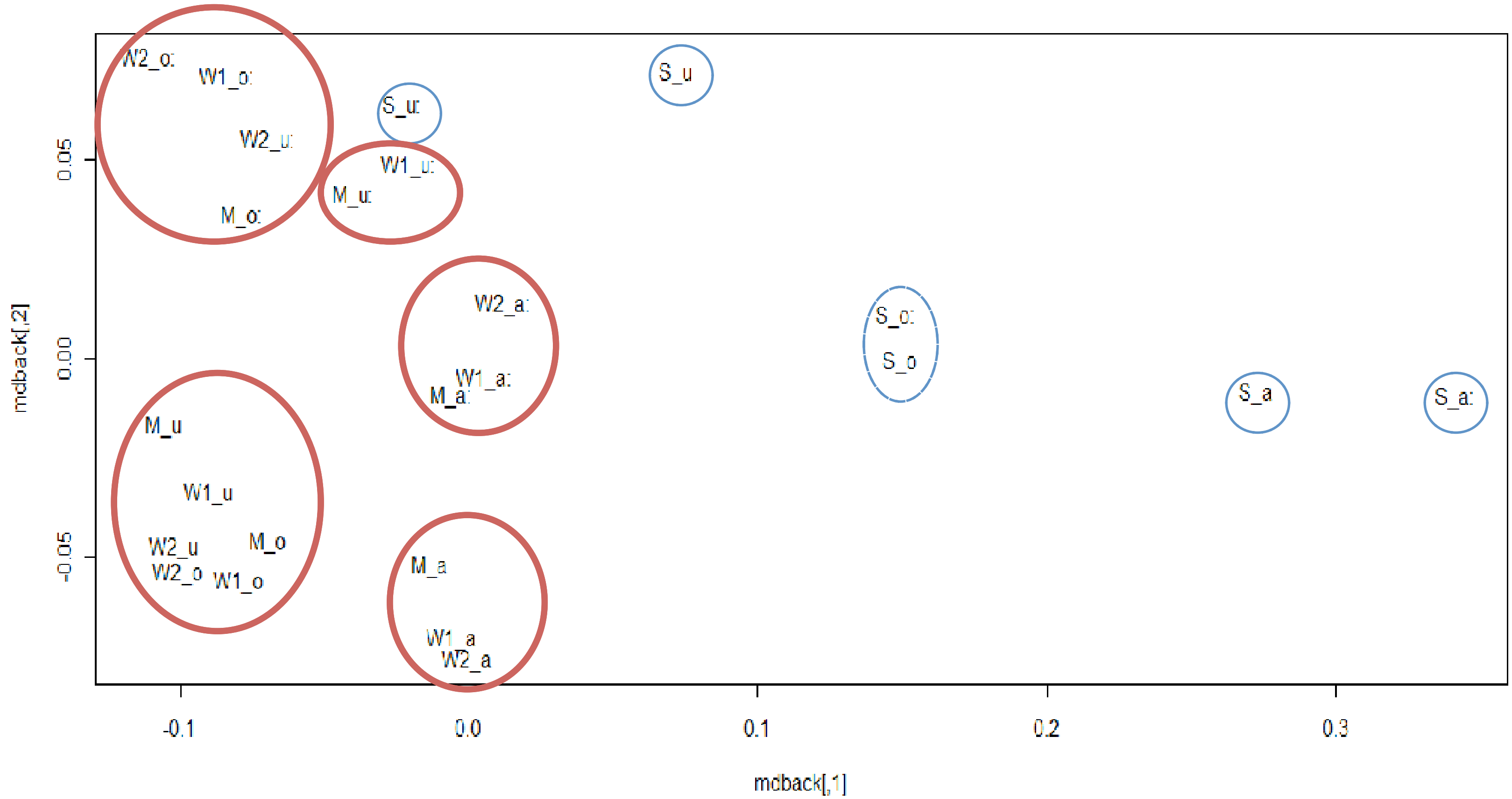

Figure 34. Summary plot of dimension 1 (horizontal) and dimension 2 (vertical) of the multi-dimensional scaling similarity distances of Numu back vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, o =ɔ , o: = ɔ:*)

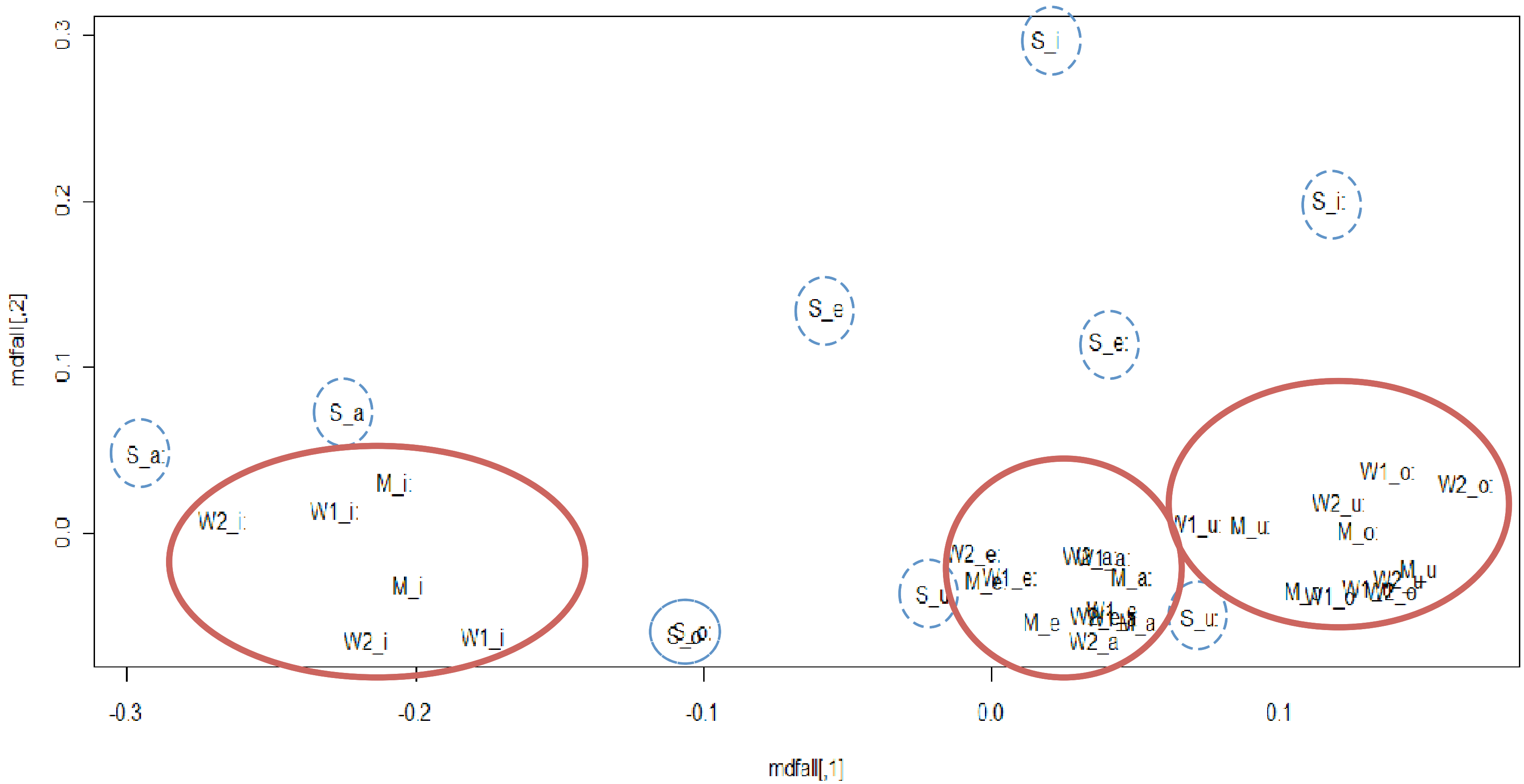

Figure 35. Summary plot of dimension 1 (horizontal) and dimension 2 (vertical) of the multi-dimensional scaling similarity distances of all Numu vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, e = ɨ, e: = ɨ:, o =ɔ, o: = ɔ:*)

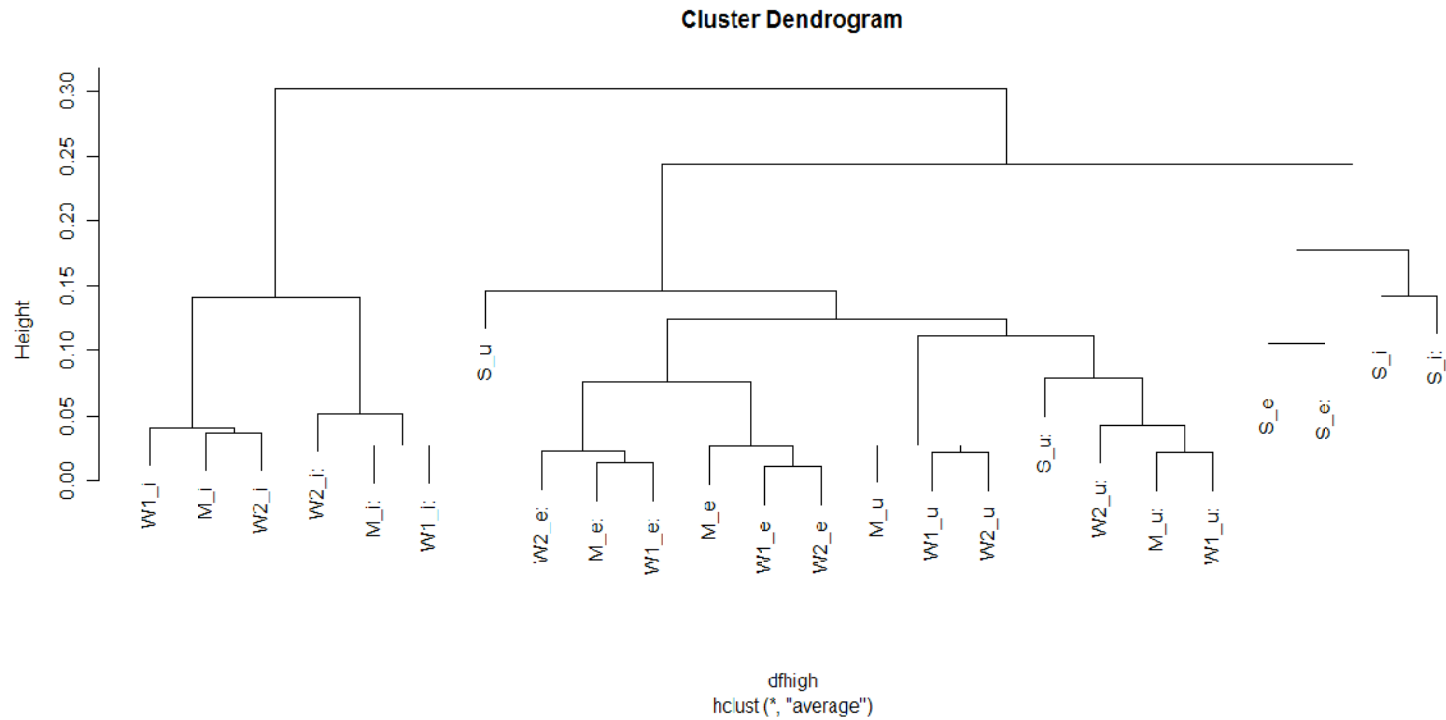

Figure 36. Results of a hierarchical clustering analysis of the multi-dimensional scaling similarity distances of Numu high vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, e = ɨ, e: = ɨ:*)

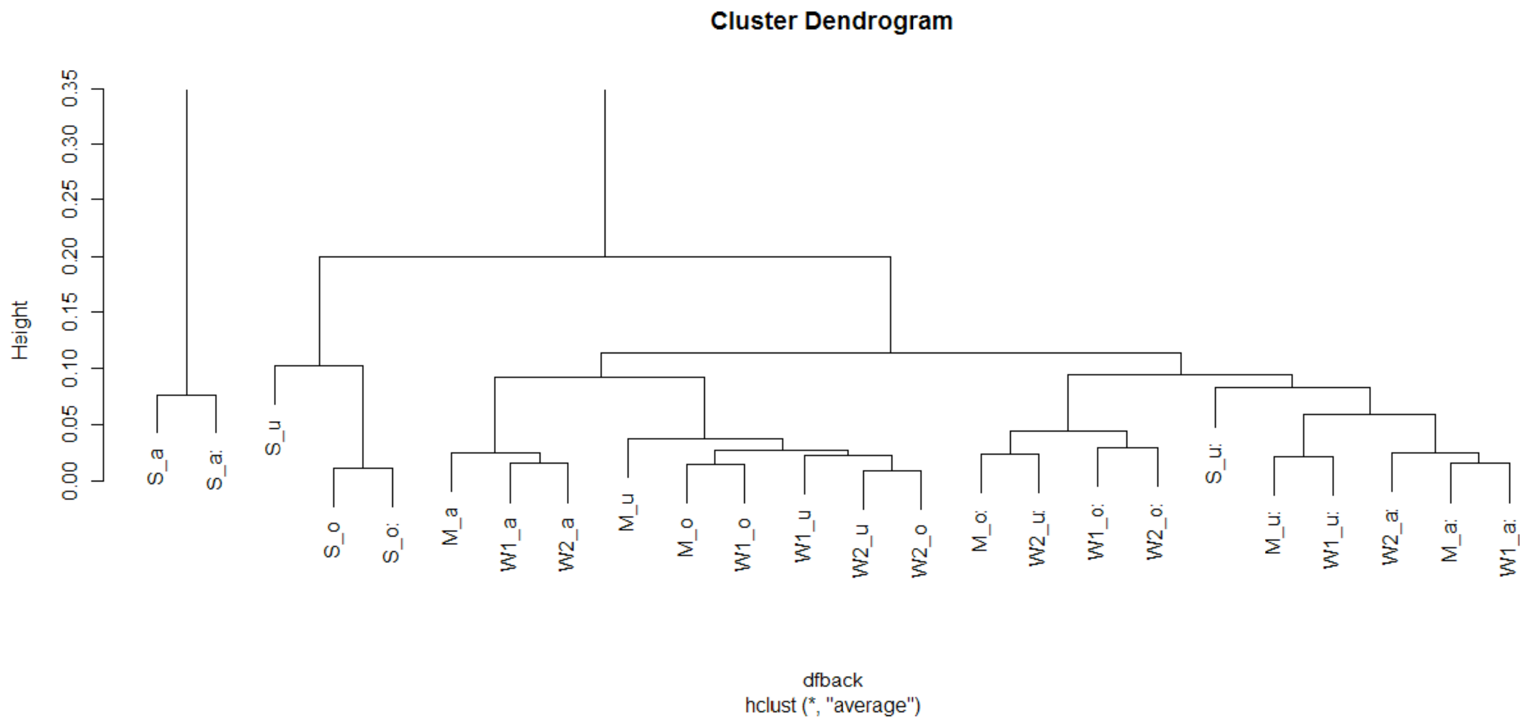

Figure 37. Results of a hierarchical clustering analysis of the multi-dimensional scaling similarity distances of Numu back vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, o =ɔ , o: = ɔ:*)

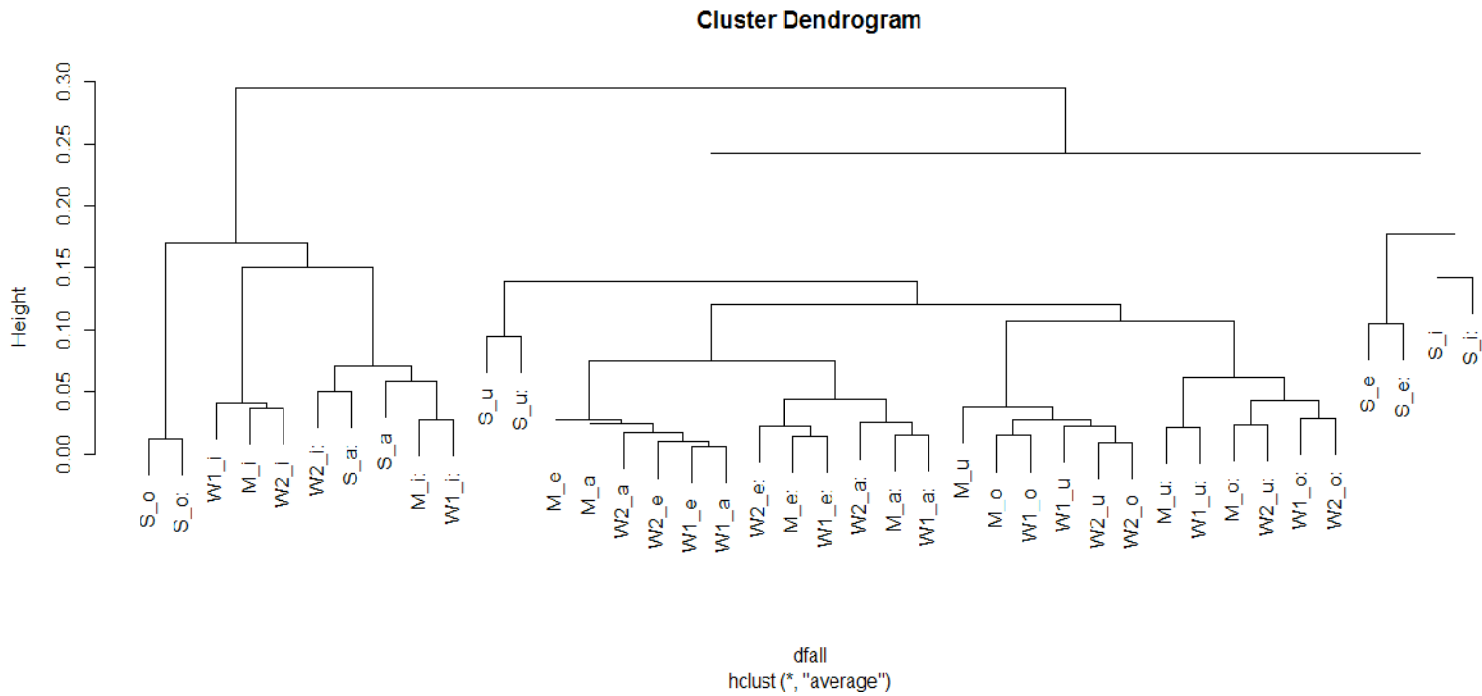

Figure 38. Results of a hierarchical clustering analysis of the multi-dimensional scaling similarity distances of all Numu vowels.

(*M = Madras, W1 = Warm Springs 1, W2 = Warm Springs 2, S = Fluent Speaker, e = ɨ, e: = ɨ:, o =ɔ, o: = ɔ:*)

3.5.2 Vowel duration

Monophthong duration was measured for all participant tokens from the beginning of the first vocalic glottal pulse until the closure of the articulators for word-medial stressed vowels, and until the end of the final visible glottal pulse for word-final stressed vowels. A Praat script was used to record vowel duration for all stressed vowels; boundaries were labeled by hand. Like fluent speakers, non-speaker groups produce significantly longer vowels in final position than in word-medial position for both short vowels [t(4493)=29.9, p<0.001] and long vowels [t(228)=9.9, p<0.001]. As discussed in Chapter 2, this word-final lengthening is expected of English speakers and may be a universal tendency (see, for example, Oller, 1973; Johnson & Martin, 2001). Results for the mean duration of short vowels in both positions is presented in Table 45 by group.

Table 45. Mean duration for short vowels by group.
(Standard deviations are in parentheses.)

	Madras Vowel Duration (ms)		Warm Springs 1 Vowel Duration (ms)		Warm Springs 2 Vowel Duration (ms)		Fluent Speaker Vowel Duration (ms)	
	Medial	*Final*	*Medial*	*Final*	*Medial*	*Final*	*Medial*	*Final*
i	114 (46)	170 (41)	115 (38)	170 (43)	122 (37)	175 (47)	118 (26)	168 (36)
ɨ	126 (44)	157 (40)	129 (50)	172 (41)	123 (41)	172 (46)	126 (34)	163 (38)
u	132 (31)	160 (37)	137 (34)	164 (41)	110 (24)	159 (42)	135 (11)	146 (35)
ɔ	122 (55)	162 (53)	124 (43)	171 (49)	128 (51)	168 (47)	124 (36)	163 (42)
a	127 (47)	149 (36)	122 (40)	155 (38)	124 (38)	154 (43)	133 (29)	158 (37)
All	122 (48)	157 (41)	122 (42)	163 (42)	123(41)	164 (45)	126 (31)	161 (37)

For short medial vowels, analysis of variance show no significant main effect of Group, though there is a main effect of Vowel (i, ɨ,u, ɔ, and a) [F(4)=4.9, p<0.001]; there is no significant interaction. Short final vowels appear to break the expected pattern, with the Warm Springs groups exhibiting longer overall durations than either the Madras or Fluent Speaker groups. An analysis of variance in final vowels shows a marginal main effect of Group [F(3)=3.3, p<0.05] and a highly significant main effect of Vowel [F(4)=21.1, p<0.001]; again, there is no significant interaction of Group by Vowel. A post-hoc Tukey pairwise comparison reveals marginally significant differences between short final vowel duration produced by the Madras and Warm Springs 1 groups, and between the Madras and Warm Springs 2 groups. There is no significant difference between the Fluent Speaker group and any of the the non-speaker groups for short final vowel duration.

