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An Acoustic Phonetic Analysis of Northern Minnesota English Vowel Spaces

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An Acoustic Phonetic Analysis of Northern Minnesota English Vowel Spaces

by

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Abstract

The dialect of Northern Minnesota English (NMNE) has been acknowledged as a leading suspect in the search for the Minnesota accent. The majority of the commenters who accept the Minnesota accent at the bottom of a Youtube video page (Bartholid, 2015, Are You MN Enough?) indicate that if any Minnesotans have this accent, it is *probably* the residents of Northern Minnesota. Thus, this study begins to reveal just what that particular dialect of Northern Minnesota actually looks like acoustically. Twenty speakers from the queried region were recorded saying the following eleven vowel phonemes three times [i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ] within an isolated hVd structure. After recordings were imported into Praat, they were spliced, measured, and analyzed under six acoustic correlates: F1, F2, F3, duration, F0, and intensity. The total number of tokens analyzed in this study is 3,960 (20 x 11 x 3 x 6).This acoustic data was then compared with four other English dialects, General American English (Peterson & Barney, 1952), Midwest English (Hillenbrand, Getty, Clark, & Wheeler, 1995), Central Minnesota English (Koffi, 2017b; 2016c; 2014; 2013), and Winnipeg Canadian English (Hagiwara, 2006). What has been exposed thus far is that NMNE men are most similar to men who speak Winnipeg Canadian English (WCE) although there are some inconsistencies. The men who speak NMNE and the men who speak WCE share common characteristics like the masked lot/cloth [ɑ/ɔ] vowel, reversing of the kit [ɪ] and face [e] vowels, lowering of the foot [ʊ] vowel, and heavy vocalic inventories in the mid level of vowel height and the front region of tongue retraction. They also carry similar patterns such as vowels pertaining to all three levels of vowel height and all three regions of tongue retraction. The only major distinctions between NMNE men and WCE men are the strut [ʌ] vowel and the trap [æ] vowel. Although both dialects realize the strut [ʌ] vowel as a mid vowel sound, WCE men's strut [ʌ] vowel has been fronted so much compared to its NMNE equivalent that it actually runs the risk of masking with the NMNE trap [æ] vowel. That also leads to the second distinction which is the WCE trap [æ] vowel. It has been lowered quite a bit in comparison to its NMNE counterpart. Nevertheless, these male speech patterns remain as the most similar out of all the comparative dialects. However, these conclusions are not reflective in the women's speech. NMNE women are actually more similar to their southern neighbors, Central Minnesota English (CMNE) speakers. With the exact same T-shape in their vowel space quadrant, women who speak CMNE and women who speak NMNE are almost completely identical in their vowel space charts. Vowel sounds are produced in all three levels of vowel height along with all three regions of tongue retraction in each dialect. Furthermore, although they have multiple vowels which are realized distinctively, [ɪ, ɛ, ɑ, ɔ, ʊ, ʌ], CMNE women follow most of the same dialectal patterns as do NMNE women such as merging the lot [ɑ] and cloth [ɔ] vowels, reversing their kit [ɪ] and face [e] vowels, and lowering the foot [ʊ] vowel. Conclusively, NMNE women are more closely aligned with CMNE women than any other comparative dialect of women. However, their divergences merely begin with one pattern found the speech of NMNE women. All NMNE women's vowels are raised in comparison to their southern neighbors. While some of these movements are in fact obvious to the naked ear, there are others which are only obvious in the acoustic data provided within this study.

Acknowledgements

When I first encountered the topic of the Minnesota accent for a study, the idea terrified me. I had been told for many years that I had a *thick* Minnesota accent. However, I was unaware of what that even meant. I could not hear it at all in myself or any other speaker for that matter. Luckily for me, I had the pleasure to work with Kandice Byron and Chris Reigstad. Kandice helped me face my fear and take the challenge head on while Chris taught me how to understand and acoustically locate particular features pertaining to said accent without being able to hear it. With the guidance from Chris along with some direction from Dr. Sadrai, I was able to depend on the science of formant frequencies and spectrograms to *show* me what the Minnesota accent looked like. You three initiated my passion for the finding the Minnesota accent and you gave me the most basic tools that I needed to pursue it: courage, confidence, and a basic knowledge of Praat. Thank you Kandice Byron, Chris Reigstad, and Dr. Sadrai.

Subsequently, another professor by the name of Dr. Koffi caught wind of our small classroom study. He was so overjoyed by the idea of Kandice and me presenting the topic that he consistently asked about future pursuits in this area. Had it not been for his persistent reminders of the topic I do not think I would have considered it since I had only a very basic knowledge about the topic with no prior experience in the area outside of that previous study. Dr. Koffi, however, made the idea for a thesis seem so exciting and intriguing that I finally accepted. So to Dr. Koffi, thank you for your persistence.

I began taking classes from Dr. Koffi, three in total, which were all based around acoustic phonetics and phonology. Although they were extremely hard, the classes were absolutely

unbelievable. Dr. Koffi is like the equivalent of drinking from Mimir's well[1]. I did not just learn *some* things from him but instead I learned everything. His knowledge exceeded the classroom and spread through a multitude of articles and books as well. Furthermore, if ever there was a question, it was exciting to watch as he lit up while explaining his answer with such detail. It made pursuing this thesis so much fun and even at the end I am sad that I will no longer be surrounded by a world of acoustic phonetics. So again to Dr. Koffi, thank you for sharing with me your knowledge of and enthusiasm for acoustic phonetics.

Lastly, I would have never made it through my thesis without the help from so many patient listeners. Thank you to my mama, my stepdad, and my sister, Rachel, for pushing me forward and supporting me the whole way through. Thank you to my amazingly patient husband, Ricardo Lopez Guzman, for listening to me talk about my thesis for months and still choosing to marry me. Thank you to all of my close friends at St. Cloud State University who continuously encouraged me with this thesis and kept me company during those long nights of study with pizza parties. Thank you Angelica Carnero, Thammy San Alarcón, Glymaris Lugo, Chris Reigstad, Yuman Zhao, Mohammed Al-Madkhali, and Sam Carley. I miss you all more than you know. Thank you to my mother-in-law, Irene, and my sister-in-law, Romina, for listening to me talk about a strange subject, for supporting me, and for encouraging me to finish. (*Gracias a mi suegra, Irene, y a mi cuñada, Romina, por escucharme hablar sobre un tema extraño, apoyarme y estimularme a terminar esta tesis*.) Finally, I would like to thank my three readers who decided to stand behind me through all of this, thank you Monica Devers, Edward Sadrai, and Ettien Koffi. Without your support I would have never been able to have this opportunity.

[1] Mimir's well is a pool of knowledge born from Norse mythology.

The final group that I would like to thank provided me the necessary tools, participants, and opportunities that I needed to complete my thesis. Thank you to the Mass Communication department at Bemidji State University for allowing me to use your equipment and recruiting your students as participants. Thank you Roger Paskvan, Valicia Boudry, Monika Lawrence, Debra Sea, and Carl Sewall. I also want to thank the public libraries which permitted me entrance and time to recruit your patrons as participants. Thank you to Hallock Public Library, Roseau Public Library, Thief River Falls Public Library, and Two Harbors Public Library. Additionally, without my participants I would have absolutely no study at all, so thank you to all of my voluntary participants within this study. Finally, I would like to thank the Vemma corporation for your *bod•ē Burn* drink. I have never been a coffee drinker but I have however enjoyed your product every morning as I woke up and started work on my thesis.

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Chapter 1: Introduction

Statement of the Problem

The Minnesota (MN) accent is one of many dialects of American English that is recognizable across the U.S. (Bartholdi, 2015). National attention to this dialect can be attributed to the movie *Fargo* (1996). Since the Hollywood movie's big debut, the accent of the movie has become a statewide marked dialect of English spoken specifically in Minnesota. Just under 20 years later a follow-up Youtube Video was produced and uploaded by Batholdi (2015). The video was called *Are You Minnesota Enough?*. In her video production, Bartholdi makes reference to the nationally-known accent of the movie *Fargo* but she also draws a slight distinction between the movie and the marked MN accent. "While we might not sound quite like this…sometimes we get pretty close" (Batholdi, 2015). Within the video there are four actors using the MN accent. Alongside of this Bartholdi includes nine other interviewees in the Mall of America who are asked to talk about and/or demonstrate the MN accent. (It is assumed that all of the interviewees are from Minnesota with the exception of one who may be from New York.) Of those interviewees some admit to having a MN accent, another states that it is "ugly", and there is even one Minnesotan who denies having any accent at all. These varying opinions of the MN accent are only the beginning. Minnesotans throughout the whole state share their true feelings of this accent in the commentary area of this video's webpage.

It is interesting to note that throughout this video, there is no reference to any boundaries around the MN accent other than state lines. However, the accompanied comments underneath

the video seem to tell otherwise. There are a total of 195 comments[2] made by Minnesotans while the rest either didn't stipulate their origin or clearly stated that they were not from Minnesota. Therefore, they are not considered in the tally. One hundred and forty Minnesota commenters (71%) completely rejected the idea of any Minnesotans speaking like those actors and interviewees from *Are You Minnesota Enough?* Of that group, there were 15 people who specifically associated the accent with Canadian English rather than Minnesota English. Figure 1.1 below presents this data.

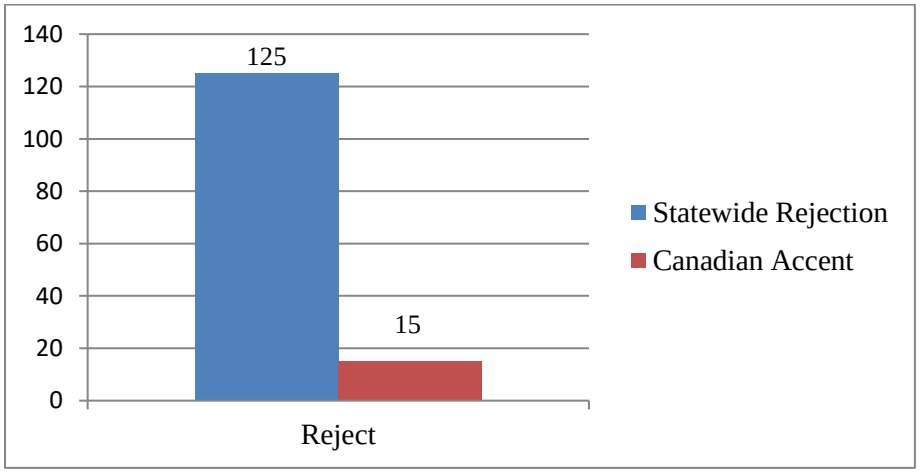

Figure 1.1: A representation of Minnesota commenters who reject the MN accent.

Comments by Jeremiah Gorian (2016) and Anonymous Gaming (2016) are only two examples of the former groups in the rejection category. They explicitly reject that Minnesotans use the accent of interest presented in the video. Furthermore, as is evident in the figure above, they are not alone in this opinion.

[2] Replies to any comments were not considered in this tally.

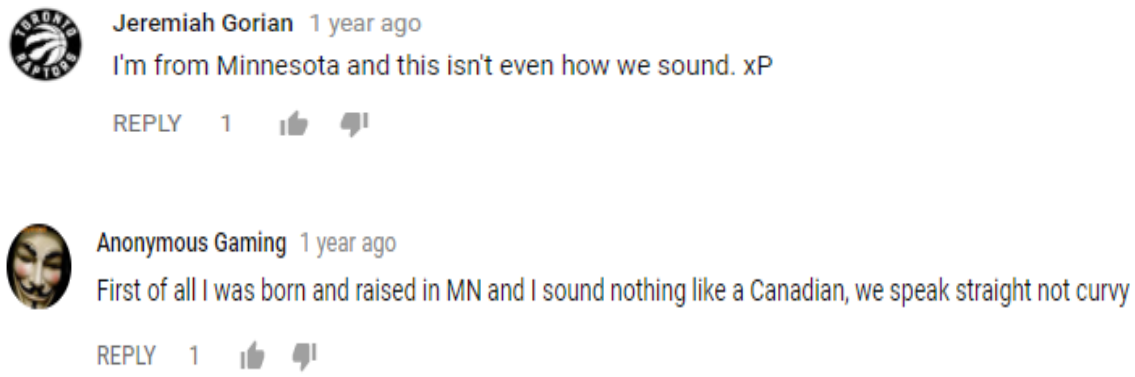

Figure 1.2: A representation of Minnesota commenters rejecting the MN accent.

At the other side of the spectrum, 55 of the Minnesota commenters (28%) accepted the accent although 31 people of that group (15%) stipulated that the accent is associated with a particular region, the older generation, and/or the rural areas of the state. The latter 24 people gave no indication of any boundary surrounding the Minnesota accent. For this reason, they have been classified as recognizing that the Minnesota accent is statewide. The largest amount of people who restricted the Minnesota accent to specific boundaries includes a group of 24 people. This group specified that the MN accent is only found in Northern Minnesota. Another group of five commenters (2%) stated that it is only the older generation and/or rural areas of the state that speaks with the MN accent. The last two accepting commenters stated that the Minnesota accent is restricted to specific region of Minnesota. However, one person lacks the mention of the specific region to which they are referring while the other commenter confines the MN accent to the central region of Minnesota. Figure 1.3 presents data for the Minnesotans whom have accepted the MN accent.

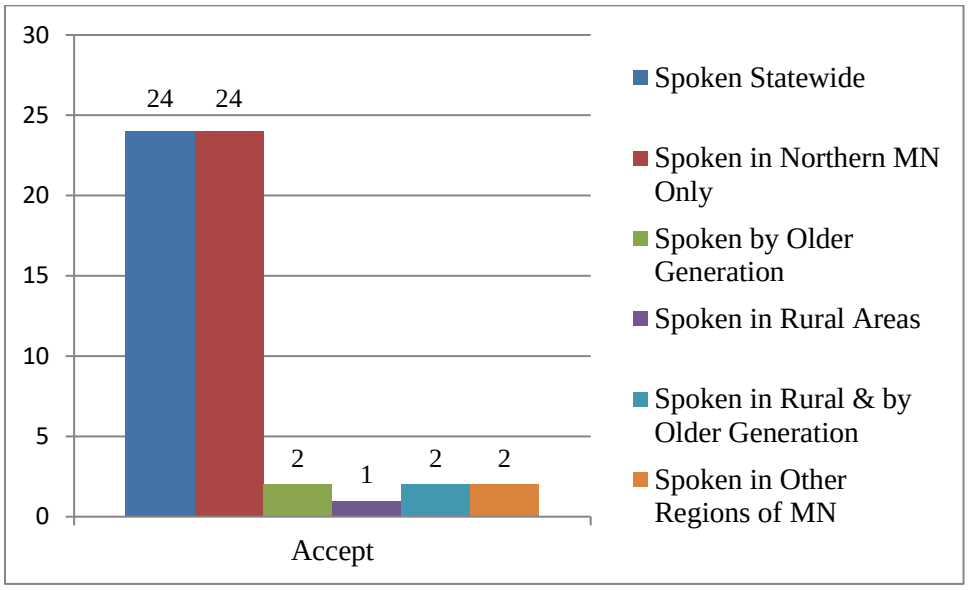

Figure 1.3: A representation of Minnesota commenters who accept the MN accent.

Examples of these types of comments are presented below. Individuals such as Trini Tae (2017) does not actually state whether they use the accent but does in fact acknowledge knowing people within their area (Northern Minnesota) that do have the MN accent. Others such as Ryan Hostad completely reject the accent in their area (the metro area) and push it off to a different region outside of their own.

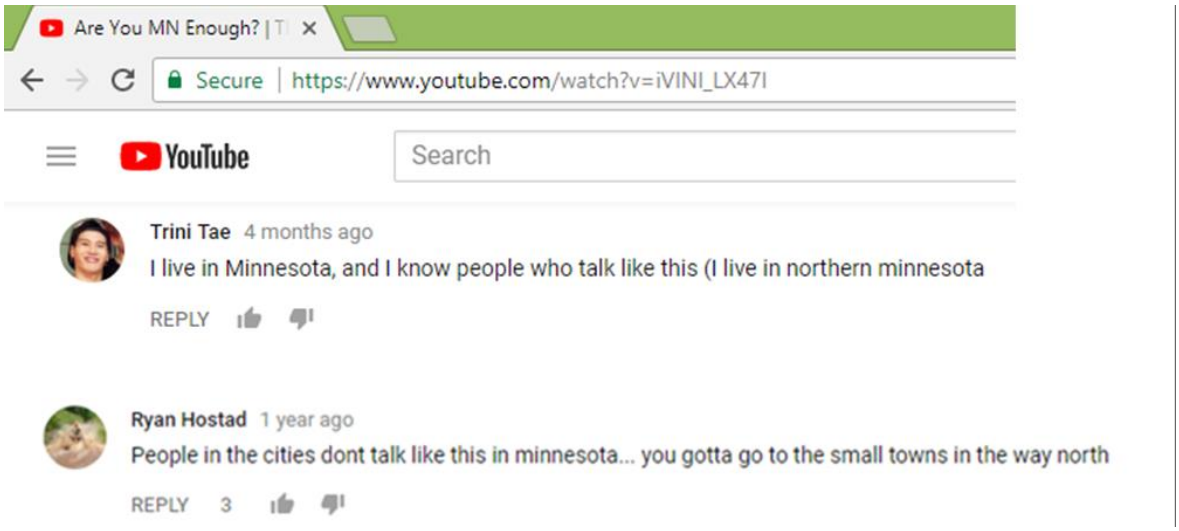

Figure 1.4: A representation of Minnesota commenters accepting the MN accent.

In general, it is extremely difficult to actually scientifically prove who is correct based on the information presented in the video and its accompanied comments below. Unfortunately, there are no numerical data defining any dialectal patterns or features. Therefore, one is left to making assessments based on inference which can easily be influenced subconsciously. To actually find these answers, some investigations must first be done. Initially, one must know the exact dialectal features and patterns associated with the *true* Minnesota accent. To find this information, studies need to cover all areas of Minnesota and then, after enough data have been collected, one can start to make generalizations at a state level. Only then, can a person start comparing the Minnesota dialect with other dialects. Secondly, the Canadian accent must also be specified. Are the commenters referencing to the Standard Canadian English dialect investigated by Boberg (2008)? Is it a dialect from a single Canadian providence that shares the international border with Minnesota such as Manitoba or Ontario? Maybe it is just a city dialect from one of the said providences such as the Winnipeg Canadian English dialect investigated by Hagiwara

(2006)? That leads to the last investigation which requires an acoustic phonetic analysis of those actors and interviewees from Bartholdi's Youtube video production. Then, a comparison can be drawn between their accent, those of Northern Minnesota English, and the specified Canadian English. So, although there are a multitude of opinions that will continue to congregate at the bottom of this referenced video's page, the actual scientific answers remain hidden until more studies are pursued and the appropriate data are revealed.

For this reason, the current study is in pursuit of one of the investigations mentioned above. This study is an instrumental description of the acoustic phonetic vowel spaces of Northern Minnesota English. Although there are not enough participants to represent the entire Northern Minnesota region for generalization purposes, this study is adding to the collection of acoustical data from Minnesota.

Rationale

The importance of this study lies in its location. Previous studies over the Midwest dialect reported by Hillenbrand, Getty, Clark, and Wheeler (1995) and the Central Minnesota dialect reported by Koon (2010) and by Koffi (2013, 2014, 2016c, & 2017b) have made some reference to Minnesota. However, those references reflected a sampling that was either too broad—Hillenbrand et al.'s study—or too narrow—Koon and Koffi's research—to appropriately represent the northern region of the state. Furthermore, Hagiwara produced a study (1995) along with a subsequent letter (1997) which encouraged more "'local' studies" such as this as a means of "cooperatively producing an 'acoustic atlas' of American English dialects as indicated by formant frequencies" (1997, p. 655). Therefore, to continue contributing to the "acoustic atlas,"

this current study has collected and analyzed 645[3] vowels uttered by 20 participants specifically from Northern Minnesota.

The state of Minnesota consists of eight different districts according to the Minnesota Department of Transportation (2018). Starting from the top, there are the Northeast and Northwest districts of Minnesota (District 1 and 2), District 3 is Central Minnesota, District 4 is West Central Minnesota, District 5 is Metro Minnesota, District 6 is Southeast Minnesota, District 7 is South Central Minnesota, and finally District 8 is the Southwest District of Minnesota. However, since the main interest of the current study is Northern Minnesota, no more will be said about the six latter districts.

[3] There should have been a total of 660 vowels realized by the participants. However, due to certain participants mispronouncing words or laughing during the recording, I was unable to utilize 15 uttered vowels.

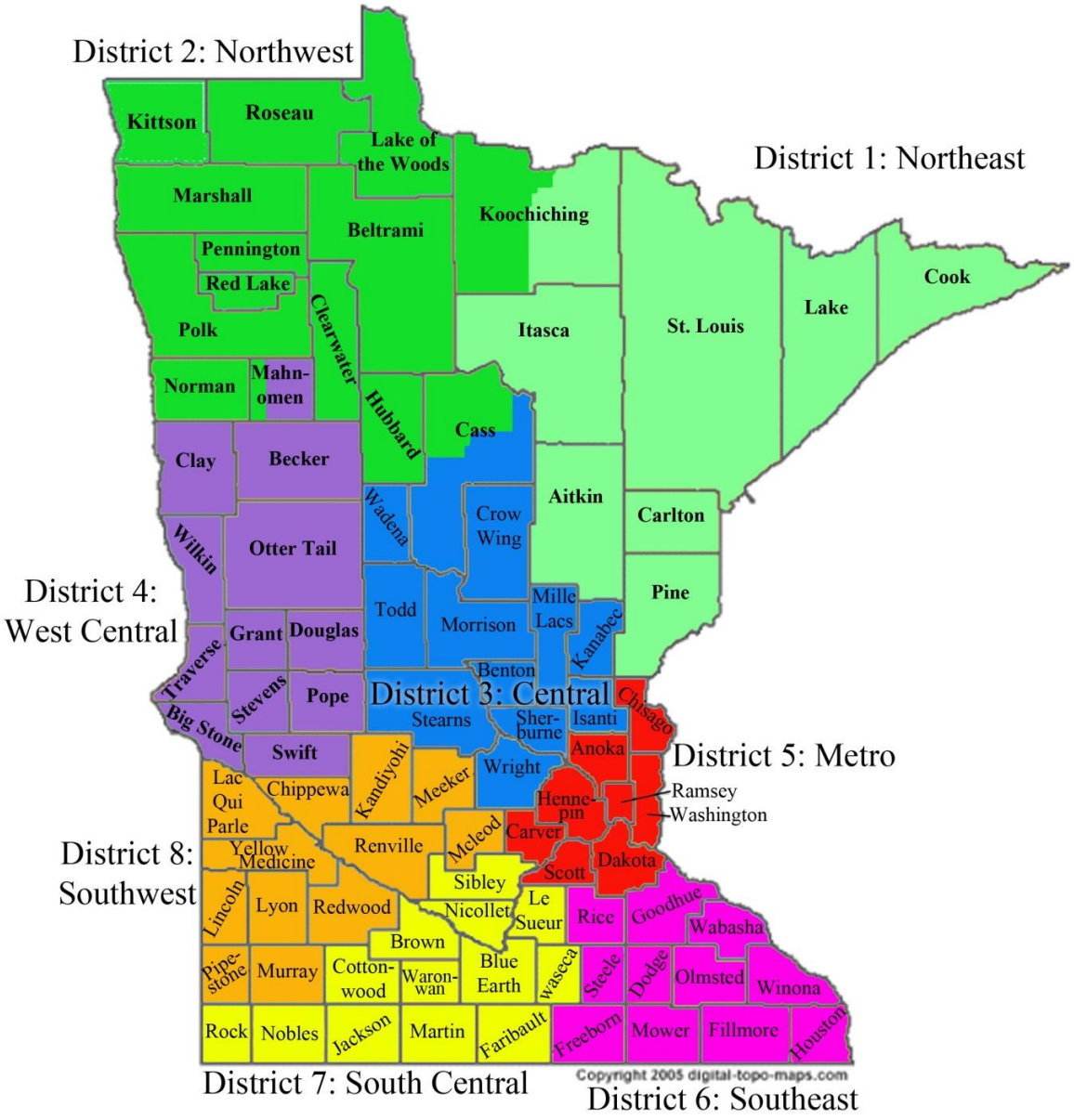

Figure 1.5: A map of Minnesota districts according to the Minnesota Department of Transportation (2018).

Northern Minnesota is an area that encompasses a total of 21 counties. Although the area has been divided into two districts by the Minnesota Department of Transportation, the current study recognizes the Northeast and the Northwest districts as one region, that is, the Northern region of Minnesota. Below are the counties of the region:

Table 1.1

Counties of Northern Minnesota Table

NO	Counties of NMNE	Counties Sampled
1.	Aitkin	No
2.	Beltrami	Yes
3.	Carlton	No
4.	Cass	Yes
5.	Clearwater	Yes
6.	Cook	No
7.	Hubbard	Yes
8.	Itasca	Yes
9.	Kittson	Yes
10.	Koochiching	Yes
11.	Lake	Yes
12.	Lake of the Woods	No
13.	Mahnomen	No
14.	Marshall	Yes
15.	Norman	No
16.	Pennington	Yes
17.	Pine	No
18.	Polk	Yes
19.	Red Lake	No
20.	Roseau	Yes
21.	St. Louis	Yes

Northern Minnesota has a total population of 550,443 people (U.S. Census Bureau, 2010). Of this population about 87.8% is white, 3.8% is American Indian, 1.7% is Latino, and the Asian (0.5%) and African American (0.5%) populations average below one percent. This region may also be considered as rural because the majority of the towns' populations are around

15,000[4] or less (U.S. Census Bureau, 2017). Contrary to this finding, the city of Duluth—the fourth biggest city in all of Minnesota according to the U.S. Census (2010)—has a population of 86,266 people, which greatly exceeds any other neighboring towns in the region by at least 50,000 people. The last geographical detail about Northern Minnesota is that it shares an international border with Canada. There are seven counties that are along this international border. Those counties are Kittson county, Roseau county, Lake of the Woods county, Koochiching county, St. Louis county, Lake county, and Cook county.

[4] Minnesota does not actually stipulate any size of population which distinguishes a city from a town (U.S. Census Bureau, 2017, p. 9-5). However, according to Wikipedia, "Common population definitions for a city range between 1,500 and 50,000 people" (Dec. 13, 2017).

Chapter 2: Literature Review

Vowel Sounds

Although the "acoustic space," or the mouth, in which vowels are produced shares similar human constraints, vowel sounds still manage to maintain a distinctive nature about them no matter the number of vowels within the space. According to Liljencrantz and Lindblom (1972, p. 841) this is possible because of the *principle of maximum contrast*. This principle stipulates that vowels naturally "repel" from one another and because of this repellent behavior they retain divergent characteristics.

