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Michel Backstrom
St. Cloud State University, mebackstrom@stcloudstate.edu

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AN ACOUSTIC PHONETIC ANALYSIS OF NORTHERN MINNESOTA ENGLISH VOWEL SPACES

MICHEL LOPEZ-BACKSTROM

ABSTRACT

The dialect of Northern Minnesota English (NMNE) has been acknowledged as a leading suspect in the search for the Minnesota accent. Bartholdi (2015) produced a video, asking Minnesotans: "Are You MN Enough"? The majority of those who responded associated the Minnesota accent in the video with Northern Minnesota. This study seeks 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, a, ɔ, o, ʊ, u, ʌ] within an isolated hVd structure. The recordings were imported into Praat, spliced, measured, and analyzed for 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). Some of the main characteristics of NMNE are the following: the merger of the "lot" [a] and "cloth" [ɔ] vowels, the reversal of positions of the "kit" [ɪ] and "face" [e] vowels, and the fronting and lowering of the "foot" [ʊ] vowel.[1]

1.0 Geographical Location of the Study

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 is a map that shows this region. Northern Minnesota is outlined at the top of the map and the stars represent each northern county that has been sampled within the current study.

[1] The labeling of vowels follows J.C. Well's lexical set, as used and explained in Ladefoged and Johnson (2015:102-103).