Recall that participants with previous exposure to Ichishkin and Kiksht may have an advantage in the production of long vowels, as vowel length is contrastive in both of these languages. Indeed, an analysis of variance in long vowel duration among participants with previous Ichishkin or Kiksht experience, participants in the Warm Springs 1 group with no previous Ichishkin or Kiksht experience, and participants in the Warm Springs 2 group, shows that there is no significant difference between members of the Warm Springs 2 group and participants with previous Ichishkin or Kiksht experience. Both of these groups have significantly longer medial long vowels (30 milliseconds and 31 milliseconds, respectively) than participants without previous Ichishkin, Kiksht, or Numu experience [F(2)=7.0, p<0.01]. There is no significant difference among the Warm Springs groups for final long vowels, which is not surprising given that final vowel lengthening is likely a universal phenomenon (Johnson & Martin, 2001). Because the focus of this study is on the effects of previous Numu experience on non-speaker productions of Numu, it is beyond the scope of this study to conduct an extended analysis of the effects of other languages on Numu productions. However, it is worth noting that because 5 of the 8 members of the Warm Springs 1 group have previous experience with Ichishkin or Kiksht, medial long vowel durations are elevated in this group.

Mean durations for medial and final long vowels in the four previously established groups are given in Table 46. For medial vowels, the Warm Springs 2 group has the longest overall duration, while the Fluent Speaker group has the longest overall duration for final vowels. An analysis of variance in medial long vowels shows a highly significant main effect of Group [F(3)=30.9, p<0.001] and of Vowel (iː, ɨː, uː, ɔː, and aː) [F(4)=19.8, p<0.001], with no significant interaction. There is no significant difference between the Fluent Speaker group and either Warm Springs group, though there is a marginally significant difference (p<0.05) between the Warm Springs 1 and Warm Springs 2 groups, and the Madras group is highly significantly different (p<0.001) from all other groups for medial long vowels. This result must be regarded with some caution, however, as the Warm Springs groups' previous experience with AIE may give them an advantage in the production of long vowels (see the discussion of AIE in §3.2.2.2). Phonological research on AIE as it is spoken in Warm Springs would be required to determine if this is indeed the case.

Table 46. Mean duration for long vowels by group.
(Standard deviations are in parentheses.)

	Madras Vowel Duration (ms)		Warm Springs 1 Vowel Duration (ms)		Warm Springs 2 Vowel Duration (ms)		Fluent Speaker Vowel Duration (ms)	
	Medial	*Final*	*Medial*	*Final*	*Medial*	*Final*	*Medial*	*Final*
iː	169 (50)	358 (86)	170 (49)	392 (82)	197 (60)	382 (99)	214 (37)	349 (53)
ɨː	186 (59)	210 (45)	213 (60)	234 (43)	231 (69)	256 (69)	214 (51)	302 (57)
uː	225 (91)	n/a	253 (76)	n/a	253 (80)	n/a	238 (60)	n/a
ɔː	205 (100)	244 (49)	266 (101)	220 (56)	266 (113)	236 (53)	274 (117)	316 (57)
aː	184 (66)	n/a	208 (75)	n/a	231 (78)	n/a	230 (64)	n/a
All	191 (73)	270 (94)	220 (77)	293 (100)	236 (82)	301 (101)	231 (71)	321 (56)

For final long vowels, an analysis of variance shows a marginal main effect of Group [F(3)=3.8, p<0.05] and a highly significant main effect of Vowel [F(4)=103.0, p<0.001], with no significant interaction. The only between-group difference is a marginally significant (p<0.05) difference between the Madras and Fluent Speaker groups

Long to short vowel ratios are computed in Table 47 for medial and final vowels. Fluent speakers have the largest final vowel ratio, followed by Warm Springs 2, Warm Springs 1, and the Madras group. For medial vowels, however, the Warm Springs 2 group has the largest ratio, followed by the Fluent Speakers group, and the other two non-speaker groups in order of experience. These relationships are expressed graphically in Figure 39, with the medial and final vowel ratios plotted as lines on the right-hand vertical axis, and the mean durational values for each vowel series (short medial, short final, long medial, long final) plotted as bars on the left-hand axis.

Table 47. Mean long to short vowel ratios for medial and final vowels by group.

	Madras Long:Short Vowel Ratio		Warm Springs 1 Long:Short Vowel Ratio		Warm Springs 2 Long:Short Vowel Ratio		Fluent Speaker Long:Short Vowel Ratio	
	Medial	*Final*	*Medial*	*Final*	*Medial*	*Final*	*Medial*	*Final*
i	1.48	2.11	1.48	2.31	1.61	2.18	1.81	2.08
ɨ	1.48	1.34	1.65	1.36	1.88	1.49	1.70	1.85
u	1.70	n/a	1.85	n/a	2.30	n/a	1.76	n/a
ɔ	1.68	1.51	2.15	1.29	2.08	1.40	2.21	1.94
a	1.45	n/a	1.70	n/a	1.86	n/a	1.73	n/a
All	1.57	1.72	1.80	1.80	1.92	1.84	1.84	2.00

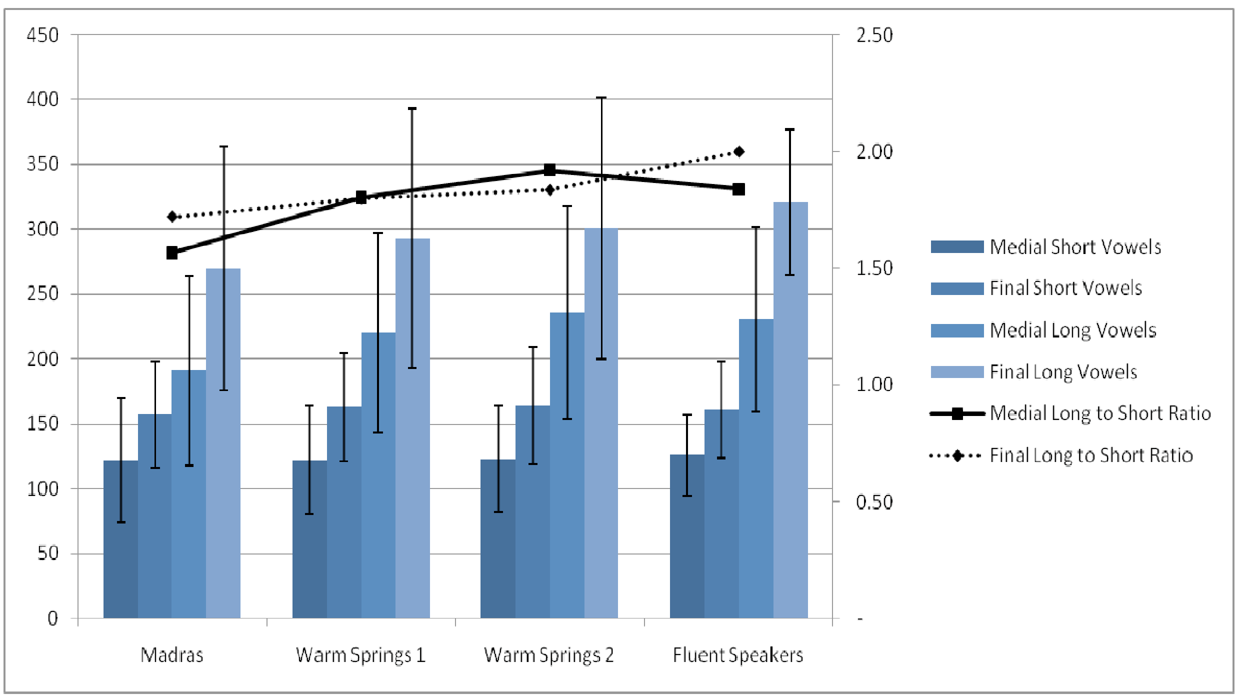

Figure 39. Comparison of mean vowel duration for short and long medial and final vowels (bars –error bars indicate ∓ one standard deviation) and ratios of long to short medial and final vowels (lines).

3.5.3 Quality vs. duration

In the previous two sections, we have examined the differences in both spectral and durational measures of Numu vowels among the non-speaker and fluent speaker groups. We have found that for spectral measures, there seems to be no special advantage of experience among the non-speaker groups, which did not distinguish different vowels as robustly as the fluent speakers. We have also found that all groups differentiate long and short vowels on durational measures, with the greatest differences found in the groups with the most Numu experience. In this section, we look at both of these measures in a subset of the Numu long and short vowels. In Chapter 2, the spectral overlap assessment method (SOAM) developed by Wassink (2006) was used to quantify the interactions of temporal and spectral measures for fluent speakers. This method is repeated here for the non-speaker groups in order to compare the degree to which they use quantity and quality to differentiate long and short vowel pairs.

The SOAM is described in detail in Wassink (2006), and its use for the purposes of this study is described in Chapter 2. Briefly, the SOAM incorporates normalized duration values and log normalized spectral values into two models: the first is a two-dimensional model that calculates the overlap of normalized F1 and F2 values for a given long and short vowel pair, and the second is a three-dimensional model that adds normalized durational values to the two-dimensional model. The amount of overlap between the long and short vowel pair found along spectral dimensions is then compared to the amount of overlap found along both spectral and durational dimensions. The result indicates to what degree the speaker relies upon spectral information to distinguish the vowel pair, and to what degree the speaker relies upon durational information; the greater the degree of overlap, the lesser the distinction along that dimension. This procedure is repeated for all system-peripheral vowel pairs.

In the case of Numu, system-peripheral vowel pairs include i~iː, u~uː, and a~aː. For this study, the SOAM was applied to spectral and durational data for these vowel pairs from each participant group. Recall from Chapter 2 that data from one of the speakers, Speaker B, was not used in the Fluent Speaker model because her spectral vowel data deviated too widely from the other speakers. Accordingly, participant data that was derived from Speaker B's input has not been included in the current model.

Figures 40-45 show the two-dimensional (F2xF1) and three-dimensional (F2xF1xduration) graphical results of best-fit ellipses and ellipsoids for i~iː, u~uː, and a~aː, respectively. Fluent speaker figures are included for comparison. A summary of the overlap figures and the differences between the two-dimensional and three-dimensional results is provided in Table 48. In the spectral domain, the amount of overall vowel pair overlap is greatest for the Warm Springs 2 group and least for the Fluent Speaker group, indicating that fluent speakers differentiate short and long vowels along spectral dimensions more than the non-speaker groups. This is also true of the F2xF1xDuration comparison, where the amount of overlap decreases as a function of Numu experience, indicating that fluent speakers also differentiate short and long vowels along temporal dimensions more than the non-speaker groups.

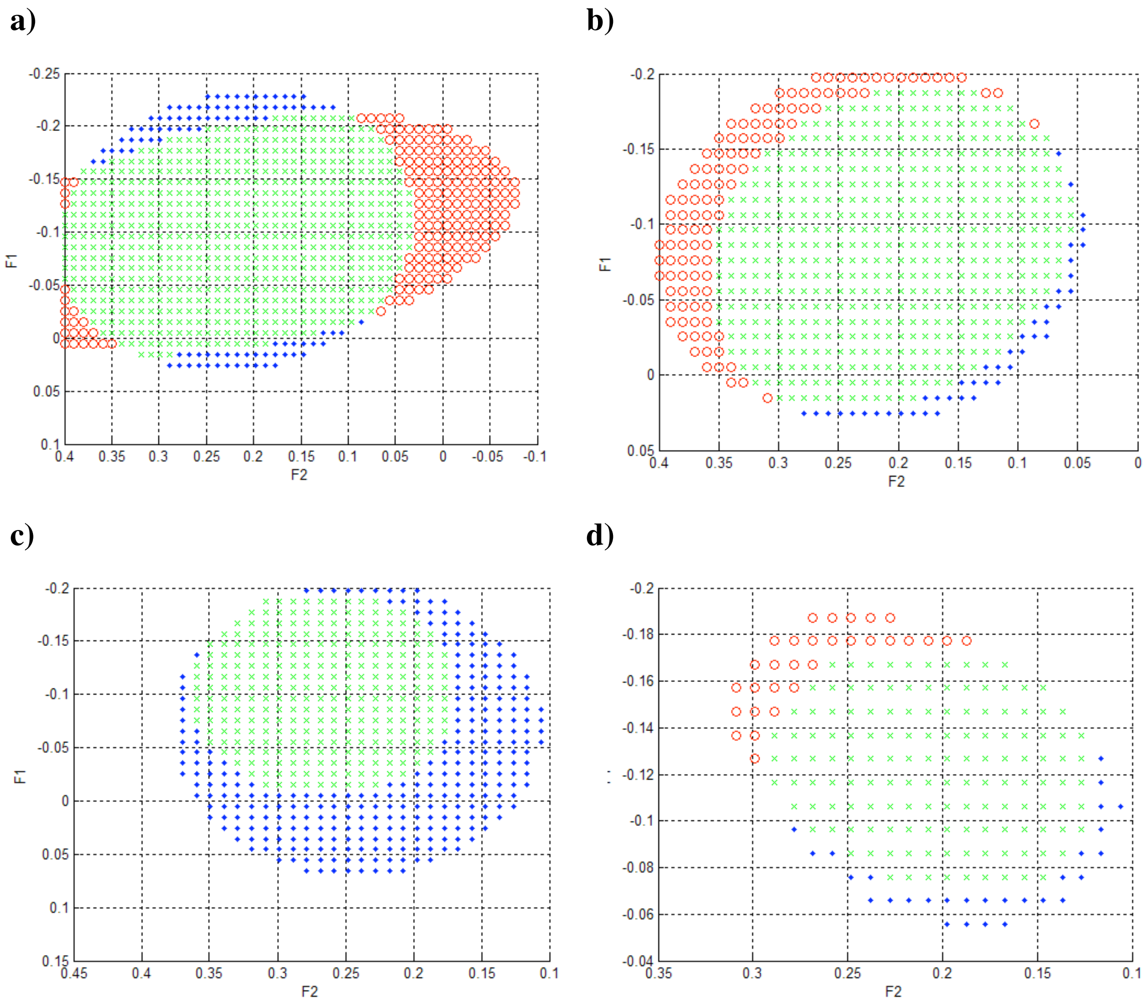

Figure 40. F1xF2 overlap of i~i: for a) Madras, b) Warm Springs 1, c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

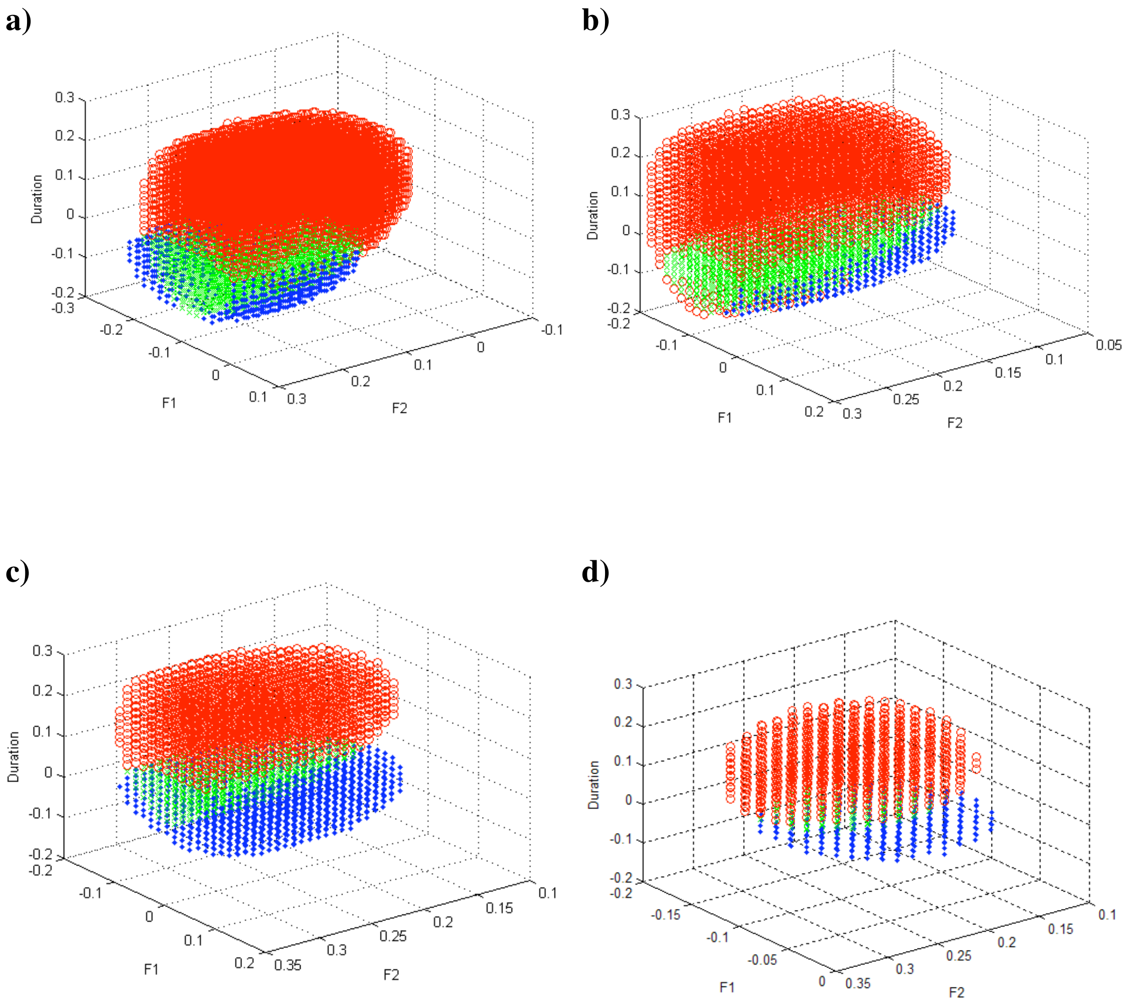

Figure 41. F1xF2xDuration overlap of i~i: for a) Madras, b) Warm Springs 1, c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

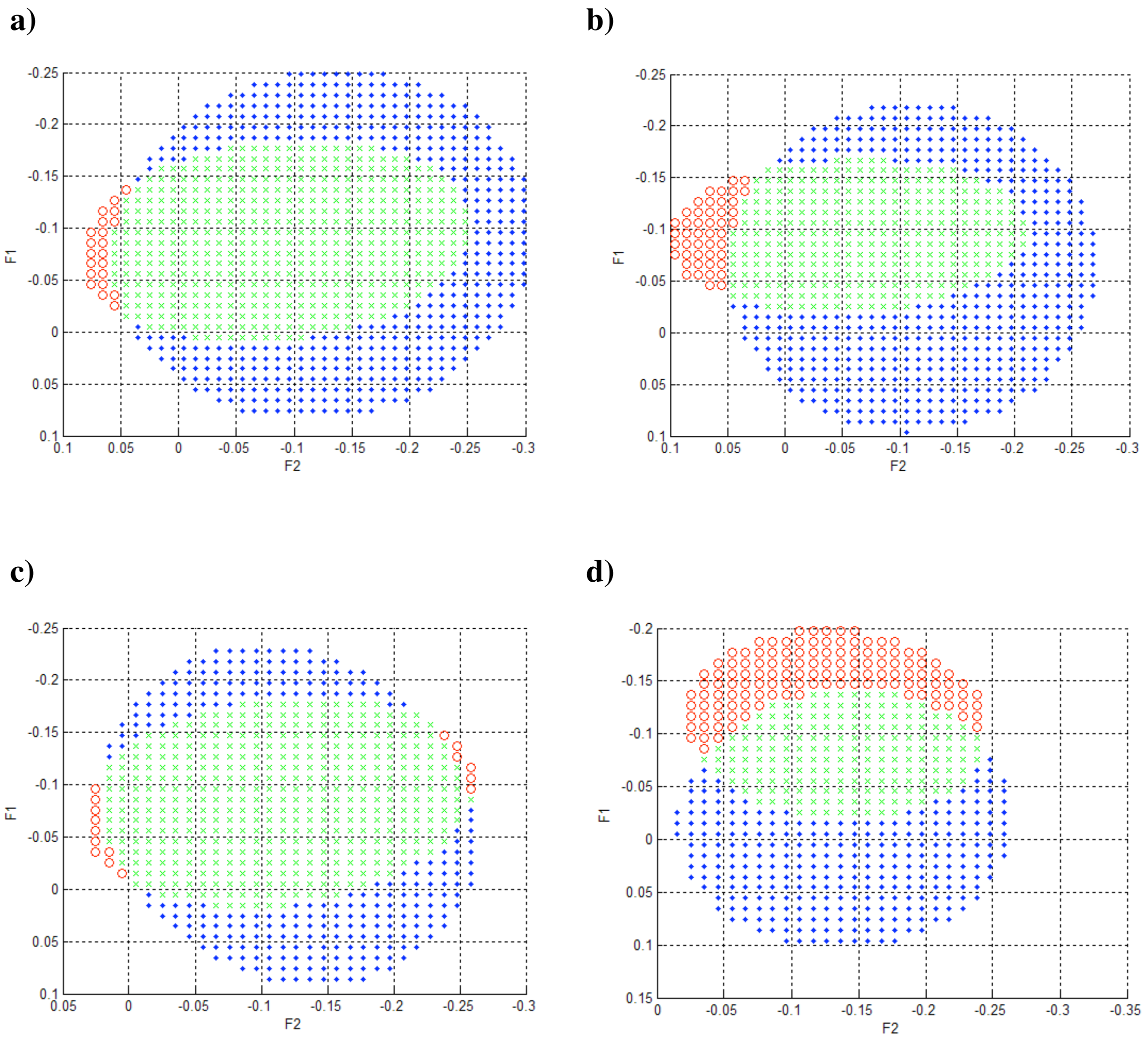

Figure 42. F1xF2 overlap of u~u: for a) Madras, b) Warm Springs 1, c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

