Models of Northern Cities Vowel Shift Reversal and Other Vocalic Phenomena in Michigan

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Abstract

This study investigates the vowels of Michigan's Lower Peninsula in order to document any patterns of the Northern Cities Vowel Shift (NCS) reversal as well as any other vocalic phenomena. I demonstrate that Michigan vowel spaces differ by demographic and region by surveying vowels from urban and non-urban areas while observing participant age and sex to create a chronology for various vocalic phenomena in the Michiganders. This study surveys vowels produced by 25 native born Michigan residents from the East, West, and Northern Lower Peninsula of the state, with representatives from urban, suburban, and rural areas ranging in three Age-Groups spanning from the 1940s to the early 2000s. Participants were presented with a 175 item wordlist to pronounce in automated succession isolating nine monophthong target vowels /i, ɪ, ɛ, æ, ʌ, u, ʊ, ɔ, ɑ/. I first provide the results for the collective regions, derived from the average vowel positions of East, West, and Northern Michigan, finding all the regions having shifted /æ, ɑ, ɛ/ in accordance to the NCS, but with no indication of progression or reversal. I then analyze each region using the three Age-Groups to provide a chronological direction to the data, finding clear reversal by the 1990s in East and West Michigan. Using speaker demographics, I present two different models of Northern Cities Reversal, with West Michigan reversing in young women independent of environment and East Michigan reversing in non-urban environments. The two models of reversal observed provide an interesting insight into the nature of vocalic change and patterns of language change, where the Northern Cities Shift advances in a uniform manner throughout the Inland North in set stages but is shown here to have two patterns of reversal. Further observations into the other phenomena, especially the fronting of /u/ and its contributing factors are of particular worth for future investigation due to the insight it might offer on what processes are viable for the engenderment of language change.

Introduction

Goals & Background

In the course of this project I undertake three tasks: to survey and catalogue the vowels of Michigan's Lower Peninsula, diagnose the extent of the Northern Cities Vowel Shift (NCS) in the region, and document the stages of the NCS and any other phenomena in apparent time noting the various geographic and demographic boundaries they may observe.

The Lower Peninsula of Michigan is the southern portion of the State of Michigan nestled by the Great Lakes in the Northern-Midwest of the United States. The northern portion of the state, the Upper Peninsula is a topic of its own study and is not included in these findings. Michigan is considered to be part of the Inland North dialect of North American English (Labov et al., 2006) and is subject to the Northern Cities Vowel Shift that began with the influx of workers to the Erie Canal built from 1817-1825 ("Canal History," n.d.), resulting in a six stage vowel chain shift starting in major midwestern cities surrounding the Great Lakes. It has been documented in Rochester, Syracus, Buffalo, Detroit, Kalamazoo, Grand Rapids, Cleveland, Toledo, Gary, Hammond, Chicago, Rockford, Milwaukee, Madison, as well as other periphery cities to those (Hillenbrand, 2003).

Stages of the Northern Cities Shift

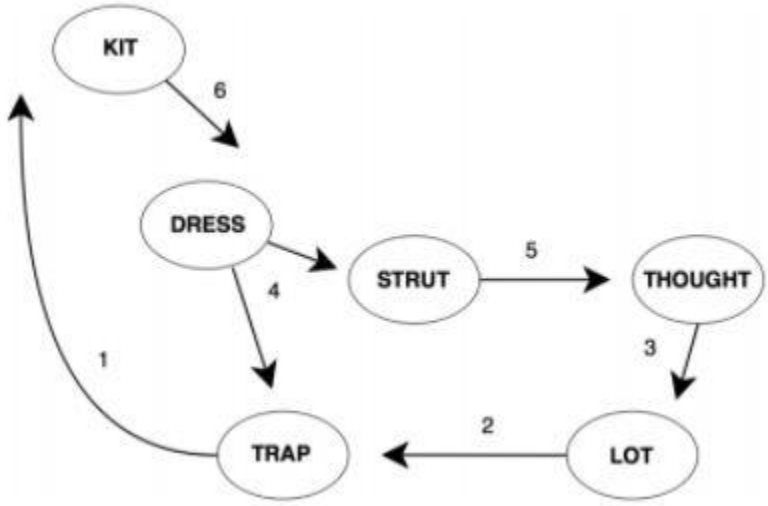
1) /æ/ fronts and raises above /ɛ/
2) /ɑ/ fronts towards the former position of /æ/
3) /ɔ/ lowers toward the former position of /ɑ/
4) /ɛ/ lowers and backs

5) /ʌ/ backs towards the former position of /ɔ/

6) /ɪ/ lowers towards the general direction of /ɛ/

Figure 1

Mechanism of the Northern Cities Shift **(Wagner et al., 2016)**



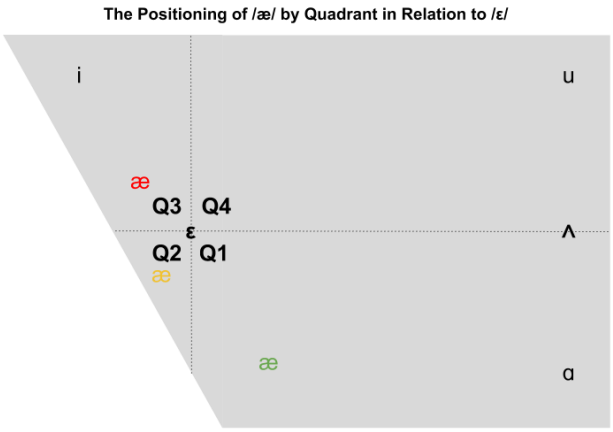
Fasold 1969 makes some of the first observations on the NCS, taking note of a shift in the vowels /æ/ /ɑ/ /ɔ/ in Detroit accompanied by diphthongization in some vowels and that variation could be observed between groups by terms of socio-economic class, sex, and age (Fasold, 1969).

Labov (2007) analyzed the relationship between the rate of NCS progression and how it is transmitted between individuals and generations, concluding that the slow and partial "diluted" transmission of the NCS was more indicative of transmission between adults where every speaker introduced to the shift begins with the first stage rather than a completed shift. While a child born in a family with complete shifted vowels and who has grown up in a predominantly shifted community may adopt the whole shift, the principal continuation of the shift is by

partially or un-shifted adult speakers adopting the most adjacent stage of the shift. This mechanism helps explain why urban areas are the first to adopt the shift, as they contain a higher population density to permit a higher concentration of certain speakers to encourage a perception of prestige, and also undergo more speaker traffic, with city-to-city movement bypassing less populous medial regions, which only undergo shifts themselves when adequate social-pressure has diffused from more urban areas. Labov also lists a string of tests in *The Atlas Of North American English* (*ANAE*) for a researcher to apply to any vowel data in order to diagnose the presence or absence of the NCS. The EQ Measure is the diagnostic most discussed here. It tracks the position of /æ/, designating four quadrants of its positioning: Quadrant 1 (Q1) signifies /æ/ in its expected unshifted position below and behind /ɛ/. Quadrant 2 (Q2) sees the fronting of /æ/ before /ɛ/ and Quadrant 3 sees the full extent of the Northern Cities' shift of /æ/ by raising the fronted vowel above /ɛ/. There is no documented attestations of Quadrant 4, where /æ/ has raised above /ɛ/ but has backed behind it as well (Labov et al., 2006). These quadrants are referenced frequently in this paper wherever the positioning of /æ/ is discussed and can be seen illustrated below in Figure 2.