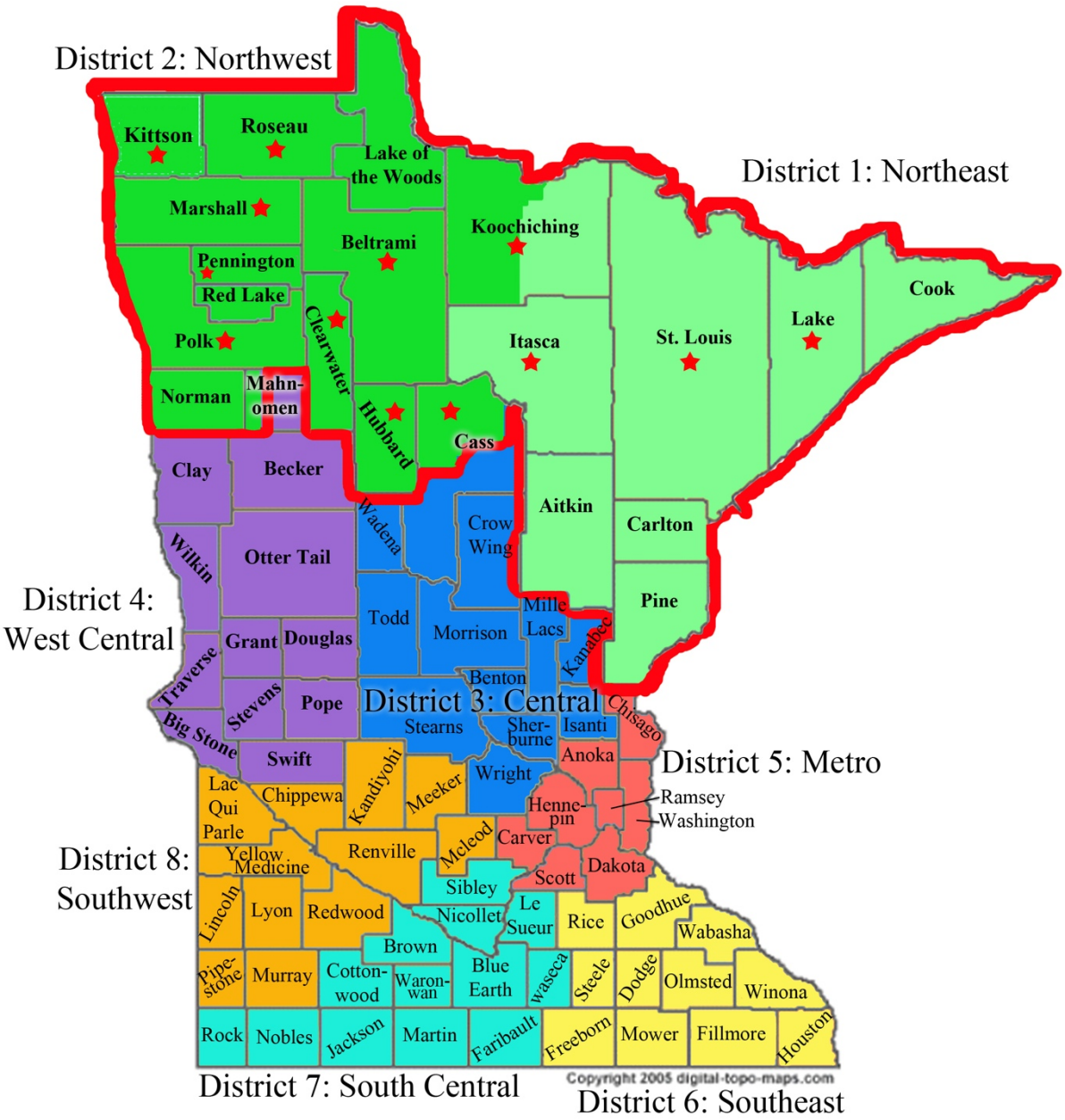

Figure 1: Northern MN districts according to the Minnesota Department of Transportation (2018)

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. The Asian (0.5%) and African American (0.5%) populations average below one percent. This region may be considered rural because the majority of the towns' populations are around 15,000[2] or less (U.S. Census Bureau: 2017). 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. Another geographical detail

[2] Minnesota does not actually stipulate any size of populations which distinguishes a city from a town (U.S. Census Bureau: 2017, 9-5). However, according to Wikipedia, "Common population definitions for a city range between 1,500 and 50,000 people (Dec. 7, 2018)."

about Northern Minnesota is that it shares an international border with Canada. There are seven counties that are along this international border. The counties in question are:

1. Kittson
2. Roseau
3. Lake of the Woods
4. Koochiching
5. St. Louis
6. Lake
7. Cook

2.0 The Methodology and Participants

This study replicates the methodology that Peterson and Barney (1952) used to study General American English (GAE) vowels. Twenty participants (10 men and 10 women) aged 20 to 64 years old were recruited. They are all native speakers of the Northern Minnesota English (NMNE) dialect of American English. They all spent their linguistically formative years, that is, age 1 to 17[3], in the region of Northern Minnesota highlighted in Figure 1. Tables 1A and 1B provide the relevant sociometric information about the participants.

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 1A: Men's Background Information

[3] Labov, Rosenfelder, and Fruehwald (2013: 39) stated that from the age 17 and on, speakers diminishing rate of dialectal variance follows the "1/age". 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.

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

Table 1B: Women's Background Information

