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A SOCIOPHONETIC ACCOUNT OF THE SIMILARITIES BETWEEN NORTHERN MINNESOTA ENGLISH AND WINNIPEG CANADIAN ENGLISH

MICHEL LOPEZ-BACKSTROM AND ETTIEN KOFFI¹

ABSTRACT

The Minnesota dialect of American English is often confused with some vague “Canadian English” (Bartholdi 2015).² The current study aims to identify precisely which Canadian dialect of English. In so doing, we extract F1 and F2 measurements of 11 monophthong vowels of English ([i, ɪ, e, ε, æ, a, ɔ, o, ʊ, u, ʌ]) produced by 20 Northern Minnesota speakers (10 males and 10 females) and compare and contrast the same set of vowels produced by 10 speakers (5 males and 5 females) of Winnipeg Canadian English whose vowels were measured by Hagiwara (2006). Our findings confirm the impressionistic claims that Northern Minnesotans sound like Canadians. The sociophonetic investigation shows that the phonological processes that raise the “face” vowel [e] over the “kiss” vowel [ɪ], those that front and lower the “foot” [ʊ], and those that have caused the “lot” vowel [a] and the “cloth” vowel [ɔ] to merge are the same in both dialects. However, in our considered opinion, the most important contribution of this paper to variationist sociolinguistics is “the discovery” that male Northern Minnesota English (NMNE) sound like males in Winnipeg Canadian English (WCE) speakers because of F1, while female NMNE speakers sound like female WCE speakers because of F2.

Keywords: Northern Minnesota English, Winnipeg Canadian English, Sociophonetic Variation, Acoustic Vowel Space, Extraction of F1 and F2 Features, Acoustic Phonetics of Dialect Variation.

1.0 Introduction

This paper is a sequel in an ongoing research on the acoustic phonetic analysis of Northern Minnesota English Vowels.³ This study specifically compares acoustic phonetic vowel data from Northern Minnesota and the dialect of Canadian English spoken in Winnipeg in southern Manitoba. The study is motivated by the fact that speakers from Northern Minnesota are often mistaken for being Canadian. Bartholdi (2015) produced a video featuring a speech sample purporting to be from Minnesota. Upon watching the video, the viewers made various comments, likening it to an unspecified Canadian English accent. For example, Figure 1.1 below shows that out of 195 Minnesotans who watched the video, 15 identified the speakers as

¹ **Authorship Responsibilities:** Author 1 took several acoustic phonetic and sociophonetic courses from Author 2. She also wrote an MA thesis on Northern Minnesota English vowels under the supervision of Author 2. The idea of this paper originated from her MA thesis. Author 1 provided Author 2 with an earlier draft of this paper. Author 2 made copious observations and re-analyses of the first draft and sent it back to Author 1 for revisions. Subsequently, Author 2 has rewritten significant portions of the second draft and has provided additional analytical clarity regarding the roles that F1 and F2 play in sociophonetic variations. To the extent that the measurements provided by Author 1 are accurate, they both share equally the rights, privileges, and responsibilities of this publication.

² The Youtube video can be found at: https://www.youtube.com/watch?v=iVINI_LX47I

³ This study can be found at the following website.

https://repository.stcloudstate.edu/cgi/viewcontent.cgi?article=1095&context=stcloud_ling

Canadian English, 55 identified them as Minnesotan English, while 125 claimed that the speakers did not sound like a Minnesotan.