> To illustrate, let us consider an analogy of two particles with an equal electrical charge. They will repel each other with a force that is inversely proportional to the square of their distance. If we now place these particles in a limited space within which they can move freely, then the particles will move away from each other because of the force of repulsion. Eventually they will hit the boundary of the space, and then possibly move along the boundary, if their mutual distance can be increased that way. Finally, an equilibrium is reached where their distance cannot be increased any more. Characteristic of this state is the fact that the mutual energy has reached a minimum. If other particles are introduced into the space, the whole set will move to new positions, always fulfilling the very general equilibrium criterion, that of minimal energy. For this analogy, we must of course assume that the energy released when the particles move apart is dissipated in some way; otherwise the system would exhibit perpetual oscillations, like the molecules in a gas.

This analogy makes sense from the perspective of the interpreter because without those divergent characteristics it would be difficult to decipher the words of a speaker. This is especially true for the English language since it is highly impacted by vocalic sounds. “English is a language in which the differences between dialects are largely in the vowels” (Ladefoged, 2005, p. 27). It is for this reason as well that English vowels remain a cornerstone of dialectal studies. However, the study of vowels has not always been so simple.

The articulatory patterns of vowel sounds have not always been the easiest to describe since no two articulators make contact during vowel production. According to Ladefoged (1971, p. 67), vowels are best “described as points on a continuum”. In using this analogy, one can better understand the movements of the main articulator (the tongue) throughout the open area of the mouth. For example, on this continuum, the tongue moves vertically between the high and low areas of the mouth. Vowels such as [i] and [æ] in the words <fleece> and <trap> exemplify these two extremes. Likewise, the tongue also moves horizontally on a continuum between the front and the back regions of the mouth. An example vowel for the front region is again [i] (the fleece vowel) while the back region is typically represented by [u] (the goose vowel). However, this analogy alone does not entirely solve the problem of describing vowels. It merely begins to set the stage for vowel classification such as vowel height, tongue retraction, and lip rounding. Within each of the three classes there are various types of vowels and it is here that the main issue finally arises. “Part of the problem in describing vowels is that there are no distinct boundaries between one type of vowel and another” (Ladefoged & Johnson, 2015, p. 92).

The current study describes vocalic sounds based on formant frequencies, duration and intensity, or in other words, numerical data presented in Hertz (Hz), milliseconds (ms), and

decibels (dB). Therefore, vocalic boundaries cannot just be defined by a name such as high, back, rounded, or long but rather by actual numerical data. Since it is not entirely common to draw physical boundaries around vowel types, insights from two studies have been combined for the purpose of deriving necessary data. The first study is one produced by Liljencrantz and Lindlom (1972). They developed formant frequencies for 13 prototype vowels. Of course, not all the prototype vowels are associated with the English language. Therefore, the table below presents only eight of the prototype vowels which are found in English along with their formant frequencies.

Table 2.1

Liljencrants and Lindlom's Prototype Vowel Data for Men Table

Prototype	i	e	ɛ	æ	ɑ	ɔ	o	u
F1 men	250	400	550	700	675	550	400	250
F2 men	2225	2000	1775	1600	1000	925	825	750
F3 men	3000	2935	2800	2500	---	---	---	---

Liljencrantz and Lindlom only provide numerical data that are "closely similar to those of a typical male speaker" (1972, 840). However, the current study also includes women's data and according to Read and Kent "the frequency value for a particular acoustic feature will be on the order of 20% higher for a woman than for a man" (2002, p. 194). Therefore, prototype vowels for women have been calculated with respect to Read and Kent's finding and are presented below.

Table 2.2

Liljencrants and Lindlom's Prototype Vowel Data for Women Table

Prototype	i	e	ɛ	æ	ɑ	ɔ	o	u
F1 women	300	480	660	840	810	660	480	300
F2 women	2670	2400	2662	1920	1200	1110	990	900
F3 women	3600	3522	560	3000	---	---	---	---

While numerical data is necessary for drawing vocalic boundaries, it alone is not enough to distinguish vowel types since Liljencrantz and Lindlom did not specifically classify any of their prototype vowels. For this reason, a second study by Ladefoged and Johnson (2015) is referenced as a means of classifying said vowels. These two researchers, although they have no numerical data defining their vowel sounds, do in fact classify a total of 14 English vowels. According to them, there are five levels of vowel height for English vowels which are *high*, *mid-high*, *mid*, *mid-low*, and *low*. Figure 2.1 presents Ladefoged and Johnson (2015, p. 46)'s classifications of all English vowels.

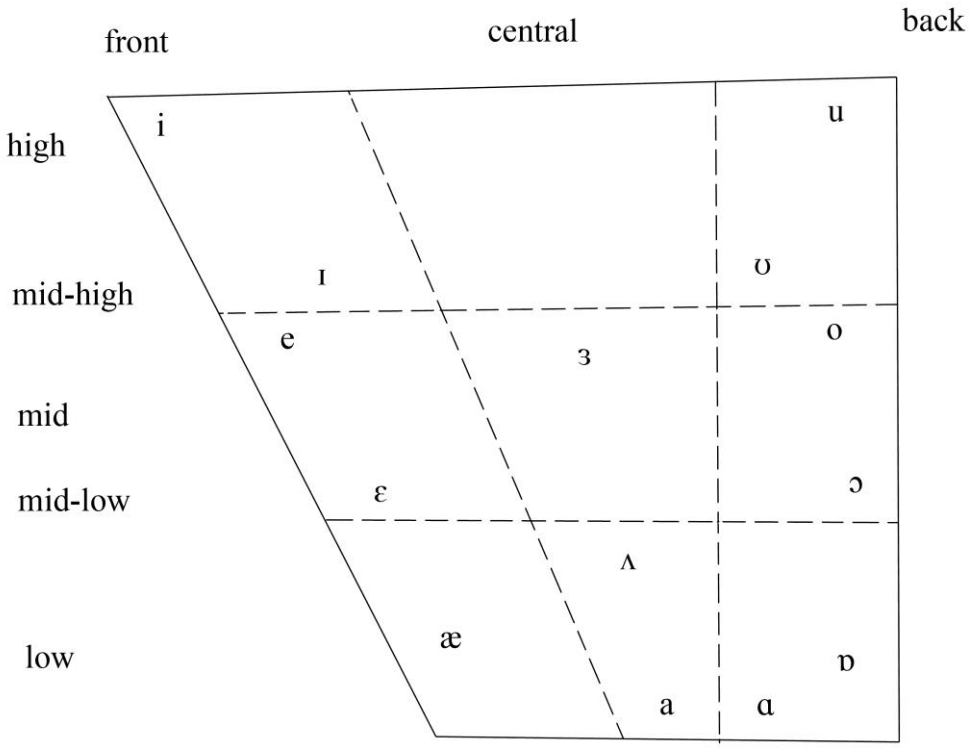

Figure 2.1: A representation of Ladefoged and Johnson (2015, p. 46)'s vowel space chart of English vowels.

The current study uses only three broad vowel heights, namely high, mid, and low. Given the biological differences between men and women alluded to earlier, here are the numerical values that correspond to the boundaries between vowels. F1 correlates with vowel height, F2 correlates with backness, and F3 correlates with rounding:

Table 2.3

F1 Boundaries for each Level of Vowel Height Table

	High	**Mid**	**Low**
F1 men	> 400	400 – 600	< 600
F1 women	> 480	480 – 720	< 720

Table 2.4

F2 Boundaries for each Region of Tongue Retraction Table

	Front	**Central**	**Back**
F2 men	≥ 1600	1200 – 1599	< 1200
F2 women	≥ 1920	1440 – 1919	< 1440

Table 2.5

F3 Boundaries for each Degree of Lip Rounding Table

	Rounded	**Unrounded**
F3 men	< 2500 Hz	≥ 2500 Hz
F3 women	< 3000 Hz	≥ 3000 Hz

Vowel Features

The current study classifies vowel sounds by four distinct features: vowel height, tongue retraction, lip rounding, and vowel duration. Each feature is divided into either two or three types of vowels. Alongside of these four features, vowel intensity and vowel pitch are also briefly discussed. However, the latter two acoustic correlates do not divide into distinct sub-classes. Furthermore, for all six features, there is an acceptable range of variance before a vowel becomes distinguished from other phonemic sounds and, as in the former four features, moves into a new type of vowel. Those ranges of variance are known as the *Just Noticeable Difference* (JND)[5].

Vowel Height

Vowel height is a vowel feature that is divided into three types, high vowels, mid vowels, and low vowels. Of all four features, vowel height is the most prominent due to its correlation

[5] For more details on the concept of JND please refer to the following study by Koffi and Bloch (2017, p. 41).

with the F1 cue. The first formant has the greatest impact on vowel quality and "on average, has 80% of the energy in a vowel" (Ladefoged & Johnson, 2015, p. 207). It is important to note that F1 measurements are indirectly proportional to the height of a vowel. Therefore, high vowels have low F1 values, while their lower neighboring counterparts have high F1 values. According to Koffi (2016b, pp. 121-22), as long as there is less than 63 Hz between two vowels, the human ear has a hard time detecting any distinction between two vocalic sounds. Measurements which exceed this threshold are different vowels.

Tongue Retraction

The second feature describing vowels is tongue retraction. This feature breaks down similarly to that of the original chart produced by Ladefoged and Johnson (2015) in Figure 2.1. They recognize three types of tongue retraction which are front vowels, central vowels, and back vowels. High F2 values are associated with front vowels while low F2 values represent back vowels. The JND for this correlate is stipulated by Koffi as the following, "*In the F2 frequency band, pairs of contiguous vowels whose acoustic distance is ≥ 200 Hz are clearly perceived, but those whose acoustic distance falls below 200 Hz may be subject to confusion*" (2016a, p. 12). Therefore, any vowels which fall within the 200 Hz range are more likely to be recognized as the same sound whereas vowels which fall outside of this threshold are more likely to be recognized as having slightly distinctive characteristics.

Lip Rounding

The third feature is lip rounding. Its acoustic correlate is the third formant. High F3 values are associated with unrounded vowels while low F3 values represent rounded vowels. Back vowels are known for having a higher degree of lip rounding than front vowels (Thomas,

2011, p. 48; Crothers, 1978, pp. 96-97). With that said, all back vowels from Liljencrantz and Lindlom (1972) study are considered as rounded and their front vowels are considered as unrounded. Thus, the boundaries presented in Table 2.5 were then derived accordingly. Lastly, the acceptable range of F3 variance, or JND, is as follows, "*In the F3 frequency band, pairs of contiguous vowels whose acoustic distance is ≥ 400 Hz are clearly perceived, but those whose acoustic distance falls below 400 Hz, may be subject to confusion*" (Koffi, 2016a, p. 13). In other words, two vowels which hold a distance of at least 400 Hz are more likely to be recognized as slightly distinctive sounds and those which fall inside of this threshold have more potential for being identified as the same sound.

Vowel Duration

The fourth feature is vowel duration. Even though this feature does not have a huge impact phonemically on English vowels, according to Lisker (1974, p. 226), there may be some biological factors that influence the length of a vowel.

> [A] mechanical effect due to a temporal constraint on the movement of the relatively large mass of the lower jaw, with that of the tongue sometimes also implicated: if open or low vowels involve more jaw movement than do the close vowels, then the greater so-called "intrinsic duration" of the former is a natural consequence, provided we believe that in speech we regularly operate close to the limits set by the physical constraints on the mechanism.

In other words, lower vowels are biologically more inclined to be longer than high vowels due to the articulatory gestures involved in their production[6]. According to Koffi and Lopez-Backstrom, the JND for vowel duration is as follows, "The JND ≥10 ms is most appropriate for segments lasting less than 200 ms. For those lasting 200 ms or longer, the optimal JND is ≥17 ms" (2018, p. 6). Lastly, the current study measured vowel duration in the second formant. Measurements commenced at the first obvious vocal fold after the [h] and terminated with the last vocal fold before the [d].

Vowel Intensity & Vowel Pitch

Even though intensity and pitch have never been explicitly associated with vowel description, researchers have still continued to include this data (Peterson & Barney, 1952; Hillenbrand, Getty, Clark, & Wheeler, 1995). For this reason the current study continues to measure these two acoustic correlates although neither feature is broken down into various types.

Intensity is an acoustic correlate that is associated with the loudness of a sound. It is also called absolute intensity. According to Koffi, the JND of intensity is as follows. "*Segments whose intensity is ≥ 5 dB are clearly perceptible, but those whose intensity difference is ≤ 3 dB are barely aurally distinguishable*" (2016a, p. 14).

The last acoustic cue under investigation is pitch which is also known as the fundamental frequency or F0. This correlate has a threshold that is quite small in comparison to all the previous acoustic cues. For distinctiveness to be perceived by the naked ear, the following

[6] There is expected variation of duration outside of the biological constrains that is dependent on context. However, this study evades that variation considering that all vowels appear in the same isolated phonological environment

threshold must be exceeded. "*In the F0 frequency band, an acoustic distance of ≥ 1 Hz is needed to distinguish between two contiguous segments on the same octave band*" (Koffi, 2016a, p. 9).

Chapter 3: Methodology

Research Questions

This study commences an investigation around the following three research questions. Data for each question are addressed in the subsequent chapter.

1. What are the acoustic vowel qualities of the following English vowels [i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ] in the dialect of 20 Northern Minnesotan speakers?
2. In the F1 and F2 features, how similar or different are the 20 participants of Northern Minnesota from other speakers with dialects such as General American English[7], Midwest English, Central Minnesota English, and Winnipeg Canadian English?
3. In the F1 and F2 features, to which dialect is Northern Minnesota English most similar?

These research questions intend to elicit salient dialectal characteristics and patterns associated with the Northern Minnesota English dialect as well as to verify whether or not the NMNE dialect converges to and/or diverges from other American English dialects. With these answers, one can begin to determine whether or not the Northern Minnesota English dialect is unique to its region.

Procedures

This study replicates the methodology used by Peterson and Barney (1952) in their study of General American English. In their research they focused on two areas, speech production and

[7] When comparing NMNE and GAE, there are only nine vowel pairs which are discussed. Because Peterson and Barney (1952) did not include the face [e] vowel or the goat [o] vowel, I was forced to compare only the latter nine phonemes. However, NMNE data for the face [e] vowel and the goat [o] are still present in the accompanied tables and vowel space charts. Therefore, whenever necessary, small discussions focus on the NMNE face [e] and goat [o] vowels and how they interact with the GAE vowel phonemes.

speech perception. However, this study focuses only on speech production. Peterson and Barney investigated the acoustic vowel spaces of ten vowels in General American English. Each vowel was embedded in an hVd structure and then realized two times in isolation. This hVd structure was very important since it allowed for easy vowel location and extraction. The current study reproduces the methodology of Peterson and Barney with three slight adaptations.

My first adaptation was to develop three tasks[8] for the participants. The commencing task, Task 1, elicited demographic information from each speaker. The eight demographic questions were adapted from Koon (2010, pp. 164-66). The subsequent task, Task 2, elicited 11 vowels produced in isolated hVd structures. All 11 phonemic vowels are listed in Table 3.1.

Table 3.1

Vowels under Investigation Table

NO	Phoneme	hVd Structure	Names of Vowels
1.	/i/	heed	fleece
2.	/ɪ/	hid	kit
3.	/e/	hayed	face
4.	/ɛ/	head	dress
5.	/æ/	had	trap
6.	/ɑ/	hod	lot
7.	/ɔ/	hawed	cloth
8.	/o/	hoed	goat
9.	/ʊ/	hood	foot
10.	/u/	who'd	goose
11.	/ʌ/	hud	strut

[8] Each task is located in the Appendix.

The final task consisted of each participant reading a paragraph. This paragraph is an adapted version of the original George Mason University Speech Accent Archive. The original paragraph only included 69 words whereas the adapted paragraph utilized in this study contains a total of 120 words. This paragraph is presented below.

> *Please call Stella. Ask her to bring these things with her from the store: Six good spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a foot long sandwich as a snack for her brother Bob. We also need a small plastic snake, a yellow book, a rubber duck, a paper I-pad, the dog video game, a big toy frog for the kids, but not the faked gun. She can scoop these things into three red bags and two old backpacks, and we will go meet her, Jake, and Jenny Wednesday at the very last train station at the edge of the zoo. Also, let Stella know that the toy frog is running low on battery.*

The second adaptation was two parts: repeated vowel utterances by participants and measuring vowel duration. In the original Peterson and Barney (1952) study there were no reports on vowel duration. However, more current studies such as Hillenbrand, Getty, Clark, and Wheeler (1995) and Koffi (2017b) have begun reporting on this correlate. Therefore, to maintain consistency, this study also includes vowel duration as another acoustic correlate for describing the vowel spaces of Northern Minnesota English. The second part of this adaptation is that vowels are uttered three times rather than only twice. This was implemented for normalization purposes. Each speaker was averaged over their three utterances. Following this, overall men averages and overall women averages were found for each word.

The last adaptation to the Peterson and Barney (1952) methodology was the implication of vowel types. While it is basic linguistics to recognize high vowels from low vowels and front

vowel from back vowels, the actual boundaries between each is a bit more complex (Ladegfoged & Johnson, 2015, p. 92). The complexity only worsens when mid vowels and central vowels are introduced. Therefore, *general* vocalic boundaries between vowel types have been developed for ease of classification. More on these vowel types is discussed in Chapter 2.

Participants

Data was collected from 20 participants whose origins are scattered in 13 different Northern Minnesota counties—Beltrami, Cass, Clearwater, Hubbard, Itasca, Kittson, Koochiching, Lake, Marshall, Pennington, Polk, Roseau, and Saint Louis. There are ten men who are between the ages of 20 and 50 while the ten women have an even greater range of 18 through 64 years of age. Each of the participants is considered as a *native resident* of Northern Minnesota. *Native resident* can be defined as persons who grew up in the region of inquiry during their influential years of youth which refers to ages one through seventeen. Therefore, any participants asked to participate in the study were screened by three factors. The first screener narrowed in on all participants who spoke English as their first language. The second screener required that participants were within the age bracket of 18-64 years. The final screener required that all participants lived in Northern Minnesota during the years of one through seventeen. Labov, Rosenfelder, and Fruehwald (2013) stated that from the age 17 and on, speakers diminishing rate of dialectal variance follows the "1/age" (p. 39). In other words, as speakers grow in years their accent becomes more and more fixed and the chance of speakers drastically changing their accent becomes less with time. For example, if there are two speakers, a 56 year old speaker and a 7 year old speaker, the 56 year old person is less likely to drastically change his or her dialect since their diminishing rate is 1/56. The 7 year old speaker, on the other hand,

has a much greater possibility of dialectal variation since their diminishing rate is 1/7. It is for this reason that speakers are required to have remained all of their influential years of youth (1-17) in Northern Minnesota.

Out of all the 20 speakers who participated in this study, 40% of the participants declared having some knowledge of a second language—Korean, Japanese, Ojibwe, Finish, and Bulgarian. If participants indicated any form of partial fluency of a second language such as "some", "partial", or "not fluent", all answers are considered as having *partial fluency* and are labeled as "*second language* (not fluent)". Table 3.2 below represents the men's background information which was collected from the Task 1 Survey. Table 3.3 contains the women's background information from said task.

Table 3.2

Men's Background Information Table

Participants	**Age**	**First Language**	**Other Languages**	**County**	**Years outside of Northern MN**
Speaker 1M	20	English	NA	20 (Beltrami)	0
Speaker 2M	23	English	NA	23 (Itasca)	0
Speaker 3M	24	English	Korean (not fluent)	20 (Clearwater) 4 (Beltrami County)	0
Speaker 4M	50	English	NA	48 (Kittson)	0
Speaker 5M	21	English	NA	21 (Lake)	0
Speaker 6M	30	English	NA	30 (Pennington)	0
Speaker 7M	21	English	NA	18 (Polk) 3 (Beltrami)	0
Speaker 8M	21	English	NA	21 (Beltrami/Hubbard)	0
Speaker 9M	27	English	NA	27 (Beltrami)	0
Speaker 10M	42	English	NA	9 (Pennington)	0

Table 3.3

Women's Background Information Table

Participants	**Age**	**First Language**	**Other Languages**	**County**	**Years outside of Northern MN**
Speaker 1F	53	English	NA	Beltrami (46)	5.5 yrs (Texas) 9 mths (Alaska)
Speaker 2F	22	English	Japanese	22 (Lake)	0
Speaker 3F	22	English	Ojibwe (not fluent)	19 (Cass) 3 (Beltrami)	0
Speaker 4F	20	English	Finish (not fluent)	16 (Clearwater) 4 (Beltrami)	0
Speaker 5F	55	English	NA	55 (Kittson)	0
Speaker 6F	20	English	NA	18 (Koochiching) 2 (Beltrami)	0
Speaker 7F	30	English	Bulgarian	25 (Marshall) (*math results in 21 years*)	3 yrs (Bulgaria) 6 yrs (Metro Area, MN)
Speaker 8F	21	English	NA	18 (Pennington) 3 (Beltrami)	0
Speaker 9F	64	English	NA	46 (Roseau)	0
Speaker 10F	22	English	NA	22 (St. Louis)	0

The last point worth making pertains to the last column on each table above which is titled "Years outside of Northern MN". As the title reads, this is time that the participants spent outside of Northern Minnesota. However, it should be borne in mind that any time spent outside of this region was after the influential years (1-17). Therefore, according to Labov, Rosenfelder, and Fruehwald (2013, p. 39), this time away does not have any significant effects on their dialects.

Equipment

The speakers for this study were recruited in one of two ways, either from the Mass Communication department at Bemidji State University (BSU) or from public libraries scattered

in various counties of the northern region of Minnesota. Personal connections with students and professors in said department at BSU made it possible to recruit Mass Communication students and to acquire a sound proof recording studio. These volunteer students were recorded in one of the department's recording studios with an ElectroVoice RE20 microphone connected by a BSW XLR cable to a Behringer U-Phoria UMC22 audio interface which was connected to a Windows 10 Enterprise Dell desktop with an Intel Zeon processor and a 64-bit operating system. The program used for recording was Adobe Audition CC 2017. Speakers recorded in the public libraries were recorded with an Audio-Technica AT8035 Shotgun Condenser which was connected to a Zoom H4nSP Handy Recorder by a JSJ OFC XLR cable. If permitted by public libraries (such as in Lake county), a separate room was used for recording speakers. Otherwise recordings were done in a quiet corner of the library if no room was available (such as with Kittson, Pennington, and Roseau county). The subsequent tables indicate the location of recording for each speaker.

Table 3.4

Recording Locations of Men Table

Men recorded at BSU sound proof room	**Men recorded at public libraries**
Speaker 2M	Speaker 1M
Speaker 3M	Speaker 4M
Speaker 7M	Speaker 5M
Speaker 9M	Speaker 6M
	Speaker 8M
	Speaker 10M

Table 3.5

Recording locations of women Table

Women recorded at BSU sound proof room	**Women recorded at public libraries**
Speaker 3F	Speaker 1F
Speaker 4F	Speaker 2F
Speaker 6F	Speaker 5F
Speaker 10F	Speaker 7F
	Speaker 8F
	Speaker 9F

After the recordings were made, they were transferred either by a K&ZZ 16 GB 2.0 USB Flashdrive Swivel (transferring from the desktop) or a SanDisk SDHC card (transferring from the Zoom H4nSP Handy Recorder) to my personal computer which is an HP Pavilion g6 Notebook PC with an Intel processor and 64-bit operating system. Once each recording was transferred, they were immediately imported into the computer software program, Praat, where the vowel sounds from Task 2 were isolated, measured, and analyzed under six acoustic correlates: first formant (F1), second formant (F2), third formant (F3), duration (DUR), intensity, and pitch.

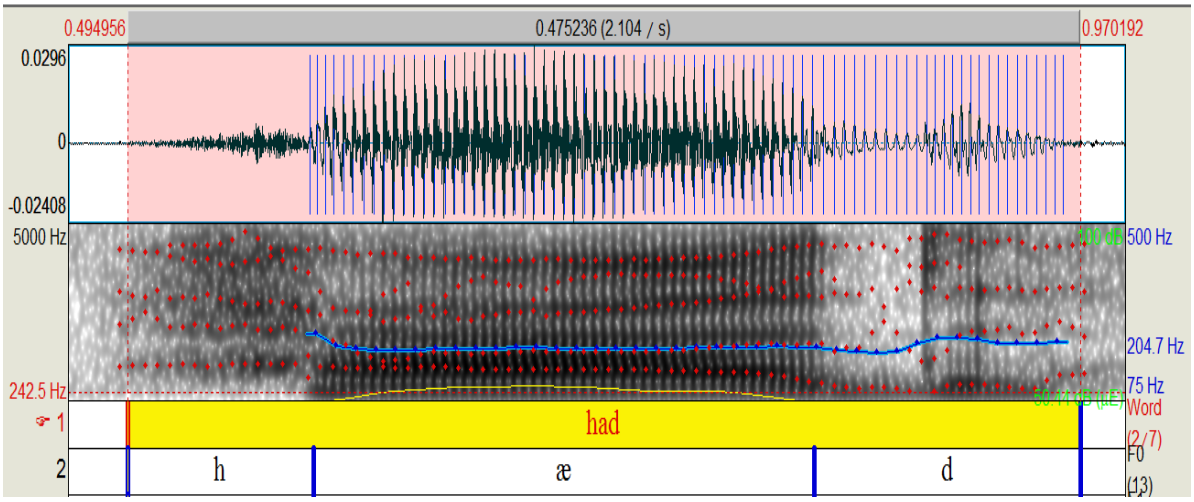

Figure 3.1: A representation of speaker 2F's first realization of the word <hæd >.

Spectrographs such as the one presented in Figure 3.1 above exemplify how vowels were isolated, measured and analyzed. In a narrow frame such as this, the "steady state" of a vowel was first located. The "steady state" is associated with the acoustic energy of a vowel. Fricatives such as [h] and voiced stops such as [d] have differing acoustic frequency patterns than those of vocalic sounds. The initial [h] sound has no vibrations of the vocal folds whereas a vowel does. Furthermore, even though vocal vibrations are also present in the realization of [d], just before this stop there is normally a very prevalent pause of airflow. However, as is quite clear in the F1, there is a continuous sound that does not easily distinguish between vowels and voiced stops. For this reason, the second formant was utilized for vowel location since it more clearly reveals the separation of the two types of sounds. This method was used consistently throughout the whole study.

Once the "steady state" was found, then each vowel could be measured and analyzed. The acoustic correlates analyzed were the first formant (F1), second formant (F2), third formant (F3), duration, intensity, and pitch. More details on these cues are discussed in Chapter 2.

Measurements for each word were pooled into two groups, men and women (for obvious biological purposes). Each group was first averaged individually, since each speaker produced each word three times. Then, overall averages for every word were calculated from each biological group. After all the averages were calculated, standard deviation was taken for each word in both groups. Lastly, overall averages were transferred to Norm[9] where the data was plotted in vowel space charts accordingly.