The participants were recorded saying the following eleven phonemes [i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ] three times within an isolated /hVd/ word structure. The vowels and their phonological environments are presented in Table 2:

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

Table 2: Vowels under investigation

The recordings were imported into Praat where they were spliced, measured, and analyzed for 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).

3.0 An Overview of Vowel Sounds

Vowel sounds maintain a distinctive nature about them no matter the number of vowels within the space. According to Liljencrantz and Lindblom (1972: 841) this is possible because of the *Principle of Maximum Contrast*. It stipulates that vowels naturally "repel" from one another. Because of this repellent behavior, vowels retain divergent characteristics. However, just because they remain distinctive does not mean that they are easy sounds to study. Since no two articulators come into contact during the production of a vowel sound, vowels are best "described as points on a continuum" (Ladefoged 1971: 67). 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 to produce vowels such as [i] and [æ] in the words <fleece> and <trap>. Likewise, the tongue also moves horizontally on a continuum between the front and the back regions of the mouth to produce vowels such as [i] (a front sound) and [u] (a back sound) like in the words <fleece> and <goose>. However, when mid and central vowels are introduced to this space, such as is the case for English dialects, the boundaries start to become unclear. Ladefoged and Johnson (2015: 92) note that "Part of the problem in describing vowels is that there are no distinct boundaries between one type of vowel and another." The following vocalic boundaries are based on information from Liljencrantz and Lindlom (1972: 840), Crothers (1978: 96-97), Kent and Read (2002: 194), Thomas (2011: 48), and Ladefoged and Johnson (2015: 46)[4].