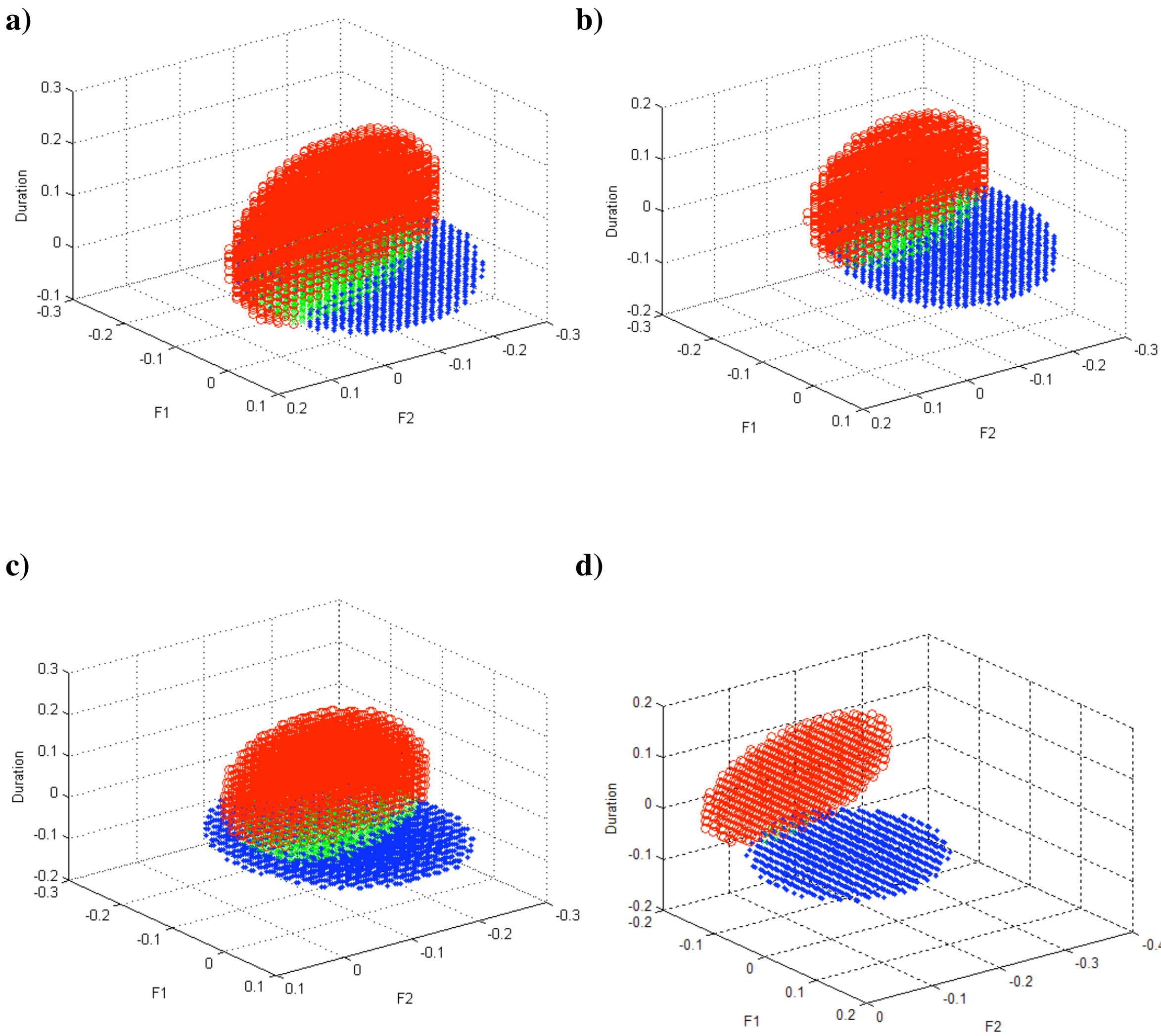

Figure 43. F1xF2xDuration overlap of u~u: for a) Madras, b) Warm Springs 1, c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

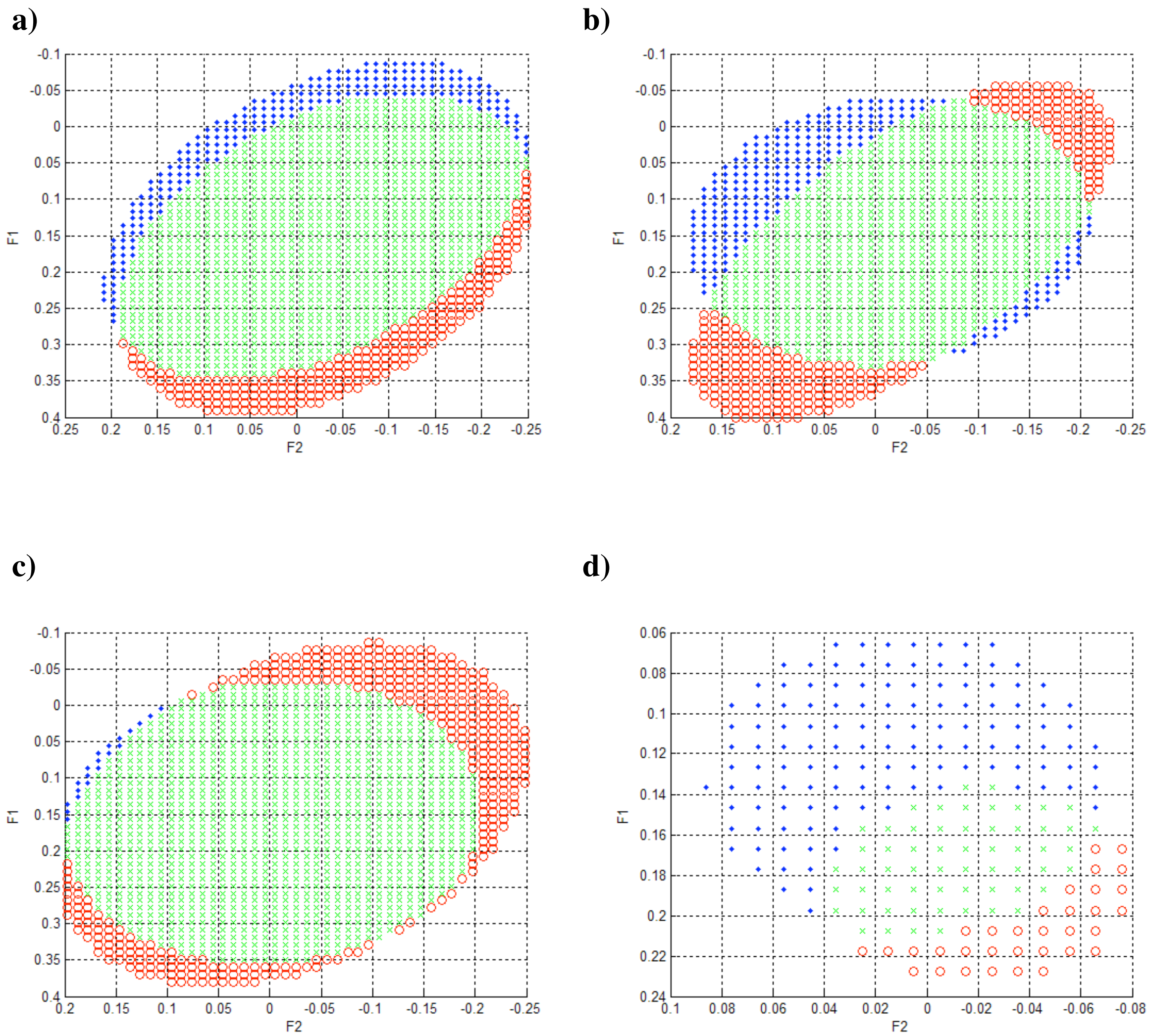

Figure 44. F1xF2 overlap of a~a: for a) Madras, b) Warm Springs 1, c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

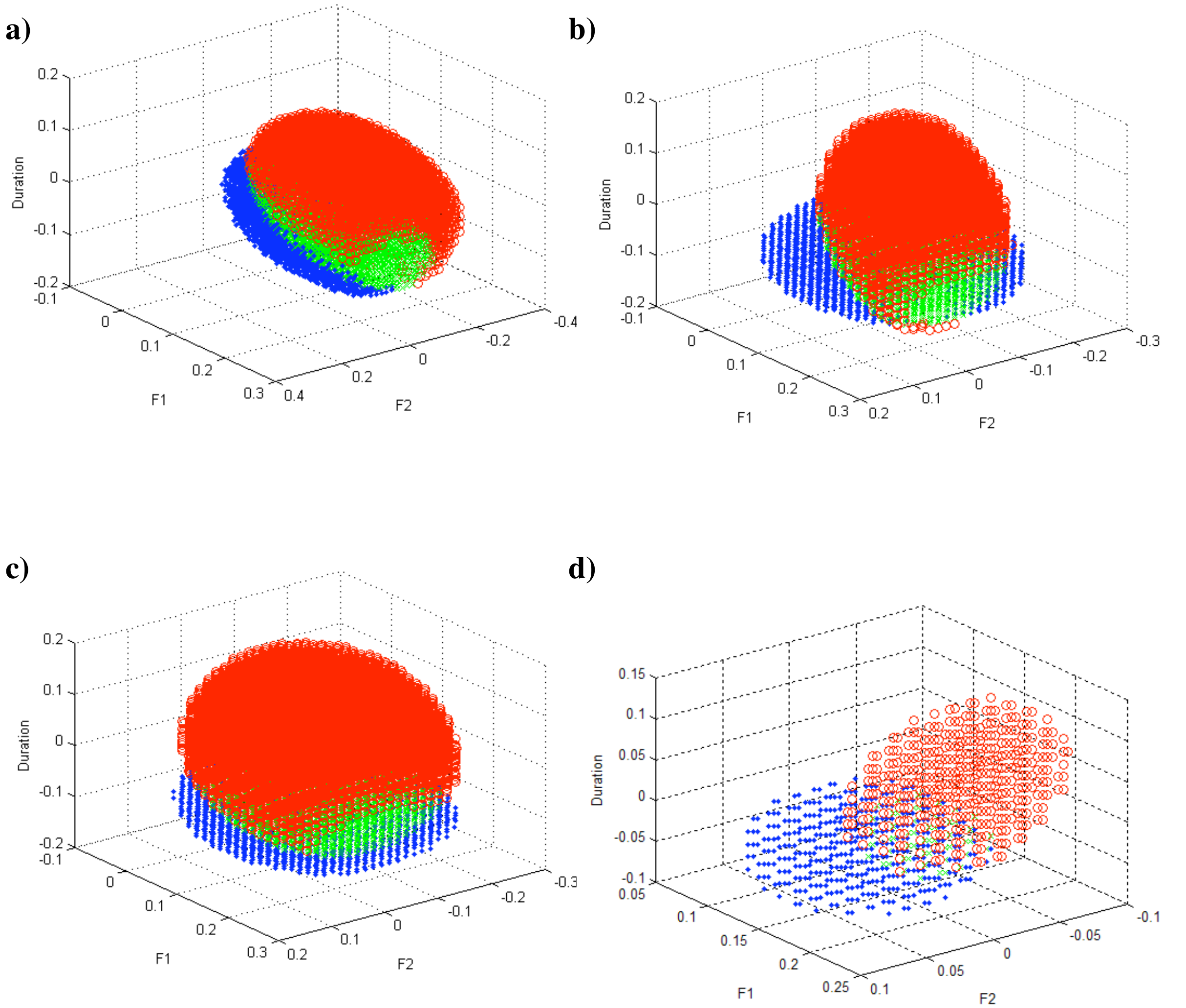

Figure 45. F1xF2xDuration overlap of a~a: for a) Madras, b) Warm Springs 1,c) Warm Springs 2, and d) Fluent Speakers.
(Long vowels are red circles, short vowels are blue diamonds, and overlapping points are green x's.)

Table 48. Two-dimensional (*2D*) and three-dimensional (*3D*) overlap percentages, and the difference between them (*Diff.*) for each peripheral vowel pair, by group.

	Madras			**Warm Springs 1**			**Warm Springs 2**			**Fluent Speakers**		
	2D	***3D***	***Diff.***	***2D***	***3D***	***Diff.***	***2D***	***3D***	***Diff.***	***2D***	***3D***	***Diff.***
i~i:	87%	76%	11%	92%	82%	10%	100%	35%	65%	83%	32%	51%
u~u:	96%	40%	56%	87%	25%	62%	96%	36%	60%	59%	1%	58%
a~a:	83%	75%	8%	77%	64%	13%	98%	66%	32%	64%	12%	52%
All	89%	64%	25%	85%	57%	28%	98%	46%	53%	69%	15%	54%

These trends are further reflected in the amount of difference between two-dimensional overlap and three-dimensional overlap, where we see that the fluent speakers have the greatest difference, followed by the Warm Springs 2 group, the Warm Springs 1 group, and finally the Madras group. The difference between the two-dimensional and three-dimensional models indicates how much more a given group distinguishes vowel pairs on durational information than spectral information, so these results indicate that fluent speakers rely more heavily on duration to distinguish long and short vowels than do the non-speakers. Figure 46 represents these trends graphically.

Overall, it seems that fluent speakers make a distinction between long and short vowels along both spectral and temporal dimensions more than the non-speaker groups. However, they also show a greater differentiation of long and short vowel pairs along temporal dimensions than do non-speaker groups, as indicated by the larger difference between two-dimensional and three-dimensional overlap results. These findings reflect the difficulties of producing proper vowel distinctions in a primary quantity language (like Numu) when one's first language is a primary quality language (like English).

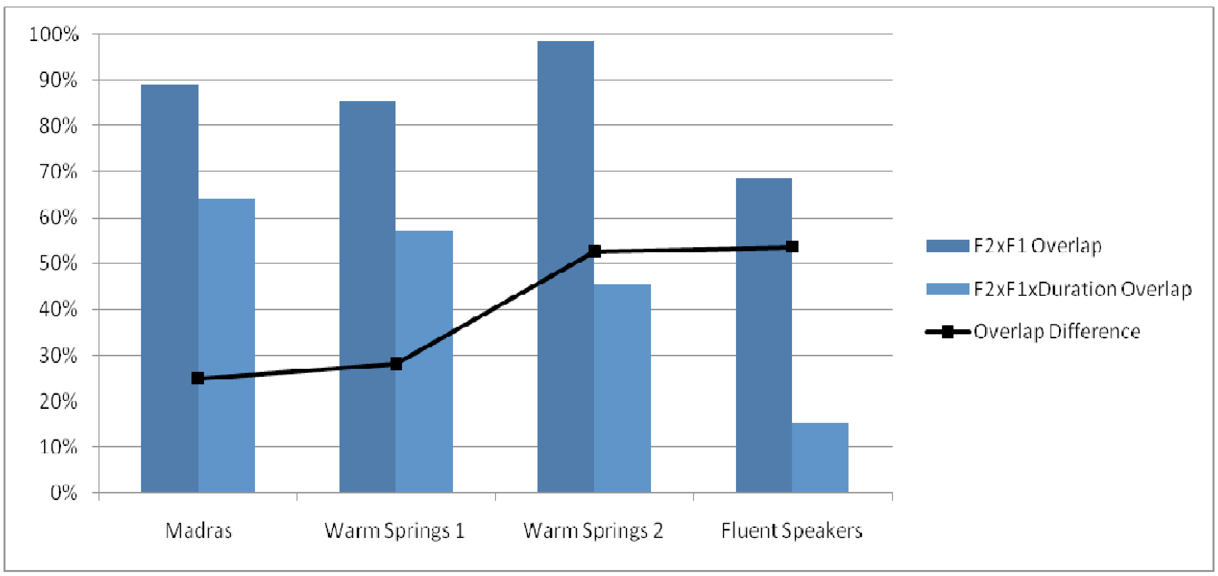

Figure 46. Comparison of overall F2xF1 overlap and overall F2xF1xDuration overlap (bars), plotted with the difference in overlap values between the two models (line), by group.

Those with the most Numu experience, participants in the Warm Springs 2 group, come closest to replicating Numu long/short vowel differentiation along temporal dimensions, and their two-dimensional overlap values were greater than those of any group, indicating that they make the least distinction between vowel pairs along spectral dimensions. As with other phonetic measures, it is possible that the Warm Springs 2 groups' productions reflect some degree of conscious awareness of the language's features, including the fact that Numu has long and short vowel pairs, possibly understood as differing only in duration. This pattern holds despite the fact that several members of the Warm Springs 1 group have experience with Ichishkin or Kiksht, which also make temporal distinctions in vowel groups, though no data is available to determine the amount of overlap between two dimensional and three dimensional models of these languages' vowels.

3.5.4 Vowel conclusion

Participants in the Warm Springs groups seem to have a greater sensitivity to differences in vowel duration than participants in the Madras group, and occasionally even exceed fluent speaker durational values (though not significantly). In a comparison of the interaction of temporal and durational measures in the four groups, it was found that the predicted pattern of Madras < Warm Springs 1 < Warm Springs 2 < Fluent Speakers holds true in terms of the degree of difference between vowel distinctions made on spectral measures and vowel distinctions made on temporal measures. It also holds true for long medial vowel durations and long to short vowel final vowel ratios, despite possible effects of Kiksht or Ichishkin experience among some members of the Warm Springs 1 group.

However, it does not appear that members of the Warm Springs groups have the same advantage in the spectral measures of Numu vowels. They pattern closely with the other non-speaker groups in cluster analyses of normalized Euclidean distances between vowels along F1, F2, and F3 dimensions.

3.6 Conclusion

At the beginning of this chapter, it was predicted that members of the Warm Springs groups, especially the Warm Springs 2 group, would exceed the members of the Madras group in reaching fluent speaker production targets. While this pattern has held true in some cases, it has not in others, with one or both of the Warm Springs groups occasionally patterning with the Madras group, falling far behind the other non-speaker groups, or exceeding fluent speakers on some phonological or phonemic measure. Instances of overproduction of voiceless vowels and productions of ejectives are two especially striking cases of Warm Springs participants exceeding fluent speaker productions.

In the next chapter, phonological and phonemic differences among the groups will be examined in light of current proposals of endangered language change, which include transfer effects from a more socio-politically dominant language, regression to language universals (e.g., Cook, 1995), and socio-culturally motivated intensification of prominent language features (e.g., Wolfram, 2002). In Chapter 5, the differences will be submitted to ratings by fluent speakers, in an attempt to discover which of the potential changes that are manifested in these production differences contribute to a perceivable accent in non-speakers.

CHAPTER 4

Transfer Effects and Hypercorrection in Numu

4.1 Sources of rapid change in endangered languages

One widely recognized characteristic of language endangerment is the accelerated changes that these languages undergo (Hinton & Ahlers, 1999). While all languages are under a constant process of change, this process is not thought to be as drastic or rapid in thriving languages as in endangered languages. Endangered languages are widely thought to undergo a process of *simplification*, which Silva-Corvalán (1990) defines as the loss of linguistic features through contracted use. But there is little agreement about the source of such change –some researchers have attributed it entirely to contact with a dominant language (e.g., Goodfellow, 2005), while others attribute it primarily to internal system pressures (e.g., Dorian, 2006). Still others liken the process of change to the formation of a pidgin, which involves both regularization and contact-induced change. Schumann (1974, 1982) originally proposed a theory of *pidginization* for second language acquisition, arguing that language learners in early stages of acquisition and speakers of pidgins are similar in their need to communicate in the most effective and efficient manner possible. They also have restricted input and must fall back on structures from their first language if they can't express themselves in the target language. Other researchers have made similar claims for the changes that occur in endangered languages (e.g., Dressler & Wodak-Leodolter, 1977; Hinton, 2001a).

However, Wolfram (2002) provides a convincing argument that theories of pidginization do not offer a complete picture of endangered language change. Social factors also play a large role in language use and loss, and these factors cannot be ignored in a model of language change.[16] Furthermore, the difference in social functions between pidgins and endangered languages is too large to be ignored. As Schumann (1974) notes, pidgins are formed in multilingual situations for the purpose of communicating ideas, and are not used to express identity. They are highly regularized for the purpose of "easing the processing load of the hearer" (Foley, 2006, p. 4). Endangered languages, on the other hand, are spoken in communities where everyone is usually capable of communication through a different, socially dominant language. Language revitalization is often an ideological choice, therefore, rather than a choice of necessity, and identity therefore plays a large role in people's choice to learn and speak an endangered language (e.g., Fishman 1991, Goodfellow 2005).