[9] Norm is a website for creating vowel space charts. It can be found at http://lingtools.uoregon.edu/norm/norm1.php

Chapter 4: Results

This chapter is divided into six sections. The first section discusses the acoustic qualities of vowels spaces in men's speech from Northern Minnesota, focusing on six different acoustic correlates (F1, F2, F3, Duration, Intensity, and Pitch). The second section, following a similar structure, discusses the acoustic vowels spaces within women's speech from Northern Minnesota. The third section commences the comparisons between Northern Minnesota English dialect with other American English dialects. General American English and Northern Minnesota English are compared first. The forth section covers the comparison of Northern Minnesota English and Midwest English. The comparison of Northern Minnesota English and Central Minnesota English is discussed in the fifth section. The final section is dedicated to comparing Northern Minnesota English and Winnipeg Canadian English.

NMNE Men F1: Vowel Height

Vowel height correlates to the first formant and is distinctive when there is at least 63 Hz between two phonemic vowels (Koffi, 2016b, pp. 121-22). Within the vowel height feature there are three levels of vowels which are high vowels, mid vowels, and low vowels. Boundaries for these levels are dependent upon biological factors which divide men from women (Read & Kent, 2002, pp. 189-95). To briefly recall, vocalic boundaries within vowel height have been developed from insights from Liljencrantz and Lindlom (1972) as well as Ladefoged and Johnson (2015). Each level has a specific range of Hertz (Hz) and those ranges for men are as follows. High vowels must be less than 400 Hz. Mid vowels must fall within the range of 400 Hz to 600 Hz. Low vowels must be greater than 600 Hz. The subsequent table presents acoustic data from ten NMNE men.

Table 4.1

NMNE Men F1 Measurements Table[10]

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F1	276	442	453	535	623	723	723	513	473	301	586
Speaker 2M	F1	285	425	374	485	591	671	694	431	441	312	531
Speaker 3M	F1	274	441	401	581	685	748	731	490	533	288	606
Speaker 4M	F1	311	447	408	512	623	707	694	448	487	348	578
Speaker 5M	F1	291	422	378	561	649	667	606	NA	436	347	NA
Speaker 6M	F1	277	405	367	534	656	624	607	414	431	323	544
Speaker 7M	F1	276	434	425	576	715	734	798	494	469	342	578
Speaker 8M	F1	262	405	364	479	520	569	679	450	422	315	557
Speaker 9M	F1	251	401	351	472	639	NA	650	444	418	308	489
Speaker 10M	F1	302	419	392	454	502	596	585	431	447	355	532
Average		**280**	**424**	**391**	**518**	**611**	**671**	**676**	**457**	**455**	**323**	**555**
Standard Deviation		17.73	16.74	31.18	45.43	67.89	63.39	66.15	33.71	35.39	22.84	35.71

NMNE men collectively produce vowels in all three levels of vowel height. Within the highest level of vowel height, NMNE men realize three vowels as high vowels. In the next level, they realize five vowels as mid vowels. Lastly, NMNE men realize three vowel phonemes in the lowest level of vowel height.

[10] It should be noted that Speakers 5M and 9M all mispronounced words during task 2. Speaker 5M produced <hoed> and <hud> as [who'd] and [hʊd] respectively. Likewise, Speaker 9M realized the word <hod> as [hʊd]. Therefore, these data were not included in any of the tables and I have chosen to write NA in the corresponding boxes in Table 4.1. This same gap in data can be expected for these speakers throughout the rest of the study.

Commencing with the highest level, NMNE men realize the fleece [i] vowel (280 Hz), the goose [u] vowel (323 Hz), and the face [e] vowel (391 Hz) as high vowel sounds. Of the three, the fleece [i] vowel has the lowest standard deviation (17.73 Hz) and it is realized as the highest vocalic sound of this dialect. The second highest vowel of the NMNE men's dialect is the goose [u] vowel. Like the fleece [i] vowel, it has a low standard deviation of only 22.84 Hz. The face [e] vowel, on the other hand, is averaged as the lowest of the high vowels and, since its location is so close to the 400 Hz boundary, four of the speakers (Speaker 1M, Speaker 3M, Speaker 4M, and Speaker 7M) produce it as a mid vowel. However, considering this fluctuation between levels, standard deviation for the face [e] vowel is still quite low (31.18 Hz).

Mid vowels are more numerous in NMNE men's speech. The mid level contains five out of the eleven vowels (45%), which is just under half of men's phonemic vowels from the Northern Minnesota English dialect. Beginning with the highest and moving toward the lowest, the mid level vowels consist of the kit [ɪ] vowel (424 Hz), the foot [ʊ] vowel (455 Hz), the goat [o] vowel (457 Hz), the dress [ɛ] vowel (518 Hz), and the strut [ʌ] vowel (555 Hz). Similar to high vowels, standard deviations for mid vowels are also low. The kit [ɪ] vowel has the lowest standard deviation of only 16.74 Hz while the highest standard deviation is found in the dress [ɛ] vowel. It deviates only by an average of 45.43 Hz.

Finally at the lowest level of vowel height, NMNE men realize three vowel phonemes as low vowels. F1 averages of these vowels show that the lowest vowel of this dialect is the cloth [ɔ] vowel, which is realized at 676 Hz. It is closely pursued by the lot [ɑ] vowel (671 Hz). Trailing in last is the trap [æ] vowel and it is realized at an average of 611 Hz. Interestingly enough, deviations in this level are much higher in comparison to the former levels of vowel

height. The trap [æ] vowel has the greatest standard deviation of 67.89 Hz. The cloth [ɔ] vowel follows next with 66.15 Hz. Finally, the lot [ɑ] vowel comes in with the lowest value of standard deviation which is 63.39 Hz. All of these values of standard deviation do in fact exceed the 63 Hz threshold and this is a result of at least one speaker producing each sound as a mid vowel. The trap [æ] vowel is realized as a mid vowel by three speakers, Speaker 2M, Speaker 8M, and Speaker 10M. Speaker 8M and Speaker 10M also realize the lot [ɑ] vowel as a mid vowel and only Speaker 10M realizes the cloth [ɔ] vowel as a mid vowel. Consequently, the low vowels have the highest standard deviations while the high level vowels maintain the lowest standard deviations.

NMNE Men F2: Tongue Retraction

Tongue retraction, represented by the F2 correlate, is divided into three regions which are front, central, and back. Similar to the levels of vowel height, the regions of tongue retraction also have particular ranges which are as follows. For men, front vowels must have an F2 value that is greater than or equal to 1600 Hz. Central vowels must be within the range of 1200 Hz and 1599 Hz. Back vowels must be less than 1200 Hz. Acoustic data under the second formant for NMNE men are presented below in Table 4.2.

Table 4.2

NMNE Men F2 Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F2	2336	2012	2149	1935	1872	1226	1203	1140	1296	1037	1340
Speaker 2M	F2	2510	1912	2123	1779	1712	1284	1298	1097	1414	1169	1426
Speaker 3M	F2	2262	1907	2122	1727	1608	1236	1193	1052	1390	1217	1364
Speaker 4M	F2	2244	1852	2060	1778	1628	1298	1291	1321	1432	1348	1478
Speaker 5M	F2	2257	1900	2164	1938	1801	1056	1149	NA	1180	1234	NA
Speaker 6M	F2	2483	2153	2408	2139	1947	1196	1135	889	1515	1074	1448
Speaker 7M	F2	2349	1965	2215	1850	1763	1270	1358	1016	1374	1070	1388
Speaker 8M	F2	2194	1775	2039	1689	1646	1254	1632	1184	1356	1359	1465
Speaker 9M	F2	2214	1853	2076	1638	1534	NA	1137	907	1143	999	1225
Speaker 10M	F2	2256	1894	2174	1841	1828	1181	1232	906	1318	1070	1334
Average		**2310**	**1922**	**2153**	**1831**	**1733**	**1222**	**1262**	**1056**	**1342**	**1157**	**1385**
Standard Deviation		109.12	103.37	104.81	145.8	130.77	73.37	149.78	145.57	112.45	128.38	80.13

Northern Minnesota English men realize vowels in all three regions of tongue retraction, with the exception of Speaker 4M. Five vowels are produced in the front region, the central region has four vocalic phonemes, and there are only two vowel sounds realized in the back region.

The front region has the biggest inventory because these men realize 45% of all their vowel phonemes here. The most fronted vowel of the dialect is the fleece [i] vowel. It has an average of 2310 Hz. The face [e] vowel is the second most fronted vowel in the men's dialect

with an average of 2153 Hz. The kit [ɪ] vowel comes in third, where it is realized at 1922 Hz. The dress [ɛ] vowel trails behind at 1831 Hz and the trap [æ] vowel comes in last at 1733 Hz. Standard deviations for all front vowels are low since none exceed the 200 Hz threshold.

Central vowels include the lot [ɑ] vowel (1222 Hz) which is the most fronted of all the central vowels, followed by the cloth [ɔ] vowel (1262 Hz), the foot [ʊ] vowel (1342 Hz), and finally the strut [ʌ] vowel (1385 Hz). Even though all of the standard deviations remain low under the F2 cue, most of the male participants do in fact still vary in their regions of production while uttering these particular vowels. The cloth [ɔ] vowel, for instance, is realized in all three regions of tongue retraction. It is produced as a central vowel by Speaker 1M, Speaker 2M, Speaker 4M, Speaker 7M, and Speaker 10M (50% of men). The cloth [ɔ] vowel is produced as a back vowel by Speaker 3M, Speaker 5M, Speaker 6M, and Speaker 9M (40% of men), and it is realized as a front vowel by Speaker 8M (10% of men). Likewise, the lot [ɑ] vowel is realized as both a central vowel by 66% of the participants and a back vowel by 33% of the speakers (Speakers 5M, 6M, and 10M)[11]. The foot [ʊ] vowel also follows this same pattern. Eighty percent of the speakers realize the foot [ʊ] vowel as a central sound, whereas Speaker 5M and Speaker 9M realize it as a back vowel. The strut [ʌ] vowel is the only central vowel which is realized by all of the speakers as a central sound (with the exception of Speaker 5M due to a mispronunciation during the recording).

According to the criteria in Table 4.2, there are only two back vowels in the Northern Minnesota English men's dialect although the lot [ɑ] and cloth [ɔ] vowels are both realized at the

[11] Speaker 9M mispronounced the lot [ɑ] vowel. Consequently, his data for this word was unable to be used in this study. It is for this reason that I choose to take percentages from a pool of nine participants rather than ten.

borderline of the central and back regions. The NMNE back vowels include the goat [o] vowel and the goose [u] vowel. Of the two, the goat [o] vowel is the most stable in its region of tongue retraction since all but Speaker 4M produce it as a back vowel (with the exclusion of Speaker 5M who mispronounced this vowel). Furthermore, the goat [o] vowel is the most backed vowel of the two. It has an F2 average of 1056 Hz. The goose [u] vowel, on the other hand, is realized at 1157 Hz. This close proximity to the 1200 Hz boundary explains why 40% of the speakers realize the goose [u] vowel as a central sound. Despite this fluctuation, both of the back vowels, as well as the front vowels and central vowels for that matter, maintain low values of standard deviation.

NMNE Men: Acoustic Vowel Space Chart

An acoustic vowel space chart is a scatter plot graph that depicts the location of vowels within the acoustic space. Data for this chart include only F1 and F2 averages. Along the y-axis are the data points for the F1 correlate and along the x-axis are the data points for the F2 correlate. The acoustic vowel space chart for men is correlated with their particular vowel boundaries. Data from the ten men from Northern Minnesota are presented below in Figure 4.1.

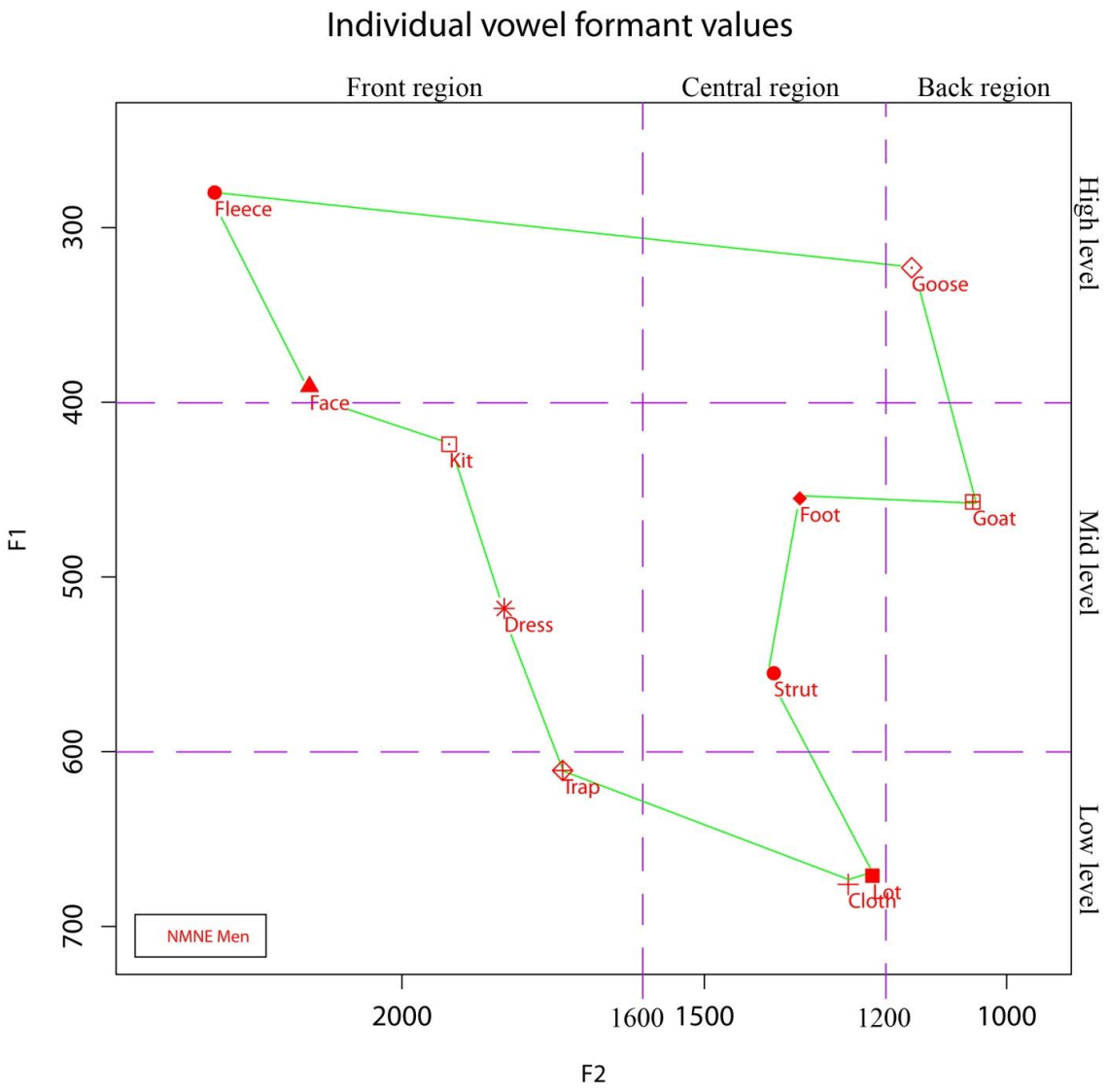

Figure 4.1: A representation of the NMNE men's acoustic vowel space chart.

The NMNE men's acoustic vowel space chart makes it much easier to identify the extreme vowels of the dialect, which are the high and fronted fleece [i] vowel, the low cloth [ɔ] vowel, and the backed goat [o] vowel. Furthermore, there are other characteristics about the NMNE men's dialect that also become more apparent which may not have been as evident

before in the previous tables. A few of the most significant findings are merged vowels, reversed vowel positions, and distinctive vowel qualities.

The first finding is the merged lot [ɑ] and cloth [ɔ] vowels. According to Koffi, vowels become merged "when the F1 distance between two adjacent vowels that are phonetically similar but functionally different is less than 60 Hz" (2017a, p. 109). As it appears in the figure above, the cloth [ɔ] vowel (676 Hz) is almost directly on top of the lot [ɑ] vowel (671 Hz). This is because the acoustic space realized between the two sounds is only 5 Hz. As a result, the men's dialect from this study is unable to distinguish between the two phonemes. This finding is not entirely unexpected considering Hillenbrand et al.'s confusion data (1995, p. 3108). They also found that hearers confuse these two sounds 13.8% of the time.

The second significant finding in the NMNE men's acoustic vowel space chart is the reversed positions of the kit [ɪ] vowel and the face [e] vowel. Recalling back to Ladefoged and Johnson's (2015, p. 46) original vowel space chart alluded to in chapter 1, the kit [ɪ] vowel is actually a high sound (or a mid-high sound rather) while the face [e] vowel is a mid sound. However, it is the complete opposite in the NMNE men's dialect. The face [e] vowel (391 Hz) is the lowest constituent of the high vowels since it does not meet or exceed the 400 Hz boundary separating mid sounds from high sounds. The kit [ɪ] vowel (424 Hz), on the other hand, is actually the highest sound of all the mid vowels but still easily falls below the mid-high vowel boundary. Consequently, the ten men from Northern Minnesota have in fact changed the order of their vowel inventory.

The last significant finding is the distinctive qualities of the NMNE men's foot [ʊ] vowel. Presented by Ladefoged and Johnson (2015, p. 46), the English foot [ʊ] vowel is a high (mid-

high), back vowel. However, this is not the same location of realization for the NMNE men's foot [ʊ] vowel. As is apparent in the figure above, the NMNE men's foot [ʊ] vowel has actually been lowered from a high (mid-high) vowel sound to a mid vowel sound. Likewise, it has also been fronted from the back region of tongue retraction to the central region. Consequently, the NMNE men's foot [ʊ] vowel is realized as a mid, central vowel because of its F1 average of 455 Hz and F2 average of 1342 Hz.

NMNE Men F3: Lip Rounding

Lip rounding is an acoustic correlate that "provides information about the position of the lips in the production of sounds" (Koffi, 2016a, p. 13). In this current study this correlate has been broken down into two distinct categories: rounded and unrounded. Men who utter words that are classified into the former category must produce a sound that is averaged below 2500 Hz. The latter category entails of sounds produced equal to or above 2500 Hz. Lastly, if any two sounds are perceptually salient in this cue, there must be at least 400 Hz between each sound (Koffi, 2016a, p. 13). The table below presents F3 data from ten NMNE men.

Table 4.3

NMNE Men F3 Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F3	3125	2672	2734	2670	2612	2518	2516	2573	2439	2449	2550
Speaker 2M	F3	3107	2827	2843	2651	2514	2295	2407	2485	2659	2503	2615
Speaker 3M	F3	2957	2611	2626	2550	2479	2376	2319	2249	2364	2182	2427
Speaker 4M	F3	2959	2815	2741	2715	2683	2768	2723	2756	2465	2802	2611
Speaker 5M	F3	3056	2703	2907	2702	2483	2463	2794	NA	2374	2626	NA
Speaker 6M	F3	3162	2922	2963	2958	2557	2500	2483	2776	2592	2389	2480
Speaker 7M	F3	2790	2732	2921	2951	2886	2942	2793	2488	2531	2253	2675
Speaker 8M	F3	3001	2621	2628	2622	2645	2665	2751	2725	2704	2732	2671
Speaker 9M	F3	2893	2571	2603	2540	2424	NA	2524	2480	2403	2246	2514
Speaker 10M	F3	2882	2480	2920	2696	2615	2667	2700	2578	2398	2585	2382
Average		**2993**	**2695**	**2788**	**2705**	**2589**	**2577**	**2601**	**2567**	**2492**	**2476**	**2547**
Standard Deviation		119.71	133.1	139.09	144.14	132.74	202.44	171.76	168.14	122.45	211.94	104.69

Rounding vowels is not a common feature in the speech patterns of NMNE men nor is it an entirely robust correlate. To begin, there are only two rounded vowels within the data which are the foot [ʊ] vowel and the goose [u] vowel. The central foot [ʊ] vowel is averaged at 2492 Hz, which falls just below the 2500 Hz limit. Likewise the back goose [u] vowel also just passes this limit with an F3 average of 2476 Hz. However, these averages are not reflective within each idiolect. For instance, speaker 8M is the only participant who does not round any of his vowels. Furthermore, the lack of robustness of the F3 cue is more than obvious in Table 4.3 above. For

instance, the goose [u] vowel has the lowest F3 average of this dialect, and out of all the ten other vowels, only the fleece [i] vowel is distinct from it. The two sounds are separated by a total distance of 517 Hz (2476 Hz – 2993 Hz). The face [e] vowel, on the other hand, is averaged at 2788 Hz. Even though the face [e] vowel holds the second greatest distance from the goose [u] vowel, the two vowels are only separated by 312 Hz. A similar conclusion can be said about the latter eight vowels whose distance from the goose [u] vowel only decreases.

NMNE Men Dur: Vowel Duration

Vowel duration is an acoustic cue that describes the length of a sound. Even though in English this correlate is not an essential cue for distinguishing vowel phonemes, it still does provide some vowel characteristics which may or may not reveal dialectal patterns. For perceptual salience in this correlate, there must be at least 10 ms between sounds that are less than 200 ms in length. However, if a sound lasts 200 ms or longer, there must be at least 17 ms between each sound for vowel distinction (Koffi & Lopez-Backstrom, 2018, p. 6). Acoustic data for duration from the ten men from Northern Minnesota is presented below.

Table 4.4

NMNE Men Vowel Duration Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	DUR	182	142	209	149	193	218	197	203	146	170	139
Speaker 2M	DUR	189	168	257	158	245	213	227	222	157	181	138
Speaker 3M	DUR	208	135	218	125	222	204	214	182	112	168	97
Speaker 4M	DUR	213	136	222	161	271	226	258	257	152	224	127
Speaker 5M	DUR	237	187	234	169	290	207	232	NA	171	189	NA
Speaker 6M	DUR	253	128	222	150	143	234	256	245	131	210	123
Speaker 7M	DUR	237	172	239	190	269	248	215	245	161	236	150
Speaker 8M	DUR	196	149	230	178	222	234	242	214	150	173	119
Speaker 9M	DUR	281	205	281	230	331	NA	305	266	209	273	171
Speaker 10M	DUR	233	149	280	164	299	300	230	265	154	176	136
Average		**222**	**157**	**239**	**167**	**248**	**231**	**237**	**233**	**154**	**200**	**133**
Standard Deviation		30.99	25.09	25.37	28.13	55.41	29.34	30.24	29.49	25.27	34.97	20.7

Duration data for NMNE men reveal that there is a group of vowels which is realized as the longest sound, one vowel that is realized as the second longest sound, and one vowel realized as the shortest sound of this dialect. The longest vowel sound of NMNE men is held by the trap [æ] vowel (248 ms). However, sharing this title is also the face [e] vowel (239 ms), the cloth [ɔ] vowel (237 ms), the goat [o] vowel (233 ms), and finally the lot [ɑ] vowel (231 ms). Since each of these vowels is within a distance of 17 ms of each other, the human ear is unable to detect a difference between their durations. Interestingly enough, all three levels of vowel height are

represented by at least one constituent of this group (high [e], mid [o], low [æ, ɑ, ɔ]). The second longest sound includes only the fleece [i] vowel. It is a high vowel that has a duration of 222 milliseconds. The last category of the shortest sound also includes only one vowel. The shortest vowel of the NMNE men's dialect is the strut [ʌ] vowel. It is a mid sound that is averaged at 133 ms and it does not share this title with any other. In fact, the closest durational neighbor, which is the foot [ʊ] vowel, is separated from the strut [ʌ] vowel by a total of 21 ms (154 ms – 133 ms).

NMNE Men Int & F0: Vowel Intensity & Vowel Pitch

Vowel intensity and vowel pitch, similar to vowel duration, do in fact describe some vowel characteristics, although they are not robust features for distinguishing between vowel phonemes. The Just Noticeable Difference for vowel intensity is that sounds must be separated by at least 5 dB to be distinguished. Vowel pitch, on the other hand, only calls for 1 Hz between each vowel to cause a distinction between vowel sounds. Acoustic data for NMNE men is presented in the following two tables. Vowel intensity data is presented first and then it is followed by vowel pitch.

Table 4.5

NMNE Men Vowel Intensity Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	INT	53	51	52	52	52	53	53	53	52	56	54
Speaker 2M	INT	77	80	75	75	74	74	73	77	77	79	75
Speaker 3M	INT	73	74	70	73	72	76	75	72	75	73	73
Speaker 4M	INT	53	53	50	50	49	50	47	49	53	54	52
Speaker 5M	INT	63	65	65	57	56	58	58	NA	63	63	NA
Speaker 6M	INT	48	53	53	50	54	49	48	54	52	56	51
Speaker 7M	INT	58	58	58	58	57	58	61	59	61	61	58
Speaker 8M	INT	52	54	53	51	47	48	46	50	52	51	46
Speaker 9M	INT	55	56	55	54	54	NA	57	57	58	58	55
Speaker 10M	INT	59	56	57	51	53	54	52	57	54	59	54
Average		**59.1**	**60**	**58.8**	**57.1**	**56.8**	**57.7**	**57**	**58.6**	**59.7**	**61**	**57.5**
Standard Deviation		9.39	9.84	8.40	9.33	9.05	10.40	10.21	9.63	9.45	8.71	9.88

Table 4.6

NMNE Men Vowel Pitch Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F0	121	109	114	108	116	105	109	126	118	131	117
Speaker 2M	F0	174	145	133	130	136	134	129	137	135	153	129
Speaker 3M	F0	127	132	126	127	123	127	141	133	144	140	130
Speaker 4M	F0	112	109	100	97	91	92	85	93	99	113	100
Speaker 5M	F0	139	131	126	119	120	120	123	NA	131	131	NA
Speaker 6M	F0	100	101	110	121	112	105	94	109	112	124	105
Speaker 7M	F0	127	115	123	113	121	117	121	113	126	138	103
Speaker 8M	F0	110	115	110	110	108	108	112	116	122	128	110
Speaker 9M	F0	120	117	118	114	112	NA	117	126	129	144	121
Speaker 10M	F0	101	81	100	79	79	85	76	85	84	98	83
Average		**123**	**115**	**116**	**111**	**111**	**110**	**110**	**115**	**120**	**130**	**110**
Standard Deviation		21.61	17.85	11.2	14.97	16.34	15.87	20.27	17.58	17.78	15.79	15.11

NMNE men do not realize any two vowels distinctively in the intensity correlate. The highest intensity is found in the goose [u] vowel (61 dB) while the lowest intensity is found in the cloth [ɔ] vowel (57 dB). Considering that they are separated by only 4 dB, the two most extreme sounds are still difficult to distinguish. In other words, hearers of these vowels interpret all 11 vowels at the same level of intensity. Despite this finding, standard deviations do not support this same conclusion. In fact, all 11 vowels have standard deviations that actually exceed

the 5 dB threshold. For that reason, it can be stated that the intensity correlate does distinguish between the men's idiolects even though it does not distinguish between vowels.