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

Table 2: F1 boundaries for each level of vowel height

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

Table 3: F2 boundaries for each region of tongue retraction

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

Table 4: F3 boundaries for each degree of lip rounding

[4] For more information on how the vocalic boundaries were derived, please refer to the original study by Lopez-Backstrom (2018) which can be retrieved at the following website. https://repository.stcloudstate.edu/cgi/viewcontent.cgi?article=1191&context=engl_etds

4.0 Vowel Height: F1 Correlate

Vowel height is the most prominent vowel feature in describing vowels. It is represented acoustically by F1. It has the greatest impact on vowel quality and "on average, has 80% of the energy in a vowel" (Ladefoged and Johnson 2015: 207). This feature is divided into three types: high vowels, mid vowels, and low vowels. It is important to note that F1 measurements are indirectly proportional to the height of a vowel. Therefore, high vowels have lower F1 values, while their lower counterparts have higher F1 values. Furthermore, according to Koffi (2016: 11), as long as there is less than 60 Hz between pairs of adjacent front, back vowels, or low vowels, the human ear has a hard time detecting any distinction between two vocalic sounds. Measurements which exceed this threshold are perceived as different vowels.

4.1 Vowels in Men's Speech

According to Van Herk (2012: 93-94), men tend to have stronger regional accents than women. For this reason, men's data are presented first. The men whose speech is represented in 5A are from the following counties: Beltrami, Clearwater, Hubbard, Itasca, Kittson, Lake, Pennington, and Polk. Their ages range from 20 to 42 years and they all lived the entirety of their lives within the region under consideration. F1 data for NMNE men is presented in Table 5A and it is followed by their F2 data in Table 5B.

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

Table 5A: F1 measurements of NMNE men[5]

[5] It should be noted that Speakers 5M and 9M 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 N/A in the corresponding boxes.

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**
St. Deviation		109.12	103.37	104.81	145.8	130.77	73.37	149.78	145.57	112.45	128.38	80.13

Table 5B: F2 measurements of NMNE men

NMNE men collectively produce vowels in all three levels of vowel height and all three regions of tongue retraction. Within the area of vowel height, NMNE men realize three sounds as their high vowels [i, u, e], five sounds as their mid vowels [ɪ, o, ʊ, ɛ, ʌ] and three vowel phonemes as their low vowels [æ, ɑ, ɔ]. Tongue retraction, on the other hand, breaks up a bit differently. NMNE men realize five vowels as their front sounds [i, e, ɪ, ɛ, æ], four vowels phonemes as their central sounds [ʌ, ʊ, ɔ, ɑ], and two sounds as their back vowels [u, o].

The acoustic phonetic measurements of their vowels reveal a few other salient dialectal patterns. The first noticeable pattern is an overlapping behavior of the lot [ɑ] and cloth [ɔ] vowels. There is a mere 5 Hz separating the F1 values (671 Hz – 676 Hz) and 40 Hz separating the F2 values (1222 Hz – 1262 Hz). Considering that the human ear is unable to distinguish any two sounds within 20 Hz of each other in the F1 cue (Koffi 2017: 109), it is more than obvious that [ɑ] vowel and [ɔ] have completely merged in this dialect. However, some speakers still produce them distinctly. Speaker 5M, Speaker 7M, and Speaker 8M do in fact still distinguish their [ɑ]s from their [ɔ]s. Therefore, [ɑ] and [ɔ] have merged only in the pronunciation of six of the nine men (66%).[6] However, it is worth mentioning that Speaker 8M is the only one who distinguishes between [ɑ] and [ɔ] in both F1 and F2.