Figure 2

***Quadrants of* /æ/**



Note. Quadrants are diagnostic to the first stage of the Northern Cities Shift, with Q1 representing no shift, Q2 the shift in early progression or regression, Q3 with /æ/ in its fully shifted position.

Roeder (2010) observed variation among Age-Groups in Lansing, Michigan over their extent of NCS, as well as identified women as the primary actors of linguistic change in their community but was unable to determine whether the NCS was ongoing or not. Wagner et al. (2016) however, confirms in Lansing that in younger groups of people the effects of the NCS are reversing while /æ/ undergoes its own patterning, reversing in the NCS (lowering) but becoming more split by continuing to raise its pre-nasal allophone.

The findings about /æ/ are confirmed by Hillenbrand (1995) and (2003) investigating perception of vowels in North America, noting that /æ/-/ɛ/, /u/-/ʊ/, and /e/-/ɛ/ show lengthening and diphthongization in at least one of the pairs to disambiguate them from another.

In the course of this study, much is compared to previous findings and observations of phenomena, from the Northern Cities Shift to related and unrelated vowel character such as the diphthongization of /æ/ or the fronting of /u/. The final asset in observing these is the *The Atlas of North American English* by Labov, Ash, and Boberg, which documents vowels across North America giving reference to many tests and classifications of vowels, including the EQ, ED, and UD Measures to diagnose the NCS presence in a given speaker (see under "Demographic Results"). The data therein is collected from the Teslur Telephone Survey conducted from 1992-1999.

Methods

Materials

The survey tested the vowels /i, ɪ, ɛ, æ, ʌ, u, ʊ, ɔ, ɑ/. I use the IPA throughout with exception to orthographic representations, usually for digraphs such as <sh> (/ʃ/). For each of these vowels there are five sets of minimal pairs. Direct minimal pairs where each vowel is between the same consonants for every vowel were not always possible for each combination of consonant types, but it was ensured that every entry did have an associated entry with which to form a pair. The different consonant combinations surrounding the tested vowels represented combinations of stops /p,b,t,d,k,g/, fricatives /f,v,s,ʃ, h/, liquids /ɹ, l/ and vowel initial entries. Another set was created placing each vowel in a pre-nasal environment (/m, n/) in five variations. If any entry had a pre-nasal environment in the first set, it was re-used for the pre-nasal set.

These 175 word entries (see Appendix B) were then compiled and randomized into the list. Each entry in the list was assigned a slide in an automated slideshow that progressed one

slide every 1.30 seconds. No standardized recording equipment or software was able to be used in collecting samples.

Test Population

The population of the survey was limited to native English speaking adult (18+) residents of Michigan who had lived in the state from ages 4-15 to ensure that the bulk of their linguistic exposure that might affect their speech was with other people in the target area of Michigan.

Participants were classed into three different age-groups. The first consisted of participants born from 1940-1956 (ages 65-80 at time of study), those from 1960-1980 (ages 40-60), and 1990-2002 (ages 30-18). The age-groups are designated Eldest, Middle, and Youngest respectively. There were five members of the Eldest Age-Group, thirteen in the Middle Age-Group, and eight in the Youngest Age-Group.

The study consists of a population of twelve male participants and fourteen female participants. The Eldest Age-Group has a male/female ratio of 2:3, the Middle Age-Group a ratio of 6:10, and the Youngest Age-Group a ratio of 4:4.

Twelve participants were childhood residents exclusively of West Michigan, and nine exclusive childhood residents of East Michigan. Only one participant was exclusively from the Northern Lower Peninsula.

Two participants were of mixed residence: these are representative of both Northern and Western Michigan having moved between these regions during the critical residence period of the study (ages 4-15). They are principally representative of West Michigan, but due to their extensive time in Northern Michigan and the lack of participants in this region, they are also

analysed for the North. Due to this, combined with the lack of participants from Northern Michigan, conclusive results for the region are impossible to draw, thus any statements made concerning Northern Michigan should be viewed as a preliminary survey of the region, and further research is required.

The terms by which a participant is classified as a member of urban, suburban, rural, or any combination of those descriptions was determined by two factors. The first was individual participant response concerning the environment in which they grew up as a child, and were provided with the choices of urban, suburban, or rural. The second factor was a review of census data relevant to the time of that participant's upbringing, with population densities $+1000/km^2$ considered as urban, everything below $500/km^2$ rural, and those in between suburban. A designation of multiple environments is a result of either the population density of the region in question being very close to the bounds determined above and differs from participant response, or it was designated by the participant that they dwelt in multiple environments for equal periods of time.

For more information on the demographic breakdown of the test population, refer to Appendix A.

Procedure

Participants were presented with an online survey inquiring about their demographics before recording their samples. The questions focused on year of birth, sex, the city where their childhood speech interactions occurred, and whether that environment was urban, suburban, or rural. Participant evaluation of population density was later referenced with census data to

confirm their evaluation with the parameters set by this study, but were also evaluated if the participant specified they grew up outside of the bounds of the general census data. This demographic data is in turn linked with the audio samples each participant submitted.

Following the survey, participants were instructed to begin recording and start the automated slideshow and to read the presented words when "prompted, in a normal, conversational voice." Following a countdown, participants were presented with the target words from the list by increments of 1.30 seconds. Participants were allowed to slow the timing between slides by increments of 0.20 seconds but there was no recorded instance of this occurring. The automated timing was meant to discourage careful articulation of words as regular speech was desired for the analysis of the vowels. By limiting the time available for the participant to produce the word it encourages them to pronounce the word they would in regular speech rather than how they might perceive it to be "properly" pronounced.

Once the slide show had finished, participants were instructed to exit the presentation and stop recording and then submit the sample.

Collected audio samples were analysed for data using speech and phonetic analysis software. Formant positions were extracted from spectrograms of the samples for analysis. The site of formant sampling was determined by the following set of hierarchical criteria:

- At the longest, stablest formant
- At the clearest formant
- At a distance from any consonants that would affect the formant positioning
- At or close to 50% vowel duration

Formants are high amplitude frequency bands that appear in spectrograms of speech that are markers used by the brain to identify vowels and other phonetic features. The First Formant (F1) is used to identify the height of a vowel in the vowel space (between the palate and soft palate of the mouth), where the lower the frequency of the formant the higher the vowel is articulated in the vowel space. The Second Formant (F2) is used to identify the advancement of a vowel in the vowel space, where the higher the frequency of the formant the more towards the front of the vowel space the vowel is articulated. Only F1 and F2 are of importance in this study.