Vowel pitch is a bit more distinctive. Although there are three groups of vowels which are not distinguished by pitch (1: the dress [ɛ] and trap [æ] vowels, 2: the lot [ɑ], cloth [ɔ], and strut [ʌ] vowels, and 3: the kit [ɪ] and goat [o] vowels), there are still the remaining vowels that are realized distinctively. The most extreme cases are the goose [u] vowel along with the lot [ɑ], cloth [ɔ], and strut [ʌ] vowels. The goose [u] vowel is realized with the highest pitch (130 Hz) while the lot [ɑ], cloth [ɔ], and strut [ʌ] vowels are realized with the lowest pitch (110 Hz) of this dialect. What's more is that lying between those two extremities are also five more distinct levels of pitch. Thus, it is clear that NMNE men do in fact distinguish majority of their vowels (63%) in the pitch correlate. Standard deviations, on the other hand, reveal that all ten participants do realize their vowels differently.

NMNE Women F1: Vowel Height

Acoustic data for the ten women from Northern Minnesota are presented independently from their male counterparts. "Because women's vocal tracts are generally shorter than men's, women have higher values for formant frequencies" (Read & Kent, 2002, p. 194). Thus, distinct boundaries for vowel height have been developed for women's speech as well. Although vowel height for women still encompasses the same three levels as their male counterparts (high, mid, and low), the boundaries were divided differently from men's so as to compensate for the biological differences of women's vocal tracts. Therefore, for women, high vowels must be less than 480 Hz. Mid vowels must be within 480 Hz to 720 Hz. Low vowels must be greater than 720 Hz. Table 4.7 below presents acoustic data from ten NMNE women.

Table 4.7

NMNE Women F1 Measurements Table[12]

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F1	349	522	468	623	709	738	724	501	531	389	637
Speaker 2F	F1	383	462	416	644	799	704	720	444	478	417	575
Speaker 3F	F1	390	548	504	837	979	935	948	593	564	410	812
Speaker 4F	F1	333	502	423	717	962	862	828	485	521	385	615
Speaker 5F	F1	314	505	433	634	753	718	761	460	494	386	674
Speaker 6F	F1	372	493	516	711	963	882	854	509	557	408	727
Speaker 7F	F1	366	412	382	505	773	572	590	433	447	378	559
Speaker 8F	F1	326	598	520	699	862	891	807	654	672	434	734
Speaker 9F	F1	387	400	395	490	614	777	836	NA	420	380	638
Speaker 10F	F1	339	497	417	693	844	804	788	507	530	395	675
Average		**355**	**493**	**447**	**655**	**825**	**788**	**785**	**509**	**521**	**398**	**664**
Standard Deviation		27.35	58.96	50.92	102.62	120.08	109.55	95.92	71.69	70.22	18.34	77.27

F1 values for Northern Minnesota English women represented in Table 4.7 clearly demonstrate three distinct levels of vowel height. Although not all speakers produce the same vowels for each level, every speaker does in fact realize at least one vowel in all levels (high, mid, and low). Similar to their male counterparts, NMNE women realize three vowels in the high level, five vowels in the mid level, and three phonemic vowels in the low level.

[12]It should be noted that speaker 9F mispronounced the word <hoed> as [hud] during task 2. Consequently, her data was unable to be used for the goat [o] vowel and because of this I have chosen to write NA in Table 4.7. This same gap in data can be expected throughout the rest of the study.

According to the general vocalic boundaries derived within this study, the three high vowels are the fleece [i] vowel (355 Hz), the goose [u] vowel (398 Hz), and the face [e] vowel (447 Hz). Both the fleece [i] vowel and the goose [u] vowel have low standard deviations. In other words, women from this study have a similar area of realization for each vowel and they do not deviate from these locations much at all. The last high vowel, and the lowest of the three, is the face [e] vowel. It has a standard deviation of 50.92 Hz. Although this is still on the low side since it doesn't exceed the 63 Hz threshold, standard deviation for the face [e] vowel is a bit higher in comparison to the fleece [i] and goose [u] vowels. Furthermore, its close location to the 480 Hz boundary explains why Speaker 2F, Speaker 5F, and Speaker 7F realize it as a mid vowel instead of a high vowel like the latter 70% of the speakers.

According the data in Table 4.7, NMNE women realize the majority of their vowels in the mid level. Out of eleven vowels, five of them (45%) are included in this particular level. These sounds include the following vowel phonemes. Beginning with the highest mid vowel, the kit [ɪ] vowel (493 Hz) does not waiver between levels at all and its standard deviation (58.96 Hz) is just beneath its peak of 63 Hz. However, this vowel maintains the lowest standard deviation of all the mid vowels realized by the ten NMNE women. The latter four vowels have standard deviations which easily exceed the 63 Hz threshold. The second highest mid vowel is the goat [o] vowel. It has an F1 value of 509 Hz, a standard deviation of 71.69 Hz, and it is realized by every speaker as a mid vowel. Next is the foot [ʊ] vowel which has very similar acoustic characteristics as the goat [o] vowel. The foot [ʊ] vowel has an F1 average of 521 Hz, its standard deviation is 70.22 Hz, and it is also produced as a mid vowel by each woman. Trailing in last are the dress [ɛ] vowel (655 Hz) and the strut [ʌ] vowel (664 Hz). These are the only two

mid vowels which are produced in two distinct levels of vowel height. Speaker 3F realizes the dress [ɛ] vowel as a low vowel (837 Hz) while the latter nine participants produce it as a mid vowel. Likewise, the strut [ʌ] vowel is realized as a low vowel by Speaker 3F, Speaker 6F, and Speaker 8F, whereas the latter seven speakers produce it as a mid vowel. Consequently, the dress [ɛ] vowel and the strut [ʌ] vowel carry the highest standard deviations of this level which are 102.62 Hz and 77.27 Hz, respectfully.

Low vowels for NMNE women consist of three vocalic phonemes. Unlike their male counterparts, the lowest of these sounds is the trap [æ] vowel (835 Hz). It is realized by 80% of the speakers as a low vowel while two speakers, Speaker 1F and Speaker 9F, produce it as a mid vowel. Consequently, the trap [æ] vowel holds the greatest standard deviation of all eleven vowels in Table 4.7. Its standard deviation is 120.08 Hz. Proceeding this in a similar manner is the lot [ɑ] vowel. It has an F1 average of 788 Hz and its standard deviation is 109.55 Hz. Lastly, the highest of all low vowel phonemes is the cloth [ɔ] vowel. It has an F1 value of 785 Hz and a standard deviation of 95.92 Hz. Even though standard deviations for the lot [ɑ] vowel and the cloth [ɔ] vowel are not as dramatic as the trap [æ] vowel, they still easily exceed the 63 Hz threshold. Similar to the trap [æ] vowel, this is a result of multiple participants producing both the lot [ɑ] vowel and the cloth [ɔ] vowel as mid vowels instead of low vowels. Speaker 2F and Speaker 5F produce the lot [ɑ] vowel as a mid vowel and Speaker 7F realizes both the lot [ɑ] and cloth [ɔ] vowels as mid vowels. Out of all the vowel height levels, low vowels, along with the dress [ɛ] vowel which is a central sound, have the highest standard deviations of all vowels in this particular dialect.

NMNE Women F2: Tongue Retraction

Within the F2 feature women also have their own specific boundaries which are distinct from their male counterparts even though they maintain the same regions of tongue retraction which are front, central, and back. For women, the boundaries of front vowels must be greater or equal to 1920 Hz. Central vowels must fall with the range of 1440 Hz to 1919 Hz. Back vowels must be less than 1440 Hz. Acoustic data for the F2 correlate for women of Northern Minnesota are presented below in Table 4.8.

Table 4.8

NMNE Women F2 Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F2	2539	2022	2361	1968	1870	1363	1327	971	1397	1117	1629
Speaker 2F	F2	2414	2101	2470	1674	1396	1271	1344	1130	1506	1330	1411
Speaker 3F	F2	2839	2280	2499	2002	1703	1377	1387	1136	1554	1246	1623
Speaker 4F	F2	2755	2153	2631	2022	1610	1344	1376	1132	1589	1110	1574
Speaker 5F	F2	2665	2120	2483	1974	1875	1259	1238	744	1337	868	1548
Speaker 6F	F2	2213	2374	2536	2098	1845	1482	1420	1172	1641	1262	1719
Speaker 7F	F2	2495	2300	2598	2135	2012	1139	1226	990	1338	1123	1447
Speaker 8F	F2	2299	2090	2184	1759	1951	1451	1472	1190	1596	1335	1645
Speaker 9F	F2	2941	2511	2492	2344	2088	1593	1538	NA	1626	1352	1808
Speaker 10F	F2	2690	2184	2577	2035	1908	1444	1426	1088	1498	1140	1559
Average		**2585**	**2213**	**2483**	**2001**	**1825**	**1372**	**1375**	**1061**	**1508**	**1188**	**1596**
Standard Deviation		**235.04**	150.56	129.77	186.76	**204.66**	129.32	97.17	140.86	114.79	148.15	117.79

Similar to the three levels of vowel height, all three regions of tongue retraction are also represented in the NMNE women's dialect. The front vowels include four sounds, the central region has three vowel sounds, and the back region has four vowel phonemes produced within it.

Front vowels realized in the NMNE women's dialect include the fleece [i] vowel, the face [e] vowel, the kit [ɪ] vowel, and the dress [ɛ] vowel. The most fronted sound of this dialect is the fleece [i] vowel. It has an F2 average of 2585 Hz. Furthermore, out of all the front vowels, the fleece [i] vowel has the highest standard deviation of 235.04 Hz which exceeds the 200 Hz threshold. Although all speakers do realize this sound as a front vowel, some speakers, Speaker 3F (2839 Hz) and Speaker 9F (2941 Hz), are far more fronted than all the rest. As a result, this vowel reveals slightly distinctive F2 characteristics among the ten NMNE women. The second most fronted vowel is the face [e] vowel since its F2 average is 2483 Hz. It has a low standard deviation of 129.77 Hz and is realized by each of the ten women as a front vowel. Similarly, the kit [ɪ] vowel follows the same pattern. It is the third most fronted vowel with an F2 average of 2213 Hz. The kit [ɪ] vowel has a low standard deviation of 150.56 Hz and all speakers produce it as a front vowel. The last vowel of this group, and the least fronted, is the dress [ɛ] vowel. Its average F2 value is 2001 Hz and it has a low standard deviation of 186.76 Hz. However, its close proximity to the central-front boundary of 1920 Hz has caused a slight division within the speakers. Speaker 2F and Speaker 8F both realize this sound as a central vowel rather than as front vowel like the latter 80% of women.

Central vowels for these ten women are the trap [æ] vowel (1825 Hz), the foot [ʊ] vowel (1508 Hz), and the strut [ʌ] vowel (1596 Hz). The former is realized closest to the 1920 Hz boundary between the front and central regions. It is for this reason that Speaker 7F, Speaker 8F

and Speaker 9F produce the trap [æ] vowel as a front sound rather than as a central one. In contrast, Speaker 2F deviates in the opposing direction and realizes the trap [æ] vowel as a back vowel. Consequently, standard deviation reaches its peak at 204.66 Hz and the women remain divided. At the other side of the central region are the foot [ʊ] vowel (1508 Hz) and the strut [ʌ] vowel (1596 Hz). Even though women do produce these two vowels as well in various regions of tongue retraction, they still maintain low standard deviations, unlike the trap [æ] vowel. The foot [ʊ] vowel, for instance, has a standard deviation of only 114.79 Hz even though three participants, Speaker 1F, Speaker 5F, and Speaker 7F, produce the foot [ʊ] vowel as a back vowel. Likewise, the strut [ʌ] vowel also has a low standard deviation of 117.79 Hz, although Speaker 2F realizes it as a back vowel. Considering these small divisions among the ten NMNE women, they still do not deviate enough in their realizations of either the foot [ʊ] vowel or the strut [ʌ] vowel to produce any distinctive characteristics in the F2 correlate. The trap [æ] vowel, on the other hand, does deviate much more than its central vocalic counterparts. It is realized in each of the three regions of tongue retraction with the majority (60%) settled in the central region.

Women from Northern Minnesota realize four of the eleven vowel phonemes as back vowels. The lot [ɑ] vowel is most fronted of all back vowels. It has an F2 average of 1372 Hz and it has a low standard deviation of 129.32 Hz. Furthermore, this vowel lies right at the central-back boundary of 1440 Hz. For this reason 40% of the speakers (Speaker 6F, Speaker 8F, Speaker 9F, and Speaker 10F) realize this sound as a central vowel rather than as a back one. Sitting only 3 Hz away is the cloth [ɔ] vowel (1375 Hz). It too has a low standard deviation of 97.17 Hz and it also sits close to the 1440 Hz boundary. As a result, similar to the lot [ɑ] vowel,

Speaker 8F and Speaker 9F both realize the cloth [ɔ] vowel as a central vowel. The next back sound is the goose [u] vowel. It is the third most fronted of the back vowels with an F2 value of 1188 Hz. Standard deviation is low (148.15 Hz) and all speakers produce it as a back vowel. Lastly, the goat [o] vowel is the most backed vowel of all the eleven vowels. It has an F2 average of 1061 Hz, a low standard deviation of 140.86 Hz, and all speakers realize it as a back vowel. Overall, back vowels, as well as central and front vowels (with the exception of the trap [æ] vowel and the fleece [i] vowel), have low standard deviations in the F2 correlate.

NMNE Women: Acoustic Vowel Space Chart

Since men and women are biologically distinctive within the F1 and F2 correlates (Read & Kent 2002), their acoustic vowel space charts are presented individually. Similar to their male counterparts, the NMNE women's acoustic vowel space chart is also correlated with their distinct boundaries. The F1 and F2 data for NMNE women are presented in the subsequent figure.

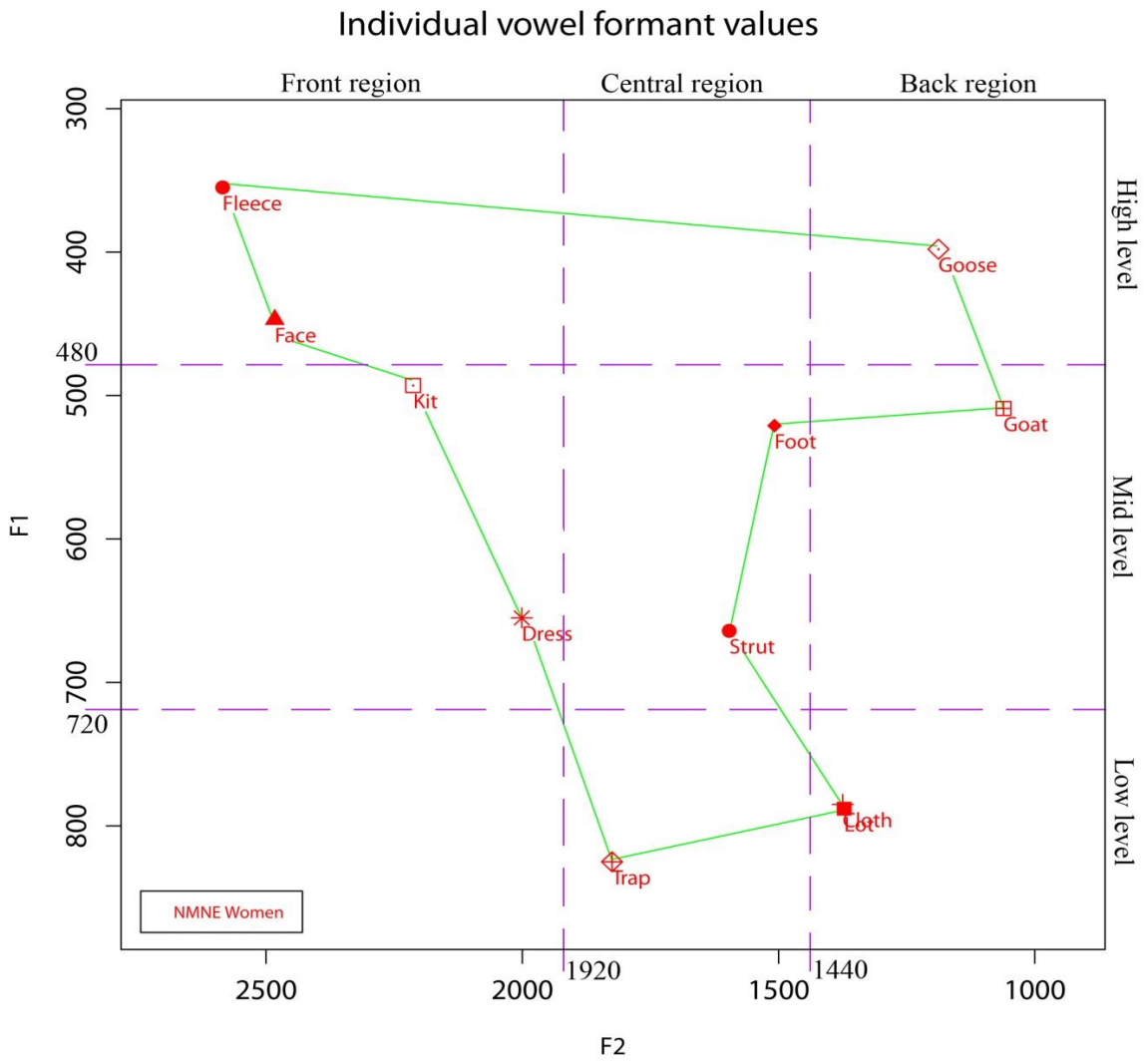

Figure 4.2: A representation of the NMNE women's acoustic vowel space chart.

Women from Northern Minnesota follow a slightly similar pattern of extreme vowels as their male counterparts. For instance, the fleece [i] vowel is both their highest and most fronted vowel of their dialect. Likewise, the goat [o] vowel is their most backed sound. However, these extreme vowels are not entirely identical. In place of realizing the cloth [ɔ] vowel as their lowest sound, NMNE women actually realize the trap [æ] vowel in this position. Their trap [æ] vowel (825 Hz) easily drops below their cloth [ɔ] vowel (785 Hz) by a total of 40 Hz. Outside of this

inconsistency, NMNE women still do uphold the same dialectal patterns as their male counterparts which are presented in the previous sections. Those dialectal patterns include merged sounds, reversed vowel positions, and distinctive vowel qualities.

Northern Minnesota English women, like the ten NMNE men, have merged their cloth [ɔ] vowel with their lot [ɑ] vowel. This is a result of the cloth [ɔ] vowel being lowered and fronted so much that it eventually masked the latter vowel. Now, the cloth [ɔ] vowel (785 Hz) is only 3 Hz away from the lot [ɑ] vowel (788 Hz). Consequently, hearers of these two vowels are unable to decipher between the two sounds because of the unintelligible distinctions (Koffi, 2017a, p. 109).

The second dialectal pattern that is also apparent in the women's speech from Northern Minnesota is the reversed vowel positions of the kit [ɪ] vowel and the face [e] vowel. Ordinarily, the kit [ɪ] vowel pertains to the high level of vowel height (Ladefoged & Johnson, 2015, p. 46). However, the ten women from Northern Minnesota have actually lowered this sound so that it is now realized as a mid vowel sound. The face [e] vowel, on the other hand, deviates in the opposing direction. It has been raised from a typical mid vowel to a high vowel sound. Thus, just as the ten men from Northern Minnesota, the ten NMNE women have reversed the positions of their kit [ɪ] vowel and their face [e] vowel.

This final dialectal pattern is the distinctive qualities of the foot [ʊ] vowel. It is originally represented as a high, back vowel (Ladefoged & Johnson, 2015, p. 46). However, this is not the case for the ten women from Northern Minnesota. Instead, they have dropped this vowel down to the mid level of vowel height as well as fronted this sound so much that it crossed into the

central region of tongue retraction. Similar to the NMNE men, the results of these movements is an entirely new title which is now called a mid, central vowel sound.

NMNE Women F3: Lip Rounding

Lip rounding categories for women are the same, rounded and unrounded. However, the ranges of frequencies for each are different from their male counterparts. For women, a rounded vowel must have an F3 value less than 3000 Hz. An unrounded vowel, on the other hand, must hold an average of at least 3000 Hz or greater. NMNE women's acoustic data is presented below in Table 4.9.

Table 4.9

NMNE Women F3 Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F3	3179	2979	2927	2964	2751	2830	2811	2761	2873	2866	2872
Speaker 2F	F3	2996	2920	2885	2817	2599	2728	2903	2725	2782	2652	2804
Speaker 3F	F3	3219	3014	2871	2944	2531	2460	2618	2705	2760	2726	2831
Speaker 4F	F3	3174	2703	2943	2909	2613	2840	2760	2615	2644	2564	2924
Speaker 5F	F3	3214	2997	2849	2863	2771	2881	2845	2952	2900	2978	2872
Speaker 6F	F3	3257	2861	2848	2706	2545	2777	2752	2887	2907	2869	2885
Speaker 7F	F3	3197	2919	2989	2918	2722	2689	2598	2536	2490	2588	2792
Speaker 8F	F3	2929	2806	2784	2429	2655	2500	2923	2806	2791	2715	2848
Speaker 9F	F3	3352	3303	3167	3210	3143	3095	2953	NA	3094	2844	3124
Speaker 10F	F3	3316	2997	3029	2977	2772	2673	2760	2589	2729	2563	2777
Average		**3183**	**2949**	**2929**	**2873**	**2710**	**2747**	**2792**	**2730**	**2797**	**2736**	**2872**
Standard Deviation		130.7	158.28	110.41	202.56	176.66	185.01	120.24	137.86	163.5	146.75	99.26

Rounding vowels in the speech patterns of the ten women from Northern Minnesota is a common feature. Out of all 11 uttered vowels, ten of them are rounded (90%). Only the front fleece [i] vowel is unrounded because of an F3 average of 3183 Hz. Even though this is almost completely contradictive to the pattern of lip rounding found in the ten NMNE men's speech, there is still a shared commonality between each biological group and that is that the F3 cue still lacks robustness. Similar to their male counterparts, the only distinct vowel is the fleece [i] vowel. When comparing it to the latter vowels, the fleece [i] vowel is distinguished from the trap

[æ] vowel (2710 Hz), the lot [ɑ] vowel (2747 Hz), the goat [o] vowel (2730 Hz), and the goose [u] vowel (2736 Hz). They all remain at a distance that is greater than 400 Hz (473 Hz, 436 Hz, 453 Hz, and 447 Hz respectively). However, with the exclusion of the fleece [i] vowel, the remaining ten vowels are completely indistinguishable from one another in the F3 correlate since none exceed a distance of at least 400 Hz.

NMNE Women Dur: Vowel Duration

Vowel duration for women holds the same thresholds for perceptual salience as men. Therefore, sounds under 200 ms only need at least 10 ms between them for salience while sounds with 200 ms or more must hold at least 17 milliseconds. Acoustic data for the ten NMNE women is presented below.

Table 4.10

NMNE Women Vowel Duration Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	DUR	191	145	225	147	207	215	206	196	154	194	117
Speaker 2F	DUR	239	170	245	172	235	261	276	264	204	208	148
Speaker 3F	DUR	255	210	313	207	293	294	310	305	196	249	165
Speaker 4F	DUR	219	130	223	134	214	217	225	238	130	182	92
Speaker 5F	DUR	281	193	286	206	338	352	343	297	181	259	151
Speaker 6F	DUR	217	146	214	157	238	230	211	231	152	187	106
Speaker 7F	DUR	205	105	215	117	209	202	246	230	116	188	103
Speaker 8F	DUR	147	138	175	122	193	193	187	200	140	157	118
Speaker 9F	DUR	180	99	203	131	187	157	197	NA	83	160	82
Speaker 10F	DUR	214	192	246	183	258	252	278	252	203	221	171
Average		**214**	**152**	**234**	**157**	**237**	**237**	**247**	**245**	**155**	**200**	**125**
Standard Deviation		38.11	37.63	40.29	33.21	47.64	55.54	52.21	38.08	40.3	34.16	31.29

Northern Minnesota English women do not have entirely similar patterns of vowel duration as their male counterparts. However, they are not completely different either. NMNE women realize a group of vowels as their longest sound. Likewise, for their second longest sound they realize two vowels at perceptually the same duration. However, the title for shortest vowel is taken by only one vowel phoneme, like NMNE men.

The group which holds the title for the longest sound of this dialect consists of five different phonemes. The first longest phoneme is the cloth [ɔ] vowel. It is a low vowel that has

an average duration of 247 milliseconds. Following next is the goat [o] vowel. It is a mid vowel that is averaged at 245 milliseconds. The third is both the trap [æ] vowel and the lot [ɑ] vowel. Each of these low vowels has a durational average of 237 milliseconds. Finally, the last constituent of this group is the high face [e] vowel. It has an average duration of 234 milliseconds. The greatest range between these vowels is only 13 ms (247 ms – 234 ms). Therefore, all of these sounds are perceptually the same duration, even though they are realized in three completely different levels of vowel height.

The second longest sound of this dialect includes both the fleece [i] vowel and the goose [u] vowel. Each of these sounds is realized in the high level of vowel height. The fleece [i] vowel has an average duration of 214 milliseconds. The goose [u] vowel, on the other hand, is realized at an average of 200 milliseconds. Despite the 14 ms difference, both the fleece [i] vowel and the goose [u] vowel are recognized as the same duration to the human ear.

Finally, the shortest sound of this dialect is the mid strut [ʌ] vowel. It is realized by NMNE women at an average duration of 125 milliseconds. Its closest neighbor, the kit [ɪ] vowel, is separated from it by a total of 27 ms (152 ms – 125 ms).

NMNE Women Int & F0: Vowel Intensity & Vowel Pitch

Vowel intensity and vowel pitch for women have the same JND thresholds. Vowel pitch is distinguished with 5 dB or more between each sound. Likewise, vowel intensity calls for only 1 Hz to distinguish vowels. The NMNE women's acoustic data for vowel intensity is presented first in Table 4.11. Subsequently, in Table 4.12 is the women's acoustic data for vowel pitch.