The second dialectal pattern that surfaces in the men's F1 data is the reversal of [ɪ] and [e]. With the exception of Speaker 1M, all nine NMNE men (90%) produce the "face" vowel [e] higher than the "kit" vowel [ɪ]. According to Ladefoged and Johnson's vowel space chart of English vowels (2015: 46), [ɪ] is actually a high vowel (or a mid-high) while [e] is a mid-vowel. However, it is obvious in the vowel space chart below (and from the F1 measurements in Table 5A) that the order is reversed in the pronunciation of the majority of NMNE men.

The last salient pattern is the fronting and lowering of the "foot" vowel [ʊ]. Still in reference to Ladefoged and Johnson's vowel space chart, [ʊ] vowel is a high, back sound. However, in the data, [ʊ] vowel is actually produced as a mid, central vowel by 80% of the ten

[6] Speaker 9M was not included in this pool due to a mispronunciation of the word <hod>.

male participants. Two participants, Speakers 5M and 9M, produce [ʊ] as a mid, back vowel instead of producing it as mid, central vowel like the eight other men. We can see all these processes in Figure 2.

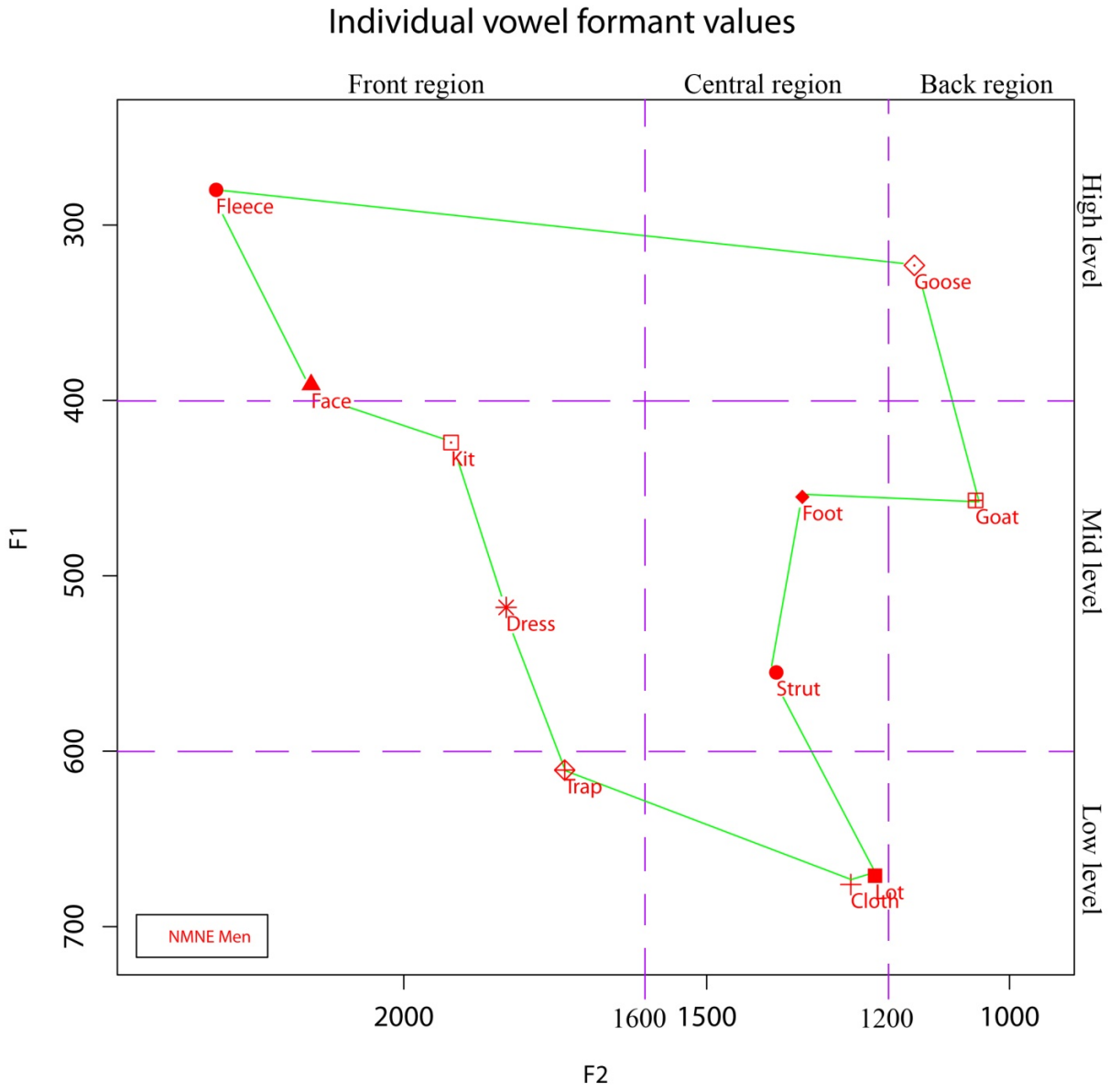

Figure 2: NMNE men's acoustic vowel space chart

4.2 Vowel Height in Women's Speech

Again, according to Van Herk (2012: 93), women are usually at the forefront of dialect change. Like the men, the women are from ten different northern counties (Beltrami, Cass, Clearwater, Kittson, Koochiching, Lake, Marshall, Pennington, Roseau, and St. Louis). Their ages range from 20 to 64 years and 80% of the NMNE women have lived the entirety of their lives in the northern region of Minnesota. Speaker 1F and Speaker 7F are the only exceptions to this. However, any accumulated time outside of the queried region occurred after age 17, that is,

their linguistically formative years. NMNE women's F1 and F2 data are presented below in Tables 6A and 6B.

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

Table 6A: F1 measurements of NMNE women[7]

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**
St. Deviation		**235.04**	150.56	129.77	186.76	**204.66**	129.32	97.17	140.86	114.79	148.15	117.79

Table 6B: F2 measurements of NMNE women

The measurements in Table 6A and 6B clearly demonstrate three different levels of vowel height and three distinct regions of tongue retraction. Although not all speakers produce the same vowel constituents for each level and each region, every NMNE woman does in fact realize at least one vowel in all three levels of vowel height (high, mid, and low) and all three regions of tongue retraction (front, central, and back). Similar to their male counterparts, NMNE

[7]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 N/A in Tables 6A and 6B.

women realize three vowels in the high level [i, u, e], five vowels in the mid level [ɪ, o, ʊ, ɛ, ʌ], and three phonemic vowels in the low level [ɔ, ɑ, æ]. In tongue retraction, on the other hand, women start to diverge from men. They produce four vowels in the front region [i, e, ɪ, ɛ], three vowels in the central region [æ, ʌ, ʊ], and four vowel phonemes in the back region [ɔ, ɑ, u, o]. However, even with this slight divergence from NMNE men, women from Northern Minnesota still reveal the same three dialectal patterns as their male counterparts.