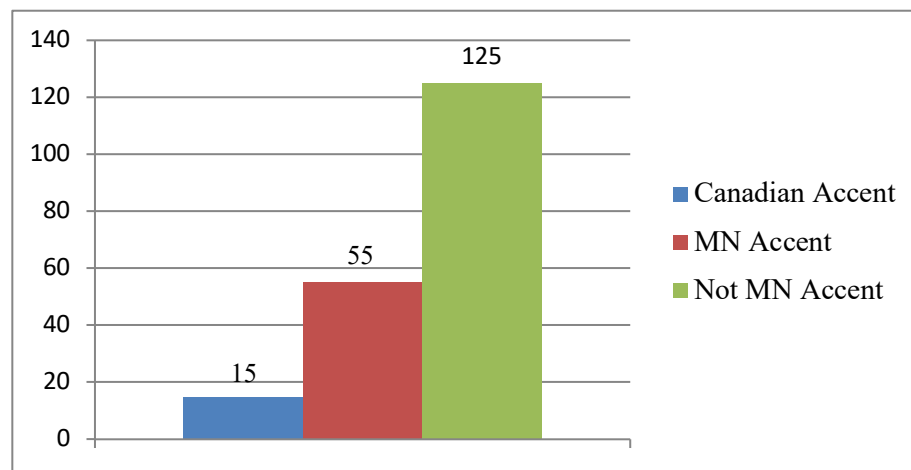


Figure 1: Commentators on Video

A commenter by the name *Anonymous Gamming* states his opinion as follows:

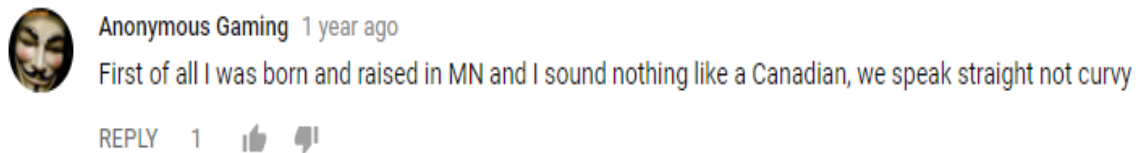


Figure 2: Anonymous Comment

The goal of the current study is to determine whether or not Northern Minnesota English (NMNE) speakers sound like Winnipeg Canadian English (WCE) speakers, and if so, demonstrate the similarities acoustically.

2.0 Geographical Location

Although they are located in two separate countries, Northern Minnesota and Winnipeg are not very far from one another, about 70 miles. Northern Minnesota, for instance, is a region that stretches along the international border of two Canadian provinces, Manitoba and Ontario. Winnipeg, on the other hand, encompasses only a city that is located in southeastern corner of Manitoba, which is only 70 miles north of the former queried region. Therefore, there is not much distance between Northern Minnesota and the city of Winnipeg. However, it should be noted that even though the distance is short, there are in fact natural barriers between them, i.e., an international border, forests, and lakes. The latter extend almost the entire distance across northern Minnesota. The figure below shows each of these areas and their proximity to one another.



Figure 3: A map of Winnipeg and Northern Minnesota
U.S. (Google Image: 2017)

Additionally, northern Minnesota and Winnipeg have similar demographics. The vast region of northern Minnesota has 21 counties and a total population of 550,443 (U.S. Census Bureau: 2010). Likewise, Winnipeg has an overall population of 705,244 persons (Canada Statistics: 2016). The population in northern Minnesota is quite dispersed. The rural areas contain around 15,000 people. The majority of the people in this region live in Duluth, the fourth biggest city in Minnesota (U.S. Census Bureau: 2010). In contrast, Winnipeg is considered urban since its whole population remains within the parameters of one city alone. Figure 3 highlights in red the area from Minnesota whose dialect is compared to the dialect of the Canadian English spoken in Winnipeg:

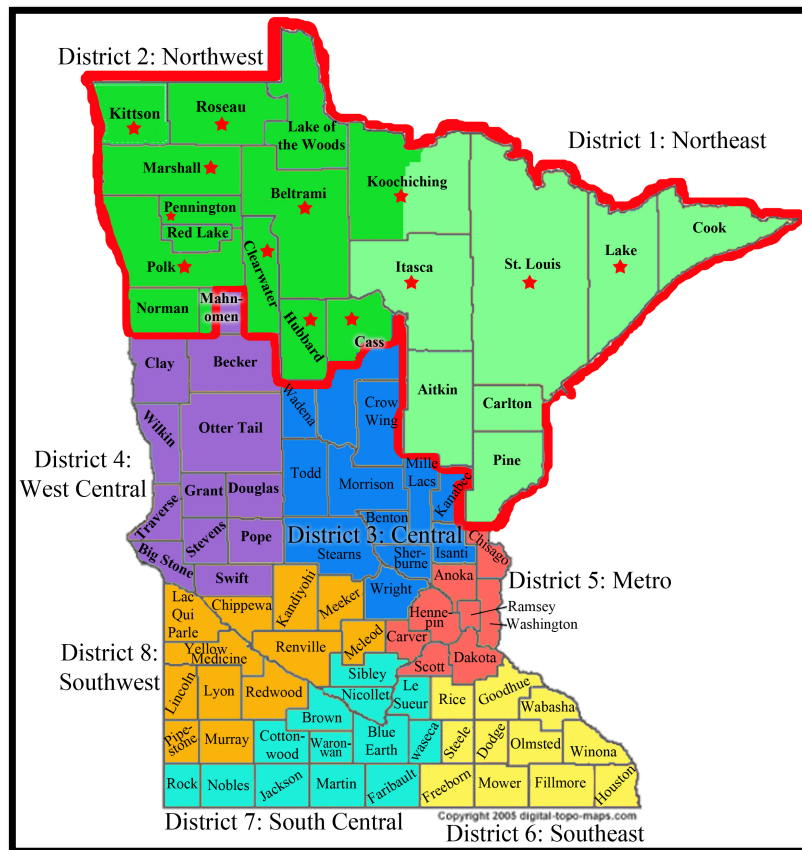


Figure 4: Northern MN districts (Minnesota Department of Transportation (2018))

3.0 The Methodology and Participants

This study replicates Peterson and Barney (1952)'s methodology although there have been slight adaptations to the original such as including the phonemes [o] and [e] as well as adding a third utterance of each vowel sound⁴. The data from northern Minnesota comes from 20 participants who were recorded while producing the words in Table 3.1. Each word was repeated three times.

NO	Phoneme	hVd Structure	Names of Vowels
1.	/i/	heed	fleece
2.	/ɪ/	hid	kiss
3.	/e/	hayed	face
4.	/ɛ/	head	dress
5.	/æ/	had	trap
6.	/ɑ/	hod	lot
7.	/ɔ/	hawed	cloth
8.	/o/	hoed	goat

⁴ For a more in depth look at all the adaptations, please refer to the original study (Backstrom: 2018).

9.	/ʊ/	hood	foot
10.	/u/	who'd	goose
11.	/ʌ/	hud	strut

Table 1: Vowels under investigation

The files were imported to Praat, spliced, measured, and analyzed for six acoustic correlates: F1, F2, F3, duration, F0, and intensity. In total, there were 3, 960 tokens (20 x 11 x 3 x 6), which were analyzed. For the purposes of this paper, only the first two formants: F1 and F2 are discussed. The participants are 20 (10 men and 10 women). They were selected according the following criteria:

1. English is their first language.
2. They have lived the majority of their life in northern Minnesota.
3. Their age bracket is 18 to 64 years.

Tables 2 and 4 provide comprehensive demographic 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 2: Male Participants

All of the men from Table 2 originate from separate counties. There are only few who overlap, such as Speaker 3M, 7M, and 8M. These men grew up in the first county. The successor, if there is one, represents where they were living at the time of the study. It was only Speaker 8M who claimed to grow up in both Beltrami and Hubbard counties. First formant and second formant data collected from these male participants is presented in Table 2.1.

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]
F1	280	424	391	518	611	671	676	457	455	323	555
F2	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385

Table 3: Male Participant's Data

Table 4 provides information about female speakers, while Table 5 display F1 and F2 measurements extracted from their pronunciation of vowels.

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) <i>(math results in 21 years)</i>	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 4: Female Participants⁵

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]
F1	355	493	447	655	825	788	785	509	521	398	664
F2	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596

Table 5: Female Participant's Data

⁵ It should be noted that even though Speaker 1F and 7F do, in fact, spend some time outside of the queried region, this accumulated time transpired after their linguistic formative years, which is between the ages of 1 to 17⁵. Therefore, according to Labov, Rosenfelder and Fruehwald (2013: 39), it should have little to no affect on their accent.

4.0 Data from Winnipeg

The Winnipeg data comes from Hagiwara's (2006) study. The participants are five men and five women from the city of Winnipeg whose ages range from 18 to 25 years.