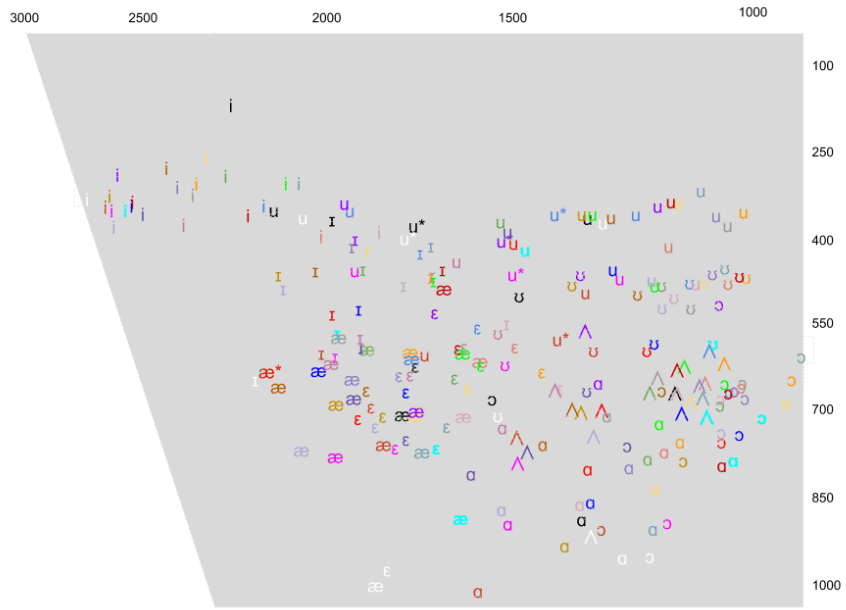
Results

Data

The resulting data was transferred onto a vowel chart, with the x-axis corresponding with Second Formant (vowel advancement) and the y-axis corresponding with the First Formant (vowel height), providing a representation of where the vowels occur within the vowel space. In Figure 3, the average vowels of individual participants are coded by colour.

Figure 3

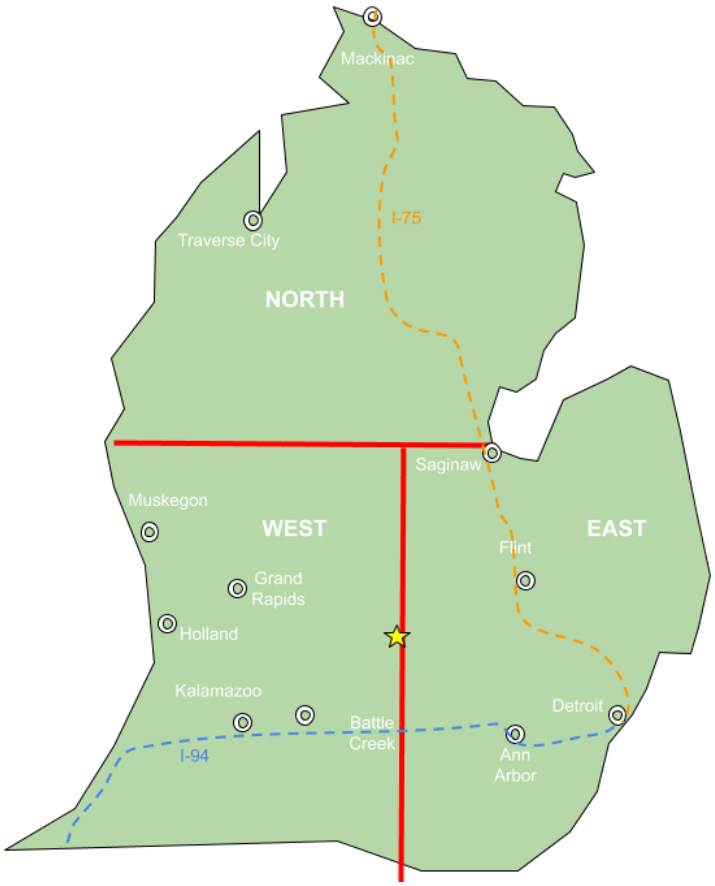
Vowel Chart of Individual Michiganders



This data was then organized by geographic region and the demographic divisions of this study. The first division of the data was along the bounds of North, East, and West Michigan as seen in Figure 4. In the study, the division between East and West was on what side a site fell in accordance with the state capital of Lansing, and along between these southerly divisions and the North rests in a line crossing Michigan by the crook of the Thumb, thus roughly speaking anything above Saginaw is considered Northern Michigan by this study. It should be noted that these divisions were made purely for analysis based on geographic factors and do not necessarily correlate with any dialectical boundaries unless reinforced by any isoglosses that bundle over these designations.

Figure 4

Map of Study Regions in the Lower Peninsula of Michigan



These regions were then divided again along the various demographic divisions collected by the study for further analysis. Each region provided an average vowel position derived from the mean value of that vowel of each participant in each that region, which can be seen displayed in Table 1. The F1 positions of these are illustrated in comparison by region in Figure 5 with higher values corresponding with lower vowel height. F2 positions for each region are compared in Figure 6 in direct correspondence with vowel advancement.

Table 1

Regional Average Vowel Positions and (Standard Deviation)

Formants (Hz)		**/i/**	**/ɪ/**	**/ɛ/**	**/æ/**	**/u/**	**/ʊ/**	**/ʌ/**	**/ɔ/**	**/ɑ/**
East N=9	**F1**	341 (69)	496 (73)	683 (86)	719 (70)	396 (53)	520 (54)	669 (80)	693 (108)	808 (112)
	F2	2385 (280)	1877 (174)	1736 (163)	1906 (199)	1471 (354)	1323 (188)	1278 (136)	1187 (204)	1382 (134)
West N=14	**F1**	361 (46)	532 (72)	720 (98)	704 (119)	393 (34)	547 (73)	701 (80)	726 (84)	815 (79)
	F2	2528 (220)	1966 (154)	1775 (128)	1959 (170)	1401 (254)	1284 (175)	1290 (147)	1113 (133)	1383 (159)
North N=3	**F1**	381 (4)	539 (49)	672 (79)	628 (18)	414 (12)	557 (41)	669 (57)	693 (48)	770 (64)
	F2	2385 (277)	1905 (182)	1730 (193)	2000 (306)	1485 (196)	1322 (219)	1309 (145)	1077 (60)	1442 (154)

Note. The standard deviation for F1 in one participant speaker's vowels was on average 51, and for F2 it was 117.