For this reason, it is worth examining what is meant by the terms *simplification*, *pidginization*, and *loss*, and the ramifications of using these terms in descriptions of endangered languages. In her ground-breaking paper on the "expert rhetoric" of language endangerment, Hill (2002) encourages researchers and other academics to carefully examine the language they employ in consideration of the diverse audience who may hear or read about language revitalization efforts. Specifically, she asks of potential audiences from endangered language communities, "Do they find [the rhetoric] empowering and encouraging, unintelligible and alienating, or something in

[16] But cf. King (1989), who argues against the pidginization explanation, but who finds that variation remains in a declining variety of Acadian French *despite* the loss of social differentiation of the distinctive features.

between?" (p. 119). Though her focus is primarily on the rhetoric surrounding endangered language advocacy, the same question might be asked of the rhetoric surrounding the process of language change in situations of endangerment, which is often centered around the terms above. A detailed examination of this question would take us too far afield, but I will submit the following postulation: these terms, which have specific technical meanings for linguists and other language specialists, are similar to or even homophonous with non-technical terms that have generally negative connotations, especially *simplification* and *loss*. The result is that the widespread use of these terms in the endangered language literature sets up a frame of *endangered language revitalization as a hopeless cause.*

It might also be postulated that these terms produced a similar effect in language researchers, limiting the scope of their investigations to a single (simple) direction of language change. The result is a paucity of research exploring other possibilities of language change. Wolfram (2002) makes a similar observation about terms associated with language endangerment, stating,

> Unfortunately, the metaphor of death and decay so often used to describe language loss has tended to obscure an understanding of the varied responses to obsolescing language varieties... Innovative options are available to speakers of moribund language varieties, arguing against a simplistic, unidimensional reduction-based model of language obsolescence (p. 781).

That said, the very ubiquitousness of these terms make it difficult to avoid them in a discussion of previous research on endangered language change. However, I will attempt to avoid them whenever possible, employing instead the terms *regularization* and *language change*, terms that encompass their own rhetoric, but that I hope have a more neutral connotation. In doing so, I hope to avoid obscuring the complexity of language change in endangered language communities, a topic that I examine in this chapter. The chapter continues with a discussion of various theories of second language acquisition by adults, and how these relate to theories of rapid language change in endangered languages. Based on these comparisons, I then formulate predictions about directions of change in languages spoken primarily by adult second language learners. Finally, these predictions are tested against the observations made in Chapter 3 about the differences in production of Numu between fluent speakers and the three groups of non-speakers, and an additional theory of language change is proposed.

This research will not be able to show empirically the future direction of language change in Numu, but rather will make predictions about this change based on the features present (or absent) in the different groups' productions. Indeed, as Milroy (2003) points out, synchronic demonstrations of language change are not possible due to the complexity of social factors involved in long-term change, and Hamp (1989) demonstrates this complexity in a number of threatened languages that show vastly different characteristics of conservatism and convergence. Moreover, this research does not address any changes that have already occurred in fluent speakers due to extensive contact with English or other natural processes. However, we will treat this latter point as moot for the purposes of this research; we are concerned with changes that may occur in the future due to second language learner acquisition of Numu, not changes that have already occurred (in any direction).

4.2 Transfer effects

One of the most widely accepted views of rapid language change in endangered languages is that there is convergence towards a more dominant language due to extensive contact with that language and widespread bilingualism. As Silva-Corvalán (1990) notes, convergence may be caused by internally motivated changes (e.g., the acceleration of an already actuated change), but contact is a major contributor. Indeed, for languages that will be spoken and taught primarily by second language learners in coming generations, it is very likely that their first language will have a profound effect. Most, if not all, second language acquisition researchers agree that one's first language affects the phonology of the second language, though the mechanism by which this occurs remains somewhat controversial. This section briefly reviews the proposed theories of transfer from the first language to the second, upon which predictions are then made about the effects of English on Numu in adult learners' productions.

Early explanations of language transfer effects in adults proposed that they were due to lateralization and loss of plasticity in the brain (Lenneberg, 1967; Penfield & Roberts, 1966; Scovel, 1969). These proposals led to widespread acceptance of the Critical Period Hypothesis (CPH), which postulated loss of the ability to acquire native-like phonological skills by the onset of puberty or earlier. However, the CPH has been called into question due to a lack of neurological evidence that native-like acquisition and relevant stages of brain development coincide (see Flege, 1987), and because it does not appear to be universal among all cultural groups (Hill, 1970). Though neurological explanations have not been entirely abandoned (see Sebastián-Gallés, 2005), it is generally acknowledged that other factors are at play in the development of a second language accent.

Flege (1995) has proposed that a person maintains their ability to acquire sounds throughout their entire life. However, the presence of a complete first language sound system, as found in older children and adults, "interferes" with the acquisition of the second language sound system (and vice versa to some degree), as the sounds must exist in a single phonological space. This proposal, the Speech Learning Model (SLM), predicts that a person "assimilates" sounds from the second language that are closest to sounds in the native language (i.e., perceiving and producing second language sounds as similar to first language sounds), while establishing new phonological categories for sounds in the second language that are the most dissimilar from sounds in the native language. Moreover, as new sounds are acquired, the combined first language-second language space becomes more crowded. In order to maintain phonological contrasts within and between languages, sounds may "deflect away" from each other, causing sounds in both the first language and the second language to differ slightly (or greatly) from sounds produced by a monolingual speaker of either language.

Similarly, Best's (1994; 1995) Perceptual Assimilation Model (PAM) predicts that a second language sound which is similar to a native language sound will be perceived as the native exemplar, whereas second language sounds that are sufficiently different will not be perceived as exemplars of native speech sounds. Discrimination of phonological contrasts in the second language therefore depend on whether the sounds are associated with same or different native categories from the perspective of the learner.

Based on these models, we can predict that non-speakers of Numu will have varying degrees of success in producing Numu sounds, depending on the similarity of a given Numu sound to sounds in the English language inventory. Experience may also have an effect, as Flege & Liu (2001) have demonstrated that ability in a second language is commensurate with the quantity (and quality) of input (see also Flege, 2009 and Moyer, 2009). Even ambient exposure to the language may have a positive production effect, as we saw among the different non-speaker groups in Chapter 3, or as demonstrated for Spanish learners by Knightly et al. (2003). In cases where a Numu sound can be easily assimilated to an English phonological category, we expect to see assimilation of the Numu sound to English, in a process commonly called *transfer* in second language acquisition literature. To incorporate the possible effects of previous language experience, let us divide transfer into two categories: *full transfer* and *gradient transfer*. In *full transfer*, all non-speaker groups are predicted to perform significantly differently from fluent speakers, with productions that are similar to what we would expect to find in English. In *gradient transfer*, production ability is correlated with experience, with the more experienced non-speakers performing significantly better than less experienced non-speakers; the more experienced group may or may not achieve fluent speaker targets in their productions.[17] Finally, if a given feature is sufficiently similar in both languages, native-like pronunciation may be achieved by all non-speakers. This effect has been termed *positive transfer* in second language acquisition literature (see Major, 2001). Here, to emphasize that the languages share similar features, I will call it *equivalency.*

These three possibilities are presented in Table 49. Hypothesized production patterns are presented for each prediction, based on the average measurement of a given feature for each study participant group. The groups are presented in order of magnitude for a given quantifiable measurement (e.g., VOT, vowel duration, percentage of voiceless vowels produced). Each pattern is presented with double-headed arrows (⇔) to indicate that the measurement may be either increasing or decreasing across groups. An equal sign (=) is used to represent similarity (or non-significant differences).

The predictions presented here account for differences in production by non-speakers due to transfer effects from English, but they do not account for the fact that in some cases, learners produce segments that are found in neither the first or the second language. For example, Goodfellow (2005) notes that the youngest generation of $K^{w}ak^{w}ala$ speakers (an endangered indigenous language of British Columbia) have introduced labialized velar fricatives to maintain lexical contrasts that are threatened by the loss of uvulars and glottalized stops. While the loss of uvulars and glottalized stops may be attributed to the influence of English, it is difficult to make this argument for the introduction of labialized velar fricatives, which are not part of the English phonological inventory.

Indeed, analogous situations are common in second language acquisition, leading many researchers to adopt a view of acquisition that encompasses both transfer effects and other factors. For example, Major (2001) proposes that in the beginning stages of language learning, the interlanguage (i.e., the language that second language learners produce before achieving fluency; see Chapter 1) consists almost entirely of features from the first language. As

[17] Gradient performance in subphonemic measures has been shown by both Babel (In Press) and Yu (2008) in endangered language productions.

competence in the second language increases, the role of the first language decreases, until ideally the learner reaches a state of complete second language phonology acquisition. Major attributes all deviations from both first language and second language phonological features to universal phenomena, a view that is shared by many second language acquisition researchers (e.g., Epstein, Flynn, & Martohardjono, 1996; Escudero & Boersma, 2004; Schwartz & Sprouse, 1996; but see O'Grady, 2008). The next section will discuss the adoption of universal grammatical features in second language acquisition.

Table 49. Hypothesized patterns for changes due to transfer from English. (Group names refer to average group measurements for a given feature.)

Change Type	***Hypothesized Production Pattern***	***Notes***
Full Transfer	Speaker ⇔ WS2 = WS1 = Madras = *English*	English transfer effects override previous exposure to the language.
Gradient Transfer	Speaker ⇔ WS2 ⇔ WS1⇔ Madras = *English* *or* Speaker ⇔ WS2 ⇔ WS1 = Madras = *English* *or* Speaker = WS2 ⇔ WS1 = Madras = *English* *or* Speaker = WS2 = WS1 ⇔ Madras = *English*	Amount of previous exposure to the language determines magnitude of English transfer effects.
Equivalency	Speaker = WS2 = WS1 = Madras = *English*	The target language feature is the same as the corresponding feature in English.

4.3 Universals

The classical view of language change favors explanations that incorporate endogenous (internal) factors rather than contact-induced factors (Lass, 1997). This view has also been proposed for rapid change in endangered language situations (Cook, 1995; Trudgill, 1989). These proposals generally hold that languages change in the direction of universally unmarked features, maintaining marked features only when they have a high functional load (i.e., when they contribute crucially to meaning). In research on second language acquisition, universal features have been invoked by incorporating markedness constraints into proposed interlanguage grammars (Eckman, 1991; Major & Kim, 1996). For example, Broselow, Chen, & Wang (1998) employ universal markedness constraints in an Optimality Theory framework to explain unexpected productions by Mandarin speakers in the acquisition of English.

Due to the importance placed on universal features in the literature on language change and on second language acquisition, it is useful to examine the role of universal features in the differences between the productions of Numu by non-speakers and productions by fluent speakers. Unfortunately, the determination of what constitutes a universal feature in language learning entails several difficulties. One difficulty is teasing apart features that are attributable to English and features that are attributable to a universal grammar; Eckman (2004) admits that there is often overlap between first language features and universal features. Another difficulty is the fact that adult second language phonologies tend to deviate from what is observed in child first language acquisitional phonologies. For example, Young-Scholten (2002) reports that adults show a preference for epenthesis to break up complex clusters in their second language, while children tend to use deletion for the same clusters in their first language.[18]

In fact, though the notion of linguistic universals is a central principle in the development and application of a wide range of theoretical phonology models such as Generative Phonology (Chomsky & Halle, 1968), Natural Phonology (Stampe, 1979), Autosegmental Theory (Goldsmith, 1976), and Optimality Theory (Prince & Smolensky, 1993), theoretical linguists seem no closer to proposing a universal grammar than second language acquisition researchers. One key aspect that is missing from the debate about language learning and universal grammar is a clear idea of what constitutes a linguistic "universal." Kinney (2005) points out that the term "universal" is used by linguists to describe both the *cause* of a particular linguistic outcome, and for the outcome itself. Indeed, this term has alternatively been invoked to describe an innate cognitive function (Pinker, 1994; Anderson & Lightfoot, 2002); human physiological mechanisms for producing and perceiving sound and language (see discussion of phonetic motivation in Maddieson, 2009); human learning, organizing, and structuring methods (e.g., Kirby, Smith, & Brighton, 2004); and finally, the resulting outcomes of any given mechanism – namely a set of features that are predicted to occur in all human languages.

As this study is generally not concerned with the origin of universal linguistic behaviors in humans, but rather with the resultant outcomes, we will remove ourselves from the debate about *why* some linguistic features appear to occur universally, or nearly universally in human language. Instead, we will focus on the features themselves. We are specifically concerned with what Hyman (2008) refers to as *descriptive universals*, or universal features that can be directly observed, as opposed to *analytic universals*, which are dependent on a specific theory. This is because we wish to classify non-speaker deviations from the speaker target in terms of possible directions of language future change rather than their adherence to a particular phonological theory.

Unfortunately, descriptive phonological universals based on natural language tend to be extremely general, such as, "Every phonological system contrasts phonemes for place of

[18] Young-Scholten attributes this deviation from first language acquisition devices to the use of orthography in language learning, noting that literacy training tends to begin at around the same age that a decline in unaccented second language acquisition is observed. Though her study findings are unconvincing, as she does not adequately control for literacy in her subjects, she brings up an intriguing issue that is worth further exploration, especially for endangered language communities choosing between oral and written forms of language instruction. Further discussion of the role of orthography in language acquisition can be found in Bassetti (2009).

articulation" (Hyman, 2008, p. 93). These rules, while important to developing an understanding of human language, are not of much use to our current study, as they are not sufficiently specific. One possible avenue for discovering phonological universals is in the study of pidgins and creoles, as these languages tend to have highly regular grammars that have been compared to the process of endangered language change (see the discussion on *pidginization,* above). There are, however, a number of problems with this approach. The first is that a comparison of endangered language change and pidgin formation may not be appropriate, as discussed above. The second issue is that the superstrate languages of the majority of pidgins and creoles under study today are European languages, and as such are not typologically diverse. We thus return to the old problem of teasing apart universal tendencies from Indo-European tendencies. Finally, the research in this area is sparse. Though much has been written about universal syntactic and morphological features in pidgins, there has been little work in this area on defining phonological universals (see Singh & Muysken, 1995). One exception is Bender (1987, p. 42), who provides a tentative (and sparsely populated) list of six phonological universals as observed in pidgins, creoles, and low varieties in diglossic situations:

1) No fortis/lenis or emphatic-plain contrasts and no affricates
2) There is a universal list of phonemes: p, t, k, b, d, g, f, s, m, n, l~r, w, y
3) No initial or final consonant clusters or geminates
4) There is a simple vowel system: i, u, e, o, a (plus possibly ɩ or ə)
5) No use of tone, stress, or intonation in lexical or morphological contrasts
6) No morphophonemic processes aside from automatic variation (e.g., assimilation)

Some attempts have also been made to define phonetic universals (see Cho & Ladefoged, 1999 and Kawasaki-Fukumori, 1992, for example), but naturally occurring variation in natural speech belies assumptions that phonetic features can be defined as discrete or static (Flege & Port, 1981; Port & Leary, 2005). As Maddieson (2009) argues, this variation is an entirely natural element of human speech, and derives "from imprecise motor control of the speech apparatus, from reproducing the results of misperceptions, and from other effects that are a consequence of the fact that humans are not automata" (p.136). For this reason, phonetic universals tend to be relational, based on the aerodynamic and mechanical properties of the speech apparatus, the properties of adjoining segments, or perceptual factors. Maddieson (1997) provides eight such phonetic universals, all other factors being equal:

1) Higher vowels have higher f_0 than lower vowels
2) Higher vowels are shorter in duration than lower vowels
3) Higher vowels have a greater tendency to devoice than lower vowels
4) A vowel before a voiced consonant is longer than a vowel before its voiceless counterpart
5) In many languages, a vowel in a closed syllable is shorter than a vowel in an open syllable
6) The f_0 of a vowel is higher after a voiceless consonant than a voiced consonant
7) Bilabial stops have longer closure duration than velar stops (coronal stops may have shorter durations than velar stops)
8) Stops that are articulated further back in the mouth have longer VOTs (however, uvulars do not tend to differ much from velars, and there is a great deal of variation in coronals depending on the manner of articulation)

In addition to the sparse set of universal phonological and phonetic tendencies described above, there are also a number of what Hyman (2008) terms *statistical universals,* or general tendencies in the phonological systems of the world's languages, such as are catalogued in Maddieson (1984). However Maddieson (2009) points out that though general linguistic tendencies are a very useful way to determine the naturalness, and thus universality, of a phonological feature, there are problems with this technique, including difficulties in interpreting relative frequencies. Indeed, the process of change towards a universal grammatical feature is largely indistinguishable from other processes; in order to persuasively tease these deviations apart from those caused by English transfer effects or other causes, we need to know specific universal targets.

Nonetheless, we can posit a general prediction about the patterns of deviations in non-speaker productions due to the adoption of a universal grammar: non-speakers will deviate from speaker productions in the direction of a universally unmarked language feature.[19] From this prediction, we can make three hypotheses that are parallel to the hypotheses posited for English transfer effects, with non-speaker productions patterning in terms of amount of previous exposure to the language (see Table 50).

Table 50. Hypothesized patterns for changes due to regularization to a universal grammar. (Group names refer to average group measurements for a given feature.)

Change Type	***Hypothesized Production Pattern***	***Notes***
Full Universal Feature Adoption	Speaker ⇔ WS2 = WS1 = Madras = *universal feature*	Universal features override previous exposure to the language.
Gradient Universal Feature Adoption	Speaker ⇔ WS2⇔WS1⇔Madras = *universal feature* *or* Speaker⇔WS2⇔WS1 = Madras = *universal feature* *or* Speaker = WS2⇔WS1 = Madras = *universal feature* *or* Speaker = WS2 = WS1⇔Madras = *universal feature*	Amount of previous exposure to the language determines magnitude of the effect of universal features.
Universal Equivalency	Speaker = WS2 = WS1 = Madras = *universal feature*	The target language feature is the same as the corresponding universal feature.

[19] It has been brought to my attention that we would expect universal tendencies to be available to the fluent speakers as well. While this is true, we would also expect them to be able to eschew these tendencies in favor of the phonological rules of the language. Second language learners, on the other hand, may not be aware of the language's rules, reverting instead to universal rules as a stopgap measure.

Under *full universal feature adoption*, non-speakers exhibit universal features in their productions despite any amount of previous exposure to the language. Under *gradient universal feature adoption,* the amount of exposure to the language is correlated with the appearance of universal features as in *gradient transfer*, and native-like targets may or may not be achieved by those who have more experience with the language. The final hypothesis, termed *universal equivalency*, denotes situations in which the target language feature is identical to an unmarked universal feature, and productions by all four groups are therefore similar.

The primary difference between these predictions and those made for English transfer effects is that non-speaker deviations pattern with the features of a universal grammar rather than with the features of English. The reliance on definable universal phonological and phonetic features diminishes the predictive power of these hypotheses, so we are therefore forced to work from the assumption that any non-speaker deviation that resembles English is due to transfer effects from English. Other types of deviations will be analyzed in terms of general linguistic tendencies, or in terms of *statistical universals,* as discussed above.

4.4 Hypercorrection

The predictions proposed in the previous two sections may not fully account for all changes brought to Numu by second language learners. The idea that languages change solely due to endogenous factors such as regularization has been refuted by a number of scholars. Thomason & Kaufman (1988) emphasize that sociocultural context is a crucial factor in language change, and Silva-Corvalán (1990) maintains that though cognitive and interactional processes are important aspects of language change, the ultimate outcome is mediated by the sociolinguistic history of the speakers. Taking this line of reason further, both Blust (2005) and Milroy (2003) have argued that social factors are important not only in the spread of language change, but also in the actuation (the emergence) of some changes. For example, Blust (2005) analyzes ten historical changes in languages of the Austronesian language family, finding that they were socially motivated. Milroy (2003) questions why a given "natural" change (e.g., nasalization of vowels) will occur in some languages but not others, or at a given time in history. He states, "Linguistic change is multi-causal and the etiology of a change may include social, communicative and cognitive, as well as linguistic factors" (p. 148). His argument is not new, nor is it excluded from consideration in Native American languages; as far back as the middle of the last century, Jacobs (1954) urged linguists to consider cultural factors in any analysis of the historic spread of features in indigenous languages of the American Northwest.

Though Blust and Milroy are primarily considering changes in thriving languages, these arguments give rise to the prediction that some language changes in endangered language communities may occur due to cultural factors, a notion that is supported by Wolfram (2002). He takes issue with the notion that endangered languages change due only to contact with a dominant language or due to regularization, arguing that, "circumstances framing obsolescing language varieties are as multidimensional and complex as any other sociolinguistic situation" (p. 781). He presents examples from endangered languages where distinctive features have persisted to support his *concentration model*, in which socially salient features are intensified due to social factors or direct intervention. Woolard (1989) also reviews several examples of endangered language situations in which a given distinctive feature has been maintained and uses these examples to support her argument that any analysis of language revitalization and change must center on the human actors involved.