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]
F1	293	420	364	560	704	637	635	411	459	313	584
F2	2207	1899	2227	1694	1519	1121	1115	899	1340	1328	1770

Table 6: Winnipeg Male Data

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]
F1	392	479	412	712	996	856	891	419	500	387	778
F2	2765	2197	2742	1956	1752	1294	1310	999	1580	1328	1770

Table 7: Winnipeg Female Data

5.0 Threshold Predictions of Dialectal Similarity

Degrees of similarities between dialects of the same language can be predicted on the basis of the acoustic distance between segments on the F1 and F2 frequency bands. On the F1 frequency band, speech signals are deemed similar if the acoustic distance between them is ≤ 60 Hz. Phoneticians are right to look to F1 in inquiring about similarities between dialects because according to Ladefoged and Johnson (2015, p. 207), it alone contains 80% of the acoustic energy of vowels. Consequently, we posit that two dialects are similar if the acoustic distance between vowels on the F1 frequency bandwidth is ≤ 60 Hz (Mermelstein 1978). Labov et al. (2006) made reference to this Just Noticeable Difference (JND) threshold in *Atlas of North American English*. Again, Labov et al. (2013) used this JND in their study on sound change in Philadelphia. It has also been noted that F2 and F3 play some role in dialect variation. Kent and Read (2003, p. 111) state it as follows, "Possibly, the F2 frequency is more sensitive to dialect and idiolectal variation than is F3 frequency." Since the contribution of F2 is more robust than F3, we limit the inquiry to F2. The standard JND on the F2 frequency bandwidth is 200 Hz (Mermelstein 1978). This threshold is higher than the one of 130 Hz reported in Kent and Read (2003, p. 110) or 158 Hz reported in Rabiner and Juang (1993, p. 152). The JND of ≤ 200 Hz is preferred because it is based on the third-Octave bandwidth frequency response system. Using these two JNDs, two dialects are said to be phonetically similar if they meet the criteria stated below:

JND Criterion for Dialectal Similarity⁶

Two or more dialects are said to be phonetically similar if and only if the acoustic distances of most of their vowels is ≤ 60 Hz on the F1 frequency bandwidth and/or ≤ 200 Hz on the F2 frequency bandwidth.

⁶ Dialectal similarity is different from idiolectal similarity. For this criterion to work well, the measurements must be based on aggregated data collected from at least 10 speakers of each dialect group.

Let's apply this threshold to the data to gauge the extent to which Northern Minnesota English is similar or dissimilar to Winnipeg Canadian English. Since male and female data have been displayed separately, we will proceed in like fashion in discussing the results and applications of the measurements. Various degrees of masking are fully discussed in Koffi (2017, p. 109). We limit ourselves to these two because they are the most pertinent to the issue at hand.

6.0 Results and Discussions of Male Data

According to the JND threshold on the F1 frequency bandwidth, 10 of the 11 monophthong vowels produced by NMNE and WCE male speakers are auditorily indistinguishable or almost indistinguishable from each other. Segments are completely indistinguishable from each other if the acoustic distance between them on the F1 frequency bandwidth is ≤ 20 . Segments are somewhat distinguishable from each other if the acoustic distance between them is between > 20 Hz but ≤ 60 Hz.

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]
F1 (NMNE)	280	424	391	518	611	671	676	457	455	323	555
F1 (WCE)	293	420	364	560	704	637	635	411	459	313	584
F1 Difference	13	4	27	42	93	34	41	46	4	10	29

Table 8: F1 data from NMNE men and WCE men (Hagiwara: 2006)

According to these more precise thresholds, if NMNE and WCA male speakers produce the vowels [i, ɪ, ʊ, u], the human ear cannot perceive any difference between them. When they produce the vowels [e, ɛ, ɑ, ɔ, o, ʌ], a very astute listener may possibly hear a tinge of difference. The only segment that can set NMNE males apart from their WCA counterparts is the “trap” vowel [æ]. It is produced somewhat higher by Northern Minnesotans (611 Hz) compared to Winnipeg Canadians (704 Hz).

The similarities between the two male dialects are confirmed by the measurements on the F2 frequency bandwidth. The acoustic distances between vowels are ≤ 200 Hz, except for the vowels [æ] and [ʌ]. The vowel [æ] is still a front vowel in NMNE whereas it is a central vowel in WCE. The reversal is going on with the “strut” vowel [ʌ]. It is produced slightly further back in NMNE whereas it is a central vowel in WCE.