Figure 5

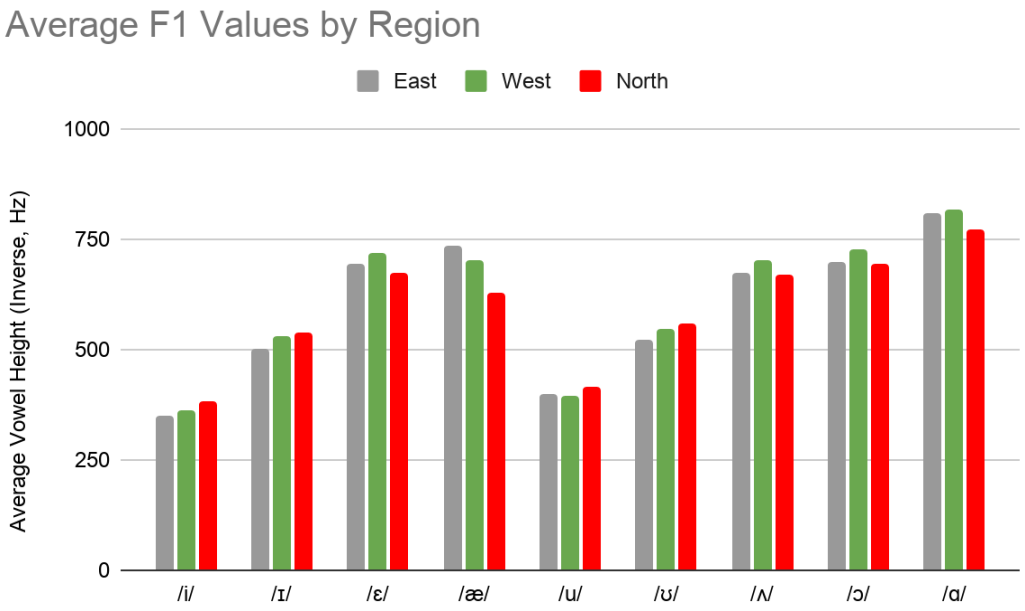
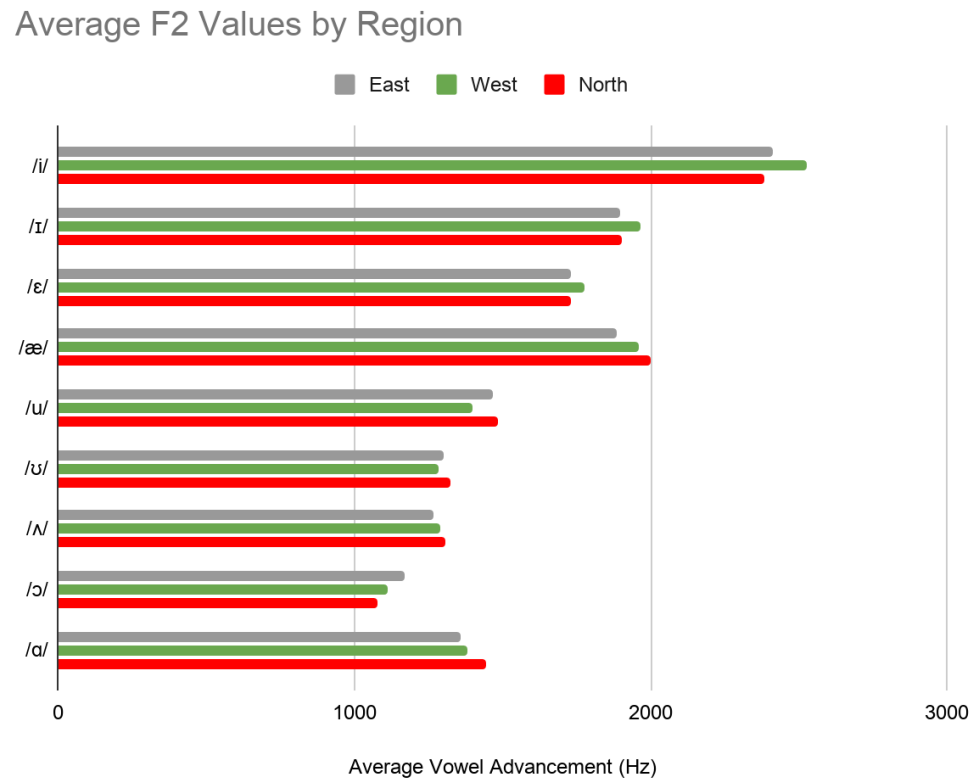


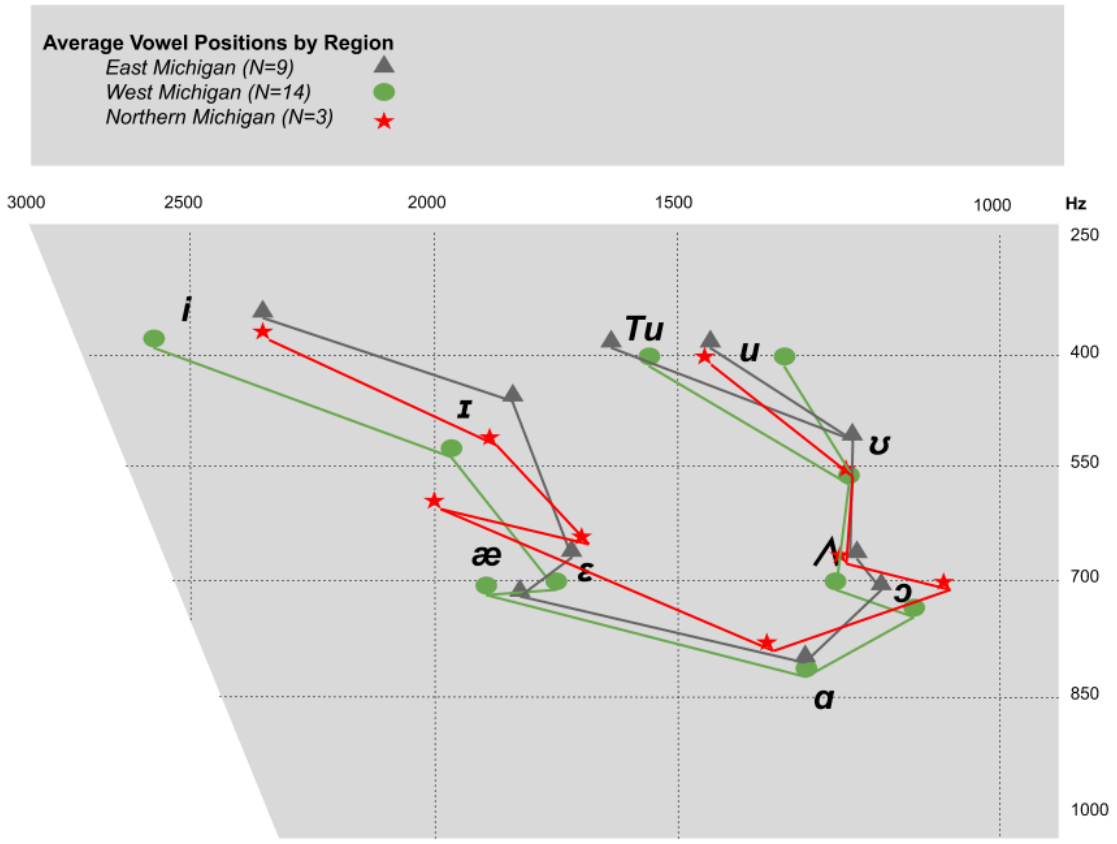
Figure 6



The vowel chart below in Figure 7 demonstrates the regional average vowels in a chart compared with one another. Trace lines connect the vowel positions to facilitate recognition of shared shapes or attributes in the vowel space, such as the jutting forward indicative of Second and Third Quadrant /æ/.

Figure 7

Vowel Chart Comparing Michigan Regional Averages



Note. Vowels reflect the average vowels of all the participants of their regions, independent of any other demographic divisions.

Figure 7 demonstrates the average /æ/ to reside in Q2 in East Michigan, and be on the border of Q2 and Q2 in West Michigan, while Northern Michigan exhibits a strong Q3 vowel. All regions demonstrate a moderately fronted /ɑ/, slightly more fronted in Northern Michigan than elsewhere. The rest of the back vowels appear in their unshifted positions, and /u/ is on average fronted in all the regions with East and West Michigan demonstrating some allophony between coronal (labeled as /Tu/) and non-coronal /u/ where /Tu/ is fronted further. Also in all regions, /ɪ/ and /ɛ/ show some signs of potential backing due to their distance from /i/.