Hinton & Ahlers (1999, p. 61) note that, "not all of the changes in the restoration [of endangered languages] involve simplification and interference. Some are consciously engineered changes." They refer specifically to lexical changes, and indeed, many endangered language communities in the United States actively discourage the borrowing of English words, preferring instead to create neologisms or to borrow words from other indigenous languages for new or foreign technologies and concepts. For example, in their discussion of ethical issues associated with revitalizing the sleeping language Mutsun, Warner, Luna, & Butler (2007) report that for the creation of new lexical items, the Mutsun community has decided to use compounding and affixation as much as possible rather than borrowing words from other languages, especially English. In the Hawaiian language community, Kapono (1994) describes the Lexicon Committee that was created to develop new vocabulary. It looks to other Polynesian languages to coin new Hawaiian words, and for wildlife words not encountered in the Pacific, it tends to choose words from mainland Native American languages (like Blackfoot or Mohawk). Moore (1988) reports that speakers of Kiksht, one of the indigenous languages spoken in Warm Springs, attribute language obsolescence to loss of vocabulary items. He says that for these speakers, "'words' have taken on certain objectual qualities, and 'language,' seen as a collection of words, has become a special kind of property" (p. 463).

More traditional morphological and syntactical forms may also be preferred to those that are perceived as affected by the dominant language. Dorian (1994b) reports on the case of Tiwi, an endangered language of Australia, where a newer form of the language is denoted by fewer verb inflections, simpler imperative forms, and loan verbs from English. In the local bilingual school program, community members have insisted on the use of the traditional language, and have reacted strongly against any publication or teaching using the new form, though it is commonly used in homes. Woolard (1989) also describes several cases of very conservative features being maintained in endangered language situations, and notes that features that diverge from a socially dominant language are retained and even emphasized in order to create a distance between the two languages.

As these examples suggest, many endangered language communities actively try to differentiate their languages from more socially dominant languages at the morpheme and word level. It stands to reason that these ideologies extend also to pronunciation, with language communities attempting to increase the perceptual distance of particularly salient features of their phonological system from features of the dominant language's phonology. In that case, we would expect members of a given community to take particular care in the production of these features, and in doing so, possibly exceed the actual fluent speaker target, resulting in the intensification or overuse of some features, or the overapplication of target language phonological rules. In fact, Campbell & Muntzel (1989) provide examples this phenomenon in several threatened languages.

Because such hypercorrection is socioculturally based, we would expect it to appear only in the productions of community members, and not at all in non-community members (those who have not had exposure to cultural ideals associated with the language). Expected patterns are presented in Table 51. Two possible patterns of hypercorrected productions are hypothesized. The first pattern, *linguistic hypercorrection*, appears only in the productions of those with the greatest amount of exposure to the language. In the second type, *cultural hypercorrection,* hypercorrection appears in the productions of both Warm Springs groups, indicating that the feature has sufficient cultural saliency to appear in the productions of those with only ambient exposure to the language.[20]

Table 51. Hypothesized patterns for changes due to hypercorrection.[21]
(Group names refer to average group measurements for a given feature.)

Change Type	***Hypothesized Production Pattern***	***Notes***
Linguistic Hypercorrection	WS2⇔Speaker⇔WS1⇔Madras	Hypercorrection appears in those with the most exposure to the language.
Cultural Hypercorrection	WS2⇔WS1⇔Speaker⇔Madras *or* WS2 = WS1⇔Speaker⇔Madras	Hypercorrection appears in those with cultural connections to the language.

In the next section, we will turn to an examination of whether these predictions are borne out in the speaker and non-speaker production data, based on the measurements presented in Chapter 3. These comparisons form a first step in determining which types of changes can be expected in Numu based on second language learner productions, and how these changes align with current theories of endangered language change.

4.5 Production data analysis

4.5.1 Subphonemic features

In the previous chapter, a number of durational and spectral measurements were taken on productions by non-speakers of Numu, and these were compared to the productions of fluent speakers. Durational measurements included VOT of onset, fortis, and lenis obstruents; fortis and lenis closure duration; nasal duration; and vowel duration. Spectral measurements were taken on vowels and on the burst of fortis and lenis consonants. In this section, the comparisons between non-speaker and speaker productions will be analyzed in terms of the predictions outlined above about possible future language change.

[20] Note that attitude towards the language is not considered as a factor. There is no evidence for a phonetic advantage in language learners who have a positive attitude towards the target language (Markham, 1997).

[21] In the current study, there is likely overlap between these two patterns, as anyone with sufficient exposure to Numu to experience *linguistic hypercorrection* also presumably has had exposure to cultural influences about the language as a resident of Warm Springs. However, it is easy to imagine that a learner may experience *linguistic hypercorrection* without *cultural hypercorrection* in other language learning situations; for example, a language learner who lives apart from the language community may still exceed production targets for a given feature.

4.5.1.1 Fortis and lenis consonants

Measurements of intervocalic fortis and lenis sounds included VOT, duration, relative burst amplitude, relative burst intensity, and spectral measures of the burst. Table 52 summarizes the durational measurements in terms of relative magnitude (or magnitude of difference between fortis and lenis) for the four participant groups. A third column lists the predicted change type that matches the production pattern. Note that though no data were collected on these speakers' productions of similar sounds in English, transfer is assumed rather than universal feature adoption, as I am unaware of any previous research that provides universal measurements of these subphonemic features.

Table 52. Production patterns for measurements of fortis and lenis productions by speakers and non-speakers of Numu.

Feature	***Production Pattern***	***Type***
Fortis VOT	Speaker = WS2 < WS1 = Madras	gradient transfer
Lenis VOT	Speaker = WS2 = WS1 = Madras	*equivalency ?*
Fortis Duration	Speaker = WS2 = WS1 > Madras	gradient transfer
Lenis Duration	Speaker < Madras < WS2 = WS1	*unpredicted*
Fortis v. Lenis VOT	Speaker < WS2 < WS1 < Madras	gradient transfer
Fortis v. Lenis Duration	Speaker > WS2 > WS1 > Madras	gradient transfer

For comparisons of speaker and non-speaker fortis and lenis productions, there were four instances of *gradient transfer*: fortis VOT, fortis duration, and the difference between fortis and lenis VOT and fortis and lenis duration. For lenis VOT values, it is possible that we are observing an instance of *equivalency*, as the values do not differ significantly among the groups. However, a comparison of Numu lenis VOT values and the VOT values for English voiced obstruents reported in Byrd (1993) reveal large differences in magnitude at each place of articulation (see Table 53). There are therefore three possibilities: 1) the VOT values reported by Byrd (1993) differ largely from the VOT values in the dialect of English spoken in Central Oregon; 2) Numu lenis VOT values match some universal tendency for VOT, which was also matched by the non-speakers; or 3) the calculation of differences among groups on this measure represents a Type 2 statistical error, caused by the large amount of variation in lenis consonant production in Numu. The first possibility is unlikely, given that Byrd (1993) performed measurements on 7985 voiced oral stop releases by 630 speakers of eight major dialects of American English. The second possibility is not disprovable, given that there is currently no measure of universal VOT tendencies (and there will likely never be such a measure, as human speech is highly variable subphonemically). The third possibility is the likeliest, and we can therefore draw no firm conclusions about language change from the measure of Numu lenis VOT.

Table 53. English and Numu voiced obstruent VOT values.

Consonant	***Numu VOT (ms)***	***English VOT (ms)***
/b/	9	18
/d/	-27	24
/g/	-7	27

Similarly, lenis closure duration yielded unpredicted results, with both Warm Springs groups exhibiting the largest values, followed by the Madras group, and finally the fluent speakers. In this case, target achievement does not seem to be commensurate with experience. However, as with lenis VOT, the results may be affected by variation in pronunciation of these sounds. It is unlikely that transfer effects play a role; in a comparison of values reported by Byrd (1993), English voiced obstruent closure duration is generally shorter than Numu lenis closure duration (see Table 54). One possible explanation for the extended lenis consonant duration among the Warm Springs community members is that they are aware that fortis sounds exist in the language and overapply closure lengthening to lenis consonants. However, this does not explain why the Madras group overshoots the lenis duration target. Given the large variability observed in lenis consonants, it would be useful in this case to conduct an additional study with more participants to determine if the patterns reported here are applicable to a larger population.

Table 54. English and Numu voiced obstruent duration values.

Consonant	***Numu Closure Duration (ms)***	***English Closure Duration (ms)***
/b/	162	64
/d/	48	52
/g/	81	54

Table 55 is adapted from Table 38 in Chapter 3 to show the measures of the burst on which each group distinguishes fortis and lenis sounds.

Table 55. Measures of the burst on which fortis v. lenis distinctions are made, by group.

	Speaker	**Warm Springs 2**	**Warm Springs 1**	**Madras**	***Pattern***
Burst Relative Amplitude		x		x	*unpredicted*
Burst Relative Intensity	x	x			gradient transfer
Burst Mean Frequency				x	gradient transfer
Burst Standard Deviation	x				full transfer
Burst Skewness					equivalency
Burst Kurtosis					equivalency

The fact that no group distinguishes fortis and lenis sounds on burst skewness or burst kurtosis may be attributable to a type of negative *equivalency*; these acoustic parameters are likely not correlated with consonant distinction in either Numu or English. The use of relative burst intensity appears to exhibit *gradient transfer*, with the Fluent Speaker and Warm Springs 2 groups patterning together in their use of it. Burst mean frequency also appears to exhibit *gradient transfer*, with only the Madras group using it to distinguish fortis and lenis sounds. The use of burst standard deviation appears to be a case of *full transfer*; only fluent speakers use it to distinguish fortis and lenis sounds. It is unclear why the Warm Springs 2 group patterns with the Madras group in the use of relative burst amplitude to make the fortis-lenis distinction, or alternatively, why the Warm Springs 1 group does not use it. One possible explanation is that five members of the Warm Springs 1 group are affected by previous exposure to Kiksht or Ichishkin, though measurements of Kiksht and Ichishkin bursts are not available to verify or disprove this claim.

4.5.1.2 Nasal duration

Duration was measured in onset nasals (which are always singletons), intervocalic singleton nasals, and intervocalic geminate nasals. An analysis of the comparison of these measurements in speakers and non-speakers is summarized in Table 56. (Parentheses indicate that the group's average measurement does not differ significantly from the other groups' measurements).

Table 56. Production patterns for measurements of nasal productions by speakers and non-speakers of Numu.

Feature	***Production Pattern***	***Type***
Onset Nasal	WS2 > WS1 > Madras (Speaker)	*unknown*
Intervocalic Singleton Nasal	Speaker < Madras = WS1 < WS2	*unpredicted*
Intervocalic Geminate Nasal	Speaker = WS2 > Madras (WS1)	gradient transfer
Geminate vs Singleton Nasals	Speaker > WS1 > WS2 = Madras	*unpredicted*

For onset nasals, the three groups of non-speakers differed significantly, but the fluent speaker group did not differ significantly from any of the non-speaker groups. This result may be because fluent speakers do not differentiate singleton nasals in onset position from intervocalic singleton nasals, while all of the non-speaker groups do so. Because no comparison to fluent speakers is possible, we cannot determine the potential direction of change that these types of productions will lead to. However, the fact that all three non-speaker groups distinguish onset from intervocalic singletons while speakers do not is attributable to *full transfer*. Interestingly, we observe that members of the Warm Springs 2 group have the longest onset nasal duration of the non-speaker groups, as well as the longest durations for both singleton and geminate intervocalic nasals. It is possible that they have an awareness of nasal gemination in Numu, and overapply it to non-geminate nasals.

The Warm Springs 2 group also falls into an unexpected pattern in intervocalic singleton nasal production, with their average nasal closure being the longest, fluent speakers' average nasal closure being the shortest, and the Madras and Warm Springs 1 groups falling in between. This may be a case of interaction between hypercorrection and transfer effects, where transfer from English causes non-speakers to produce longer singleton nasals in general, but awareness of geminates causes the Warm Springs 2 to produce nasals that are even longer. This conjecture is supported by the fact that the Warm Springs 2 group achieves the fluent speaker production target for geminate nasals, ahead of the Madras group, an exhibition of *gradient transfer*. The Warm Springs 1 group does not differ significantly from the other groups for geminate nasals, probably as a result of excessive intergroup variation; it is possible that some members of this group are aware of and able to produce geminate nasals, while others pattern with the shorter productions of the non-experienced Madras group.

The groups' differentiation of intervocalic geminates and singletons also follows an unpredicted pattern, but this pattern is not unexpected given the patterns of singleton nasal production and geminate nasal production. Though the Warm Springs 2 group exhibits the longest geminate nasal duration of any non-speaker group, they also exhibit the longest singleton nasal duration, reducing the magnitude of difference between the two nasal types. Note that it is unlikely that Warm Springs 1 group members' exposure to Ichishkin or Kiksht had any effect on this measure, as neither Ichishkin nor Kiksht contrast geminate and singleton consonants.

4.5.1.3 Onset VOT

The production pattern for onset VOT is Speaker = WS2 = Madras > WS1, where the group with a mid-level of experience patterns differently from all other groups. This pattern is not predicted by any of the theories of language acquisition. However, an analysis comparing the different groups' onset VOT presents a significant challenge due to the large amount of variation found in non-speakers' productions. Figure 47, repeated from Figure 31 in Chapter 3, demonstrates this variation in its remarkably long standard deviation bars. Note that the fluent speakers do not produce this level of variation. Note also that while all of the speakers' productions are positive, the non-speakers' productions extend well into the negative region of the graph. As discussed in Chapter 3, it is likely that non-speakers sometimes perceived the speakers' productions of non-aspirated voiceless stops as voiced stops, and indeed, some individuals produced a large number of pre-voiced stops, especially in the Warm Springs 1 group. Perhaps members of this group have enough knowledge of the language to know that Numu onset obstruents are "different" from English onset obstruents (voiceless stops in English are always aspirated), but do not have sufficient experience with the language to produce the difference accurately.

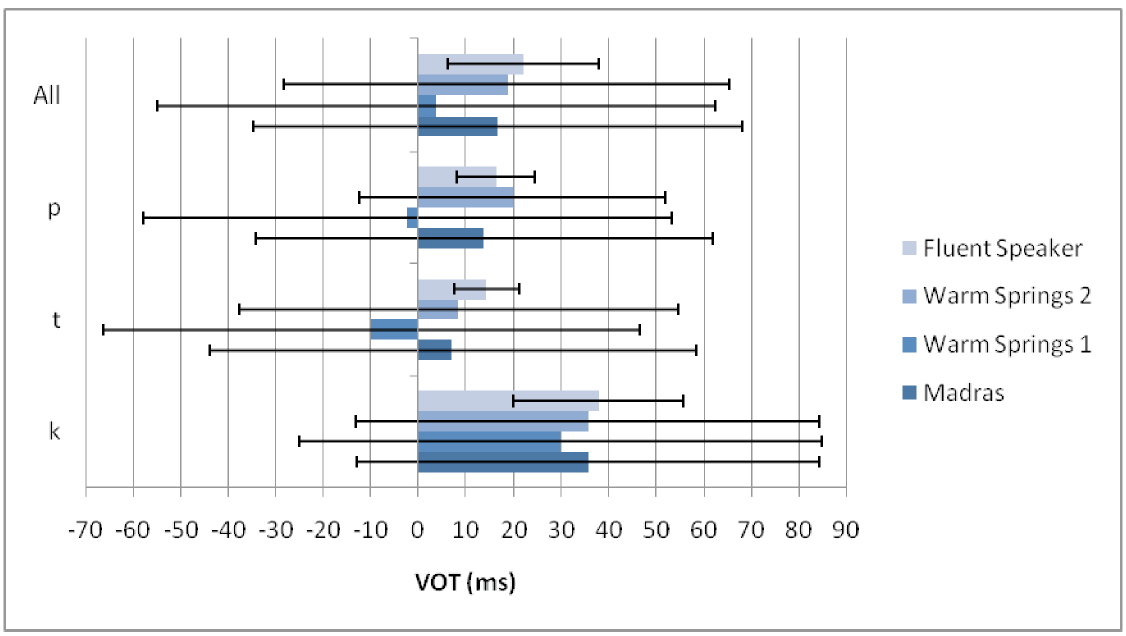

Figure 47. Mean VOT for Numu onsets produced by each group, by consonant.
(Error bars indicate ∓ one standard deviation.)
Figure repeated from Figure 31 in Chapter 3.

4.5.1.4 Vowel duration

Duration was measured for all long and short stressed vowels, and an analysis of the comparison of these measurements for the four groups is presented in Table 57. There is no significant difference in length between the groups for short medial vowels, leading to a classification of *equivalency.* Similarly, both long and short vowels are significantly longer in final position than in medial position for all groups of speakers. Though this is a also feature of English (Oller, 1973), there is evidence that it is a universal phonetic feature (see Johnson & Martin, 2001; Maddieson, 1997). Due to this evidence of universality, it will be considered an example of *universal equivalency.*

Table 57. Production patterns for measurements of vowel duration by speakers and non-speakers of Numu.

Feature	***Production Pattern***	***Type***
Short Medial Vowels	Speaker = WS2 = WS1 = Madras	equivalency
Short Final Vowels	WS2 = WS1 > Madras (Speaker)	*unknown*
Long Medial Vowels	Speaker = WS2 = WS1 > Madras	gradient transfer
Long Final Vowels	Speaker > Madras (WS2, WS1)	transfer
Final > Medial	Speaker = WS2 = WS1 = Madras	universal equivalency

For short final vowels, a pattern emerges that is similar to that for onset nasal duration, in which the non-speaker groups differ, but none differ significantly from the Fluent Speaker group. Therefore, it is impossible to determine whether they correspond with one of the hypotheses of language change. Long medial vowel measurements present an example of *gradient transfer,* with the two Warm Springs groups patterning with fluent speakers and differing significantly from the Madras group. As discussed in Chapter 3, it is likely that the Warm Springs 1 group patterns with the Warm Springs 2 group due to several members' previous exposure to Ichishkin and Kiksht, which contrast vowel length. Participants from Warm Springs may also have an advantage as speakers of AIE, in which case the pattern would be one of *equivalency* between the two languages. However, this hypothesis is merely speculative without a detailed examination of Warm Springs AIE. Long final vowel measurements appear to exhibit transfer effects, as fluent speakers have significantly longer durations than members of the Madras groups. However, as neither the Warm Springs 1 nor the Warm Springs 2 group differs significantly with any other group, it is impossible to be certain which type of transfer these measurements represent.

4.5.1.5 Vowel quality

The discussion of vowel quality in Chapter 3 did not include comparisons of spectral measurements among groups. However, it was observed that in general, previous Numu experience did not give members of either of the Warm Springs groups a production advantage; all of the non-speakers tended to cluster together in their productions of Numu vowels, while the fluent speakers clustered separately. This pattern would seem to indicate *full transfer* in vowel spectral production. In particular, non-speakers appear to have trouble distinguishing back and central vowels.

4.5.1.6 Vowel duration vs. vowel quality

Chapter 3 included an analysis of the distinction made between long and short vowel pair productions as a factor of duration and of spectral quality. This examination was presented in terms of the percent of overlap between F1 and F2 values for a given long-short vowel pair (two-dimensional model), and the percent of overlap remaining when a third temporal dimension was added (three-dimensional model). Table 58 presents the production patterns for the four groups for percent overlap in the two-dimensional model, percent overlap in the three-dimensional model, and the difference in percentages between the two models.

Table 58. Production patterns for two- and three-dimensional vowel overlap models by speakers and non-speakers of Numu.

Feature	***Production Pattern***	***Type***
F1xF2 overlap %	Speaker < WS1<Madras<WS2	*unpredicted*
F1xF2xDuration overlap %	Speaker < WS2<WS1<Madras	gradient transfer
Difference	Speaker=WS2>WS1=Madras	gradient transfer

For the two-dimensional model, fluent speakers had the smallest amount of overlap in long and short vowel pairs (though even theirs was fairly high at 69%) indicating that fluent speakers differentiate long and short Numu vowels more on spectral dimensions than do non-speakers. The Warm Springs 1 group had the next lowest degree of spectral overlap, followed by the Madras Group. The Warm Springs 2 group broke from predicted production patterns, with the highest degree of overlap in spectral productions of long and short vowels (98%). This is potentially another case of the interplay of transfer effects and hypercorrection. It is likely that Numu long and short vowel pairs sound very similar to English speakers and are therefore produced with a greater degree of spectral overlap. Members of the Warm Springs 2 group, aware of the long and short vowel distinction in Numu, focus so much on differentiating vowels along durational parameters, they ignore possible spectral differences. This hypothesis is supported by the fact that the Warm Springs 2 group has lower overlap values in the three-dimensional model than the other non-speaker groups and differentiates the two models to a higher degree than the other two non-speaker groups. The percent overlap values for the three-dimensional model and the difference between the two- and three-dimensional models show a pattern of *gradient transfer*.

4.5.2 Phonological features

Productions of four Numu phonological features were examined in Chapter 3, including the affricate /ts/ in onset position, uvularization of velar consonants before low vowels, the devoicing of word-final unstressed vowels, and word-level prosody. In addition, it was observed that several study participants in the Warm Springs 1 and Warm Springs 2 groups produced ejective consonants, though no ejectives were present in the input. Table 59 summarizes the results of these observations, with the observed production patterns presented in the second column, and the third column providing an analysis in terms of the predictions made by each theory of change.