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]
F2 (NMNE)	2310	1922	2153	1831	1733	1222	1262	1056	1342	1157	1385
F2 (WCE)	2207	1899	2227	1694	1519	1121	1115	899	1340	1328	1770
F2 Difference	103	23	74	137	214	101	147	157	2	171	385

Table 9: F2 data from NMNE men WCE men and (Hagiwara: 2006)

The similarities and differences are displayed in the acoustic vowel space in Figure 5. Arrows are used to highlight the vowels [æ] and [ʌ] that are different in the two dialects.

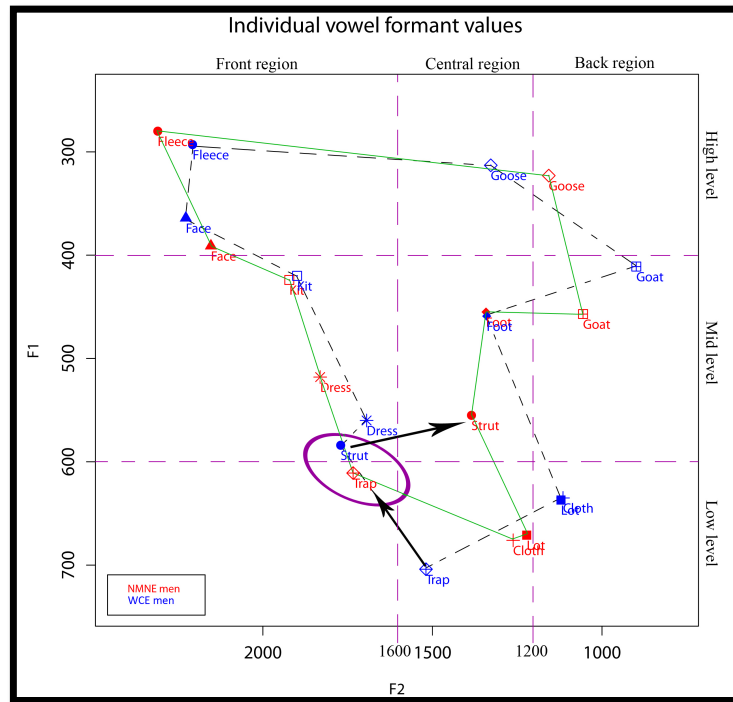


Figure 5: Acoustic vowel space chart for NMNE men and WCE men

7.0 Results and Discussions of Female Data

The same JNDs discussed in section 5.0 are applied to the female data in Tables 9 and 10 below.

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]
F1 (NMNE)	355	493	447	655	825	788	785	509	521	398	664
F1 (WCE)	392	479	412	712	996	856	891	419	500	387	778
F1 Difference	37	14	35	57	171	68	106	90	21	11	114

Table 10: F1 data from NMNE women and WCE women (Hagiwara: 2006)

Six of the 11 vowels produced by NMNE females [i, ɪ, e, ɛ, ʊ, u] are aurally indistinguishable from those produced by their counterparts in WCE. The three vowels that are substantially different are [æ, ɔ, ʌ]. We recall that [æ] and [ʌ] are also different in male speech. The “cloth” vowel [ɔ] is unexpectedly different in female speech in WCE because [ɑ] (856 Hz) and [ɔ] (891 Hz) have not yet fully merged in WCE. The acoustic distance between them is still 35 Hz. However, they have completely merged in female speech in NMNE, since the acoustic distance between them is only 3 Hz, that is, 788 Hz vs. 785 Hz. They have also merged in male speech in both NMNE (671 Hz vs. 676 Hz) and WCE (637 Hz vs. 635 Hz).

The view that F2 plays a very important role in the assessment of dialect variation is upheld by the measurements in Table 11:

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]
F2 (NMNE)	2585	2213	2483	2001	1825	1372	1375	1061	1508	1188	1596
F2 (WCE)	2765	2197	2742	1956	1752	1294	1310	999	1580	1328	1770
F2 Difference	180	16	259	45	73	78	65	62	72	140	174

Table 11: F2 data from NMNE women and WCE women (Hagiwara: 2006)

NMNE and WCE produced their vowels identically from as far as F2 is concerned because the acoustic distance between their respective vowels is ≤ 200 Hz. The only exception to this is the “face” vowel [e]. The similarities and differences in F1 and the similarities in F2 are highlighted by the acoustic vowel space in Figure 6:

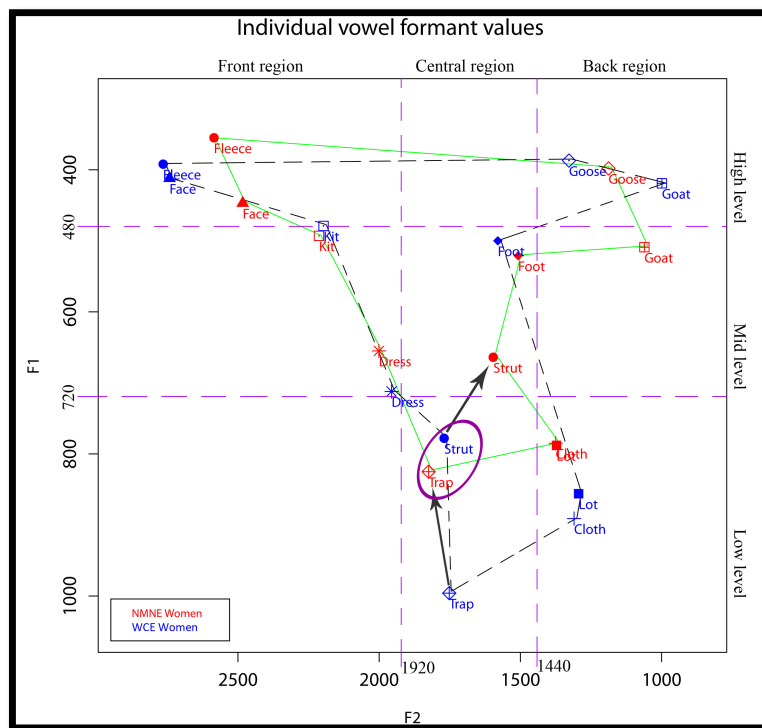


Figure 6: A representation of the acoustic vowel space chart for WCE women and NMNE women.

8.0 Overall Discussions and Implications

Irrespective of the criterion used to gauge dialectal similarities and differences, be it F1 or F2, or F1 and F2 combined, NMNE and WCE are almost identical. No wonder that outsiders mistake Minnesotans for Canadians. The same phonological processes of lowering of high lax vowels apply in both dialectal varieties (Koffi 2016). That Minnesotans sound like Canadians should not come as a surprise. Yet, it is good to present sociophonetic evidence to support this popular intuition. However, as far as sociolinguistic theory is concerned, the most important

finding in this paper is the fact that the similarities between the two dialects manifest themselves differently in the speech of males and females. Our data shows that dialectal similarities are manifested in the F1 signals in male speech whereas, in female speech F2 is the main correlate. If these observations hold in other dialects, then this would be a significant development in sociolinguistic research.

9.0 Voice biometric Implications and Applications

Extracted acoustic phonetic features can be put to a wide variety of uses. The motivating factor behind this paper is to account for the sociophonetic similarities and differences between NMNE and WCE. Yet, the data can be put to voice biometric use for the purposes of speaker verification or identification. The similarities between NMNE and WCE notwithstanding, the same measurements can be used for purposes of forensic analysis. F1 and F2 correlates can be used to apprehend criminals or verify the identity of people crossing US-Canadian border simply by having them say a few words in which the vowels [æ] and [ʌ] occur. Their F1s and F2s effectively discriminates between NMNE and WCE males and females. If further differentiation is needed, the F1 of [o] and [ɔ] can be used to set NMNE females apart from their counterparts who speak WCE.

10.0 Summary

Although there has been a lot of personal opinions out there about whether Minnesotans sound like Canadians or not, this study was able to confirm specifically that Northern Minnesotan English speakers do in fact sound very similar to Winnipeg Canadian English speakers. According to the data found here, they differ by only a few vowel sounds. Men sound more alike in F1 while women sound more alike in F2. The same phonological processes operate in both dialects. Both men and women from Winnipeg and northern Minnesota have raised the “face” vowel [e] and lowered the “kiss” vowel [ɪ]. Both have fronted and lowered the “foot” vowel [ʊ]. Even though women in Winnipeg have not yet merged the “lot” vowel [ɑ] and the “cloth” vowel [ɔ], like their male counterparts or female speakers in NMNE, this is only a matter of time because the acoustic distance between them has been reduced to only 35 Hz. In our considered opinions, this paper makes a significant contribution to sociolinguistics in providing that similarities between dialects can be proven acoustically by relying either F1 or F2 or on F1 and F2. Our main findings are that male NMNE speakers sound like male WCE speakers because of F1, while female NMNE speakers sound like female WCE speakers because of F2.