The following tests are used to identify prevalent NCS vowels.

Table 2

Michigan NCS Diagnostic Tests by Region

		/i/	/ɪ/	/ɛ/	/æ/	/u/	/ʊ/	/ʌ/	/ɔ/	/ɑ/
East N=9	**F1**	341	496	683	719	396	520	669	693	808
	F2	2385	1877	1736	1906	1471	1323	1278	1187	1382
NCS Tests				**Q2**	ae F1 <700			**F2∧<F2a**		**F2e-F2a<375**

		/i/	/ɪ/	/ɛ/	/æ/	/u/	/ʊ/	/ʌ/	/ɔ/	/ɑ/
West N=14	**F1**	361	532	720	704	393	547	701	726	815
	F2	2528	1966	1775	1959	1401	1284	1290	1113	1383
NCS Tests				**Q3**	ae F1 <700			**F2∧<F2a**		**F2e-F2a<375**

		/i/	/ɪ/	/ɛ/	/æ/	/u/	/ʊ/	/ʌ/	/ɔ/	/ɑ/
North N=3	**F1**	381	539	672	628	414	557	669	693	770
	F2	2385	1905	1730	2000	1485	1322	1309	1077	1442
NCS Tests				**Q3**	ae F1 <700			**F2∧<F2a**		**F2e-F2a<375**

- The ‘Q’ marks the quadrant /æ/ is in with Q3 as red, Q2 as yellow, and Q1 as green. All other tests mark green for fulfilled and red for failed. This is known as the EQ Measure. A passed EQ is considered to be in Quadrant 3. A change in progress will be in or approaching a boundary of Quadrant 2.

- The test ‘ae F1 < 700’ is checking if the First Formant (vowel height) is less than 700. If so, then that is indicative of a raised /æ/.

- The test ‘F2 ʌ < F2 a’ checks to see if /ʌ/ is behind /ɑ/, which is indicative of an /ɑ/ in the process of fronting and a /ʌ/ in the process of backing. This is known as the UD Measure.

- The test ‘F2 e - F2 a < 375’ checks that the difference between the Second Formant values (vowel advancement) is less than 375Hz. This is indicative of /ɛ/ backing and an /ɑ/ fronting. This is known as the ED Measure.

These measures are important indicators in the consideration that every individual vowel space is unique to itself, meaning it is difficult to track similar spaces on a chart when identical phenomena can be occurring in different places depending on the speaker. These tests represent the phenomenon regardless of the whole vowel space’s position but rather refer to the positions of the vowels in relation to one another in that speaker.

A combination of the EQ, ED, and UD Measures are considered by to be the minimum bundle of isoglosses to delineate a region of having a strong NCS vowel space (Labov et al., 2006). As composites of the population in those regions, neither East Michigan nor West nor North Michigan have all three isoglosses bundled; however, the author argues that the EQ and UD measurements are more indicative of the NCS than the ED. If the ED is eliminated as a requirement, then both North and West Michigan qualify as regions where the Northern Cities Shift is prevalent. Interestingly enough this is not the case in East Michigan where the NCS entered the state through Detroit in the first place, and is historically the bastion of the shift

within the state and a prevalent NCS city among the other urban regions in the Inland North (Labov et al., 2006).

Analysis of the results is presented in three stages. The first two are organized by region with the first being the overall results of the average population and the second concerned with how vowels may vary by the demographics of age, sex, and population density of the area. Finally, stage three is devoted to the other phenomena observed in the data and an exploration of their demographic distributions.

Analysis of the Age-Groups permits the viewing of the vowels in apparent time, theoretically making postulate that the data from older speakers are representative of those prevalent during the time they were learning language and has not changed since (Bailey, 2002). While adults may not always maintain previous pronunciations, if, as an identifiable group in age (with or without additional demographic classifications) demonstrate a unified trait in contrast to a group of another age, it should be likely that the traits observed in these groups are particular to those groups. It is similarity, not disparity between groups that becomes much more difficult to decisively determine without a chronic iterative study whether that trait is due to continuation of a native trait or merely an adoption of another group's traits. Transparent analysis of age is given where possible.

Regional Results

Under examination of the whole region, East and West Michigan show very little variation in Figure 7, and the principal difference in Northern Michigan is the positioning of /æ/. It is important to recognize, however, that this is indicative only of the region as a whole being a

composite of all the participants of that region without accounting for any variation of participant speakers' age or demographic. So while the three regions of the Lower Peninsula show remarkable similarity in their collective vowels, the components that make up that collective pattern differ from one another and require their own analysis, region by region.

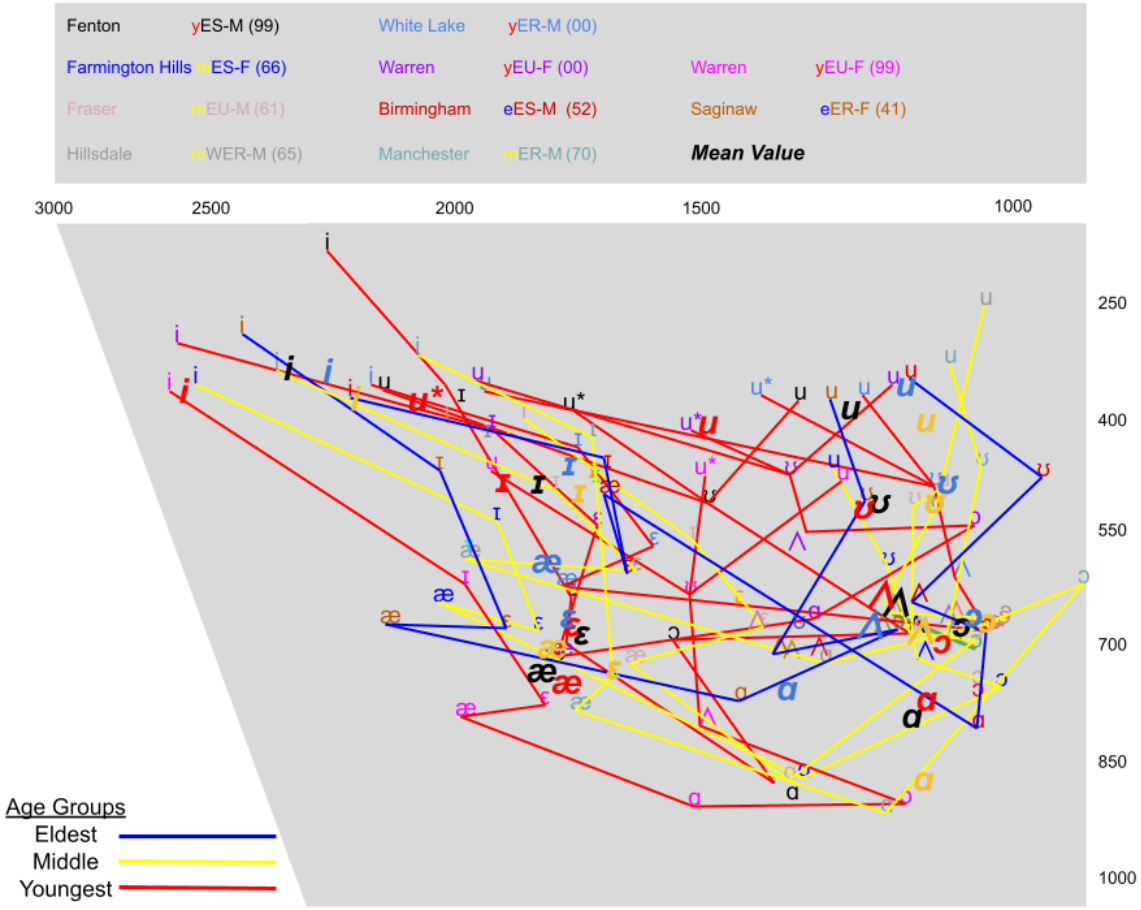
East Michigan

East Michigan displays /æ/ in Q2 advanced in front of but not raised above /ɛ/. The position of /ɑ/ is back, not fronted with /ʌ/ and /ɔ/ also in non-NCS positions, and /u/ demonstrating allophony between post-cornonal and non-coronal positions with post-coronal vowels (/Tu/) being slightly more advanced. There continues to be little to no evidence of a 'cot/caught' merger of /ɑ/ and /ɔ/ in the region.