In the production of onset /ʦ/, the three non-speaker groups performed significantly differently from each other and from the speaker group, with the frequency of correct productions increasing by the amount of Numu experience for each group. This production pattern is predicted by both *gradient transfer* and *gradient universal feature adoption.* However, distinguishing which of these two theories applies to the /ʦ/ data is difficult. Bender's (1987) list of phonological features that are universal to simplification specifies a lack of affricates. But English also disallows word initial /ʦ/, though some other affricates are licensed in initial position. The affricate /ʦ/ was reduced to /s/ in most cases in the data, but in some cases, another affricate (e.g., /tʃ/ and /ʤ/) was substituted. Though it is not certain that reduction to /s/ does not represent adoption of universal features, the use of other affricates is almost certainly a case of transfer from English. Thus, this pattern is classified as *gradient transfer*.

Table 59. Production patterns for observations of phonological productions by speakers and non-speakers of Numu.

Feature	***Production Pattern***	***Type***
/ʦ/	Speaker > WS2 > WS1 > Madras	gradient transfer
uvularization	Speaker > WS2 = WS1 = Madras	full transfer
vowel devoicing	WS2 > Speaker > WS1 > Madras	linguistic hypercorrection
stress	Speaker = WS2 = WS1 = Madras	equivalency
ejectives	WS2, WS1 ≠ Speaker, Madras	*areal hypercorrection*

In the case of uvularization of velar consonants, it was observed that the non-speaker groups had significantly lower production frequency than did speakers, but that the production did not differ significantly among non-speaker groups. This pattern appears to be a case of either *full transfer* or *full universal feature adoption*, but again, it is difficult to tease the two possibilities apart. Maddieson (1984) reports that while 99.4% of the languages in the UCLA Phonological Segment Inventory Database (UPSID) have velar stops, only 14.8% have uvular stops; velar fricatives are also more frequent than uvular fricatives. In terms of *statistical universals*, then, velar consonants appear to be more universally unmarked than uvular consonants. As non-speakers produced far more velar than uvular stops in low vowel contexts, this may be considered an adoption of a universal feature. However, it is also the case that English does not license uvular consonants. Because velar and uvular stops are close in articulation, it is possible that the production of velar stops in a uvular stop context is a product of phonological category assimilation, as predicted by Flege's (1995) Speech Learning Model. Though the theories of transfer and universal features are indistinguishable in this case, I will assume *full transfer*, as I previously adopted the stance that any non-speaker deviation that resembles English is due to transfer effects from English (see §4.3).

For word-final vowels, it was found that the number of voiceless vowel productions by participants in the Warm Springs 2 group exceeded the number of voiceless vowel productions by fluent speakers, a case of *linguistic hypercorrection*. Moreover, two participants, one in each of the Warm Springs groups, produced devoicing in contexts that are not licensed by Numu phonology. This is a case of *cultural hypercorrection*, with the pattern WS2 = WS1 > Speaker > Madras. As only two participants produced unlicensed devoicing, it is unclear how important this result is in terms of possible future changes to the language. However, it appears that devoicing is a socially salient feature of Numu for at least some of the Warm Springs participants.

The production of Numu stress appears to fall under the classification of *equivalency*, though not because English and Numu necessarily have the same stress patterns. Rather, English stress is irregular and carries a high functional load, leading English speakers to pay careful attention to stress placement (e.g., stress placement forms the primary difference between a verb such as *recórd* and its noun counterpart *récord*). However, it is possible that the complexity of English stress rules may confuse English speakers who attempt to produce Numu words from memory (rather than by imitation, as in the current study); they may underestimate the regularity of Numu prosody, instead attempting to replicate the complexity of English prosody by overapplying English rules.

Interestingly, several participants in the two Warm Springs groups produced unlicensed ejectives in both word-initial and word-internal positions. This phenomenon cannot be presumed to be a transfer effect, as English does not have ejectives, nor is it an adoption of universal features, as glottalization is comparatively rare in the phonological inventories of the world's languages (Maddieson, 1984 reports that only 16.4% of the UPSID languages have voiceless ejectives). However, it also does not match any of the predicted patterns of hypercorrection; both *linguistic hypercorrection* and *cultural hypercorrection* assume that the hypercorrected feature is part of the target language's grammar.

Though ejectives don't occur in Numu, they are a distinctive feature of many indigenous languages of the Northwest. Jacobs (1954) reports the presence in all languages north of California (except the Aleut-Eskimo languages) of at least five, and often more than five, glottalized consonants (recall that Numu originated south of California's and Nevada's northern borders). The two other indigenous languages spoken in Warm Springs, Ichishkin and Kiksht, both have extensive inventories of ejective consonants, including glottalized obstruents and affricates. I therefore propose that the Warm Springs participants' production of ejectives is another form of hypercorrection that I will call *areal hypercorrection*, or the use of a socially salient feature from another indigenous language that is spoken in the same geographic region. In the next section, I will discuss this phenomenon in more detail.

4.5.3 Areal hypercorrection

The areal spread of phonological features is a longstanding linguistic tradition in indigenous languages of the Pacific Northwest. Jacobs (1954) discusses sound features that are widespread in the region, noting that it is remarkable to find such similarities in extremely different languages (see also Sherzer, 1973). For example, despite the fact that they belong to a number of different language families, nearly all Northwest languages have glottalized consonants; both velar and uvular stops and fricatives, including a labialized series; the lateral series /l/, /ɬ/, /λ/, /ƛ/, and /ƛ'/; and both /ʦ/ and /ʦ'/. These are all noteworthy series, as they are relatively uncommon in the world's languages. They also represent several sounds that are not found in English, and it is therefore easy to believe that they would gain some social saliency in communities where these languages are spoken.

The possibility that these sounds could be adopted by second language learners whose first language does not have them, into a language whose inventory also does not have them, is particularly interesting for two reasons. The first reason is that *areal hypercorrection* represents the appearance of distinctive features with no contrastive function, which is opposed to what is predicted by Anderson (1982). He argues that phonological distinctions are reduced in endangered languages except for those present in the matrix language (e.g., English) and those with a "high functional load," by which he means sounds that are necessary to distinguish word contrasts. Though sounds borrowed from other indigenous languages may develop a contrastive meaning over time, it is unlikely that they fulfill this purpose for the second language learners who introduce them. Instead, it is likely that the sounds are used to create a perceptual distance from English, and possibly to index speakers' identities as a Native American (cf. Ahlers, 2006). However, it is possible to retain Anderson's thesis if we reconsider what is meant by "functional load" and include both the ability to communicate content and to communicate social norms. Therefore, though features borrowed from a geographically close indigenous language may not have *contrastive function,* they have a strong *social function*. This view is supported by Wolfram (2002), who argues that it is possible for some linguistic structures to take on unique social meaning in endangered language change. He states, "This is not to say that all variability in obsolescing language varieties is socially meaningful, but it is certainly possible for some receding features to take on social significance" (p. 780).

Secondly, the presence of ejectives in non-speakers' productions, and the possibility that these could one day become features of the language may raise the question of the "naturalness" of such a sound change. If viewed from the perspective of endogenous change, *areal hypercorrection* appears highly unnatural. However, this type of change would represent a very traditional sound change for the Northwest region. As Hill (1978) discusses, historically, the presence of tribal exogamy, areal network systems, and widespread intergroup communication in the Northwest contributed to the spreading of unique phonological features throughout the indigenous languages of the region. Multilingualism was widespread, and a rich oral tradition required the use of multiple languages for proper retelling of myths. Thus, this type of sound change would appear to be very natural for members of an indigenous Northwest community, and the introduction of ejectives into Numu can be interpreted as the continuance of a long-standing historical tradition of areal phonological spread in the region.

4.6 Discussion

This examination of the hypotheses of endangered language change has revealed that future changes in Numu brought into the language by second language learners will likely include a mixture of transfer effects from English, adoption of universal features, hypercorrection, and the adoption of salient features from neighboring languages, or *areal hypercorrection*. *Gradient transfer* appears to be the most likely avenue of language change for subphonemic features of Numu. Of the 26 group comparisons of subphonemic measures made in §4.5.1, there were 10 clear cases of this type. Evidence of *full transfer* and both types of *equivalency* were also apparent in some subphonemic features. For measures of the phonological features, evidence was found for *gradient transfer, full transfer, equivalency, linguistic hypercorrection, cultural hypercorrection,* and *areal hypercorrection*.

In addition, there was evidence of interactions between transfer effects and hypercorrection for two of the subphonemic features (intervocalic singleton nasal duration and F1xF2 overlap percentage). The result of this interaction is an unpredicted pattern of group measurements, in which one or both of the Warm Springs groups' productions are further from native targets than the productions of the Madras group. These and other instances of hypercorrection, including vowel devoicing and ejective production, are of particular interest, as they indicate that these features have particular social salience for members of the Warm Springs community. These features will be examined in the next chapter in terms of their perceived importance to fluent speakers. It will be found that speakers tend to give lower ratings to non-speaker productions that exhibit these hypercorrections, and that in general, speaker ratings tend to follow the pattern of *gradient transfer*.

4.7 Conclusion

In the preceding examination of differences in Numu productions by non-speakers and fluent speakers, we have seen evidence for three proposed theories of endangered language change, transfer, adoption of universal features, and hypercorrection, as well as potential interactions between them. A fourth proposal, *areal hypercorrection*, has also been introduced to account for the unexpected emergence of ejective consonants in the data. There is another proposed path of language change that has not been examined in this chapter, concerning the overgeneralization of unmarked features by partially fluent speakers (see, for example, Anderson, 1982; Campbell & Muntzel, 1989; Dorian, 1982). This process is not testable with the current data set, which includes productions by many people who have not learned the language, and therefore have not had an opportunity to develop phonological systems that are susceptible to regularization. Should Numu be acquired by a sufficient number of second language learners, such regularization is likely to appear, alongside the avenues of change examined in this chapter.

This course of research, which explores potential future endangered language change by examining the features that occur in the productions of non-speakers, can be important to gaining an understanding of language change in general. Silva-Corvalán (1990) states,

> Developing and receding languages as well as maintenance in language contact lend themselves to the examination of hypotheses about linguistic change because they are characterized by constant and rapid changes which may be observed as they arise and spread in the linguistic and social systems (p. 163).

However, it is important to remember that the current research can only point to *potential* paths for language change. Actual changes will depend on a number of factors, including the social environment in which the language is revitalized. One factor that will be explored in the next chapter is the assessment of non-speaker productions by fluent speakers. Their evaluations may have important implications in terms of whether or not the language will be considered an acceptable marker of Numu identity in the future. Though second language learners will likely bring many changes to Numu, learners who wish to avoid a marked accent will have to be especially careful in their production of features deemed important by fluent speakers and by the Warm Springs community in general.

CHAPTER 5

Speaker Perceptions of Non-Speaker Productions of Numu

5.1 Introduction

In Chapter 3, I examined differences in speaker and non-speaker productions of Numu from a phonetic and phonological perspective, and in Chapter 4, I analyzed these differences in terms of several theories of endangered language change. However, variation and change in speech is common in any language and does not always result in social judgment (see, e.g., Labov, 2001, p. 28). Therefore, the only changes in Numu that are likely to matter to the speech community are the changes that result in a perception of “accented” speech. This chapter makes an attempt to determine which differences between fluent speaker and non-speaker productions are salient to fluent speakers by means of a perception study. The results of this study provide clues as to how learner-produced speech will be received by fluent speakers and may have important implications for learners of Numu, if they wish to attain pronunciation skills that will be evaluated as native-like. The results may also indicate which features have particular social saliency for speakers, which can be compared to features that were found to be salient to non-speakers in the Warm Springs community.

Woolard (1989) points out that changes in a minority language are always in reference to the dominant language, whether they are convergent or divergent with that language. She makes this observation in reference to the languages themselves, stating, “Both convergent and divergent changes ... deform languages systematically in response to the contact situation” (p. 363). I would argue that linguists frequently work from the same perspective, describing changes to an endangered language in terms of a socially dominant language. While this information is valuable for gaining an understanding of the effects of language contact, it does not provide information about the effects of language change within the endangered language community. The study described in this chapter therefore examines fluent speaker perceptions, so that potential changes can be described with reference to Numu.

Before discussing the study or its results, however, it is useful to explore some of the underlying assumptions inherent in discussing accentedness in the context of endangered languages. One issue of particular concern to many individuals involved with language revitalization is that of retaining the language’s authenticity. Wong (1999, p.95) states, “Instead of restoring cultural and ethnic pride to a community, [language revitalization] can generate resentment from some segments of that community towards what they might view as a threat to the existence of the values embedded in the traditional version of the language.” Brody (2001) discusses several cases in which indigenous communities have purged words and grammatical elements (with or without the help of a linguist) that have been borrowed from socially dominant languages, even though, as she argues, borrowing is a natural language process.

Authenticity is closely tied to historical and cultural legitimacy. Hornberger & King (1998, p. 391) state, “For some language users, the claim of authenticity suggests that a particular variety of the language is not artificially constructed, but interwoven with their own traditions and unique heritage.” For learners of Native American languages, this might mean that an accent, which introduces elements from other linguistic traditions into the language, detracts from the authenticity and legitimacy of their speech as a marker of indigenous identity. On the other hand, the primacy of monolingualism is a Western tradition in the United States; multilingualism was the norm in many Native American communities before the arrival of White settlers (cf. Hill, 1978 about the culture of multilingualism in the Pacific Northwest, for example). It is likely, therefore, that borrowing, transfer effects, and variation in speech production were historically common, as is indicated, for example, by the widespread areal features of indigenous Pacific Northwest languages, discussed in Chapter 4. Furthermore, though it is common for researchers to assume that authenticity is defined as part of an oppositional identity to a former colonizing power (a line of reasoning that is supported by Ogbu's (1987) excellent discussion of involuntary minorities), White (2002) finds that indigenous groups can and do validate their heritage language and culture independent of issues of political resistance. The role of an accent in the perception of authentic language use is therefore a function of both the community and the individual, and cannot be assumed.

Further study is needed to ascertain the role of accent in Numu language authenticity in the Warm Springs community. However, there is an awareness among speakers of accented speech, and especially of accents that are influenced by English. Evidence of this awareness lies in the fact that Numu speakers occasionally refer to the fact that a particular production of Numu speech, "sounds like a Taibo" (i.e., a White person). While I wish to make it clear that I cannot speak for the value judgments made by speakers about accented speech, it is likely that such judgments do exist, and as such, are of interest in the revitalization of the language. What this chapter attempts to do is to map such judgments onto their acoustic correlates, thereby making it possible for learners of Numu to tease apart elements of their productions that matter (in some way) to fluent speakers and elements that are not salient.

One assumption of the current research that is relevant to issues of authenticity is the notion that the fluent speakers/teachers who have participated in this research have the authority to determine what counts as accented speech. Several distinct varieties of Numu are spoken, even within the Warm Springs community, and though the teachers in the Warm Springs Language Program make a concerted and overt effort to embrace all varieties, they are not necessarily the only fluent speakers that learners of Numu will encounter. Accentedness and authenticity are socially constructed, and the process by which this occurs is both complex and fluid. Wong (1999, p.97) states, "[Authenticity] is a negotiated concept that is ultimately related to the amount of leverage a promoter of one ideology has over another in the negotiation process." Indeed, it is my fear that the current study, because it is presented as a written text, will gain an undeserved level of legitimacy over the views expressed by fluent speakers, even the fluent speakers who participated in the study. With that risk in mind, it is not my intention to in any way standardize what is considered to be accented speech in Numu. Rather, this study attempts to catalogue the acoustic features of non-speaker speech that contribute to what the speakers in this study found to be accented, with the hope that this information will enlighten (but not be the final word on) future efforts to teach and learn the language.

The experiments conducted in this study are presented in detail in this chapter, beginning with a description of the methods in the next section (§5.2). Section 5.3 presents both a phonological and a subphonemic analysis of the results, which are discussed with reference to the findings of Chapter 4 in §5.4. Section 5.5 concludes the chapter.

5.2 Methods

Two of the fluent Numu speakers from the production experiment participated in this portion of the research. Both were teachers in the language program at Warm Springs at the time the study occurred. They were separately presented with 992 non-speaker word productions in eight separate experiment sessions and asked to rate them on a Likert scale of 1 (non-native) to 5 (native). The Likert scale appeared on a computer screen along with a written English translation of the Numu word they were presented with, using Praat's Multiple Forced Choice (MFC) listening experiment function (Boersma & Weenink, 2008). The sessions were conducted in quiet rooms, and the Numu stimuli were presented at a comfortable volume over dynamic closed ear headphones with a frequency range of 10-22,000 Hz, sensitivity of 106 dB/mW $\pm$ 3 dB, and impedance of 38 ohms $\pm$ 15%. All stimuli were normalized to the mean amplitude of all of the stimuli in each experimental session, ranging from 71.30 to 74.66 dB. The experiment participants were allowed to repeat each token as often as they desired, and they were given the option to rest after every 40 tokens.

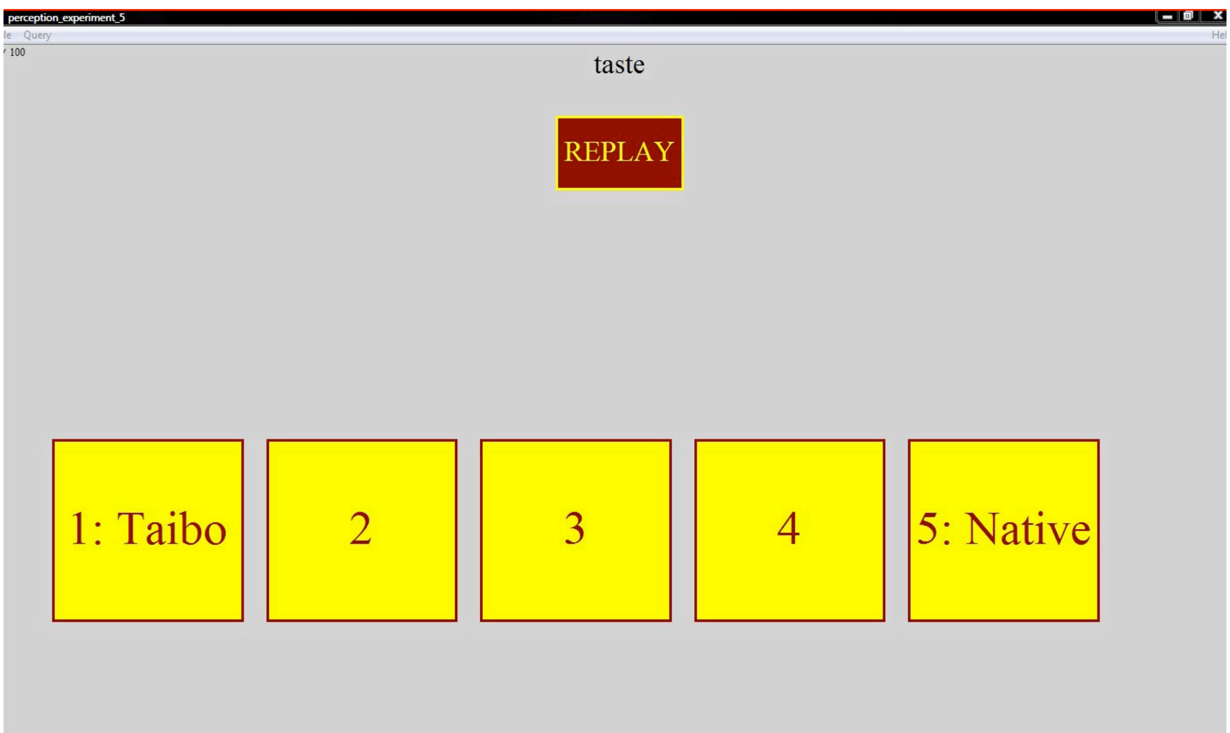

Figure 48. Screen shot from Experiment 5 (Taibo means non-Native or White person).

Figure 48 is a screen shot of the page that appeared in Experiment 5 as a non-speaker token of the Numu word for *taste* played over the headphones (*Taibo* means non-Native or White person in Numu and is often used to describe speech that sounds accented). The study participants were informed that some of the stimuli had, indeed, been produced by White people from the nearby town of Madras. This step was taken in order to encourage participants to use the full range of the rating scale, in case the perception that all stimuli were produced by Warm Springs community members would produce results skewed towards the positive end of the scale.[22]

Experimental stimuli were selected based on findings in Chapter 3, with a focus on phonological and phonetic features that differed significantly between speaker and non-speaker groups. Table 60 provides details about the primary and secondary stimuli types for each experiment. Note that each experiment features at least two primary stimuli types in order to reduce priming effects. Every experiment featured an equal or near-equal number of tokens from each non-speaker (because none of the non-speakers from the Madras group produced ejectives, there were fewer tokens from this group in Experiment 7). Recall that each non-speaker recorded four tokens of each word for the experiment in Chapter 3. Only one of these tokens was selected to represent each non-speaker's production of a given word in the current experiment, using a randomization function in Excel.

Table 60. Stimuli type and number of tokens for all perception experiments.