Table 4.11

NMNE Women Vowel Intensity Measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	INT	56	58	58	59	58	60	58	60	62	60	59
Speaker 2F	INT	52	55	55	52	50	51	52	54	56	58	52
Speaker 3F	INT	53	55	54	57	59	55	59	54	53	53	50
Speaker 4F	INT	59	62	60	62	64	61	64	64	65	62	60
Speaker 5F	INT	53	54	52	52	51	52	54	57	58	56	55
Speaker 6F	INT	51	52	52	51	51	51	51	52	50	52	49
Speaker 7F	INT	49	50	50	45	43	45	44	50	52	53	48
Speaker 8F	INT	52	55	50	55	52	58	53	53	54	51	51
Speaker 9F	INT	47	45	43	41	41	40	42	NA	42	47	42
Speaker 10F	INT	62	61	62	62	62	62	61	62	61	62	61
Average		**53.4**	**54.7**	**53.6**	**53.6**	**53.1**	**53.5**	**53.8**	**56.2**	**55.3**	**55.4**	**52.7**
Standard Deviation		4.50	5.03	5.54	6.89	7.63	7.16	7.05	4.81	6.68	5.03	6.03

Table 4.12

NMNE women vowel intensity measurements Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F0	168	146	153	147	143	156	151	166	175	183	155
Speaker 2F	F0	220	191	204	203	192	194	199	206	217	224	201
Speaker 3F	F0	221	204	202	191	188	188	187	197	208	214	152
Speaker 4F	F0	198	191	193	182	166	171	186	201	204	205	226
Speaker 5F	F0	179	197	189	184	176	187	215	202	206	219	188
Speaker 6F	F0	223	201	181	189	183	184	196	195	193	215	186
Speaker 7F	F0	194	191	144	170	146	161	115	148	193	189	150
Speaker 8F	F0	286	272	257	245	241	286	199	239	252	269	144
Speaker 9F	F0	205	185	173	170	166	176	192	NA	175	183	168
Speaker 10F	F0	211	196	192	194	187	159	179	193	168	187	91
Average		**211**	**197**	**188**	**187**	**178**	**186**	**181**	**194**	**199**	**208**	**166**
Standard Deviation		32.28	30.8	31.06	25.6	27.69	37.49	28.79	24.02	24.65	26.32	37.11

Similar to their male counterparts, NMNE women do not distinguish any vowel phonemes under the intensity correlate. They realize the goat [o] vowel with the highest intensity (56.2 dB) and the trap [æ] vowel with the lowest intensity (53.1 dB). Even though they are the furthest apart of all 11 phonemes, the goat [o] vowel and trap [æ] vowel are still only separated by 3.1 dB. However, standard deviation for this cue actually does exceed the 5 dB threshold for most vowels. In other words, when comparing the idiolects, all ten women realize nine of the 11 vowels at different levels of intensity. The only exceptions to this are the fleece [i] vowel and the

goat [o] vowel. They have standard deviations of 4.5 dB and 4.81 dB respectively, which fall just below the threshold.

Dissimilar to NMNE men, vowel pitch for NMNE women is completely different for each vowel. NMNE women do not have any sounds that are averaged with the same F0 values. Likewise, the standard deviations also reflect this same conclusion since they all surpass the 1 Hz threshold. Thus, NMNE women not only realize all 11 vowels differently under the pitch correlate, but they also realize each individual vowel at different pitch levels.

Comparison: Northern Minnesota English and General American English

General American English is a dialect that is considered as the standard dialect of American English, hence the name. It does not represent a dialect that is spoken by a minute group of people from one small area of the country, such as is the case for Northern Minnesota English. Instead, Peterson and Barney (1952) studied the speech patterns of Americans from all over the U.S. "Most of the women and children grew up in the Middle Atlantic speech area. The male speakers represented a much broader regional sampling of the United States" (1952, p. 177). Moreover, Peterson and Barney did not screen any participants for certain demographics or speaking characteristics, nor did they collect data from only monolingual English speakers. "Two of the speakers were born outside of the United States and a few others spoke a foreign language before learning English" (1952, p. 177). Contrary to this, the current study did implement various screening questions that narrowed the pool to a specific group of speakers. Therefore, the GAE dialect includes a diverse group of speakers from a variety of states. The NMNE dialect, on the other hand, includes a more homogeneous group of speakers from a minuscule area in comparison. The figure below presents a map depicting these areas of study.

Figure 4.3: US map of Northern Minnesota and Mid Atlantic region (Wikimedia Commons 2018).

Comparing Men F1 & F2: Vowel Height & Tongue Retraction

The Peterson and Barney (1952) study was the first of its kind. These two researchers initiated the measuring of the acoustic vowel spaces in General American English (GAE). They recorded a total of 76 participants, and of that group, 33 of them are men. Peterson and Barney measured ten vowels imbedded within an hVd structure. Their vowels of interest included the following [i, ɪ, ɛ, æ, ɑ, ɔ, ʊ, u, ʌ, ɚ[13]]. Each of the words was uttered in isolation two times. Once the participants were recorded, Peterson and Barney measured and analyzed the "steady state" of

[13] Peterson and Barney did not include the face [e] vowel or the goat [o] vowel because they associated them with diphthongs. For this reason, I have decided to write NA in each box lacking this data. Furthermore, the nurse [ɹ] vowel, which was investigated by Peterson and Barney, does not fall within the scope of this current study. Thus, there will be no further discussion over it.

each vowel. Their F1 and F2 data, along with the ten NMNE men's F1 and F2 data, are presented below in the subsequent table.

Table 4.13

F1 and F2 Data from GAE Men (Peterson & Barney, 1952) and NMNE Men Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE Men	F1	270	390	NA	530	660	730	570	NA	440	300	640
GAE Men	F2	2290	1990	NA	1840	1720	1090	840	NA	1020	870	1190
NMNE Men	F1	280	424	391	518	611	671	676	457	455	323	555
NMNE Men	F2	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385

General American English men and Northern Minnesota English men share slightly similar dialects when comparing the extreme quadrants of their acoustic space. The fleece [i] vowel, for instance, is the highest and most fronted vowel in each dialect. Likewise, the lot [ɑ] vowel is the lowest of both dialects. However, in the NMNE men's dialect, the title for lowest vowel is actually shared with its merged counterpart, the cloth [ɔ] vowel. Consequently, the lexical set of GAE men remains at nine distinct vowel sounds while that of the NMNE men is reduced down to ten vowel sounds (from 11) because of the masking phenomenon between the lot [ɑ] and the cloth vowel [ɔ]. (More details on this merge are explained in chapter two.) Moreover, the most backed vowel is another inconsistency between these two dialects. For GAE men, the most backed vowel is the goose [u] vowel. However, in NMNE men's dialect, it is the goat [o] vowel that is the most backed sound. The rest of this section covers only the divergent

features and masking tendencies that are perceptually salient between the GAE men and NMNE men.

There are four vowels which are perceptually salient between the GAE dialect and the NMNE dialect. Those vowels include the cloth [ɔ] vowel, the strut [ʌ] vowel, the goose [u] vowel, and the foot [ʊ] vowel. The cloth [ɔ] vowel has already been partially discussed. Because of its masking tendencies in the NMNE dialect, the NMNE cloth [ɔ] vowel (676 Hz; 1262 Hz) is lower and more fronted than its GAE equivalent (570 Hz; 840 Hz) by 106 Hz in the F1 cue and by 422 Hz in the F2 cue. However, the aftermath of this divergence does not just stop at a masked pair. This move also puts both the NMNE cloth [ɔ] vowel and lot [ɑ] vowel (671 Hz) at risk of masking the GAE strut [ʌ] vowel (640 Hz). With only 36 Hz and 31 Hz between sounds, these vowels show "moderate masking" capabilities which could "compromise intelligibility" (Koffi 2017a, p. 109). That leads us to the next distinctive vowel which is the NMNE strut [ʌ] vowel. Although it is produced as a low sound by GAE men (640 Hz), NMNE men actually realize the strut [ʌ] vowel as a mid sound (555 Hz). This is because the NMNE strut [ʌ] vowel has been raised by 85 Hz and thus is a distinguished sound between dialects. The final two distinctive vowels are fronted in the NMNE men's dialect. The foot [ʊ] vowel, for instance, has been fronted so much that it actually crossed the central-back boundary. This movement is pointed out in the figure below.

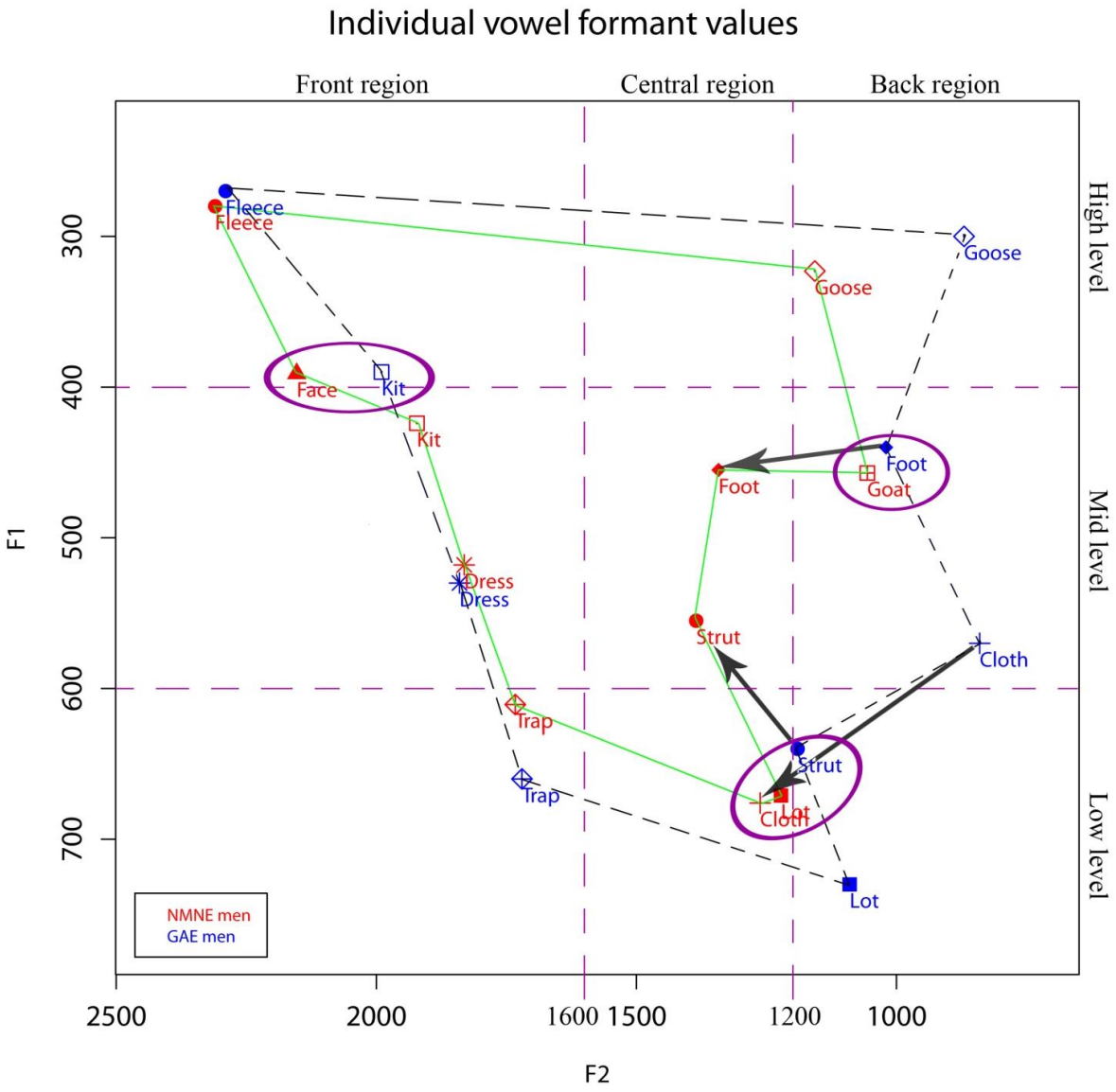

Figure 4.4: A representation of the acoustic vowel space chart for GAE men and NMNE men.

In the NMNE dialect, the foot [ʊ] vowel (1342 Hz) is realized as a central sound. However, in the GAE dialect it is produced as a back sound (1020 Hz). As a result, the acoustic space separating these two vowels is 322 Hz. Since this distance exceeds the 200 Hz threshold, the two vowels are perceptually different. Similarly, the NMNE goose [u] vowel (1157 Hz) has been fronted by 287 Hz from its GAE equivalent (870 Hz). However, GAE men and NMNE men

alike realize the goose [u] vowel in the back region of tongue retraction even though each phoneme remains distinct.

The overlapping vowels include two pairs which are GAE kit [ɪ] vowel and NMNE face [e] vowel along with the GAE foot [ʊ] vowel and NMNE goat [o] vowel. Although these phonemes are mostly identified correctly by hearers according the Hillenbrand et al. (1995, p. 3108) confusion data, NMNE men and GAE men still manage to overlap these vowels. Normally within a single dialect, the kit [ɪ] vowel and the face [e] vowel are only confused 0.3% of the time and the foot [ʊ] and goat [o] vowel are confused a mere 0.5% of the time. However, when NMNE men and GAE men interact this is not the case considering that the distances between each of the merged vowels are far below the stipulated thresholds. For instance, the former pair of high vowels is separated by only 1 Hz in the F1 cue (390 Hz – 391 Hz) and 163 Hz in the F2 cue (1990 Hz – 2153 Hz). Since the distances between GAE kit [ɪ] vowel and NMNE face [e] vowel easily fall below the thresholds of 63 Hz (F1) and 200 Hz (F2), these vowel phonemes are the same. Furthermore, according to Koffi, if two sounds are separated by 20 Hz or less in the F1 cue, they are classified in the degree of "complete masking" and are entirely indistinguishable to the human ear (2017a, p. 109). Therefore, the GAE kit [ɪ] vowel and NMNE face [e] vowel are perceptually realized as the same phoneme. Similarly, the GAE foot [ʊ] vowel and the NMNE goat [o] vowel are completely indistinctive since they are also only separated by 17 Hz in the F1 cue (440 Hz – 457 Hz) and 36 Hz in the F2 cue (1020 Hz – 1056 Hz).

Comparing Women F1 & F2: Vowel Height & Tongue Retraction

Northern Minnesota English women and General American English women are compared next. Similar to their male counterparts, the numbers of participants for each group is

not equal. Peterson and Barney (1952) recruited 28 women[14] to represent the GAE dialect. The current study, on the other hand, only includes ten women from Northern Minnesota. The following table presents F1 and F2 data from both groups of women.

Table 4.14

F1 and F2 Data from GAE Women (Peterson & Barney, 1952) and NMNE Women Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE Women	F1	310	430	NA	610	860	850	590	NA	470	370	760
GAE Women	F2	2790	2480	NA	2330	2050	1220	920	NA	1160	950	1400
NMNE Women	F1	355	493	447	655	825	788	785	509	521	398	664
NMNE Women	F2	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596

The extreme vowels realized in the GAE women's dialect include the fleece [i] vowel (310 Hz; 2790 Hz), which is the highest and most fronted of the dialect, the trap [æ] vowel (860 Hz), which is the lowest sound of the dialect, and the goose [u] vowel (950 Hz), which is the most backed sound of the dialect. However, these extreme vowels are not entirely similar to those in the NMNE women's dialect. The former two vowels maintain the same placements as the highest and most fronted, which is the fleece [i] vowel (355 Hz; 2585 Hz,) and the lowest sound, which is the trap [æ] vowel (825 Hz). However, the most backed vowel for NMNE women is actually the goat [o] vowel (1061 Hz). It has easily passed the NMNE goose [u] vowel by 127 Hz. Thus, similar to their male counterparts, NMNE women do not share the same

[14] The remaining 15 participants from the Peterson and Barney study were children. However, this current study does not include any data on children. Therefore, children's data from the Peterson and Barney study is not presented nor is it discussed.

English dialect with GAE women. The rest of this section discusses the noticeable inconsistencies and masked phonemes between each dialect.

GAE women and NMNE women actually have more divergent vowel sounds between dialects than the men of this section. However, women still mask the same number of vowel phonemes. Out of the nine vowels, seven of them are distinct. Those distinct vowels include the kit [ɪ] vowel, the cloth [ɔ] vowel, the strut [ʌ] vowel, the fleece [i] vowel, the dress [ɛ] vowel, the goose [u] vowel, and the foot [ʊ] vowel. Starting with the former, the kit [ɪ] vowel is lowered and less fronted in the NMNE women's dialect by 63 Hz in the F1 cue (430 Hz – 493 Hz) and by 267 Hz in the F2 cue (2480 Hz – 2213 Hz). Consequently, GAE women realize the kit [ɪ] vowel as a high, front sound while NMNE women realize it as a mid, front vowel. However, this salience is continued since the location of the GAE kit [ɪ] vowel almost completely overlaps the NMNE face [e] vowel. This masking phenomenon is evident in Figure 4.5 below.

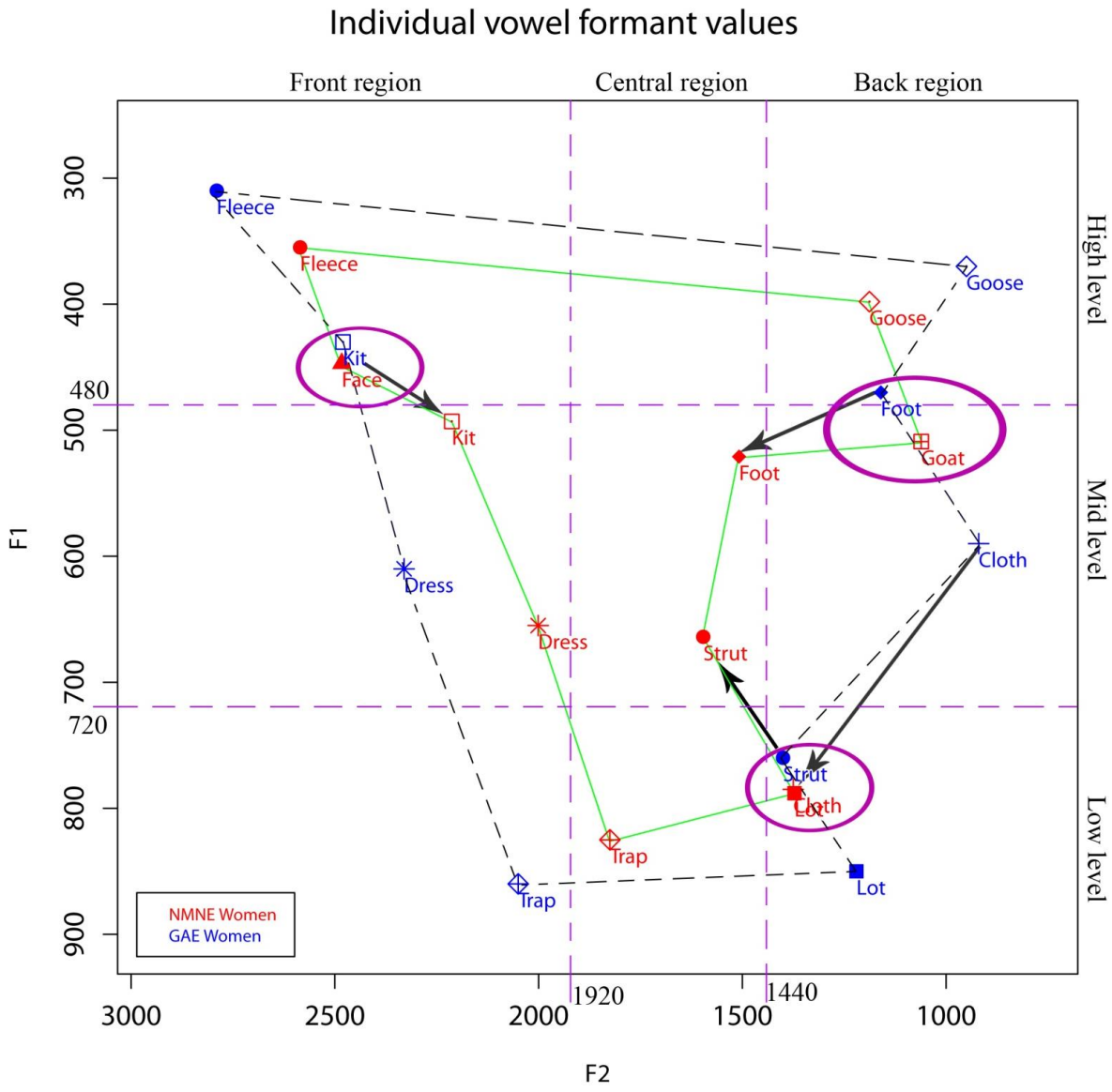

Figure 4.5: A representation of the acoustic vowel space chart for GAE women and NMNE women.

The GAE kit [ɪ] vowel lies almost directly on top of the NMNE face [e] vowel since there is only 17 Hz of a difference in the F1 cue (430 Hz – 447 Hz) and only 3 Hz of a difference in the F2 cue (2480 Hz – 2483 Hz). Because no human ear can decipher between these two sounds, the GAE kit [ɪ] vowel and the NMNE face [e] vowel are perceptually the same sound.

The second distinct vowel is the cloth [ɔ] vowel. In GAE the cloth [ɔ] vowel is produced as a mid, back vowel (590 Hz; 920 Hz). However, in the NMNE dialect, women produce it as a low, back vowel (785 Hz; 1375 Hz) along with its merged counterpart, the lot [ɑ] vowel (788 Hz; 1372 Hz). Consequently, the NMNE cloth [ɔ] vowel is lowered by 195 Hz and is fronted by 455 Hz compared to its GAE equivalent. Easily exceeding both the F1 and F2 thresholds, the cloth [ɔ] vowels are two completely different sounds. Furthermore, this divergence puts the vowels at risk for masking other phonemes, such as is the case for both the NMNE cloth [ɔ] and lot [ɑ] vowels. According to Hillenbrand et al. data (1995, p. 3108) these sounds are rarely confused since the lot [ɑ] vowel is interpreted as the strut [ʌ] vowel 3.7% of the time and cloth [ɔ] vowel is interpreted as the strut [ʌ] vowel only 1.8% of the time. For NMNE women and GAE women, however, this is untrue. The NMNE cloth [ɔ] and lot [ɑ] vowels are perceptually similar to the GAE strut [ʌ] vowel. In NMNE, the cloth [ɔ] vowel is separated from the GAE strut [ʌ] vowel by 25 Hz in both the F1 and F2 cue. Likewise, the lot [ɑ] vowel is only separated from the GAE strut [ʌ] vowel by 28 Hz in each cue. As a result, the NMNE vowel pair "moderate[ly] mask[s]" the GAE strut [ʌ] vowel (Koffi, 2017a, p. 109).

This leads us to the third perceptually salient vowel which is the strut [ʌ] vowel. Since the GAE strut [ʌ] vowel is masked by the NMNE vowel pair, its NMNE counterpart is obviously divergent. The strut [ʌ] vowel in NMNE is produced as a mid, central sound (664 Hz; 1596 Hz) rather than as a low, back sound as in GAE (760 Hz; 1400 Hz). Although it does in fact change both vowel height levels and tongue retraction regions, the only distinctive movement of the NMNE strut [ʌ] vowel is that it is raised by 96 Hz (760 Hz – 664 Hz).

The last four perceptually distinct vowels actually share a common centralizing behavior in the NMNE dialect. These sounds include the fleece [i] vowel, the dress [ɛ] vowel, the goose [u] vowel, and the foot [ʊ] vowel. Although it is a front vowel in each dialect, the NMNE women's fleece [i] vowel is backed by 205 Hz (2790 Hz – 2585 Hz) toward the central region. Similarly, the front dress [ɛ] vowel is also backed toward the central region by 329 Hz (2330 Hz – 2001 Hz) in the NMNE women's dialect. Moving in the opposing direction is the NMNE goose [u] vowel and foot [ʊ] vowel. The goose [u] is fronted toward the central region by 238 Hz (950 Hz – 1188 Hz) in comparison to its GAE counterpart, even though each goose [u] vowel is still realized as a back sound. The foot [ʊ] vowel, on the other hand, is fronted so much that it actually crossed into the central region. The NMNE foot [ʊ] vowel is fronted by 348 Hz (1160 Hz – 1508 Hz). This leaves its GAE equivalent as a back vowel and also at risk for masking another NMNE phoneme, the goat [o] vowel. NMNE men realize the goat [o] vowel (509 Hz; 1061 H) at a close proximity to the GAE foot [ʊ] vowel (470 Hz; 1160 Hz). Separated by only 39 Hz in the F1 cue and 99 Hz in the F2 cue, these two vowels fall into the degree of "moderate masking" (Koffi, 2017a, p. 109) and are consequently similar phonemes.

Comparison: Northern Minnesota English and Midwest English

The Midwest dialect, unlike General American English, encompasses only six of the fifty U.S. states. "The majority of the speakers (87%) were raised in Michigan's lower peninsula, primarily the southeastern and southwestern parts of the state. The remainder were primarily from other areas of the upper Midwest, such as Illinois, Wisconsin, Minnesota, southern Ohio, and northern Indiana" (Hillenbrand, Getty, Clark, & Wheeler, 1995, pp. 3099-3100). However, this Midwest area is larger than the area of Northern Minnesota, which remains as only a fraction

of the former. Furthermore, the encircled area of Northern Minnesota in Figure 4.6 below is the farthest north in comparison to the other sister states represented in Midwest English.

Figure 4.6: A map of Midwest and Northern Minnesota (Wikimedia Commons, 2018).

Comparing Men F1 & F2: Vowel Height & Tongue Retraction

The study of Midwest English (MWE) was a replication study of Peterson and Barney (1952) but with a more narrowed pool of participants. Participants "consisted of 45 men, 48 women, and 46 ten- to 12-year-old children" (Hillenbrand, Getty, Clark, & Wheeler, 1995, p. 3099)[15]. Furthermore, this particular study used a "screening procedure" to omit any speakers who could not distinguish between the lot [ɑ] and cloth [ɔ] vowels. Similar to the original study by Peterson and Barney, Hillenbrand, Getty, Clark, and Wheeler (here forth Hillenbrand et al.)

[15] The current study of NMNE acoustic vowels does not include any data on children. Therefore, children's data from the Hillenbrand et al. study is not presented nor is it discussed.

studied vowels uttered within an isolated, monosyllabic word that used the same hVd structure. They studied twelve vowels which were [i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ, ɚ[16]]. After the participants were recorded, the "steady state" of every vowel was measured and analyzed. Acoustic F1 and F2 data for the 45 MWE men are presented in the subsequent table along with data from the ten NMNE men.

Table 4.15

F1 and F2 Data from MWE Men (Hillenbrand et al., 1995) and NMNE Men Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
MWE Men	F1	342	427	476	580	588	768	652	497	469	378	623
MWE Men	F2	2322	2034	2089	1799	1952	1333	997	910	1122	997	1200
NMNE Men	F1	280	424	391	518	611	671	676	457	455	323	555
NMNE Men	F2	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385

MWE men share almost all of the same extreme vowels as the NMNE men. However, they still are not entirely the same dialect. Both groups of men realize the fleece [i] vowel as their highest and most fronted vowel. Likewise, the goat [o] vowel is the most backed sound and the lot [ɑ] vowel is the lowest sound. However, MWE men do not merge their lot [ɑ] and cloth [ɔ] vowel as do NMNE men. Therefore, the MWE men only have one phoneme that is realized as the lowest vowel while NMNE men actually have two. The rest of the section covers only divergences and masking phenomena.

[16] The nurse vowel is not investigated within the current study and therefore the data for it from the Hillenbrand et al. study is not presented.