ABOUT THE AUTHORS

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 published a paper on the Northern Minnesota English dialect. Additionally, 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.

Ettien Koffi, Ph.D. linguistics, teaches at Saint Cloud State University, MN. He is the author of four books and author/co-author of several dozen articles on acoustic phonetics, phonology, language planning and policy, emergent orthographies, syntax, and translation. His acoustic phonetic research is synergetic, encompassing L2 acoustic phonetics of English (Speech Intelligibility from the perspectives of the Critical Band Theory), sociophonetics of Central Minnesota English, general acoustic phonetics of Anyi (a West African language), acoustic phonetic feature extraction for application in Automatic Speech Recognition (ASR) and Text-to-Speech (TTS), and voice biometrics for speaker verification. He can be reached at enkoffi@stcloudstate.edu.

References

- Backstrom, M (2019). An acoustic phonetic analysis of northern Minnesota English vowel spaces. Saint Cloud State University, MN. USA. *Linguistic Portfolios* 8: 25-38.
- Bartholdi, M. (2015). Are you Minnesota enough? *TPT Rewire*. Retrieve from https://www.youtube.com/watch?v=iVINI_LX47I
- Google Image (2017). The miracle of Minneapolis: “the Canadian border strikes again,...”.VDARE.com. Retrieve from https://www.google.com/imgres?imgurl=https://vdare.com/wp-content/uploads/2015/02/canada-map1.png&imgrefurl=https://vdare.com/posts/the-miracle-of-minneapolis-the-canadian-border-strikes-again&h=373&w=500&tbnid=s7YoGCtIsQAA5M&tbnh=194&tbnw=260&usq=__GtKHF5ss3C1kLYdrsHbhCuwSjGw=&hl=en&docid=H5245FHLbVia6M
- Hagiwara, R. (2006). Vowel production in Winnipeg. *Canadian journal of Linguistics*, 52(2-3). University of Manitoba. MB, CA.
- Koffi, E. (2017). Relevant acoustic phonetics of L2 English: Focus on intelligibility. (Course Manuscript), St. Cloud, MN.
- Koffi, E. (2016). The Lowering of high lax vowels in Central Minnesota English: Does it happen in other dialects? *Linguistic Portfolios* 5: 2-14.
- Koffi, E. (2016). The acoustic correlates of [±ATR] vowels: An analysis by reference levels of Anyi vowels. *Linguistic Portfolios* 5: 115-134.
- Ladefoged, P., & Johnson, K. (2015). A course in phonetics (7th ed.). Cengage Learning: Stamford, CT, USA.
- Minnesota Department of Transportation. (2018). Minnesota [2018]. Retrieved from <http://www.dot.state.mn.us/>
- Labov, W., Rosenfelder, I., & Fruehwald, J. (2013). One hundred years of sound changes in Philadelphia: Linear incrementation, reversal, and reanalysis. *Language*, 89(1). Linguistic Society of America.
- Labov, W., Ash S., & Boberg C. (2006). *Atlas of North American English: Phonetics, Phonology, and Sound Change*. Mouton de Gruyter: New York.
- Mermelstein, P. (1978). Difference Limens for Formant Frequency of Steady-state and Consonant-bound Vowels. *Journal of the Acoustical Society of America* 63 (2):527-680.
- Peterson, G., E., & Barney, H., L. (1952). Control methods in a study of the vowels. *The Journal of the Acoustic Society in America*, 24(2).

Rabiner L., & Juang BH. 1993. *Fundamentals pf Speech Recognition*. Englewood Cliffs, NJ: Prentice Hall.

Statistics Canada. 2018. Retrieved from <http://www.statcan.gc.ca/eng/start>

U.S. Census Bureau. (2010). Minnesota counties [July 2010]. Retrieved from <https://www.census.gov/quickfacts/table/PST045216/27017,27137>