In Figure 8, East Michigan participants can be seen coded by Age-Group. The individual participant data points are preserved in accordance with their colour, but the trace lines are coded blue for the Eldest Age-Group (1940-1956), yellow for the Middle Age-Group (1960-1980), and red for the Youngest Age-Group (1990-2002). The mean values for each group are portrayed in large italicized characters corresponding to the colour of their respective Age-Groups.

Figure 8

Vowel Space of East Michigan Sorted by Age-Groups



Note. Age-Group divisions are Eldest (1940-1955), Middle (1960-1980), Youngest (1990-2002).

The Middle Age-Group does show a general grouping in the shape of its vowel space, while the Eldest group shows a weaker but identifiable shape, suggesting a general shared vowel space in that group as well. The Youngest Age-Group shows the greatest variation in its positioning, which suggests stronger variation of pronunciation dependent on other demographic factors. Analysis of the standard deviation in each group as seen in Table 3 reveals that the two older groups have comparable variability while the Youngest group is confirmed to be the more variable. The general trend of F1 being more consistent among speakers than F2 visible in Table

1 is further supported by Table 3, suggesting that vowel height is a much more significant part of vowel production and perception in the region than vowel advancement.

Table 3

East Michigan Vowel Standard Deviation by Age-Group

	Formant (Hz)	/i/	/ɪ/	/ɛ/	/æ/	/u/	/ʊ/	/ʌ/	/ɔ/	/ɑ/	Mean	Combined Mean
α 1940-1956	F1	7	33	46	103	14	3	44	19	31	33	
	F2	163	308	299	360	27	124	146	134	28	177	105
β 1960-1980	F1	76	63	19	42	74	65	20	59	43	51	
	F2	353	188	166	255	61	91	64	125	120	158	105
ɣ 1990-2002	F1	82	96	121	94	39	62	114	157	144	101	
	F2	250	126	123	118	140	173	146	240	165	165	133

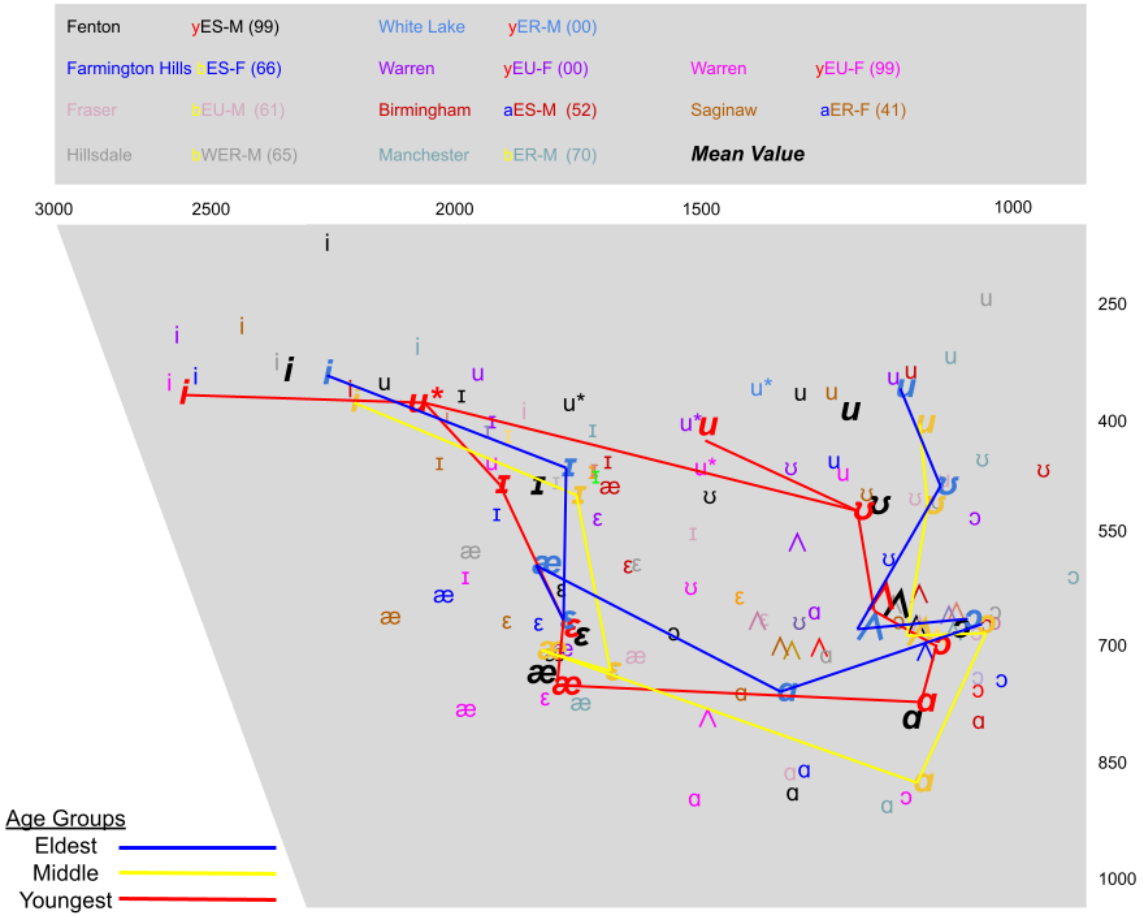
More general trends are easier to identify when the trace lines are removed, as shown in Figure 9 below, where the trace lines are limited to the average positions of vowels for each Age-Group. Where the above Figure 8 shows the disparity among individuals of an Age-Group, Figure 9 demonstrates how these groups compare directly with one another in their distribution of vowels.

The Eldest Age-Group has /æ/ in Q3 with /ɑ/ fronting and /u/ in a back position. In the Middle Age-Group /æ/ stays in Q3 but to a lesser degree, while /ɑ/ is further back and /u/ remains in its back position. The Youngest Age-Group has /æ/ lowered back to Q2, maintaining

a backed /ɑ/ and demonstrates strong allophony of /u/ and an overall fronting of the vowel independent from the rest of the back-vowel system.

Figure 9

Average Vowel Space for East Michigan Age-Groups



Note. Age-Group divisions are Eldest (1940-1955), Middle (1960-1980), Youngest (1990-2002).