Experiment	Primary Stimuli Type(s)	Secondary Stimuli Type(s)	Number of Tokens
1 (Block)	Vowel length Nasal duration	Onset VOT	130
2 (Random)	Fortis and lenis obstruents Onset VOT	High vowel quality	100
3 (Block)	Vowel length Nasal duration	Onset VOT	120
4 (Random)	Fortis and lenis obstruents Onset VOT	High vowel quality	100
5 (Random)	Nasal duration Onset VOT	Vowel length	100
6 (Random)	Nasal duration Onset VOT	Vowel length	100
7 (Random)	Ejectives Devoiced vowels	Uvularization	145
8 (Random)	Onset /ʦ/ Vowel quality	Nasal duration	197

Tokens in Experiments 1 and 3 were presented as blocks by non-speaker, with words randomly presented within the blocks, and the blocks randomly presented to the experiment participants. These two experiments primarily explored duration, and this step was taken to allow experiment participants to hear within-speaker duration ratios. There were ten words presented in Experiments 1 and 3, for a total of 250 tokens by the 25 non-speakers. Therefore, the blocks

[22] As will be discussed in §5.3.3, tokens were presented randomly or in randomly organized blocks in order to minimize any possible recognition of voices. Ideally, the raters should have recognized no one, but knowing that a portion of the tokens came from outside the community, they should have felt less discomfort in assigning lower ratings.

were divided into two experiments, with a separate experiment presented in-between to prevent monotony for the experiment participants. Stimuli in the rest of the experiments were presented randomly by speaker and token.

5.3 Results

Ratings for all tokens in all experiments were tabulated and the count of each rating (1-5) was calculated. The count and percentage of the ratings given by each fluent speaker are presented in Table 61 and in Figure 49.

Table 61. Count and percentage of each rating given by Rater 1 and Rater 2.

Rating	Rater 1 Count	Rater 1 Percentage	Rater 2 Count	Rater 2 Percentage
1	296	29.84%	144	14.52%
2	110	11.09%	90	9.07%
3	171	17.24%	42	4.23%
4	124	12.50%	144	14.52%
5	291	29.33%	572	57.66%

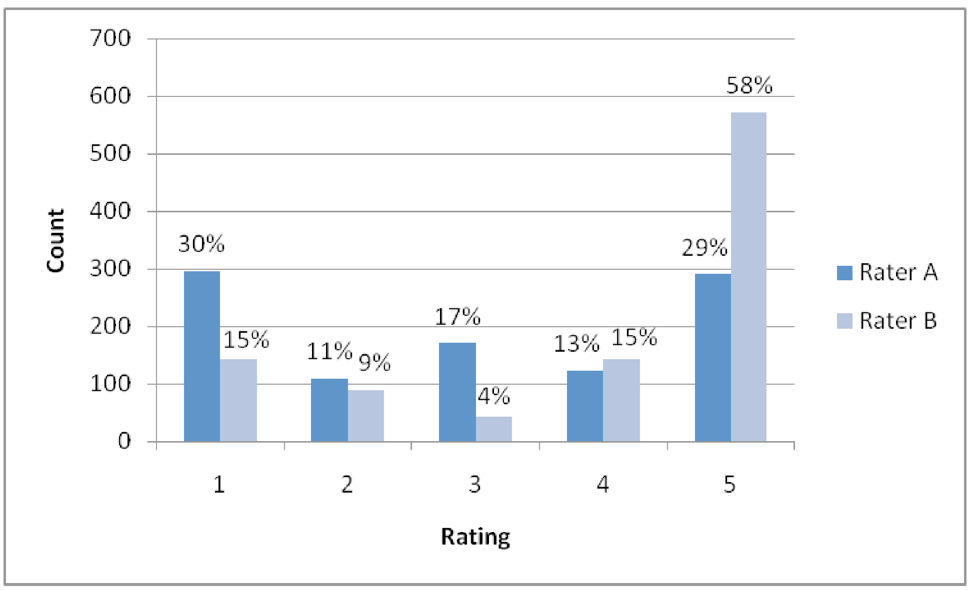

Figure 49. Count and percentage of each rating given by Rater 1 and by Rater 2.

The patterns for the two raters appear sufficiently different to cause some concern about reliability in scoring. For example, Rater 2 is very lenient, with the majority of her ratings in the 4-5 (*native* or *near native*) range, while Rater 1 has a more even distribution of ratings across the five possible scores. As might be expected, the Kendall's tau coefficient between their rating distributions is only 0.33, indicating a low amount of agreement between them. Table 62 provides the count and percentage of differences in ratings between the two raters. A full 25% of their ratings differ by 3 or 4 points. Though this situation is somewhat troublesome for analysis, it is not entirely unexpected. Recall from Chapter 2 that there were many significant differences in production among the four fluent speakers. For the measures performed in this study, these two raters (Rater 1 is Speaker A and Rater 2 is Speaker C) differed significantly in lenis duration, and as they come from different regions originally, they likely differ along other parameters as well. It stands to reason that there would also be variation in their perception. As both raters are active teachers of Numu and recognized within the Warm Springs community as language experts, the variation in their perception of accentedness is reflective of the variation that language learners would encounter in seeking feedback about their productions.

Table 62. The difference in ratings between Rater 1 and Rater 2 for each token, presented as a count and a percentage of total ratings.

Rating Difference	Count	Percentage
0	345	34.8%
1	234	23.6%
2	166	16.7%
3	144	14.5%
4	103	10.4%

The current analysis therefore proceeds with separate analyses of the ratings given by each speaker for phonological and phonetic differences between fluent speaker and non-speaker productions.

5.3.1 Phonological factors

Six phonological factors were regressed against the ratings from each rater. These six factors were those that were examined in Chapter 3, and include non-speakers': 1) production of /ts/ in the onset; 2) production of a uvular consonant following a low vowel; 3) production of a devoiced vowel; 4) vowel devoicing in the same context as the fluent speaker input; 5) production of an ejective; and 6) production of the same stress pattern as present in the fluent speaker input. It was determined that a binary model was necessary to achieve sufficient data points in each of the independent variable categories.[23] Therefore, the ratings 1-3 were recoded as "non-native" and the ratings 4-5 were recoded as "native." The 4 rating was included with the 5 rating to allow a small margin of error in the "native" category; anything less than 4, however, must be a result of some non-native sounding aspect of the word, and thus "non-native."

It was also important to account for any variance in the data caused by random effects such as the specific word being rated or the individual participants whose voices were recorded in the imitation study. Therefore, five factors were entered as random effects into a mixed effects regression model.[24] The model takes into account the amount of variance contributed by each of

[23] A rule of thumb for performing a logistic regression is that each cell formed by a categorical independent variable should contain at least one case, and no more than 20% of the cells should contain less than five cases. See Garson (2010).

[24] For more information about mixed-effects models in linguistics, see Baayen (2008, p.278).

these factors in the regression analysis. The amount of this variance is reported in Table 63 for each rater. The Numu words that raters listened to in the study and the individual non-Numu speakers who produced them are represented by *Word* and *Participant*, respectively. Also included is a variable called *Input,* which refers to the four fluent Numu speakers whose words were repeated by the non-Numu speakers. *Group* is the group that the participants were assigned to (Madras, Warm Springs 1, and Warm Springs 2). *Gender* of the participants whose voiced were recorded is the final random effect included in the regression model; for Rater 2, *Gender* did not contribute significantly to the model fit, so it was therefore not included.

Table 63. Amount of variance accounted for by individual random effects for each Rater.

Random Effect	Rater 1 Variance	Rater 2 Variance
Word	0.408	0.571
Participant	0.373	0.284
Input	0.026	0.017
Group	0.143	0.077
Gender	0.317	-

The results of a model regressing the phonological factors described above against fluent speaker ratings, with an incorporation of the random effects, are presented in Table 64 by rater. The coefficient is in respect to the "native" rating; negative odds indicate a decrease in the likelihood of obtaining this rating. For Rater 1, four of the phonological factors contributed significantly to increased odds of a reduced, or "non-native" rating, including the production of something other than /ts/ in onset position; the production of a /ts/ in onset position; vowel voicing/devoicing that differed from the voicing present in the recordings of the fluent speakers that the non-Numu speakers repeated; and the production of an ejective. Incorrect stress approached significance for Rater 1. For Rater 2, only vowel voicing/devoicing that differed from the input was a significant factor in a reduced rating; the production of an ejective and the production of incorrect stress approached significance.

Table 64. Regression results for phonological factors, by rater.

Factor	Rater 1			Rater 2		
	Coefficient	***Std. Error***	***p-value***	***Coefficient***	***Std. Error***	***p-value***
No /ts/	-1.9462	0.50	0.000 ***			
/ts/	-1.4615	0.47	0.002 **			
No uvular						
Devoiced vowel						
Different vowel voicing	-0.7094	0.26	0.006 **	-0.6836	0.26	0.008 **
Ejective	-1.7763	0.42	0.000 ***	-0.06134	0.35	0.076 ^
Incorrect stress	-0.9865	0.51	0.051 ^	-0.7602	0.45	0.089 ^

It is interesting that both the production of /ts/ and the non-production of /ts/ in onset position resulting in an increased odds of lower rating for Rater 1. It is likely that the production of /ts/ sounded accented, even when phonologically correct. So far, this chapter has focused on phonological factors that may affect the native-likeness rating given by fluent speakers of Numu to words produced by non-speakers. However, in a series of perception experiments with French speakers producing English phrases and segments (/t/, /i/, and /u/), Flege (1983) found that adult English speakers, "possess the ability to detect within-category (subphonemic) differences between language varieties, and to use this information in detecting foreign accent" (p. 680). The next section therefore explores several subphonemic factors found to be significantly different between fluent speaker and non-speaker groups in Chapter 3 to determine if these have an effect on fluent speakers' perception of accent.

5.3.2 Subphonemic factors

In this section, the subphonemic factors that were examined in Chapter 3 are regressed on the recoded accentedness ratings (1-3 = "non-native"; 4-5 = "native). The continuous independent variables were recoded as ordinal variables for the regression analysis, with four levels (or cut-points) defined at the four quartiles for each variable. The random effects described above were also included in the model for each rater. Tables 65 and 66 provide the results for the regressions for Rater 1 and Rater 2 respectively. The first column, *Factor,* names the subphonemic independent variables. The next column lists each quartile (*Quar.*), followed by a column (*Level*) that defines the value at each quartile (quartile calculations are based on the data included in the current perception study). The next three columns provide regression results, including the coefficient, standard error (*Std. Error*), and p-value. Note that the coefficient is the log odds of a factor affecting a rater's rating; positive odds indicate an increase in the likelihood of a "native" rating. The final columns report the variance in the model as the result of each random effect. Shaded rows represent non-significant factors or levels.

The raters differ in which subphonemic factors result in an increased odds of a different rating, but onset VOT, intervocalic singleton and geminate nasal duration, and long vowel duration are not significant factors for either rater. For Rater 1, fortis duration, fortis VOT, fortis relative burst amplitude, and fortis relative burst intensity play significant roles in ratings, as do lenis duration, nasal onset duration, and short vowel duration. Rater 2 also relies significantly on all four fortis measures, though for her, ratings of lenis sounds are dependent on VOT and relative burst intensity rather than on duration. Rater 2's ratings were also significant for short vowel duration. Like Rater 1, nasal onset duration in the third quartile greatly increases the odds of a "native-like" rating.

It is worth noting that Rater 2's results include two factors for which performance at any quartile resulted in increased odds of a "native" rating: fortis VOT and short vowel duration. For this rater, it appears that any production of these features is positive. The short vowel duration factor may help explain the high number of 4- and 5-ratings she assigned, as the majority of the words in the data set included a short stressed vowel (recall that all vowel measurements were made on stressed vowels).

Table 65. Rater 1 regression results for subphonemic factors.

Factor	Fixed Effects Results					Random Effects Variance				
	Quar.	***Level***	***Coeff-icient***	***Std. Error***	***p-value***	***Word***	***Parti-cipant***	***Input***	***Group***	***Gender***
Onset VOT										
Fortis Duration	1	143 ms				0.999	0.305	0.027	0.114	0.314
	2	166 ms	1.45	0.45	< 0.01					
	3	200 ms								
	4	438 ms	0.96	0.45	< 0.05					
Fortis VOT	1	17 ms				1.040	0.316	0.027	0.132	0.350
	2	28 ms	1.55	0.47	< 0.001					
	3	43 ms	1.90	0.48	< 0.001					
	4	130 ms								
Fortis Amplitude	1	0.10 Pa				1.040	0.330	0.025	0.133	0.333
	2	0.19 Pa	1.78	0.46	< 0.001					
	3	0.29 Pa	1.34	0.45	< 0.01					
	4	0.71 Pa	1.36	0.44	< 0.01					
Fortis Intensity	1	12 dB				0.995	0.311	0.020	0.122	0.314
	2	15 dB	1.25	0.43	< 0.01					
	3	18 dB	1.03	0.44	< 0.05					
	4	36 dB	1.47	0.44	< 0.001					
Lenis Duration	1	72 ms	1.15	0.38	< 0.01	1.198	0.320	0.027	0.118	0.316
	2	91 ms								
	3	118 ms								
	4	406 ms								
Lenis VOT										
Lenis Amplitude										
Lenis Intensity										
Nasal Onset Duration	1	56 ms				0.844	0.304	0.037	0.104	0.314
	2	86 ms								
	3	110 ms	1.80	0.56	< 0.01					
	4	301 ms								
Singleton Nasal										
Geminate Nasal										
Short Vowel Duration	1	118 ms				0.983	0.258	-	0.109	0.424
	2	150 ms	2.11	0.90	< 0.05					
	3	180 ms	1.79	0.90	< 0.05					
	4	345 ms								
Long Vowel Duration										

Table 66. Rater 2 regression results for subphonemic factors.

Factor	Fixed Effects					Random Effects Variance			
	Quar.	*Level*	*Coeff-icient*	*Std. Error*	*p-value*	*Word*	*Parti-cipant*	*Input*	*Group*
Onset VOT									
Fortis Duration	1	143 ms	1.08	0.48	< 0.05	0.703	0.269	0.026	0.052
	2	166 ms							
	3	200 ms	1.73	0.57	< 0.01				
	4	438 ms							
Fortis VOT	1	17 ms	0.98	0.46	< 0.05	0.866	0.292	0.023	0.061
	2	28 ms	1.71	0.51	< 0.001				
	3	43 ms	1.34	0.49	< 0.01				
	4	130 ms	1.33	0.51	< 0.01				
Fortis Amplitude	1	0.10 Pa				0.698	0.299	0.020	0.059
	2	0.19 Pa							
	3	0.29 Pa	1.33	0.49	< 0.01				
	4	0.71 Pa	0.99	0.46	< 0.05				
Fortis Intensity	1	12 dB				0.700	0.294	0.019	0.056
	2	15 dB	1.56	0.53	< 0.01				
	3	18 dB							
	4	36 dB	1.12	0.47	< 0.05				
Lenis Duration									
Lenis VOT	1	-67 ms				0.613	0.293	0.032	0.042
	2	14 ms	0.96	0.41	< 0.05				
	3	29 ms	1.16	0.45	< 0.05				
	4	146 ms							
Lenis Amplitude									
Lenis Intensity	1	13 dB	1.53	0.66	< 0.05	0.582	0.277	0.028	0.053
	2	17 dB							
	3	21 dB							
	4	32 dB							
Nasal Onset Duration	1	56 ms				0.519	0.287	0.029	0.047
	2	86 ms							
	3	110 ms	2.16	0.083	< 0.01				
	4	301 ms							
Singleton Nasal									
Geminate Nasal									
Short Vowel Duration	1	118 ms	3.09	1.17	< 0.01	0.507	0.135	-	0.078
	2	150 ms	3.17	1.17	< 0.01				
	3	180 ms	3.26	1.18	< 0.01				
	4	345 ms	3.38	1.19	< 0.01				
Long Vowel Duration									

5.3.3 Difference ratings

Phonological and subphonemic factors do appear to play a role in fluent speakers' perception of accent in non-speakers. However, what the models above do not test is the importance of degree of difference from the fluent speakers' pronunciation. To test this factor, all of the rated non-speaker productions were narrowly transcribed using the international phonetic alphabet. The fluent speaker inputs to their productions and the raters' productions of the same words were also narrowly transcribed.[25] All cases where the fluent speaker inputs and the raters' productions were appreciably different (e.g., words that showed significant dialectal difference) were removed. All cases were also removed where the two raters differed in their rating of the production by more than 1 so that both raters could be included in the same model. The resulting list of 540 transcriptions of non-speaker productions were then compared to the transcriptions of each of the raters' productions, and any differences between non-speaker and rater productions were recorded. Table 67 provides the combined distribution and percentage of ratings from both raters for these 540 words.

Table 67. Count and percentage of the ratings given by both raters for the 540 non-speaker productions that were analyzed using narrow transcriptions.

Rating	Count	Percentage
1	219	20.28%
2	95	8.80%
3	56	5.19%
4	172	15.93%
5	538	49.81%

Note that the middle rating, 3, makes up only 5.19% of data for this set, which precludes the use of ordinal logistic regression due to insufficient cases. However, excluding the 3-rated data allows the use of ordinal logistic regression of the number of production differences against ratings without a substantial loss of input. The result, which is significant at the $p < 0.001$ level, is that an increase of one difference in production from the rater's production increases the odds of one point *decrease* in native-likeness by a factor of 0.38 (log odds ratio = -0.97; standard error = 0.05).

5.3.4 Social factors

It is clear that the random factors included in the phonological and subphonemic regressions had an effect on the data, as they contributed a fair amount of variance to the models. They are therefore interesting in their own right, and were also regressed on the ratings. For these factors, there were sufficient data counts at all rating levels, and so it was possible to employ a logistic ordinal regression model. Word, participant, input, group, and gender were all regressed on ratings for each rater.The words were not significant factors for either rater. For Rater 1, the other four factors were significant, with no significant interactions. For Rater 2, only Group, representing the non-speakers' previous exposure to Numu, was significant.

The results of an ordinal regression of *Participant, Gender, Group* and *Input* on each rater's ratings are presented in Table 68. In this table, the coefficient reflects the log odds of advancing one rating level (e.g., from 1 to 2 or from 2 to 3); a negative coefficient indicates an increased odds of a reduced rating.

[25] Because the two raters also each produced a quarter of the recorded words that were used as input for the non-speaker productions, frequently the fluent speaker inputs and the raters' productions were the same.

Table 68. Results of an ordinal regression of participant, gender, group, and input on ratings, by rater.

Factor	Comparative Groups	Rater 1			Rater 2		
		Coeff-icient	*Std. Error*	*p-value*	*Coeff-icient*	*Std. Error*	*p-value*
Participant	*WS03*	0.888	0.35	0.012 *			
	WS05	1.466	0.34	0.000 ***			
	WS09	1.477	0.37	0.000 ***			
Gender	*male*	-0.793	0.14	0.000 ***			
Group	*Warm Springs 1*	0.345	0.13	0.010 **	0.435	0.14	0.002 **
	Warm Springs 2	0.689	0.14	0.000 ***	0.565	0.16	0.000 ***
Input	*Speaker B*	-0.469	0.17	0.005 **			
	Speaker C	-0.465	0.16	0.004 **			
	Speaker D						

For Rater 1, being one of the three individual non-speakers who emerged as significant in the *Participant* factor increases the odds of an increase in native-likeness ratings (note that none of these participants had previous exposure to Kiksht or Ichishkin). It is unclear why these three individuals have a tendency to sound more native-like to Rater 1; perhaps they have better pronunciation than other individuals, or perhaps Rater 1 recognized their voices. Davies (2003) argues that people's perception of accent depends a great deal on whether or not they recognize a speaker as part of a speech community. The fact that no one from the Madras group is represented here may indicate that the latter possibility is true. On the other hand, only three of fourteen participants from the Warm Springs community have significant results, though Rater 1 is acquainted with the majority of these participants. Also, raters were presented with a large number of randomly organized tokens by the non-speakers during the experimental sessions, which was meant to make voice recognition difficult.

Gender was also a significant factor for Rater 1. Being male increases the odds of a decrease in native-likeness. Also, as compared to non-speaker productions from input given by Rater 1 (Speaker A), productions of words from input from Speakers B and D resulted in the odds of a decrease in native-likeness for her. For both Raters, being a member of the Warm Springs 1 Group or the Warm Springs 2 Group increases the odds of an increased native-likeness rating, as compared to being a member of the Madras Group (the Madras group forms the comparative group and is therefore not included in the table). This result is not likely linked to voice-recognition, as the raters are acquainted with members of both groups, and because we see a pattern of increased native-likeness in the group with the most previous Numu experience.

5.4 Discussion

It is interesting that all four fortis obstruent measures played significant roles in both raters' assignments of ratings, though relative fortis burst amplitude does not significantly distinguish fortis from lenis sounds in fluent speaker productions. However, recall from Chapter 3 that fluent speakers have larger mean fortis burst amplitudes and mean fortis burst intensities than any of the non-speaker groups. The current perception results show that non-speaker productions with higher magnitude amplitude and intensity tend to result in higher ratings for both raters. It is certainly possible that fortis sounds are associated with specific subphonemic features for fluent speakers, independent of comparisons with lenis sounds. Fortis sounds do appear to be very relevant to fluent speakers, which may partially account for the presence of ejectives in the non-speaker data. Warm Springs community members are perhaps aware of the importance of "strong" fortis sounds in Numu, and conflate these sounds with the ejectives found in the two other Warm Springs languages. However, note that ejectives occurred in non-fortis positions in some non-speakers' productions, suggesting that additional factors are at play, as discussed in Chapter 4.