The vowels [ɑ] and [ɔ] have merged in the NMNE spoken by the women. On F1 frequency band, they are separated by only 3 Hz (788 Hz – 785 Hz) and 3 Hz on the F2 frequency band (1372 Hz – 1375 Hz). Since the acoustic distance between [ɑ] and [ɔ] is only 3 Hz, they do not produce them differently nor can they perceive a difference between them. Speaker 8F is the only exception. She actually produces them differently because the acoustic distance between the F1 of her [ɑ] and [ɔ] is 84 Hz (891 Hz – 807 Hz), which is higher than the JND (Just Noticeable Difference) of 20 Hz. The order of the "kit" vowel [ɪ] and the "face" vowel [e] is also reversed, as it is in the speech of men. Nine out of ten women realize a [e] higher than [ɪ], except for Speaker 6F. The "foot" vowel [ʊ] behaves similarly as in men's speech. NMNE women produce it as a mid, central vowel rather than a high, back vowel. Seven of the 10 women produce their [ʊ] this way. The only exceptions are Speaker 2F, Speaker 7F, and Speaker 9F who still produce [ʊ] as a high vowel. On the F2 frequency band, Speaker 1F, Speaker 5F, and Speaker 7F produce it as a back vowel. It is noteworthy that only Speaker 7F produces [ʊ] according to the classifications found in Ladefoged and Johnson (2015: 46). The phonological processes that the women employ to produce their vowels are depicted in Figure 3:

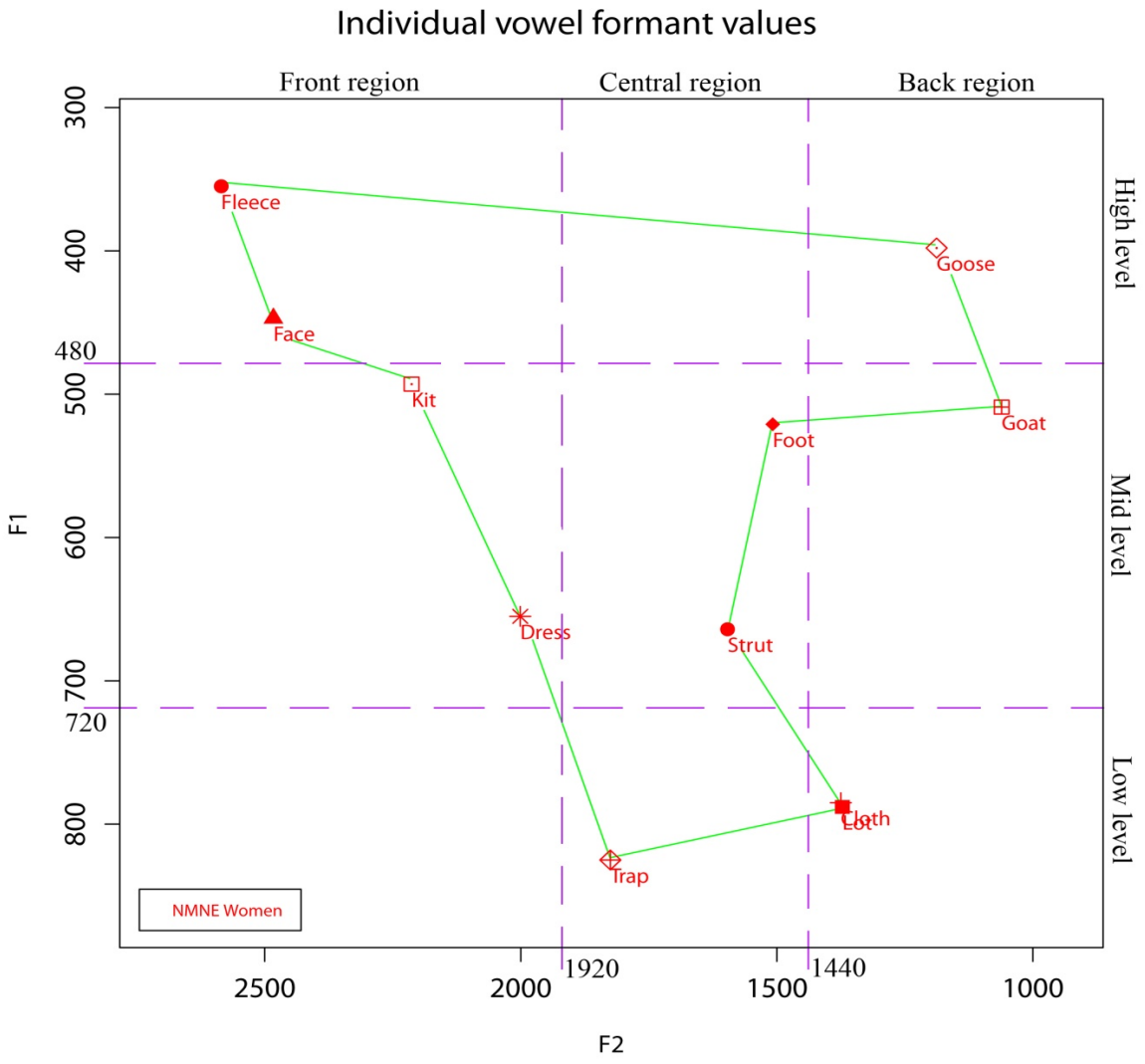

Figure 3: NMNE women's acoustic vowel space chart

6.0 Normalized Acoustic Vowel Space Charts

So far, men and women data have been discussed separately. However, it is good to normalize them in order to highlight the similarities between male and female pronunciation of the same vowels. Normalization is an algorithm that minimizes the biological differences between men and women. The normalization procedure used in this paper is *Labov ANAE, using Telsur G value*[8]. It is the same as the one that was used in *Atlas of North American English* (Labov, Ash, & Boberg 2006).

[8] The website below is where I created the vowel space charts and where I normalized the data. http://lingtools.uoregon.edu/norm/norm1.php