Together, this makes it very clear that the effects of the NCS were largely halted in the east of Michigan between the 1940s and 1950s, and began regression shortly thereafter. While advancement of the NCS has been shown to occur in stages as the chain shift drags on other

vowels, it is likely that regression would occur at once in many vowels, as it is a social change in pronunciation conforming to another group rather than a social change in response to a chain shift. The assimilation would be to a complete non-NCS pronunciation rather than a partial chain-shifted one (Labov, 2007, p. 380) Thus, if regression had occured before the 1940s, the vowels not affected by the shift would be unmoved while those that had undergone it (/æ/ and /ɑ/) were. It is therefore logical to deduce that the shift had progressed up to the 1940s and 1950s before regression began to occur.

Table 2, which contains the results for NCS Diagnostics in East Michigan exhibits a relatively strong NCS system for the region, only failing the tests concerning /æ/. This vowel is notable however, as it is the first stage in the shift, and failure here may be indicative of the health of the entire system, and so it becomes beneficial to make closer analysis along demographic lines.

The tables below are similar to Table 2, and indicate green (Q1), yellow (Q2), and red (Q3) for the progressing stages of the EQ measure (quadrants), and red/green fail/pass indicators for the rest of the tests.

The first table (4) represents the test results for the rural and suburban areas of East Michigan listed in chronological order that demonstrates a weaker NCS in rural areas that weakens further as time progresses, and while a much stronger NCS is present in suburban areas in 1967, it too weakens by the 1990s.

Table 4

East Michigan Rural/Suburban Tests

	Eldest	Middle		Youngest	
East RS	1941	1967	1970	1999	2000
Quad					
ae F1<700					
F2e-F2a<375	479	324	391	353	470
F2∧<F2a					
Demographic	aERS-F	bES-F	bER-M	yES-M	yER-M

In comparison, Table 5 displays that in urban East Michigan there was a similarly strong NCS that still weakens, but not as much as in the less populous areas seen in Table 4. This weakening appears uniform from the 1960s to the early 2000s.

Table 5

East Michigan Urban Tests

	Eldest	Middle	Youngest	
East U	1952	1961	1999	2000
Quad				
ae F1<700				
F2e-F2a<375	400	146	293	372
F2∧<F2a				
Demographic	aEU-M	bEU-M	yEU-F	yEU-F

In Comparing Gender, the female population of Table 6 shows no identifiable difference from the male test results in Table 7 that can be isolated from the other demographic factors.

Table 6

East Michigan Female Population Tests

	Eldest	Middle	Youngest	
East F	1941	1967	1999	2000
Quad				
ae F1<700				
F2e-F2a<375	479	324	293	372
F2∧<F2a				
Demographic	aERS-F	bES-F	yEU-F	yEU-F

Table 7

East Michigan Male Population Tests

	Eldest	Middle		Youngest	
East M	1952	1961	1970	1999	2000
Quad					
ae F1<700					
F2e-F2a<375	400	146	391	353	470
F2∧<F2a					
Demographic	aEU-M	bEU-M	bER-M	yES-M	yER-M

West Michigan

West Michigan as a region possesses an /æ/ in Q3, but all other vowels are in what would be their expected unshifted positions suggesting a much weaker regional NCS than the east side of the state. The participants with the most similar vowel spaces can be seen in Table 8 and Figure 10 to belong to the two older Age-Groups of (1940-1956) and (1960-1980), while the most recently born Age-Group, (1990-2002) showed some but less consistent similarity.

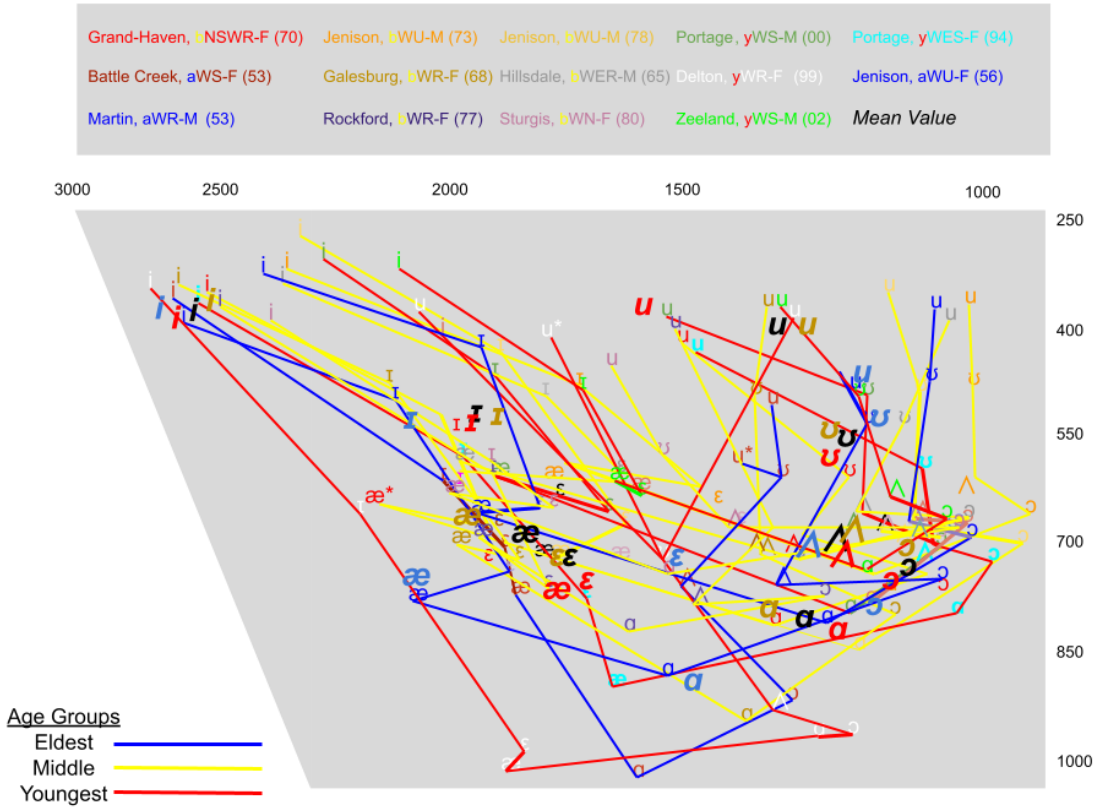
Table 8

West Michigan Vowel Standard Deviation by Age-Group

	Formant (Hz)	/i/	/ɪ/	/ɛ/	/æ/	/u/	/ʊ/	/ʌ/	/ɔ/	/ɑ/	Mean	Combined Mean
ɑ 1940-1956	F1	62	90	75	98	57	57	57	124	104	80	
	F2	194	84	72	129	212	141	219	224	191	163	122
β 1960-1980	F1	43	63	60	59	4	66	56	53	81	54	
	F2	133	135	142	155	79	191	162	156	166	147	100
ɣ 1990-2002	F1	47	95	155	187	33	98	125	136	104	109	
	F2	372	217	142	141	170	170	134	133	106	176	143