The first perceptually salient vowel is the face [e] vowel. It is produced as a mid sound by MWE men (476 Hz). NMNE men, on the other hand, realize this same phoneme as a high sound (391 Hz). As a result, the NMNE face [e] vowel is raised by 85 Hz and is at risk of masking the MWE kit [ɪ] vowel. Separated by only 36 Hz in the F1 cue (391 Hz – 427 Hz) and 119 Hz in the F2 cue (2153 Hz – 2034 Hz), these two sounds are classified in the degree of "moderate masking" (Koffi, 2017a, p. 109) and are difficult to decipher although not impossible.

The second distinctive vowel between these two dialects is the trap [æ] vowel. The NMNE trap [æ] vowel is backed by 219 Hz compared to its MWE equivalent. Moreover, because of this movement, the NMNE trap [æ] vowel is now in the perfect location to mask another MWE vowel. This masking phenomenon is evident in the figure below.

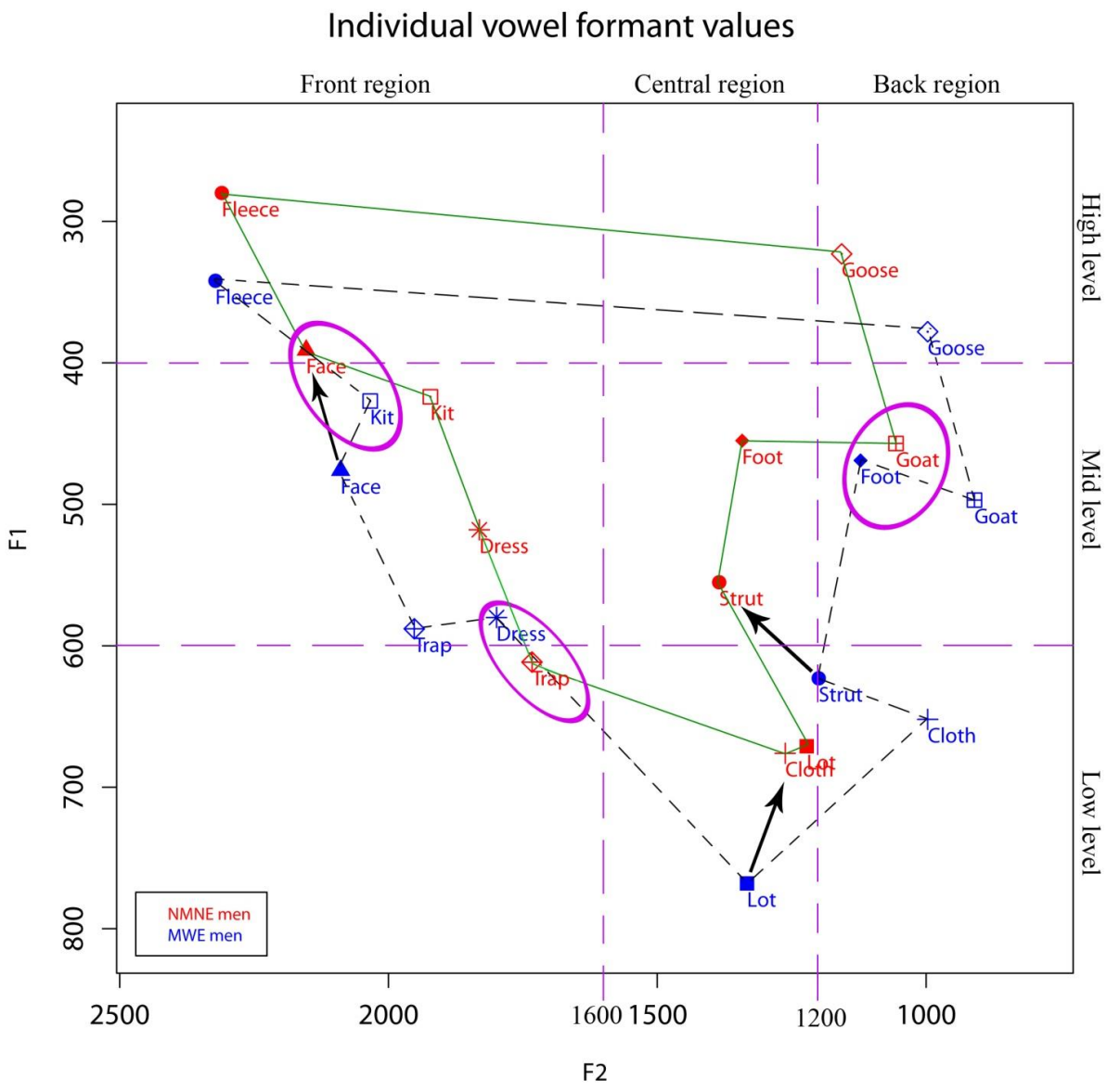

Figure 4.7: A representation of the acoustic vowel space chart for MWE men and NMNE men.

The acoustic space between the NMNE trap [æ] vowel and the MWE dress [ɛ] vowel is only 31 Hz in the F1 cue (611 Hz – 580 Hz) and 66 Hz in the F2 cue (1733 Hz – 1799 Hz). Falling into a moderate degree of masking, hearers would have trouble differentiating between the NMNE trap [æ] vowel and the MWE dress [ɛ] vowel even though in a single dialect these

vowels are only interpreted as the same sound 3.7% of the time (Hillenbrand et at., 1995, p. 3108).

The third salience includes both the lot [ɑ] vowel and the cloth [ɔ] vowel. Because these two sounds are merged in the NMNE men's dialect but are distinguished in the MWE men's dialect, they obviously are going to cause divergences when comparing the two dialects. Starting with the former, the NMNE lot [ɑ] vowel (671 Hz) is raised by 97 Hz from its MWE counterpart (768 Hz). However, although the two sounds are drastically different in the F1 correlate, they both still remain in the same vowel quadrants: low, central sounds. The cloth [ɔ] vowel, on the other hand, diverges only in the F2 cue, and because of this it also changes vowel quadrants. The MWE cloth [ɔ] vowel is realized as a back sound (997 Hz). However, NMNE men produce this vowel as a central sound (1262 Hz). As a result, there is a total of 265 Hz separating each cloth [ɔ] vowel.

The fourth divergent vowel is the foot [ʊ] vowel. In NMNE, the foot [ʊ] vowel is realized as a central sound (1342 Hz). Yet, in MWE, men produce this sound as a back vowel (1122 Hz). Consequently, the two sounds are separated in the F2 cue by 220 Hz. Furthermore, the MWE foot [ʊ] vowel also masks another sound, the NMNE goat [o] vowel, because of this divergence. Sitting at a distance of only 12 Hz in the F1 cue (469 Hz – 457 Hz) and 66 Hz in the F2 cue (1122 Hz – 1056 Hz), the MWE foot [ʊ] vowel has completely masked the NMNE goat [o], making it impossible to decipher between the two sounds.

The last divergence is in the strut [ʌ] vowel. This vowel is realized as a low, back vowel (623 Hz; 1200 Hz) by MWE men. However, NMNE men actually produce this sound as a mid, central vowel (555 Hz; 1385 Hz). Even though this vowel changes both vowel height levels and

tongue retraction regions, the strut [ʌ] vowel is only distinctive in the F1 cue since it is raised by 68 Hz in the NMNE men's dialect.

Comparing Women F1 & F2: Vowel Height & Tongue Retraction

Of each biological group studied by Hillenbrand et al., MWE women have the highest number of participants. Their data are averaged over 48 women. The F1 and F2 data for MWE women are presented below in Table 4.17 along with data from NMNE women.

Table 4.17

F1 and F2 Data from MWE Women (Hillenbrand et al., 1995) and NMNE Women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
MWE Women	F1	437	483	536	731	669	936	781	555	519	459	753
MWE Women	F2	2761	2365	2530	2058	2349	1551	1136	1035	1225	1105	1426
NMNE Women	F1	355	493	447	655	825	788	785	509	521	398	664
NMNE Women	F2	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596

English spoken by Midwest women and Northern Minnesota women varies slightly. In the extreme vowels they are almost identical. Both groups realize the fleece [i] vowel as their highest and most fronted sound and the goat [o] vowel as their most backed sound. However, the lowest sound of each dialect does not align. In MWE, women produce the lot [ɑ] vowel as their lowest sound. NMNE women, on the other hand, produce the trap [æ] vowel as their lowest sound. The remainder of the section discusses eight different discrepancies between these dialects along with three masked vowel pairs.

To begin, it should be noted that five of the eight divergent vowels follow a similar pattern which is to rise from the F1 location in MWE to that in NMNE. Those five vowels are the lot [ɑ] vowel, the face [e] vowel, the strut [ʌ] vowel, the fleece [i] vowel, and the dress [ɛ] vowel. Commencing with the most dramatic, the lot [ɑ] vowel raises a comparable amount of 148 Hz from MWE (936 Hz) to NMNE (788 Hz), although both vowels still remain in the same low level of vowel height. The face [e] vowel and the strut [ʌ] vowel are next with an equal shift of 89 Hz from MWE to NMNE. The face [e] vowel is raised from 536 Hz (MWE) to 447 Hz (NMNE). Likewise, the strut [ʌ] vowel is raised from 753 Hz in MWE to its average of 664 Hz in NMNE. Furthermore, because of these upward movements, both vowels cross over a vocalic boundary. The former crosses the mid-high boundary (480 Hz) while the latter crosses the mid-low boundary (720 Hz). Following the same pattern but to lesser extent is the fleece [i] vowel. It is raised by 82 Hz. In the MWE dialect, women realize this vowel at 437 Hz whereas in NMNE, women produce it at 355 Hz. Even though both F1 values are classified as high vowels, the distance is recognized as distinct since it surpasses the 63 Hz limit. Finally, the dress [ɛ] vowel is raised 76 Hz (731 Hz – 655 Hz). Consequently, the dress [ɛ] vowel has shifted out of the low level of vowel height and into the mid level in the NMNE women's dialect.

The other three distinctive vowels which do not assimilate to this pattern are the trap [æ] vowel, the foot [ʊ] vowel, and the cloth [ɔ] vowel. The former is the only vowel which actually deviates in both the F1 and F2 correlate. In MWE, women produce the trap [æ] vowel as a mid, front vowel (669 Hz; 2349 Hz). However, NMNE women produce it as a low, central vowel (825 Hz; 1825 Hz). As a result, each realization of the trap [æ] vowel is separated by 156 Hz in the F1 cue and 524 Hz in the F2 cue. The foot [ʊ] vowel and the cloth [ɔ] vowel, on the other

hand, are only divergent in the F2 cue. In MWE, both the foot [ʊ] vowel (1225 Hz) and the cloth [ɔ] vowel (1136 Hz) are produced as back sounds. However, in NMNE, these vowels are both fronted either into or toward the central region of tongue retraction. The NMNE foot [ʊ] vowel (1508 Hz), for instance, has completely crossed into the central region because it is fronted by 283 Hz. The NMNE cloth [ɔ] vowel, on the other hand, is still realized as a back sound (1375 Hz). However, NMNE women are still more fronted than their MWE counterparts by 239 Hz.

The last area of discussion is the masked pairs between MWE women and NMNE women. There are three masked pairs which are prevalent and those are the NMNE face [e] vowel and the MWE kit [ɪ] vowel, the NMNE lot/cloth [ɑ/ɔ] vowel and the MWE strut [ʌ] vowel, and lastly the NMNE goat [o] vowel and the MWE goose [u] vowel. Each pair is circled below in Figure 4.8.

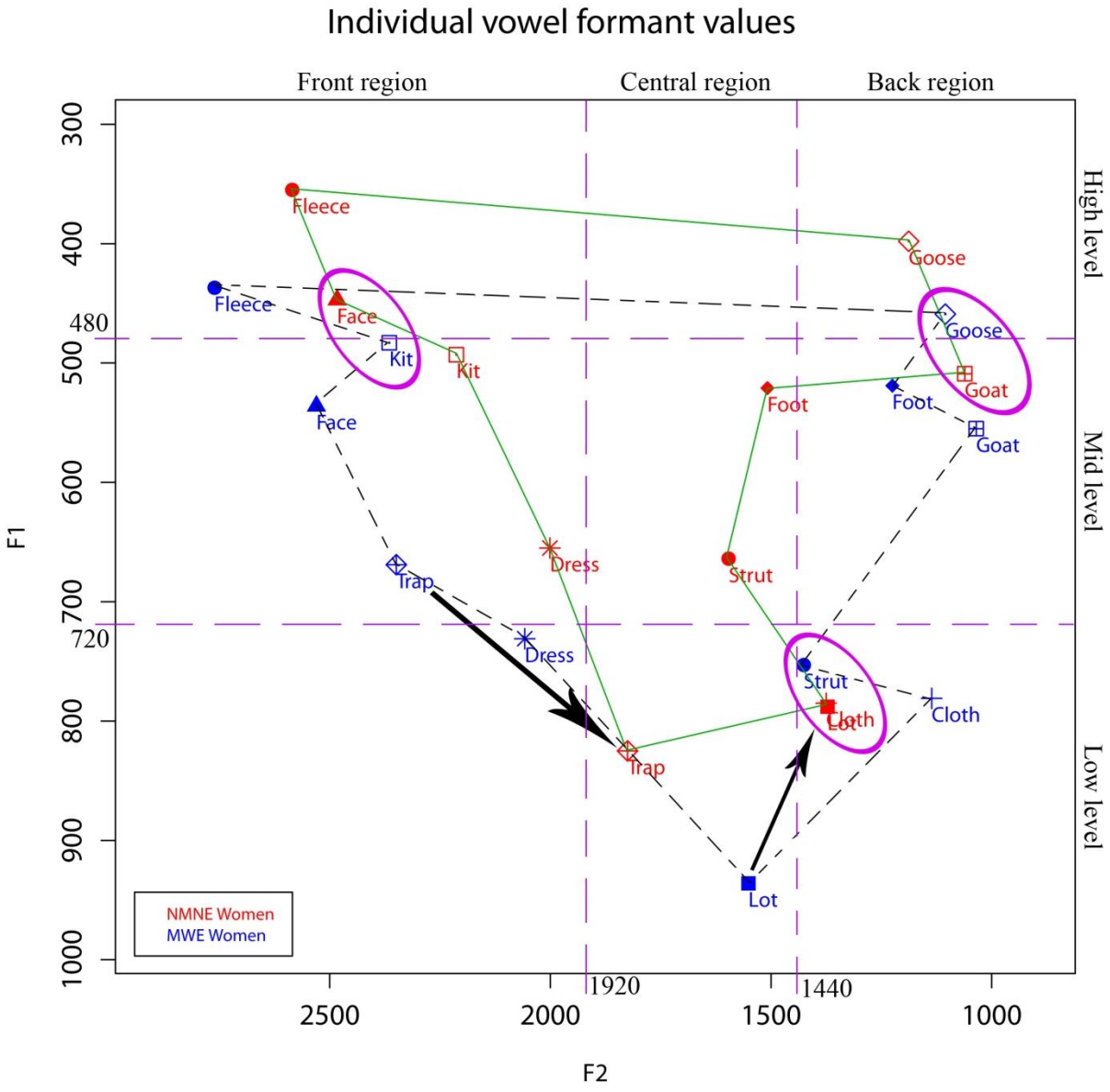

Figure 4.8: A representation of the acoustic vowel space chart for MWE women and NMNE women.

The first pair is the NMNE face [e] vowel and the MWE kit [ɪ] vowel. Although they are phonemically distinct vowels, the sounds are only separated by 36 Hz in the F1 (447 Hz – 483 Hz) and 118 Hz in the F2 correlate (2483 Hz – 2365 Hz). Therefore, this masked pair is categorized as "moderate masking" and as such, the vowel constituents are difficult to

distinguish. Likewise, the NMNE lot/cloth [ɑ/ɔ] vowel and the MWE strut [ʌ] vowel are moderately masked. The distance between each phoneme is 35 Hz in the F1 cue (788 Hz – 753 Hz) and 54 Hz in the F2 cue (1372 Hz – 1426 Hz)[17]. Thus, they are also difficult to distinguish although not impossible. The last masked pair is the NMNE goat [o] vowel and the MWE goose [u] vowel. They are only "slightly masked" according to Koffi (2017a, p. 109) because they are separated by 50 Hz (509 Hz – 459 Hz) in the F1 cue and 44 Hz in the F2 (1061 Hz – 1105 Hz). Therefore, these sounds are mostly similar, although still slightly distinguishable.

Comparison: Northern Minnesota English and Central Minnesota English

Central Minnesota English is an area that, like Northern Minnesota which includes both District 1 and 2, also consists of two districts according to the Minnesota Department of Transportation (2018). There is District 3, which is Central Minnesota, and there is also District 4, which is West Central Minnesota. These two districts were combined by Koffi (2014) to represent the whole region of Central Minnesota. "The Central Minnesota area…is divided into East Central and West Central. However, this distinction is not relevant for this study because the participants were selected from the Greater Central Minnesota area" (Koffi, 2014, p. 2).

[17] Each distance was calculated from the NMNE lot [ɑ] vowel and the MWE kit [ɪ] vowel because they hold the greatest distance in comparison to the NMNE cloth [ɔ] vowel and the MWE kit [ɪ] vowel.

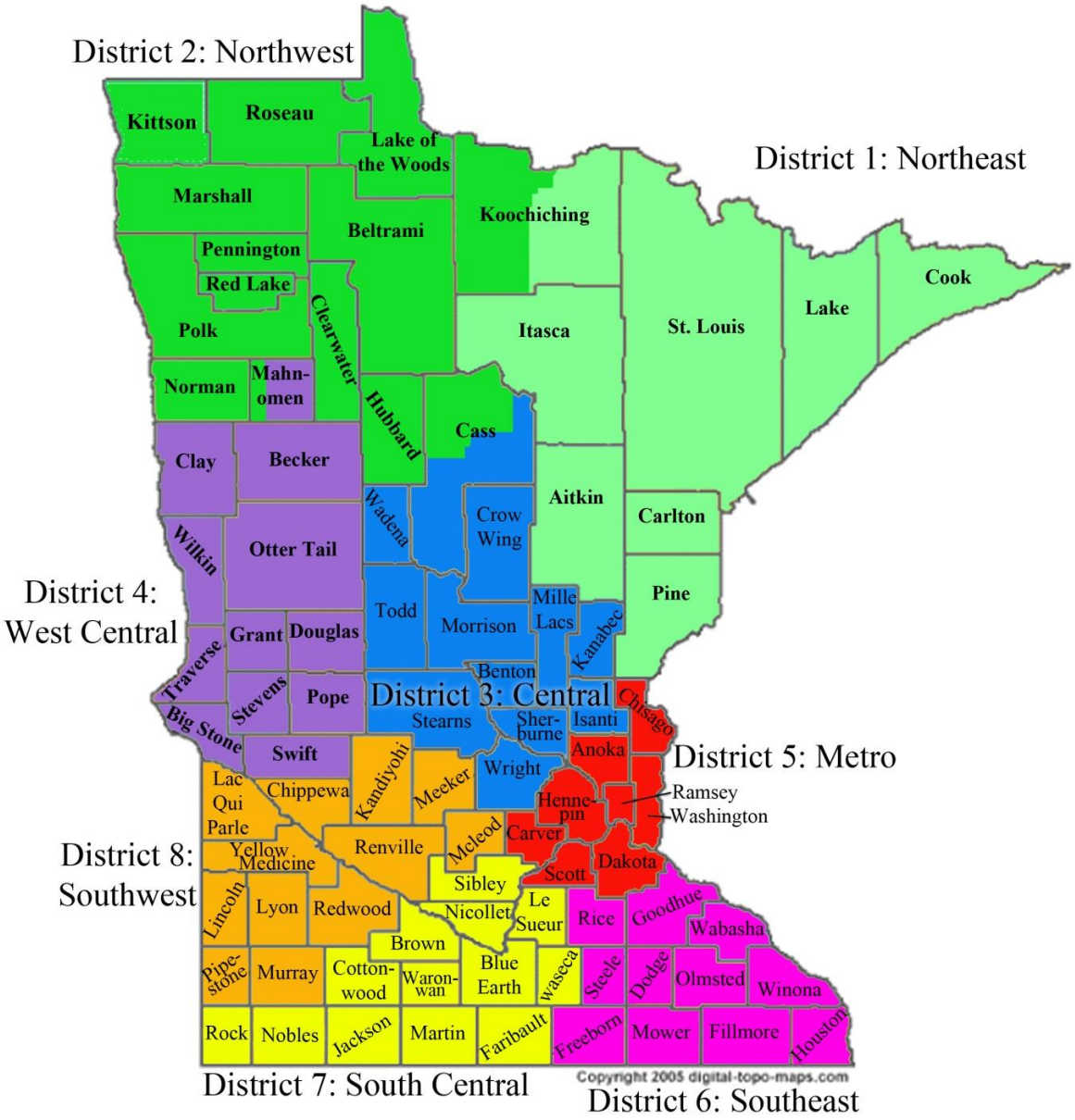

Figure 4.9: A map of the Minnesota districts according to the Minnesota Department of Transportation (2018).

As can be seen then in Figure 4.9, the Central region is located just below the Northern region of Minnesota. These two regions even share two different counties which are Cass county and Mahnomen county. Other than county and district lines though, not much is separating these

two regions other than random batches of forests and lakes (Minnesota Department of Natural Resources, 2018: Recreation Compass[18]). Furthermore, just like the Northern region is considered to be rural, the Central region of Minnesota has similar demographics since it "is not heavily urbanized" (Koffi, 2014, p. 2). Likewise, each region also has one city that poses as an exception to this. For Northern Minnesota that city is Duluth which has a population of 86,265 (US Census Bureau 2010) and for Central Minnesota that city is St. Cloud with a population of 65,842 (US Census Bureau 2010).

Comparing Men F1 & F2: Vowel Height & Tongue Retraction

Koffi (2013; 2014; 2016c; 2017b) produced various studies which reported the acoustic phonetic vowel spaces of 11 phonemic vowels realized by 34 participants from Central Minnesota. Each participant was a current or former college student of his "who identified themselves as having lived in Central Minnesota for the first 17 years of their lives" (2016c, p. 2). Furthermore, the entire pool of speakers "are Caucasians in their late teens to their early 30s" (2013, p. 5). Each of the 11 phonemic vowels is imbedded in the same hVd structure as the original Peterson and Barney (1952) study. Additionally, Koffi replicated a similar methodology as Peterson and Barney. Every participant uttered 11 monosyllabic words three times in isolation and was recording when doing so. Then, each recording was transferred into Praat where Koffi extracted, measured, and analyzed each vowel. In his first study (2013), Koffi reported acoustical data in the first two formants. The subsequent table presents acoustic data from the 12 Central Minnesota English (CMNE) men from Koffi (2013)'s study along with acoustic data from the ten NMNE men.

[18] http://www.dnr.state.mn.us/maps/compass/index.html

Table 4.18

F1 and F2 Data from CMNE Men (Koffi, 2013) and NMNE Men Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
CMNE Men	F1	289	542	434	577	709	753	699	600	516	485	616
CMNE Men	F2	2298	1963	2185	1781	1737	1289	1296	1464	1467	1541	1365
NMNE Men	F1	280	424	391	518	611	671	676	457	455	323	555
NMNE Men	F2	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385

CMNE men and NMNE men differ by only a handful of vowels while the majority of their vowels are uttered similarly. However, their extreme vowels are not as similar. For instance, the lowest vowel of the CMNE men's dialect is solely the lot [ɑ] vowel. Although this sound is masked with the CMNE cloth [ɔ] vowel because of a 54 Hz distance between each sound, the degree of this merge is only "slight masking" (Koffi, 2017a, p. 109). NMNE men, on the other hand, are completely masked since they realize a distance of only 5 Hz between their lot [ɑ] and cloth [ɔ] vowels. The most backed vowel is also different between these two dialects. In CMNE, men realize the lot [ɑ] vowel as their most backed sound while NMNE men produce the goat [o] vowel as the most backed sound. The only extreme vowel which is the same is the fleece [i] vowel. It is produced as the highest and most fronted sound for both groups of speakers. The latter portion of this section focuses on three areas: a common dialectal pattern, five perceptually salient vowels, and two masking phenomena.

The common dialectal pattern is a behavior found in 100% of the NMNE men's vowels. Each NMNE vowel is raised in comparison to its CMNE counterpart. Whether it is obvious to the hearer (like the five divergences to be discussed below) or it is only evident in the acoustic data provided in Table 4.18 (such as is the case for the latter six vowels that are not perceptually salient), every NMNE vowel phoneme is raised to some extent over its equivalent in Central Minnesota English. This raising behavior is clear in Figure 4.10 below.

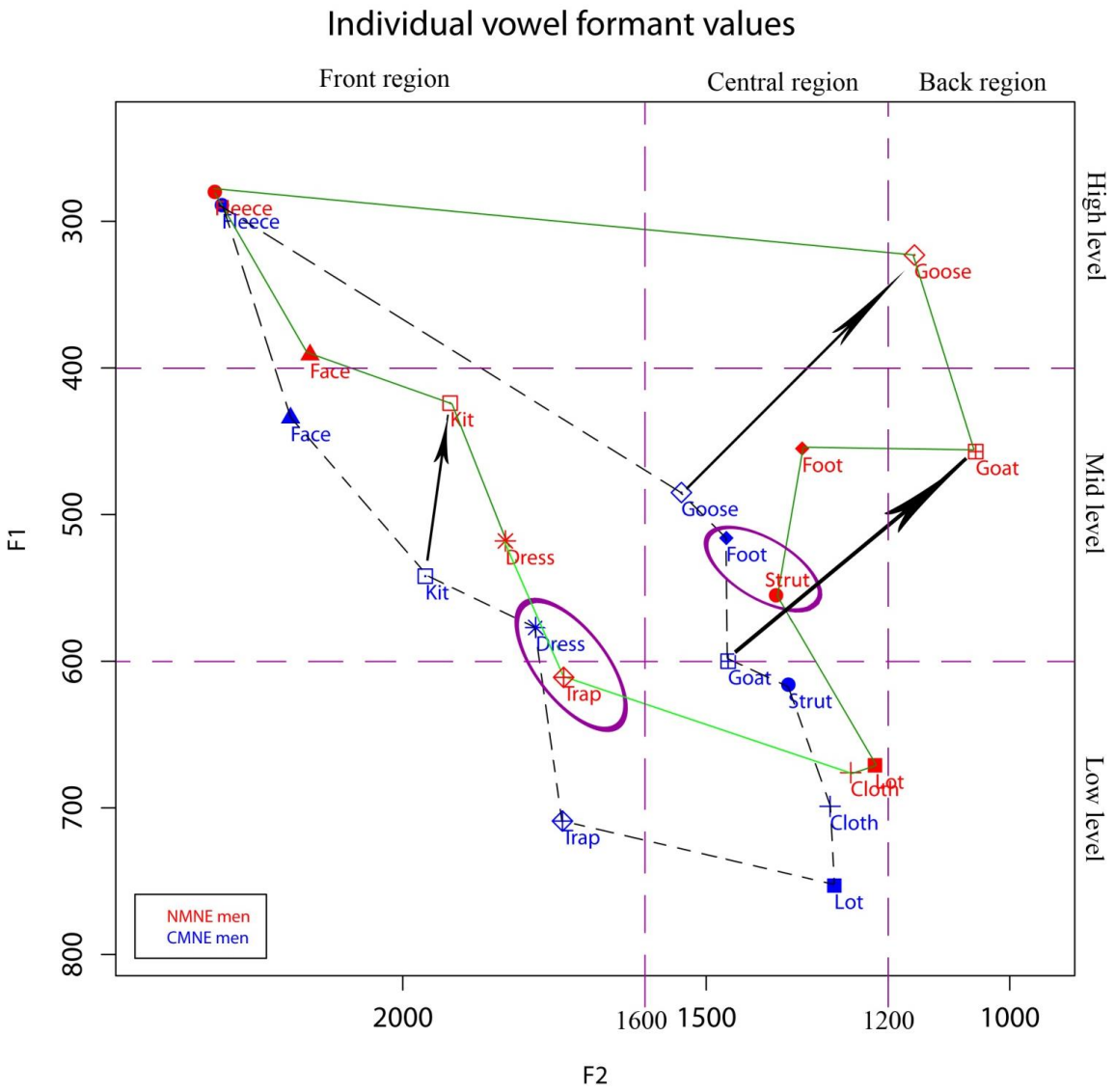

Figure 4.10: A representation of the acoustic vowel space chart for CMNE men and NMNE men.