The two raters differed in their evaluation of lenis sounds. For Rater 1, low lenis duration was associated with higher ratings, while Rater 2 tended to give higher ratings to words with low intensity lenis sounds and lenis sounds with mid-range VOT values. Recall that fluent speakers tend to differentiate fortis and lenis sounds by duration more so than by VOT, though both are significant factors. Again, perception of lenis sounds as independent segments may be associated with specific features for both raters that do not necessarily correlate with fortis/lenis differentiation.

It is also interesting that intervocalic nasal duration measures did not significantly affect ratings for either rater, though both raters tended to give higher ratings to words with longer onset nasal durations. In Chapter 3, we saw that non-speakers significantly distinguish onset from intervocalic singleton nasal duration, though fluent speakers do not, and we also observed that fluent speakers have the second shortest onset nasal duration values (following the Madras Group, which exhibited the shortest onset nasal duration). So it appears that though fluent speakers produce relatively short onset nasal duration, they value longer values in perception. It is possible that it was easier for them to distinguish which nasal was produced by non-speakers when the duration was longer, but the payoff for learners from the Warm Springs area is a valuation of their production tendencies. However, Rater 2 did not give significantly higher ratings for onset nasals produced in the highest duration quartile, so for her at least, there is a limit to the positive effects of onset nasal length.

Though Waterman (1911) reports that English and Numu onset VOT differ, this measure was not a significant factor in raters' ratings. Uvularization of velar consonants following a low vowel and stress placement were also not factors. It is likely that none of these factors affected raters' ratings because none of them play contrastive roles in the language. Similarly, it is unsurprising to find a correlation between the number of mistakes (i.e., differences between non-speaker and rater productions) made and the odds of receiving a lower rating. It is likely that fluent speakers find it easy to overlook a single mistake in a non-speaker production, perhaps even attributing it to the natural variation that occurs in human speech, but multiple mistakes begin to decrease the comprehensibility of the word. Likewise, differences in onset VOT, uvularization, and stress placement can be more easily attributed to natural variation, as they do not affect word meanings.

The production of ejectives by non-speakers from Warm Springs was also hypothesized to carry socially contrastive rather than linguistically contrastive information, and for Rater 2, ejective production was not a significant factor in ratings (though it approached significance). For Rater 1, however, the presence of ejectives in the data resulted in lower ratings. For both raters, vowel voicing/devoicing was an important factor; the devoicing of a vowel that was voiced in the input, or vice versa, resulted in significantly lower ratings. It appears that while subphonemic hypercorrection may have negligible or even positive effects (e.g., onset nasal duration), phonological hypercorrection, including areal hypercorrection, contributes to fluent speakers' perception of accentedness.

It was also not surprising to find that social factors, such as gender or the identity of individual non-speakers, played a role in the ratings of at least one of the raters. Davies (2003) argues that perceived speakerhood is as much a function of one's status in a given speech community as the actual utterance. Further study with an ethnographic component would be required to speak to these factors fully, but it is generally interesting that they had an effect. For both raters, the group that the non-speakers belonged to was a significant factor, with members of the Warm Springs 2 Group having higher odds of high ratings, followed by members of the Warm Springs 1 Group, as compared to the Madras Group. This result is well in line with the production results from Chapter 3, which frequently showed that the Warm Springs 2 Group patterned most closely with fluent speakers, followed by the Warm Springs 1 Group.

Variation may have also played a role. Recall from Chapter 2 that there is a fair amount of subphonemic variation in fluent speakers' Numu productions. We might expect this to manifest itself in ratings, which does seem to occur. Rater 2, who shows more differences in her Numu from other fluent speakers than does Rater 1 , appeared to accept more variation in non-speaker productions, giving a larger number of 5 scores and not showing significant results for some of Rater 1's significant factors (e.g., onset /ts/ production). Variation in input also appears to have played a role for Rater 1, who exhibited significantly lower odds of assigning a high rating to non-speaker productions that were repeated from recordings by Speaker B and Speaker C. Note that Speaker B and C are from a different region than Rater 1 (who is Speaker A), so regional or dialectal differences may have played a role. On the other hand, Rater 2 (who is Speaker C) did not show the same response to productions that were repeated from recordings by Speaker A. These results speak to the importance of recognizing the variability of both production and perception in individual fluent speakers. The raters in this study are both language teachers, and are thus likely to have more interactions with language learners than other fluent speakers, but other speakers may nonetheless perceive learners and their productions in unexpected ways.

5.5 Conclusion

Overall, fluent speaker ratings appear to follow the pattern of gradient transfer described in Chapter 4, with higher ratings assigned to productions that most closely align with fluent speaker productions. Overshooting fluent speaker production targets, on the other hand, is only effective if it emphasizes a language contrast (e.g., onset nasals); hypercorrection of vowel devoicing and ejective production resulted in lower ratings. Subphonemic factors without contrastive functions tended to be ignored (e.g., onset VOT, uvularization, stress), but the production of fortis sounds appeared especially relevant to speakers. Indeed, though non-speakers produced ejectives in a number of non-fortis contexts, attention to the importance of fortis sounds (or "strong" consonants) may have contributed to the production of ejectives in the first place.

These results provide a potential resource for language learners who wish to improve their pronunciation from a Numu perspective. It also demonstrates that features that draw particular attention by linguistic researchers (e.g., onset VOT) may not be very relevant to a speech community, while other aspects of speech (e.g., fortis production) are particularly salient. The implication of these findings is that it is not safe for non-community linguists to assume what language change will mean to an endangered language speech community without a thorough examination of the situation from the perspective of fluent speakers. While I do not necessarily recommend that a study such as this should be conducted in every case, I do recommend taking a collaborative approach with community members in determining what is salient (cf. Leonard & Haynes, In Press). A second implication is that Numu (and other endangered languages in similar social contexts) may continue to be an authentic marker of Numu culture, even if it incorporates some of the features of second language learner speech. This is especially true for second language learners who have had some previous exposure to fluent speakers of the language.

CHAPTER 6

Concluding Remarks

6.1 Summary of research

This dissertation has compared phonetic and phonological features of Numu words produced by fluent speakers to those produced by non-speakers. The differences between speaker and non-speaker pronunciation point to possible future language changes, as there are few remaining native speakers of Numu in Warm Springs, and the language is likely to be carried on primarily by second language learners. Most of the differences exhibit characteristics of *gradient transfer effects*, or effects correlated with previous language experience. This result was expected based on research showing that previous exposure may improve both language perception (e.g., Oh et al., 2003) and language production (e.g., Knightly et al., 2003). Non-speakers' productions also show evidence of *adoption of universal features* and *hypercorrection*. Finally, a fourth possibility for endangered language change, *areal hypercorrection*, was proposed, based on the emergence of ejectives in some non-speakers' productions. Ejectives are common to the indigenous languages of the Northwest, including the two other indigenous languages spoken in Warm Springs, but are not a feature of Numu.

The second part of the research examined fluent speakers' reactions to non-speakers' productions in an effort to identify which differences in pronunciation are perceivable. It was found that variation in non-contrastive sounds draws little attention, but that multiple deviations from fluent productions within a word contribute to a lower rating of native-likeness. Fluent speakers also tend to give higher ratings to the non-speakers with the most previous Numu experience, loosely following the *gradient transfer effects* pattern. Cases of *hypercorrection* and *areal hypercorrection*, on the other hand, were found to be less acceptable.

6.2 Implications and future research

This research highlights the possible implications of using electronic media in language revitalization, an approach that has gained popularity as more and more people have access to computers and other devices that can display and transmit large amounts of data, including sound files. On the one hand, this approach gives much broader access to people interested in learning the language and provides people an opportunity to participate in language revitalization even if their schedule or physical location would otherwise prevent it. On the other hand, without feedback from fluent speakers, learners are likely to use their own output as language input, reinforcing any errors present in their productions (see Markham, 1997, p.90). What the current research suggests is that learners with previous exposure to the language, even ambient exposure, make fewer deviations from fluent speaker productions and tend to be perceived as more native-like by fluent speakers. Thus, the use of electronic media should be supplemented by interactions with fluent speakers as often as possible.

Because there are cases where such interactions are impossible or infrequent (e.g., many Warm Springs teenagers attend high school at boarding schools away from the Warm Springs community and do not have much direct exposure to the Warm Springs languages during the school year), one potentially important future line of research is ways in which to address learner accents through electronic means. For example, Bradlow et al. (1997) have found that adult speakers of Japanese can improve their perception, and to some degree their production, of English /r/ and /l/ using a technique called perceptual learning. Perceptual learning involves a forced-choice task in which a participant listens to a minimal pair of words featuring a given phonological contrast and selects the word that contains the appropriate phoneme. They are given immediate feedback on their choice (correct or incorrect) before moving on to the next pair.

While a perceptual learning task could be easily adapted to a web-accessible learning portal, for example, further study is required to determine if it is tenable as a method for improving pronunciation in endangered language contexts. Though none of the subjects in Bradlow et al. (1997) had lived in an English-speaking country, they had all had several years of formal English training (as is typical in Japan). It would be useful to learn if these results would be reproducible in a language context where learners had little previous training or fluent speaker input. It would also be useful to know if there is an effect of type of phonological contrast on perception and production results (i.e., whether some types of contrasts are more amenable to this type of learning task). Francis & Nusbaum (2002) have partially addressed both of these questions. In a study of the acquisition of the Korean three-way stop contrast by English speakers, they found that perceptual learning can improve non-speakers' perception of both within-category similarity and between-category differences. Their subjects had no previous experience with Korean. However, they explored only perception, not production, and they concluded that it is unclear if these results extend to more general circumstances of phonetic learning. Finally, for perceptual learning tasks to be practical for language learning, they must be able to efficiently address multiple contrasts. The final question that must therefore be researched is how many contrasts can be included in a perceptual learning session before learners' perception and production outcomes diminish significantly.

These are all areas of study that merit further research, but only insofar as a given community (and/or individuals within the community) determines the need for improving language learners' pronunciation through electronic means. The current research has been inconclusive about social factors that influence Numu speakers' perception of accented speech, though it suggests that such factors may be significant. Further study using ethnographic methods are required to determine the weight of such factors and how they affect accent perception. In any given community, this information would provide important information about the acceptability of developing electronic resources for language learning and pronunciation improvement.

6.3 Conclusion

Though further research is required to better understand the place of non-speaker Numu productions in Warm Springs society, this study provides information about how these productions differ from fluent speaker productions. It also provides acoustic correlates to judgments of accented speech in Numu. My hope is that it furthers our understanding of phonetic and phonological change in an endangered language context, both from the perspective of linguistic science and from the perspective of fluent Numu speakers.

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Appendix A: Numu words used for phonetic measurements.

Warm Springs Orthography	Translation	Narrow Transcription				Total Tokens
		Speaker A	*Speaker B*	*Speaker C*	*Speaker D*	
suta'a	angry	ʃɨ'ttaʔah	ʃɨ'ttaʔa	sɨ'ttaʔa	sɨ'ttaʔa	4
tunna	antelope	tɨ'nna	tɨ'nna	tɨ'nna	tɨ'nnah	4
pahwa	aunt	pah'wa	pah'wa	pah'wa	pah'wa	4
ka'wots	back of neck	kaʔ'wɔts	kaʔ'wɔːtsa	kaʔ'wɔts	qaʔ'wɔts	4
hoona	badger	hu'na	hu'na	hu'na	hu'na	4
wohe	bark	wɔ'hi	-	wɔ'hi	wɔ'hi	3
kapa	bed	-	k^ha'ppa	ka'ppa	ka'ppa	3
nate	belt	na'tti	na'tti	na'tti	na'tti	4
tatogo	big toe	ta'ttoʁo	-	ta'ttoʁo	ta'ttoɢo	3
pabatatogo	large big toe	-	pa'batattoɢo̥	-	-	1
tooopooe	black eye	'tuːpui	-	-	'tuːpui	2
weegea	blanket	-	wi'gia	wi'gia	-	2
pa'osa	bottle	-	pa'ʔoʃa	pa'ʔosa	pa'ʔosa	3
naatse	boy	'naːtsi̥	'naːtsi̥	'naːtsi̥	'naːts	4
nana'aatse	boys	na'naatsi̥	na'naʔaːtsi̥	na'naʔaːtsi̥	na'naʔaːtsi	4
tsopege	brain	tso'ppigi	tso'ppigi	tso'ppigi	tso'ppigi	4
tukabu	bread	tɨ'kkaβɨ	tɨ'kkabɨ	tɨ'kkabɨ	tɨ'kkabɨ	4
aamusa/aamusi	bullfrog	'aːmɨʃa	-	'aːmɨs	'aːmɨʃi	3
aamusowba	bullfrog (absolute[i])	-	'aːmɨʃauba	-	-	1
tumuu	buy	tɨ'mɨː	tɨ̹'mɨː	tɨ'mɨː	tɨ'mɨː	4
saiba	cattail	'saiβa	ɕaibə	'saibə	'saibă	4
koomea	cloud	kumi'a	-	kumi'a	-	2
koomeba	cloud (absolute)	-	ku'miba	-	ku'miba	2
kooodu	coat	'kuːdɨ	'kuːdɨ	'kuːdɨ	'kuːɾɨ	4
kope'e	coffee	qo'ppiʔḭ	qo'ppiʔi	qo'ppiʔi̥	qo'ppiʔih	4
koodeenna	Crane, OR	ku'ɾiːnna	-	ku'diːnna	ku'diːnna	3
tuhudya	deer	-	tɨ'hɨttʃa	tɨ'hɨttʃ	tɨ'hɨttʃ	3
ataa'e	diarrhea	ʔa'ttaːʔi	ʔa'ttaːʔi	a'ttaːʔi̥	ʔa'ttaːʔi	4
nose	dream	no'si	no'ʃi	no'ɕi	no'ɕi	4

Warm Springs Orthography	Translation	Narrow Transcription				Total Tokens
		Speaker A	*Speaker B*	*Speaker C*	*Speaker D*	
hebe	drink	hi'βi	hi'bi	hi'bi	hi'bi	4
naka	ear	na'qqa	na'qqa	na'qqa	na'qqa	4
nahedawunu	embracing	na'hidawɨnɨ	-	na'hidawɨnɨ	-	2
poobetse	fifty_cents	'poːβitsi̥	-	-	'poːβitsi	2
masedoo	fingernail	ma'ɕidu	ma'ʃidoʔu̥	ma'sidu	ma'ʃidu	4
toge	fit	to'gi	to'gi	to'gi	to'gi	4
tonegea	flower	to'nigia	to'nigiaʔḁ	toː'nigi	to'nigia	4
masato'o	gloves	ma'satoʔo̥	ma'satoʔo	ma'satoʔo̥	ma'satoʔo̥	4
mea	go	mi'a	mi'a	mi'a	mi'a	4
kedu	groundhog	ki'dɨ	ki'dɨ̦	ki'dɨ	ki'dɨ	4
tsopuhu	hair	tso'pɨhɨ	tso'pɨhɨ	tso'pɨhɨ	tso'pɨhɨh	4
pookoo	horse	pu'kku	pu'kku	pu'kku	pu'kku	4
tseyiya'e	hungry	-	tsi'jaijaʔi̥	tsi'jaijaʔi̥	tsi'jaijaʔi	3
kooma	husband	ku'ma	ku'ma	ku'ma	ku'ma	4
waape	juniper	'waːpi̥	'waːpi	'waːpi	'waːpi	4
toidze	lazy	to'idzi	'to͡ːidzi	-	-	2
toidzeye'e	feel lazy	-	-	'toidzijɛʔi̥	'toidzijɛʔi̥	2
suunaka	leaves	-	-	'sɨːnaqqḁ	'sɨːnaqqa	2
huutse	little	'hɨːtsi	-	-	-	1
huutse'yoo	little (nominal)	-	'hɨːtsiʔju̥	'hɨːtsiʔju̥	'hɨːtsiʔju̥	3
ooonosoo	long ago	'ʔoːʔnoʃu̥	-	'oːʔnoʃ	'ʔoːʔnoʃ	3
ka'ooonosoo	long ago (evidential)	-	ka'ʔoːnoʃ	-	-	1
songo	lung	so'ŋo	-	so'ŋo	so'ŋo	3
songope	lung (absolute)	-	ʃo'ŋoppi	-	-	1
numumoko	moccasin	-	nɨ'mɨmoqqo̥	nɨ'mɨmoqqo̥	-	2
awawoo'a	morning	-	a'wawuʔḁ	a'wawuʔḁ	-	2
pea	mother	pi'a	pi'a	pi'a	pi'a	4
tupa	mouth	tɨ'ppa	tʰɨ'ppa	tɨ'ppa	tɨ'ppa	4
tammoo	muscle	ta'mmu	-	ta'mmu	tă'mŭ	3
wogomone'e	nickel	wo'ʁomoːniʔi	-	wo'ʁomoːniʔi	wo'ɢomoːniʔi̥	3

Warm Springs Orthography	Translation	Narrow Transcription				Total Tokens
		Speaker A	*Speaker B*	*Speaker C*	*Speaker D*	
sumukadoo'oopu	nine	sɨ'mɨkaduʔupɨ̥	sɨ'mɨkaduʔu̥pɨ̥	sɨ'mɨkaduʔupɨ̥	-	3
sumuyookadoopu[ii]	nine	-	-	-	sɨ'mɨʔjukadupɨ̥	1
moobe	nose	mu'βi	mu'bi	mu'βi	mu'bi	4
susung'e	numb	-	sɨ'zɨŋi	-	-	1
masuzunge	numb in hand	ma'sɨzɨŋi	-	ma'sɨzɨŋi	-	2
masuzungyoo	numb in hand (nominal)	-	-	-	ma'sɨzɨŋju	1
ookwedyadu	orange	-	-	'ɔːkʷitʃadɨ	'ɔːkʷitʃadɨ	2
tsoba	pick up	tso'βa	tso'βa	tso'βa	tso'ba	4
tanegea	put on shoes	ta'nigia	-	-	ta'nigia	2
tanegeow	put on shoes (already)	-	-	ta'nigiau	-	1
tooge	put out fire (motion toward)	tu'gi	-	-	-	1
tooga	put out fire (motion away)	-	-	tu'ga	tu'ga	2
kammu	rabbit	qa'mmɨ	ka'mmɨ	ka'mmɨh	qa'mmɨ	4
tugapu	rope	tɨ'gappɨ̥	tɨ'gappɨ	tɨ'gappɨ̥	tɨ'gap˺	4
sawabe	sagebrush	sa'wabi	ʃa'wabi	sa'wabi	sa'wabi	4
agai	salmon	a'ɢai	a'ʁai	a'ʁai	a'ʁai	4
tsapoone	show	tsa'ppuni	tsa'ppuni	tsa'ppunih	tsa'ppunih	4
tuutse'yoo	small	'tɨːtsiʔju	'tɨːtsiʔju	'tɨːtsiʔju̥	'tɨːdziʔju	4
kuupu	small squirrel	'kɨːppɨ̥	-	'kɨːppɨ̥	'kɨːppɨ̥	3
pahmoo'e	smoke	-	-	-	pah'muʔi	1
a'wesa	sneeze	aʔ'wiʃa	aʔ'wiʃa	-	ʔaʔ'wiʃa	3
wupu'ma	snowdrift	wɨ'ppɨʔma	-	wɨ'ppɨʔma	wɨ'ppɨʔma	3
tasopa	socks	ta'ʃopa	-	ta'ʃopa	ta'ʃopa	3
wunu	stand	wɨ'nɨ	wɨ'nɨ	wɨ'nɨh	wɨ'nɨh	4
see	stomach	'siː	-	'siː	'siː	3
tebo	table	ti'bɔ	ti'bɔ	ti'bɔ	ti'bɔ	4
tumma	taste	tɨ'mma	tɨ'mma	tɨ'mma	tɨ'mma	4
pammoo	tobacco	pa'mmu	pah'mmu	-	-	2
waha'yoo	two	wa'haʔju	-	wa'haʔju	wa'haʔju	3
suube	willow	'sɨːbi	-	'sɨːbi	'sɨːbi	3

Warm Springs Orthography	Translation	Narrow Transcription				Total Tokens
		Speaker A	*Speaker B*	*Speaker C*	*Speaker D*	
mogo'ne	woman	mo'ʁoʔni	mo'ɢoʔni	mo'ɢoʔn̥i̥	mo'ʁoʔni	4
atsaba	woodpecker	a'tsaba	-	-	-	1
atsabana	woodpecker (existential)	-	-	ʔa'ttsaβana	ʔa'ttsaβana	2
tupo	write	-	tɨ'bo	tɨ'bɔ	-	2
tupo'o	wrote	tɨ'boʔo	-	-	tɨ'boʔo	2

[i] Thornes (2003) notes that a subset of Northern Paiute nouns bare a historical "absolute" suffix in their citation form. He states, "[These suffixes] neither involve a change in word class nor do they alter the meaning of the stem in any way. They simply form independent stems from otherwise dependent roots" (p. 105).

[ii] *sɨ'mɨkaduʔupɨ* literally means 'one is missing', using the base form of 'one', *sɨ'mɨ*:

sɨ'mɨ kaduʔu - pɨ
one be.missing-PERFECTIVE (see Thornes, 2003, p. 212)

sɨ'mɨʔju, appearing in Speaker D's version of 'nine,' is the nominative/predicative form of 'one.' I am not certain why this speaker produced 'nine' differently.