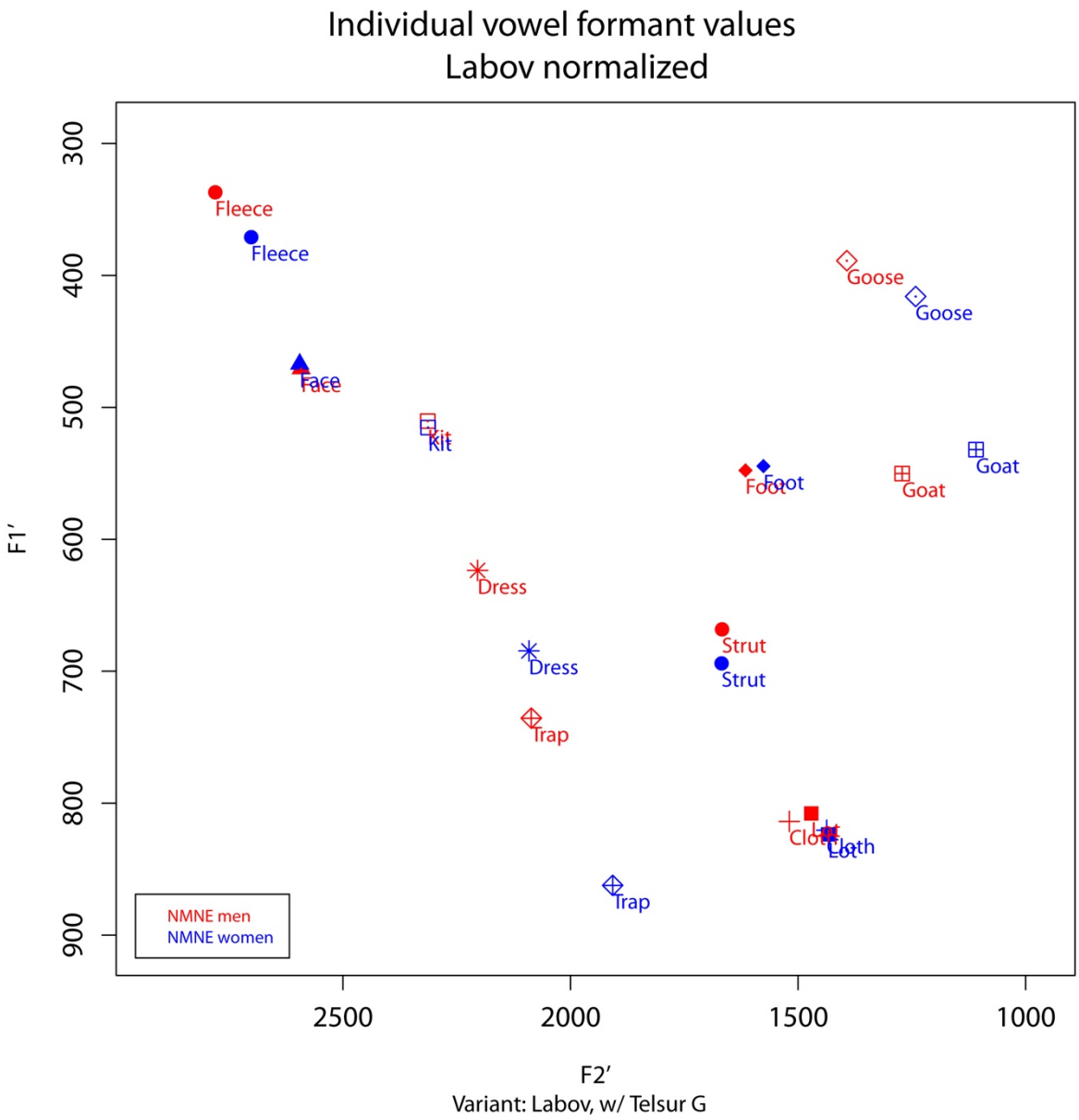

Figure 4: Normalized Acoustic Vowel Spaces

As is evident in Figure 4, the men and women from Northern Minnesota have the same dialect. Most of their vowels are produced identically. However, two vowels are realized differently. These are the "trap" vowel [æ] and the "dress" vowel [ɛ]. Women produce their [æ] lower than all other vowels. This makes it the lowest vowel of their dialect. NMNE men, on the other hand, do not follow this pattern. Their [æ] is actually the second lowest vowel. Their "cloth" vowel [ɔ] and their "lot" [ɑ] vowel are actually lower than their [æ]. The "dress" vowel [ɛ] vowel is also produced differently by men and women. However, the difference is not as drastic as is with [æ]. With these two vowels, namely [æ] and [ɛ], we can clearly see gender difference. Women produce them lower than their male counterparts.

7.0 Summary

NMNE is a dialect that does in fact have a few salient characteristics. Its acoustic vowel space is definitely different from that of American English as depicted by Ladefoged and Johnson (2015: 46). Its distinguishing features are the lowering of [ɪ] and the concomitant raising of [e], and the lowering and fronting of [ʊ]. Another important characteristic is the merger of [ɑ] and [ɔ] to such an extent that <cot> and <caught> are produced identically. There are also slight differences between men and women. The latter produce [æ] and [ɛ] lower than the former. Since this region of Minnesota shares a border with Canada, subsequent studies will compare and contrast NMNE vowels with Canadian vowels. We will do the same with Central Minnesota vowels to see whether or not NMNE speakers sound like Canadians or like other Minnesotans in the center part of the state.

ABOUT THE AUTHOR

Michel Lopez-Backstrom is an ESL teacher in the East Grand Forks school district. She recently completed her MA in Teaching English as a Second Language at St. Cloud State University, Minnesota, USA, where she studied under Dr. Ettien Koffi. Her MA thesis is on the acoustic phonetic vowel spaces of northern Minnesota. She has also co-published a paper on the acoustic characteristics of alveolar fricatives in the idiolect of a northern Minnesota female. She can be reached at michel.backstrom@gmail.com.

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