Of the five divergences, three of them are only divergent in the F1 correlate. The kit [ɪ] vowels, for instance, are separated 118 Hz in the F1 cue. Although both groups realize the kit [ɪ] vowel as a mid sound, NMNE men produce a much higher kit [ɪ] vowel (424 Hz) than do CMNE men (542 Hz). Similarly, the low trap [æ] vowel is also divergent in the F1 by 98 Hz. NMNE

men produce the trap [æ] vowel at an average of 611 Hz while the CMNE men realize the same phoneme at 709 Hz. The last divergent vowel in this group is the lot [ɑ] vowel. In NMNE, the lot [ɑ] vowel is produced as a higher sound (671 Hz) than its equivalent in CMNE (753 Hz), even though both sounds are realized as a low vowel. Consequently, the two lot [ɑ] vowels are separated by a total of 82 Hz and thus are realized distinctively.

The last two divergent vowels differ in both the F1 and F2 correlates and those sounds include the goat [o] vowel and the goose [u] vowel. As can be seen in Figure 4.10 above, these two vowels are drastically different when comparing NMNE men and CMNE men. In CMNE, the goat [o] vowel is a mid, central vowel (600 Hz; 1464 Hz). However, in NMNE, the goat [o] is a mid, back vowel (457 Hz; 1056 Hz). Even though the vowel height level remains the same, these two sounds still differ by 143 Hz in the F1 cue and by 408 Hz in the F2 cue. Likewise, the goose [u] vowel is also perceptually salient. Realized by CMNE men as a mid, central sound, the goose [u] vowel has an F1 average of 485 Hz and an F2 average of 1541 Hz. NMNE men, on the other hand, produce this vowel as a high, back sound with an F1 average of 323 Hz and an F2 average of 1157 Hz. As a result, the two sounds are separated by 162 Hz in the F1 correlate and 384 Hz in the F2 correlate.

The final area of discussion is the two masking phenomena. When comparing the 12 men from Central Minnesota and the ten men from Northern Minnesota, there are two pairs of vowels which run the risk of masking each other. The first pair is the CMNE dress [ɛ] vowel and the NMNE trap [æ] vowel. They are only separated by only 34 Hz in the F1 cue (577 Hz – 611 Hz) and 48 Hz (1781 Hz – 1733 Hz) in the F2 cue. Because of this small distance in each correlate, the CMNE dress [ɛ] vowel and the NMNE trap [æ] vowel are “moderately masked” and

therefore could potentially cause some difficulty for any hearers. Likewise, the CMNE foot [ʊ] vowel and the NMNE strut [ʌ] vowel are also merged. Although they are only interpreted as each other only 3.2% of the time according to confusion data (Hillenbrand et al., 1995, p. 3108), the CMNE foot [ʊ] vowel has only an F1 distance of 39 Hz (516 Hz – 555 Hz) and an F2 distance of 82 Hz (1467 Hz – 1385 Hz) from the NMNE strut [ʌ] vowel. As a result, the two sounds fall into the degree of "moderate masking" and thus, like the former vowel pair, are hard to distinguish although not impossible.

Comparing Women F1 & F2: Vowel Height & Tongue Retraction

In Koffi's studies (2013; 2014; 2016c; 2017b), the majority of his participants are actually women. Of all 34 speakers, only 12 of them are men while the latter 22 are women. They still fall into the same age bracket of "late teens to their early 30s" (Koffi, 2013, p. 5). Likewise, the 22 women also fall into the same demographic as their male counterparts, which is that they are all Caucasians (Koffi, 2013, p. 5). The F1 and F2 data for 22 CMNE women are presented below in Table 4.19 along with F1 and F2 data for the ten NMNE women.

Table 4.19

F1 and F2 Data from CMNE Women (Koffi, 2013) and NMNE Women Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
CMNE Women	F1	385	573	508	754	848	855	851	569	626	417	743
CMNE Women	F2	2609	2232	2487	2028	1951	1462	1420	1117	1519	1230	1643
NMNE Women	F1	355	493	447	655	825	788	785	509	521	398	664
NMNE Women	F2	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596

The extreme vowels within each dialect of Northern Minnesota English and Central Minnesota English are similar between women. Each group realizes the fleece [i] vowel as the highest and most fronted sound along with the goat [o] vowel as the most backed sound. However, the lowest vowel is not consistent. CMNE women produce the lot [ɑ] vowel as their lowest sound, similar to their male counterparts. NMNE women, on the other hand, realize the trap [æ] vowel as their lowest vowel constituent. The rest of this section discusses the following: a common pattern found within the NMNE dialect, six perceptually salient vowels, and one masking phenomenon.

Similar to their male counterparts, there is a dialectal pattern that surfaces when comparing NMNE women to CMNE women. That pattern is that all NMNE vowels are raised in comparison to their corresponding vowel constituents in Central Minnesota English. Even though just under half of the vowel pairs (45%) are not perceptually distinctive in the F1 cue, all eleven vowel pairs (100%) are separated to some degree, and it is always the NMNE vowel

constituent that is higher. Figure 4.11 below clearly demonstrates this pattern. Furthermore, it should also be noted that there are no F2 divergences obvious to the naked ear when comparing these two groups of women. They only diverge from one another in the F1 correlate alone.

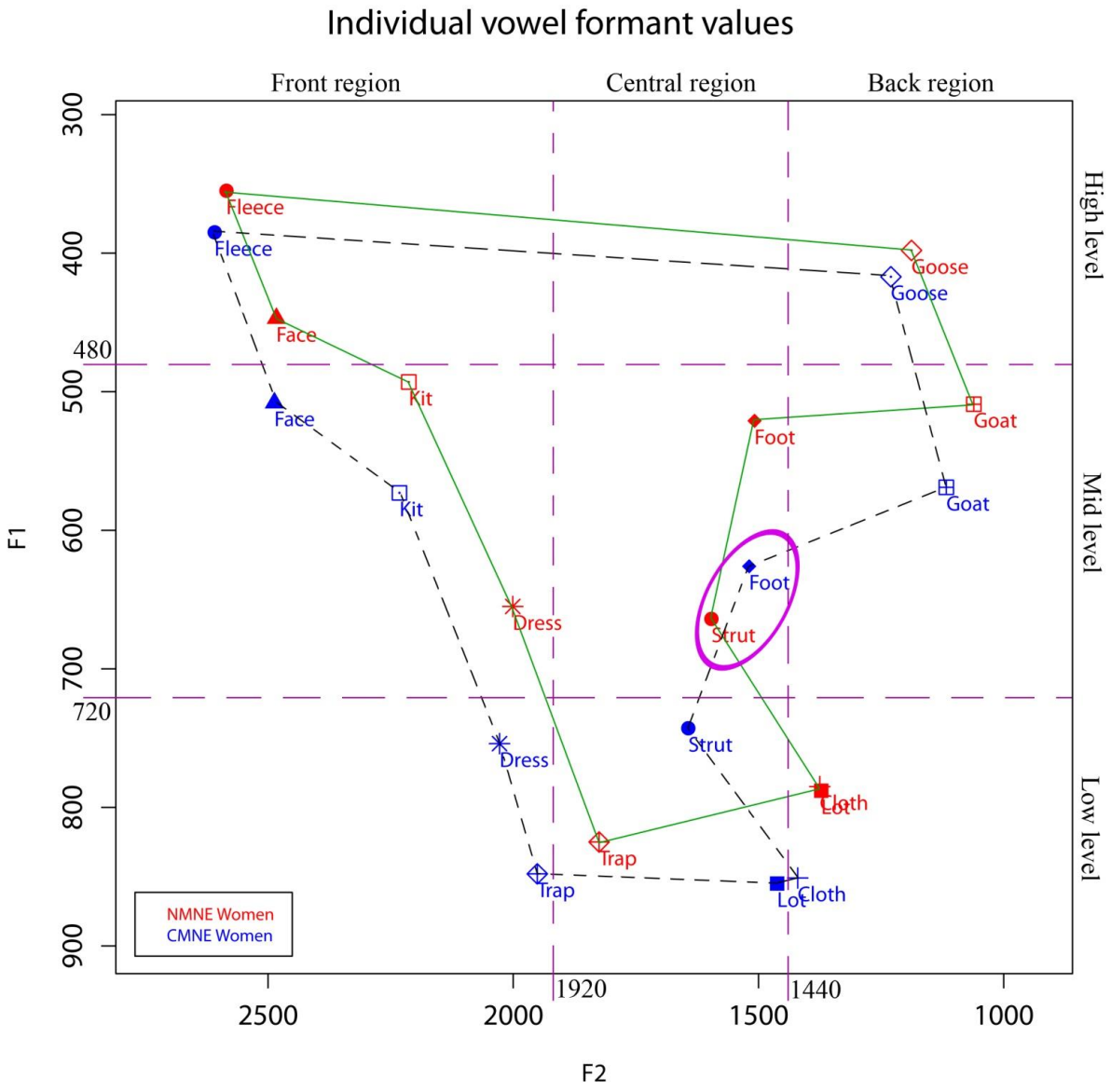

Figure 4.11: A representation of the acoustic vowel space chart for CMNE women and NMNE women.

When comparing NMNE vowels and CMNE vowels, women realize a total of six vowels distinctively. The first and most drastic is the foot [ʊ] vowel. In NMNE, the foot [ʊ] vowel (521 Hz) is raised by 105 Hz over its CNMNE equivalent (626 Hz). As a result, these two mid sounds are completely different even though they both remain in the same vowel height level. Following closely behind is the dress [ɛ] vowel. It is realized as a low sound by CMNE women (754 Hz). However, NMNE women produce it at a mid sound (655 Hz). Consequently, this vowel pair is separated by a total distance of 99 Hz and is realized in two distinct levels of vowel height. The kit [ɪ] vowel comes in third with a distance of 80 Hz separating the two vowel realizations. While both groups of women do in fact produce this vowel as a mid sound, NMNE women realize the kit [ɪ] vowel at an average of 493 Hz while CMNE women produce it at 573 Hz. Thus, the two kit [ɪ] vowels remain distinct. The strut [ʌ] vowel pair is next. In NMNE, women realize the strut [ʌ] vowel at an average of 664 Hz (in the mid level) whereas CMNE women realize it at an average of 743 Hz (in the low level). As a result, there is a total of 79 Hz between each sound as well as a vocalic boundary. The last two vowel pairs are the lot [ɑ] and cloth [ɔ] vowels. They are both in fact merged in each dialect and likewise, they are also similarly distinctive when comparing dialects. The lot [ɑ] vowels diverge by 67 Hz (778 Hz – 855 Hz) while the cloth [ɔ] vowels diverge by 66 Hz (785 Hz – 851 Hz).

The final area of discussion is the masking phenomenon taking place between two different phonemes. The CMNE foot [ʊ] vowel is masked by the NMNE strut [ʌ] vowel since they are separated by only 38 Hz (626 Hz – 664 Hz) in the F1 cue and 77 Hz in the F2 cue (1519 Hz – 1596 Hz). Falling into the “moderate masking” degree (Koffi, 2017a, p. 109), these two sounds are not easy to distinguish.

Comparison: Northern Minnesota English and Winnipeg Canadian English

The two dialects of interest in this section are the Northern Minnesota English (NMNE) and Winnipeg Canadian English (WCE). The former is represented by 21 counties in the Northern region of Minnesota while the latter is represented by Winnipeg, the capital city of Manitoba, Canada. The only physical boundary between the two dialects is an international border. As can be seen in the figure below, the city of Winnipeg sits above the northwest corner of Northern Minnesota and remains at a distance of only 70 miles from said border between the U.S. and Canada. Consequently, even though these two dialects do reside in two different countries, they still remain quite close in proximity to one another.

Figure 4.12: A map of Winnipeg of Manitoba, CA and Northern Minnesota, US (Google Image, 2017).

According to Canada Statistics (2016), the population of Winnipeg is 705,244. This population far exceeds the total population of the whole Northern region of Minnesota which is only 550,443 people (U.S. Census Bureau, 2010). For this reason, it is safe to say that Winnipeg is urbanized while Northern Minnesota is rural with the exception of the city of Duluth.

Comparing Men F1 & F2: Vowel Height & Tongue Retraction

Data on Winnipeg Canadian English (WCE) is presented by Hagiwara (2006) in his study on the acoustic phonetic vowel spaces of 12 phonemic vowels [i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ, ɹ] and three diphthongs [aɪ, aʊ, oɪ][19]. He uses the same methodology of Peterson and Barney (1952) with only four slight adaptations. The first adaptation is in the phonological environment in which each phonemic vowel appears. Although most of the uttered vowels are presented in the original hVd structure (with the exception of [e, ɑ, o]), Hagiwara adjusted this structure so as to create "real monosyllabic words" rather than the nonsensical words such as <hade, hod, hode>. His second adaptation was to implement a second phonological environment. In addition to the hVd structure, Hagiwara's participants uttered vowels in an hVt structure as well. These phonological environments in Hagiwara's study are presented below in Table 4.20.

[19] Although Hagiwara included the subsequent phonemes within his study [ɹ, aɪ, aʊ, oɪ], these sounds fall outside the scope of this study and therefore they are not included in Table 4.20 below, nor are they discussed any further.

Table 4.20

Phonological Environment of WCE Vowel Phonemes (Hagiwara, 2006, p. 2) Table

Vowel category	**/hVd/**	**/hVt/**
/i/	heed	heat
/ɪ/	hid	hit
/e/	aid	ate
/ɛ/	head	pet
/æ/	had	hat
/ɑ/	odd	hot
/ɔ/	hawed	ought
/o/	ode	oat
/ʊ/	hood	put
/u/	who'd	hoot
/ʌ/	hudd	hut

The third adaptation to Peterson and Barney's original 1952 methodology is that the words were not uttered in isolation, but rather in the phrasal frame "'say ___ once'" (Hagiwara, 2006, p. 3). This leads to the fourth and final adaptation which was the number of utterances for each phrase. Instead of saying each phrase two times or three times like the last few studies in the previous sections, speakers in Hagiwara's study realized the phrases five times each.

Speakers involved in Hagiwara's study are "ten monolingual English speakers (five women and five men), 18-25 years of age. They are natives of Winnipeg, and children of natives of Winnipeg" (Hagiwara, 2006, p. 2). After said speakers were recorded, data were measured and analyzed. "Vowel durations were determined by taking the difference between the vowel start point (the time at which periodic energy in F2 begins) and the vowel end point (the time of the onset of closure, if visible, or the last regular period of voicing in F2, if not)" (2006, p. 3).

The findings from the Winnipeg Canadian English dialect are presented in the subsequent sections along with F1 and F2 data from NMNE men as well.

Table 4.21

F1 and F2 Data from WCE Men (Hagiwara, 2006) and NMNE Men Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
WCE Men	F1	293	420	364	560	704	637	635	411	459	313	584
WCE Men	F2	2207	1899	2227	1694	1519	1121	1115	899	1340	1328	1770
NMNE Men	F1	280	424	391	518	611	671	676	457	455	323	555
NMNE Men	F2	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385

NMNE men and WCE men share very similar dialects. Out of all 11 phonemes, there are only two perceptually salient vowels, one masking pair, and two inconsistencies when comparing their extreme vowels. Furthermore, of the two perceptually salient vowels, only one is divergent in the most robust correlate, F1, while the other only diverges in the F2 cue.

To commence, the only two divergent vowels are the trap [æ] vowel and the strut [ʌ] vowel. The former is perceptually salient in the F1 correlate because of a distance of 93 Hz between each sound (611 Hz – 704 Hz). Additionally, the NMNE trap [æ] vowel and the WCE trap [æ] vowel are also salient in the F2 correlate since they are separated by 214 Hz (1733 Hz – 1519 Hz). The strut [ʌ] vowel, on the other hand, is only divergent in the F2 correlate. NMNE men realize the strut [ʌ] vowel as a central vowel with an average of 1385 Hz while WCE men

realize the same phoneme as a front vowel with an average of 1770 Hz. As a result, there is a total distance of 385 Hz between each strut [ʌ] vowel.

That leads to the one masking pair of vowels. Because the WCE strut [ʌ] vowel has been fronted so much, it now masks the NMNE trap [æ] vowel even though these two sounds are interpreted as the other 0% of the time according to Hillenbrand et al. (1995, p. 3108)'s confusion data. As can be seen in the figure below, the two vowels are in a close proximity of one another. The distance between each is merely 27 Hz in the F1 correlate (584 Hz – 611 Hz) and 37 Hz in the F2 correlate (1770 Hz – 1733 Hz). Thus, the two sounds are difficult to decipher by hearers because their degree of masking is moderate according to Koffi (2017a, p. 109).

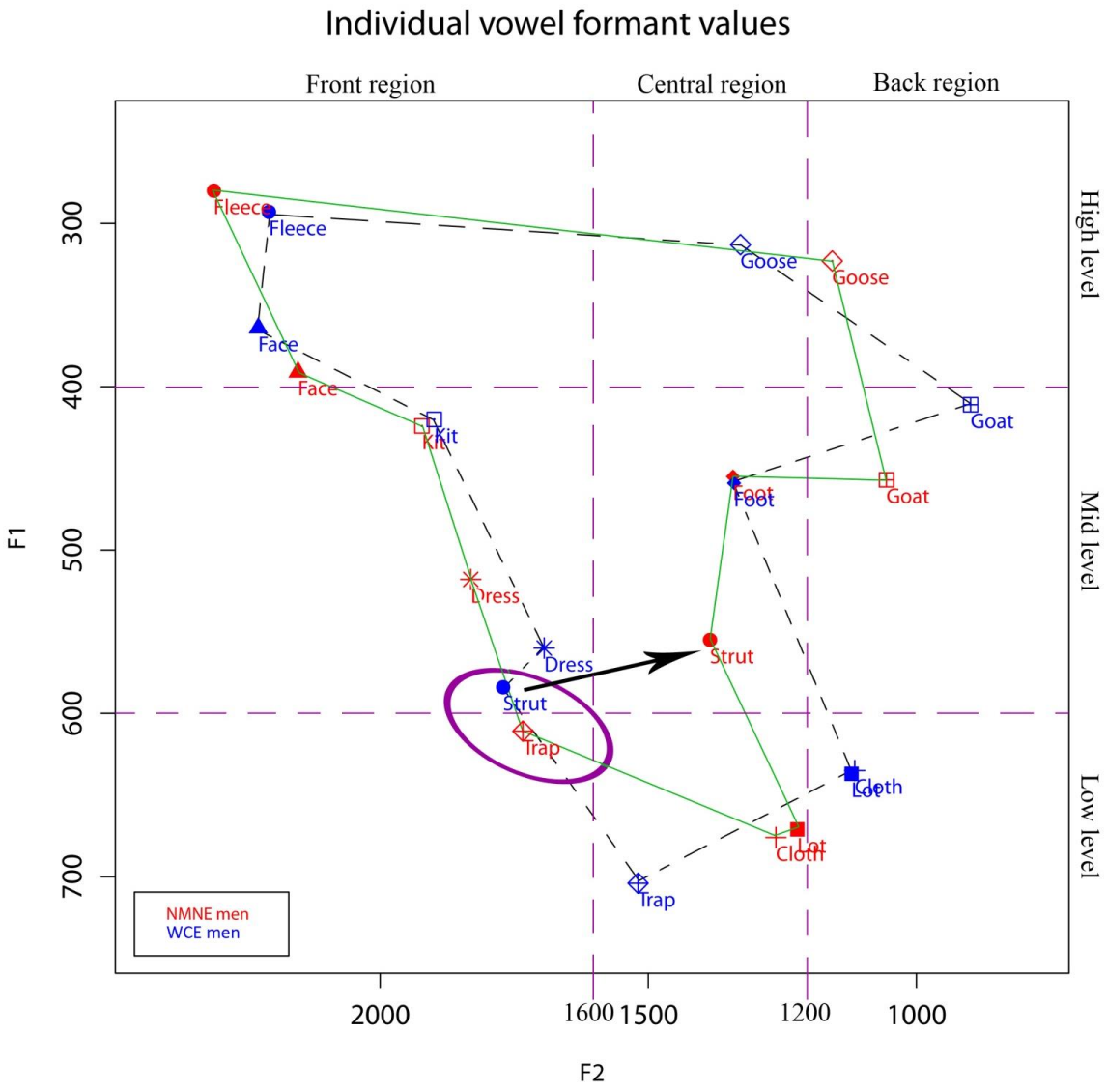

Figure 4.13: A representation of the acoustic vowel space chart for WCE men and NMNE men.

Lastly, in their extreme vowels, NMNE men and WCE men realize the fleece [i] vowel as the highest sound and the goat [o] vowel as their most backed sound. However, the most fronted sound is not the same when comparing these dialects. NMNE men realize the fleece [i] vowel as their most fronted sound while WCE men actually realize the face [e] vowel as their most fronted constituent. The lowest vowel of each dialect is also inconsistent. For WCE men, the trap [æ]

vowel is their lowest sound. NMNE men, on the other hand, produce the lot [ɑ] and cloth [ɔ] vowels are their lowest phoneme.

Comparing Women F1 & F2: Vowel Height & Tongue Retraction

The women's dialect of Winnipeg Canadian English is represented by only monolingual speakers within the age bracket of 18-25 years. Northern Minnesota English women, on the other hand, are a bit more diverse. For instance, four of the NMNE female participants speak another language to some extent. Also, the age bracket of NMNE women is greater (20-64 years of age) than that of the WCE women. However, the number of participants in each group is more aligned. NMNE women include ten speakers while WCE women include only five. F1 and F2 data for each group is presented below.

Table 4.22

F1 and F2 Data from WCE Women (Hagiwara, 2006) and NMNE Women Table

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
WCE Women	F1	392	479	412	712	996	856	891	419	500	387	778
WCE Women	F2	2765	2197	2742	1956	1752	1294	1310	999	1580	1328	1770
NMNE Women	F1	355	493	447	655	825	788	785	509	521	398	664
NMNE Women	F2	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596

NMNE women and WCE women do not share a very similar dialect such as is the case for the male speakers of these two groups. While there is only a slight difference in their extreme vowels, the number of perceptually salient vowels is up to six different phonemes. In spite of

these divergences though, WCE women and NMNE women do, however, share the same masking vowel pair as their male counterparts. The remainder of this section addresses each of these areas.

Commencing with their extreme vowels, WCE women are the first group of speakers in this study to realize the goose [u] vowel as their highest sound rather than the fleece [i] vowel, such as is the case for NMNE women. Despite this inconsistency, the rest of the extreme vowels are the same. Both groups realize the fleece [i] vowel as their most fronted sound, the goat [o] vowel as their most backed sound, and the trap [æ] vowel as their lowest sound.

Next, the six perceptually salient vowels include the trap [æ] vowel, the strut [ʌ] vowel, the cloth [ɔ] vowel, the lot [ɑ] vowel, the goat [o] vowel, and the face [e] vowel. The most drastic is the trap [æ] vowel. Easily exceeding the 63 Hz threshold, the trap [æ] vowels are separated by 171 Hz in the F1 cue. Although both groups of women do in fact realize this phoneme as a low vowel, WCE women realize a much lower sound (996 Hz) than do NMNE women (825 Hz). The strut [ʌ] vowel is the second most distinct vowel because of a difference of 114 Hz. WCE women realize this phoneme as a low vowel (778 Hz) whereas NMNE women produce it as a mid vowel (664 Hz). The third and fourth salient vowels are the merged lot [ɑ] and cloth [ɔ] vowels. Considering that these two sounds are merged in each dialect, it seems only appropriate to discuss them together. The cloth [ɔ] vowels are separated by 106 Hz (891 Hz – 785 Hz) and the lot [ɑ] vowels are separated by 68 Hz (856 Hz – 778 Hz). Although their distances are not entirely identical, the masked vowel pair still diverges together as one sound. It should also be noted that even though both groups of women merge these two vowels, WCE women have only moderately masked the two vowels because of a 35 Hz (856 Hz – 891 Hz)

distance between the WCE lot [ɑ] vowel and the WCE cloth [ɔ] vowel. NMNE women, on the other hand, have a complete merge of these two sounds since there is only 3 Hz separating each vowel (788 Hz – 785 Hz). These differences are visible in Figure 4.14 below.

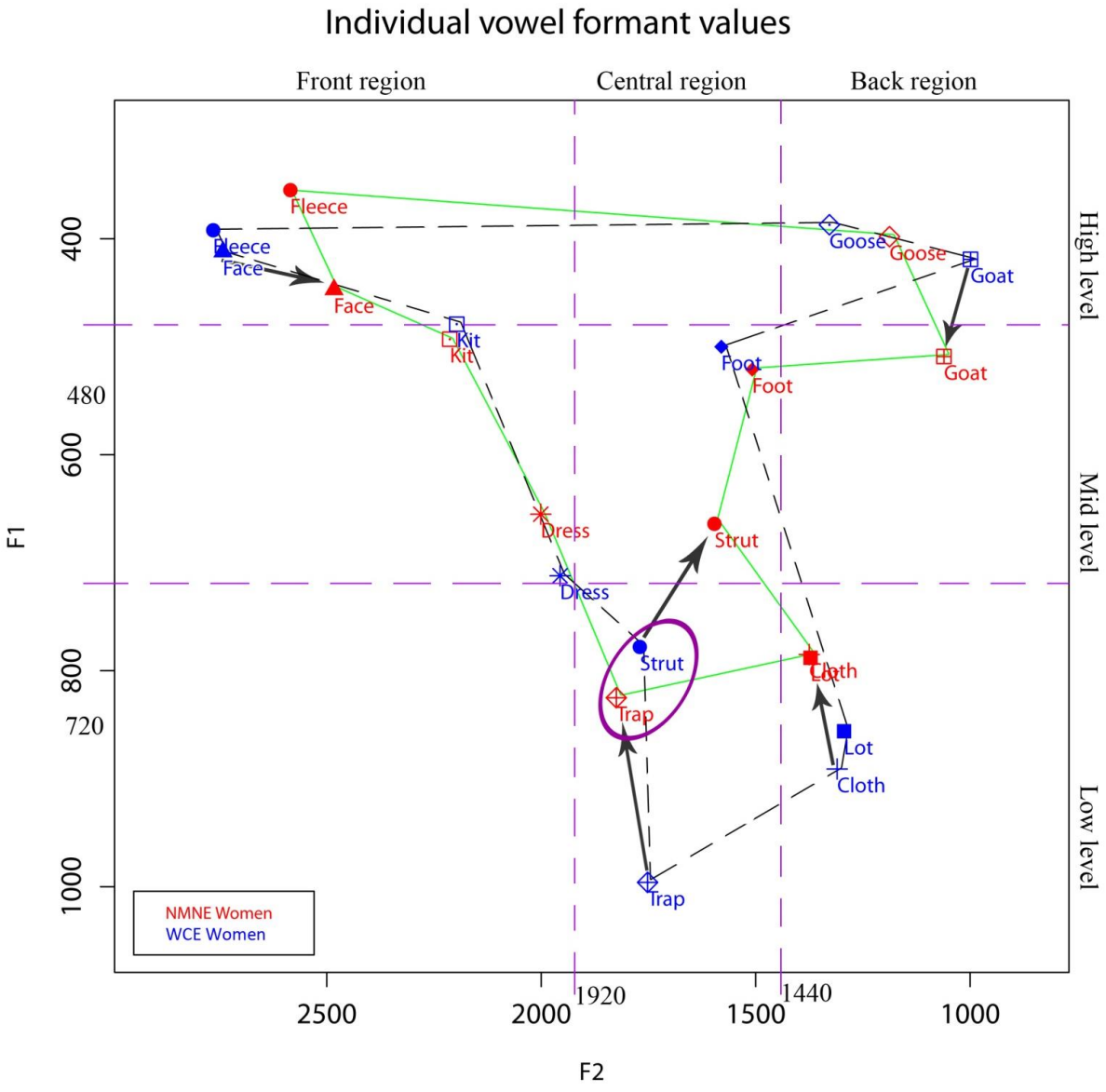

Figure 4.14: A representation of the acoustic vowel space chart for WCE women and NMNE women.

That leads to the fifth distinct vowel which is the goat [o] vowel. This is realized as a high vowel by WCE women since it has an F1 average of 419 Hz. NMNE women, on the other hand, produce it as a mid sound since it has an average of 509 Hz. Consequently, the two sounds have a total distance of 90 Hz between them. The final distinct vowel is only divergent in the F2 cue and that is the face [e] vowel. This vowel is realized as a front sound in each dialect. However, WCE women produce a sound that is far more fronted (2742 Hz), specifically 259 Hz more, than NMNE women (2483 Hz). Accordingly, these two vowels are realized slightly distinctively from one another.

The last area to discuss about these women's dialects is the sole pair of overlapping vowels. The NMNE trap [æ] vowel has merged with the WCE strut [ʌ] vowel. There is a total distance of 47 Hz between the F1 measurements (825 Hz – 778 Hz). Likewise, the F2 averages are separated by 55 Hz (1825 Hz – 1770 Hz).

Chapter 5: Discussion

Summary of NMNE Men and Women

This study set out to answer three research questions. The first question, *What are the acoustic vowel qualities of the following English vowels [i, ɪ, e, ɛ, æ, a, ɔ, o, ʊ, u, ʌ] in the dialect of 20 Northern Minnesotan speakers?*, was addressed in the first and second section of Chapter 4. Conclusions from these sections are as follows.

Northern Minnesota English speakers realize exactly the same vowels in each of the three levels of vowel height. Whether man or woman, this dialect produces the fleece [i] vowel, the goose [u] vowel, and the face [e] vowel as their high vowels. They produce the kit [ɪ] vowel, the goat [o] vowel, the foot [ʊ] vowel, the dress [ɛ] vowel, and the strut [ʌ] vowel as their mid vowels. Lastly, they realize the trap [æ] vowel, the lot [ɑ] vowel, and the cloth [ɔ] vowel as their low vowels. Likewise, these speakers also produce vowels in all three regions of tongue retraction. However, the vowel inventories for each region are not as consistent as those levels in the vowel height feature. Within the front region, the common vowels include the fleece [i] vowel, the face [e] vowel, the kit [ɪ] vowel, and the dress [ɛ] vowel. In the central region, the common vowels include the strut [ʌ] vowel and the foot [ʊ] vowel. The common back vowels consist of the goose [u] vowel and the goat [o] vowel. That leaves just three vowels which do not correlate between the men and women's dialects. The first divergence is the trap [æ] vowel. In the women's speech, the trap [æ] vowel is realized as a central vowel whereas in the men's speech it is realized as a front vowel. Similarly, the lot [ɑ] vowel and the cloth [ɔ] vowel are also inconsistent. In men's speech they are central vowel phonemes. However, in women's speech they are realized as back vowel phonemes. Furthermore, it is no coincidence that these latter two

vowel phonemes move together. This is because speakers of this dialect have actually merged their cloth [ɔ] vowel with their lot [ɑ] vowel. The greatest acoustic distance between each phoneme is either 5 Hz (NMNE men) or 3 Hz (NMNE women). Nevertheless, both distances are entirely indiscernible to the human ear. In addition to this, these speakers have also reversed their kit [ɪ] and face [e] vowels. Now, the former is a mid vowel while the latter takes the former's place as a high vowel. Finally, whether man or woman, NMNE speakers have lowered and fronted their foot [ʊ] vowel so much that it has actually caused this vowel to be classified as a mid, central vowel now rather than a high, back vowel. Considering these findings, there is only one feature that is prominent enough for any listener with normal ears to be able to perceive and that is the overlapping of the lot [ɑ] and cloth [ɔ] vowels. Since NMNE speakers have merged these two phonemes in the F1 and F2 acoustic cues, listeners will find it more than obvious that Northern Minnesotans are unable to distinguish between words such as <cot> and <caught>.

The other four acoustic correlates under investigation in this study do in fact extend the conversation of Northern Minnesota English acoustic vowel spaces. For instance, the current data shows that NMNE women are more likely to round their vowels while their male counterparts diverge in the opposing direction and prefer to unround their vowels. Furthermore, the rounding feature is not limited to back vowels as theories predict (Thomas, 2011, p. 48; Crothers, 1978, pp. 96-97). Another feature which evades discrimination is the vowel duration feature. Although the idea of "intrinsic duration" is suggested by Lisker (1974, p. 226), NMNE speakers realize high, mid, and low vowels alike as their longest sounds. Such as is exemplified by NMNE men who realize the low trap [æ] vowel, the high face [e] vowel, the low cloth [ɔ] vowel, the mid goat [o] vowel, and the low lot [ɑ] vowel as their longest sounds. They also

realize the high fleece [i] vowel as their second longest sound. Similarly, NMNE women realize the low cloth [ɔ] vowel, the mid goat [o] vowel, the low trap [æ] vowel, the low lot [ɑ] vowel, and the high face [e] vowel all as their longest sound along with the high fleece [i] and goose [u] vowels as their second longest sound. Finally, although vowel intensity is indistinguishable between the overall averages of both men and women from NMNE, the standard deviations from each reveal that majority of their vowels are in fact distinctive between idiolects. Vowel pitch, on the other hand, is mostly distinctive in both the averages as well as idiolects.

Comparison Summary of NMNE and Other American English Dialects

The second and third research questions which are presented below are addressed and summarized together due to their cohesive nature.

2. In the F1 and F2 features, how similar or different are the 20 participants of Northern Minnesota from other speakers with dialects such as General American English, Midwest English, Central Minnesota English, and Winnipeg Canadian English?
3. In the F1 and F2 features, to which dialect is Northern Minnesota English most similar?

NMNE men sound most similar to their northern neighbors in Winnipeg, Manitoba, CA. This is because of their nine common vowel phonemes. Furthermore, even though each group of men distinguish themselves when they produce the trap [æ] vowel and the strut [ʌ] vowel, hearers are more likely to notice a divergence in only the trap [æ] vowels since they diverge in the F1 correlate (Ladefoged & Johnson, 2015, p. 207; Koffi, 2016b, pp. 121-22). That being said, a listener hearing each group of men will perceive these dialects as being almost entirely the same. This is an interesting finding considering that 15 Minnesota commenters actually stated

that the dialect being used in Bartholdi (2015)'s Youtube video was actually a Canadian accent rather than a Minnesotan accent. The truth in that statement then is that, according to the data revealed in this study, Bartholdi's video may be representing an accent that is actually almost entirely the same as a Canadian accent, or more specifically a Winnipeg Canadian accent. For this reason, it can be concluded that NMNE men and WCE men speak very similar dialects and most hearers will detect only one noticeable difference, if any at all.

NMNE women, on the other hand, sound most similar to their southern neighbors in Central Minnesota because of five common vowels and various common dialectal features. However, their dialects are still very different considering that over half of their vowels diverge in the F1 correlate. Given that English dialects are highly impacted by their vowels (Ladefoged, 2005, p. 27), listeners can actually hear noticeable differences between these two groups of women. This may be why 24 of those Minnesota commenters started to draw boundaries around the *Minnesota accent*. They claim that Bartholdi's Youtube video is actually representing an accent that is only spoken in the northern region of Minnesota while the other residents of Minnesota regions speak differently. According to the current data from this study, that statement is exactly true for NMNE women, as well as for their male counterparts for that matter. NMNE women, along with NMNE men, do in fact have a dialect that is different from other Minnesota speakers. Furthermore, NMNE women have a dialect that is distinct from other speakers around them which include GAE women, MWE women, and even WCE women. Even though they do share some common vowels with all four aforementioned dialects, NMNE women have a dialect that is unique to their own region of Minnesota.

Implications

The relevance of these findings reaches into various areas of study. The first and most obvious area is Linguistics. There are countless studies produced all over the U.S. that acoustically describe American dialects. The current data of this study continues to develop this acoustic inventory even further by adding another region to the "acoustic atlas" of America (Hagiwara, 1997; 1995).

A second area which may find importance in these conclusions is Speech Technology. Similar to linguists, speech technologists can incorporate this data as means of broadening their knowledge of American English to include another salient dialect, Northern Minnesota English.

Limitations and Further Research

This study still does not even come close to collecting all of the data necessary for determining whether or not the NMNE dialect is similar to that dialect present in the Batholdi (2015)'s video production. However, it does start to reveal acoustical data for determining potential patterns and characteristics of the NMNE dialect as well as to which surrounding dialects it is most similar. That being said, to further investigate whether Barthodi's video is truly representing the Minnesota accent, researchers need to further these studies and investigate the southern region(s) of Minnesota along with the Metro region. In addition to this, researchers also need to collect data from the speakers presented in Bathodi's video. With all of the compiled data, finally then can we determine whether or not those actors and interviewees are speaking a dialect that is similar to and/or different from Minnesota dialects.

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Appendix

Appendix A: Tables—F0 of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F0	121	109	114	108	116	105	109	126	118	131	117
Speaker 2M	F0	174	145	133	130	136	134	129	137	135	153	129
Speaker 3M	F0	127	132	126	127	123	127	141	133	144	140	130
Speaker 4M	F0	112	109	100	97	91	92	85	93	99	113	100
Speaker 5M	F0	139	131	126	119	120	120	123	NA	131	131	NA
Speaker 6M	F0	100	101	110	121	112	105	94	109	112	124	105
Speaker 7M	F0	127	115	123	113	121	117	121	113	126	138	103
Speaker 8M	F0	110	115	110	110	108	108	112	116	122	128	110
Speaker 9M	F0	120	117	118	114	112	NA	117	126	129	144	121
Speaker 10M	F0	101	81	100	79	79	85	76	85	84	98	83
Average		**123**	**115**	**116**	**111**	**111**	**110**	**110**	**115**	**120**	**130**	**110**
Standard Deviation		21.61	17.85	11.2	14.97	16.34	15.87	20.27	17.58	17.78	15.79	15.11

Appendix B: Tables—F0 of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F0	168	146	153	147	143	156	151	166	175	183	155
Speaker 2F	F0	220	191	204	203	192	194	199	206	217	224	201
Speaker 3F	F0	221	204	202	191	188	188	187	197	208	214	152
Speaker 4F	F0	198	191	193	182	166	171	186	201	204	205	226
Speaker 5F	F0	179	197	189	184	176	187	215	202	206	219	188
Speaker 6F	F0	223	201	181	189	183	184	196	195	193	215	186
Speaker 7F	F0	194	191	144	170	146	161	115	148	193	189	150
Speaker 8F	F0	286	272	257	245	241	286	199	239	252	269	144
Speaker 9F	F0	205	185	173	170	166	176	192	NA	175	183	168
Speaker 10F	F0	211	196	192	194	187	159	179	193	168	187	91
Average		**211**	**197**	**188**	**187**	**178**	**186**	**181**	**194**	**199**	**208**	**166**
Standard Deviation		32.28	30.8	31.06	25.6	27.69	37.49	28.79	24.02	24.65	26.32	37.11

Appendix C: Tables—F1 of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F1	276	442	453	535	623	723	723	513	473	301	586
Speaker 2M	F1	285	425	374	485	591	671	694	431	441	312	531
Speaker 3M	F1	274	441	401	581	685	748	731	490	533	288	606
Speaker 4M	F1	311	447	408	512	623	707	694	448	487	348	578
Speaker 5M	F1	291	422	378	561	649	667	606	NA	436	347	NA
Speaker 6M	F1	277	405	367	534	656	624	607	414	431	323	544
Speaker 7M	F1	276	434	425	576	715	734	798	494	469	342	578
Speaker 8M	F1	262	405	364	479	520	569	679	450	422	315	557
Speaker 9M	F1	251	401	351	472	639	NA	650	444	418	308	489
Speaker 10M	F1	302	419	392	454	502	596	585	431	447	355	532
Average		**280**	**424**	**391**	**518**	**611**	**671**	**676**	**457**	**455**	**323**	**555**
Standard Deviation		17.73	16.74	31.18	45.43	67.89	63.39	66.15	33.71	35.39	22.84	35.71

Appendix D: Tables—F1 of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F1	349	522	468	623	709	738	724	501	531	389	637
Speaker 2F	F1	383	462	416	644	799	704	720	444	478	417	575
Speaker 3F	F1	390	548	504	837	979	935	948	593	564	410	812
Speaker 4F	F1	333	502	423	717	962	862	828	485	521	385	615
Speaker 5F	F1	314	505	433	634	753	718	761	460	494	386	674
Speaker 6F	F1	372	493	516	711	963	882	854	509	557	408	727
Speaker 7F	F1	366	412	382	505	773	572	590	433	447	378	559
Speaker 8F	F1	326	598	520	699	862	891	807	654	672	434	734
Speaker 9F	F1	387	400	395	490	614	777	836	NA	420	380	638
Speaker 10F	F1	339	497	417	693	844	804	788	507	530	395	675
Average		**355**	**493**	**447**	**655**	**825**	**788**	**785**	**509**	**521**	**398**	**664**
Standard Deviation		27.35	58.96	50.92	102.62	120.08	109.55	95.92	71.69	70.22	18.34	77.27

Appendix E: Tables—F2 of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F2	2336	2012	2149	1935	1872	1226	1203	1140	1296	1037	1340
Speaker 2M	F2	2510	1912	2123	1779	1712	1284	1298	1097	1414	1169	1426
Speaker 3M	F2	2262	1907	2122	1727	1608	1236	1193	1052	1390	1217	1364
Speaker 4M	F2	2244	1852	2060	1778	1628	1298	1291	1321	1432	1348	1478
Speaker 5M	F2	2257	1900	2164	1938	1801	1056	1149	NA	1180	1234	NA
Speaker 6M	F2	2483	2153	2408	2139	1947	1196	1135	889	1515	1074	1448
Speaker 7M	F2	2349	1965	2215	1850	1763	1270	1358	1016	1374	1070	1388
Speaker 8M	F2	2194	1775	2039	1689	1646	1254	1632	1184	1356	1359	1465
Speaker 9M	F2	2214	1853	2076	1638	1534	NA	1137	907	1143	999	1225
Speaker 10M	F2	2256	1894	2174	1841	1828	1181	1232	906	1318	1070	1334
Average		**2310**	**1922**	**2153**	**1831**	**1733**	**1222**	**1262**	**1056**	**1342**	**1157**	**1385**
Standard Deviation		109.12	103.37	104.81	145.8	130.77	73.37	149.78	145.57	112.45	128.38	80.13

Appendix F: Tables—F2 of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F2	2539	2022	2361	1968	1870	1363	1327	971	1397	1117	1629
Speaker 2F	F2	2414	2101	2470	1674	1396	1271	1344	1130	1506	1330	1411
Speaker 3F	F2	2839	2280	2499	2002	1703	1377	1387	1136	1554	1246	1623
Speaker 4F	F2	2755	2153	2631	2022	1610	1344	1376	1132	1589	1110	1574
Speaker 5F	F2	2665	2120	2483	1974	1875	1259	1238	744	1337	868	1548
Speaker 6F	F2	2213	2374	2536	2098	1845	1482	1420	1172	1641	1262	1719
Speaker 7F	F2	2495	2300	2598	2135	2012	1139	1226	990	1338	1123	1447
Speaker 8F	F2	2299	2090	2184	1759	1951	1451	1472	1190	1596	1335	1645
Speaker 9F	F2	2941	2511	2492	2344	2088	1593	1538	NA	1626	1352	1808
Speaker 10F	F2	2690	2184	2577	2035	1908	1444	1426	1088	1498	1140	1559
Average		**2585**	**2213**	**2483**	**2001**	**1825**	**1372**	**1375**	**1061**	**1508**	**1188**	**1596**
Standard Deviation		**235.04**	150.56	129.77	186.76	**204.66**	129.32	97.17	140.86	114.79	148.15	117.79

Appendix G: Tables—F3 of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	F3	3125	2672	2734	2670	2612	2518	2516	2573	2439	2449	2550
Speaker 2M	F3	3107	2827	2843	2651	2514	2295	2407	2485	2659	2503	2615
Speaker 3M	F3	2957	2611	2626	2550	2479	2376	2319	2249	2364	2182	2427
Speaker 4M	F3	2959	2815	2741	2715	2683	2768	2723	2756	2465	2802	2611
Speaker 5M	F3	3056	2703	2907	2702	2483	2463	2794	NA	2374	2626	NA
Speaker 6M	F3	3162	2922	2963	2958	2557	2500	2483	2776	2592	2389	2480
Speaker 7M	F3	2790	2732	2921	2951	2886	2942	2793	2488	2531	2253	2675
Speaker 8M	F3	3001	2621	2628	2622	2645	2665	2751	2725	2704	2732	2671
Speaker 9M	F3	2893	2571	2603	2540	2424	NA	2524	2480	2403	2246	2514
Speaker 10M	F3	2882	2480	2920	2696	2615	2667	2700	2578	2398	2585	2382
Average		**2993**	**2695**	**2788**	**2705**	**2589**	**2577**	**2601**	**2567**	**2492**	**2476**	**2547**
Standard Deviation		119.71	133.1	139.09	144.14	132.74	202.44	171.76	168.14	122.45	211.94	104.69

Appendix H: Tables—F3 of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	F3	3179	2979	2927	2964	2751	2830	2811	2761	2873	2866	2872
Speaker 2F	F3	2996	2920	2885	2817	2599	2728	2903	2725	2782	2652	2804
Speaker 3F	F3	3219	3014	2871	2944	2531	2460	2618	2705	2760	2726	2831
Speaker 4F	F3	3174	2703	2943	2909	2613	2840	2760	2615	2644	2564	2924
Speaker 5F	F3	3214	2997	2849	2863	2771	2881	2845	2952	2900	2978	2872
Speaker 6F	F3	3257	2861	2848	2706	2545	2777	2752	2887	2907	2869	2885
Speaker 7F	F3	3197	2919	2989	2918	2722	2689	2598	2536	2490	2588	2792
Speaker 8F	F3	2929	2806	2784	2429	2655	2500	2923	2806	2791	2715	2848
Speaker 9F	F3	3352	3303	3167	3210	3143	3095	2953	NA	3094	2844	3124
Speaker 10F	F3	3316	2997	3029	2977	2772	2673	2760	2589	2729	2563	2777
Average		**3183**	**2949**	**2929**	**2873**	**2710**	**2747**	**2792**	**2730**	**2797**	**2736**	**2872**
Standard Deviation		130.7	158.28	110.41	202.56	176.66	185.01	120.24	137.86	163.5	146.75	99.26

Appendix I: Tables—Duration of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	DUR	182	142	209	149	193	218	197	203	146	170	139
Speaker 2M	DUR	189	168	257	158	245	213	227	222	157	181	138
Speaker 3M	DUR	208	135	218	125	222	204	214	182	112	168	97
Speaker 4M	DUR	213	136	222	161	271	226	258	257	152	224	127
Speaker 5M	DUR	237	187	234	169	290	207	232	NA	171	189	NA
Speaker 6M	DUR	253	128	222	150	143	234	256	245	131	210	123
Speaker 7M	DUR	237	172	239	190	269	248	215	245	161	236	150
Speaker 8M	DUR	196	149	230	178	222	234	242	214	150	173	119
Speaker 9M	DUR	281	205	281	230	331	NA	305	266	209	273	171
Speaker 10M	DUR	233	149	280	164	299	300	230	265	154	176	136
Average		**222**	**157**	**239**	**167**	**248**	**231**	**237**	**233**	**154**	**200**	**133**
Standard Deviation		30.99	25.09	25.37	28.13	55.41	29.34	30.24	29.49	25.27	34.97	20.7

Appendix J: Tables—Duration of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	DUR	191	145	225	147	207	215	206	196	154	194	117
Speaker 2F	DUR	239	170	245	172	235	261	276	264	204	208	148
Speaker 3F	DUR	255	210	313	207	293	294	310	305	196	249	165
Speaker 4F	DUR	219	130	223	134	214	217	225	238	130	182	92
Speaker 5F	DUR	281	193	286	206	338	352	343	297	181	259	151
Speaker 6F	DUR	217	146	214	157	238	230	211	231	152	187	106
Speaker 7F	DUR	205	105	215	117	209	202	246	230	116	188	103
Speaker 8F	DUR	147	138	175	122	193	193	187	200	140	157	118
Speaker 9F	DUR	180	99	203	131	187	157	197	NA	83	160	82
Speaker 10F	DUR	214	192	246	183	258	252	278	252	203	221	171
Average		**214**	**152**	**234**	**157**	**237**	**237**	**247**	**245**	**155**	**200**	**125**
Standard Deviation		38.11	37.63	40.29	33.21	47.64	55.54	52.21	38.08	40.3	34.16	31.29

Appendix K: Tables—Intensity of men

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1M	INT	53	51	52	52	52	53	53	53	52	56	54
Speaker 2M	INT	77	80	75	75	74	74	73	77	77	79	75
Speaker 3M	INT	73	74	70	73	72	76	75	72	75	73	73
Speaker 4M	INT	53	53	50	50	49	50	47	49	53	54	52
Speaker 5M	INT	63	65	65	57	56	58	58	NA	63	63	NA
Speaker 6M	INT	48	53	53	50	54	49	48	54	52	56	51
Speaker 7M	INT	58	58	58	58	57	58	61	59	61	61	58
Speaker 8M	INT	52	54	53	51	47	48	46	50	52	51	46
Speaker 9M	INT	55	56	55	54	54	NA	57	57	58	58	55
Speaker 10M	INT	59	56	57	51	53	54	52	57	54	59	54
Average		**59.1**	**60**	**58.8**	**57.1**	**56.8**	**57.7**	**57**	**58.6**	**59.7**	**61**	**57.5**
Standard Deviation		9.39	9.84	8.40	9.33	9.05	10.40	10.21	9.63	9.45	8.71	9.88

Appendix L: Tables—Intensity of women

Lexical Set		fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Speaker 1F	INT	56	58	58	59	58	60	58	60	62	60	59
Speaker 2F	INT	52	55	55	52	50	51	52	54	56	58	52
Speaker 3F	INT	53	55	54	57	59	55	59	54	53	53	50
Speaker 4F	INT	59	62	60	62	64	61	64	64	65	62	60
Speaker 5F	INT	53	54	52	52	51	52	54	57	58	56	55
Speaker 6F	INT	51	52	52	51	51	51	51	52	50	52	49
Speaker 7F	INT	49	50	50	45	43	45	44	50	52	53	48
Speaker 8F	INT	52	55	50	55	52	58	53	53	54	51	51
Speaker 9F	INT	47	45	43	41	41	40	42	NA	42	47	42
Speaker 10F	INT	62	61	62	62	62	62	61	62	61	62	61
Average		**53.4**	**54.7**	**53.6**	**53.6**	**53.1**	**53.5**	**53.8**	**56.2**	**55.3**	**55.4**	**52.7**
Standard Deviation		4.50	5.03	5.54	6.89	7.63	7.16	7.05	4.81	6.68	5.03	6.03

Appendix M: Task 1

1. Sex: _____ Male or _____ Female
2. Age: _____
3. First language: _____
4. Other languages you speak: _____
5. In what city/county do you currently live? _____
6. How many years have you lived in that city/county? _____
7. How long have you lived in the Northern Minnesota region? _____

Appendix N: Task 2

1. Heed, heed, heed (**Note:** the vowel sounds like the *"ee"* in <fleece>)
2. Hid, hid, hid (**Note:** the vowel sounds like the *"i"* in <kit>)
3. Hayed, hayed, hayed (**Note:** the vowel sounds like the *"a"* in <face>)
4. Head, head, head (**Note:** the vowel sounds like the *"e"* in <dress>)
5. Had, had, had (**Note:** the vowel sounds like the *"a"* in <bath>)
6. Hod, hod, hod (**Note:** the vowel sounds like the *"o"* in <lot>)
7. Hawed, hawed, hawed (**Note:** the vowel sounds like the *"o"* in <cloth>)
8. Hoed, hoed, hoed (**Note:** the vowel sounds like the *"oa"* in <goat>)
9. Hood, hood, hood (**Note:** the vowel sounds like the *"oo"* in <foot>)
10. Who'd, who'd, who'd (**Note:** the vowel sounds like the *"oo"* in <goose>)
11. Hud, hud, hud (**Note:** the vowel sounds like the *"u"* in <hug>)

Appendix O: Task 3

Please call Stella. Ask her to bring these things with her from the store: Six good spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a foot long sandwich as a snack for her brother Bob. We also need a small plastic snake, a yellow book, a rubber duck, a paper I-pad, the dog video game, a big toy frog for the kids, but not the faked gun. She can scoop these things into three red bags and two old backpacks, and we will go meet her, Jake, and Jenny Wednesday at the very last train station at the edge of the zoo. Also, let Stella know that the toy frog is running low on battery.