Figure 10

Vowel Space of West Michigan Age-Groups

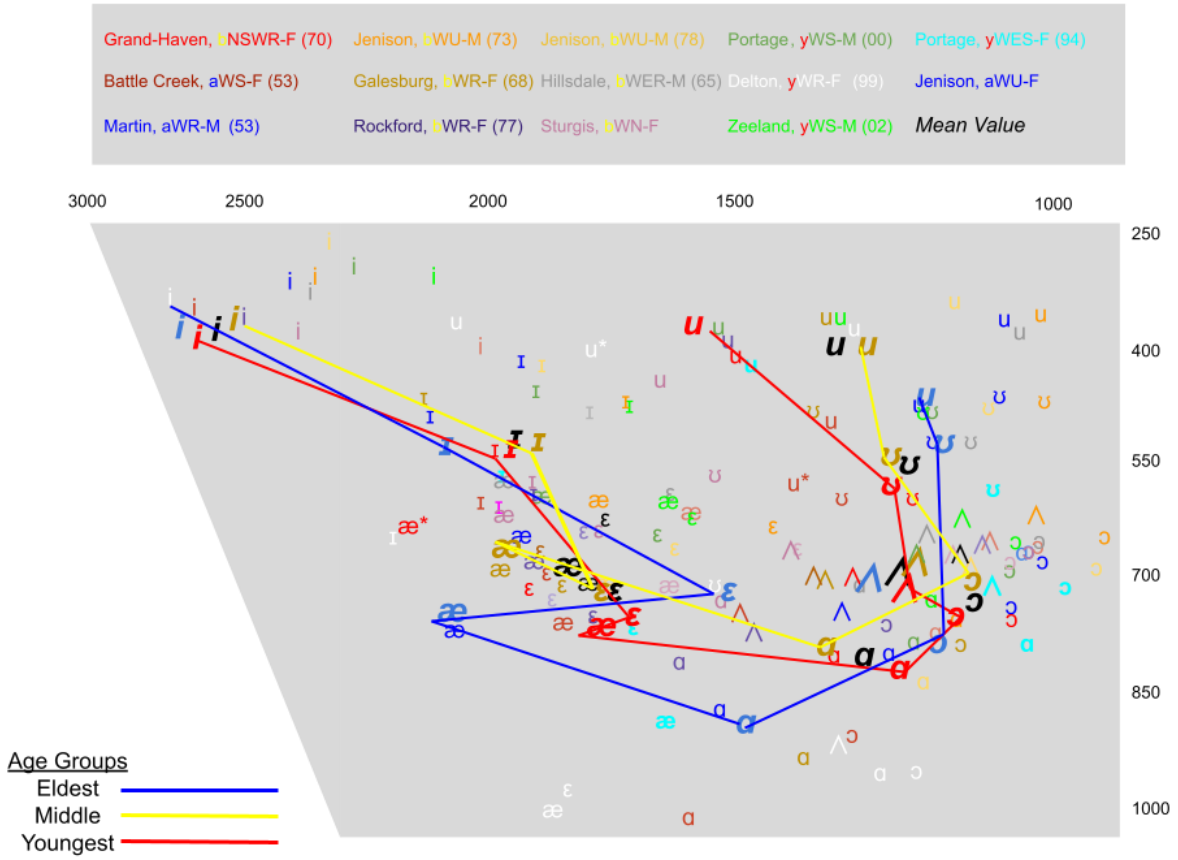


Note. Age-Group divisions are Eldest (1940-1955), Middle (1960-1980), Youngest (1990-2002).

The Eldest Age-Group demonstrates a stronger NCS with /æ/ fronted in Q2 followed by a fronting of /ɑ/. Other vowels can be seen in their unshifted positions with /u/ backed. The Middle Age-Group has the /æ/ at its furthest extent upwards in the west at Q3, but /ɑ/ has already begun to regress to its back position while /u/ begins to move forward in about half the participants. By the Youngest Age-Group, /æ/ has returned to Q2 with /ɑ/ back and /u/ at the most forward position of the groups. Compared to East Michigan, West Michigan /u/ is less advanced but more consistently so with the unfronted allophone being further forward than its eastern counterpart, resulting in less extreme allophony.

Figure 11

Average Vowel Space for West Michigan Age-Groups



Note. Age-Group divisions are Eldest (1940-1955), Middle (1960-1980), Youngest (1990-2002).

Similar to the east side of the state, West Michigan shows signs of a strong NCS vowel system during the 1950s, with the overall regions regressing back towards unshifted vowel positions following the 1960s. As seen by the data points however, this change is not universal, exemplified well by the disparity seen in the Youngest Age-Group in Figure 11. Also evident is a clear fronting trend for /u/ as time progresses.

The demographic distinctions are a little more varied on the west side of the state, especially when considering the differences between different population environments. The results for rural areas differ even from those of suburban regions as in Tables 9 and 10, showing greater disparity between them than in East Michigan.

Table 9

West Michigan Rural Tests

	Eldest	Middle				Youngest
West R	1953	1965	1970	1977	1980	1999
Quad						
ae F1<700						
F2e-F2a<375	519	416	424	171	202	432
F2∧<F2a						
Demographic	eWR-M	mWRS-M	mNWRS-F	mWR-F	mWNRS-F	yWR-F

Table 10

West Michigan Rural/Suburban Tests

	Eldest	Middle					Youngest			
West RS	1953	1965	1968	1970	1977	1980	1994	1999	2000	2002
Quad										
ae F1<700										
F2e-F2a<375	519	416	401	424	171	202	533	432	512	363
F2∧<F2a										
Demographic	eWR-M	mWRS-M	mWS-F	mNWRS-F	mWR-F	mWNRS-F	yWES-F	yWR-F	yWS-M	yWS-M

Rural regions in West Michigan indicate a stronger NCS vowel space than in the suburban areas before the 1990s, and as seen in Figure 10, the youngest Age-Group shows the

greatest variation. It is possible that urban areas continue to exhibit more NCS correlation than less populated ones, but more data is needed to be definitive, as some of the effects may be more geographic in nature with more westerly cities being slower to the adoption of the NCS, resulting in the mixed results of Table 11.

Table 11

West Michigan Urban Tests

	Eldest	Middle	
West U	1953	1972	1978
Quad			
ae F1<700			
F2e-F2a<375	291	268	416
F2∧<F2a			
Demographic	eWUS-F	mWU-M	mWU-M

It is in comparison of gender that some clarity is gained. Female populations in Table 12 appear much more internally consistent over time, with groups of shared vowel spaces visible.

Table 12

West Michigan Female Population Tests

	Eldest	Middle				Youngest	
West F	1953	1968	1970	1977	1980	1994	1999
Quad							
ae F1<700							
F2e-F2a<375	291	401	424	171	202	533	432
F2∧<F2a							
Demographic	eWUS-F	mWS-F	mNWRS-F	mWR-F	mWNRS-F	yWES-F	yWR-F

Table 13

West Michigan Male Population Tests

	Eldest	Middle			Youngest	
West M	1953	1965	1972	1978	2000	2002
Quad						
ae F1<700						
F2e-F2a<375	519	416	268	416	512	363
F2∧<F2a						
Demographic	eWR-M	mWRS-M	mWU-M	mWU-M	yWS-M	yWUS-M

The female population exhibits an unclear beginning, with the first urban entry showing some tests passed, but the initial EQ test is failed utterly at Quadrant 1. Around the turns of the 1960s and 1970s it appears to weaken but gains a passed EQ test in Quadrant 3, and by the turn of the 1980s to have strengthened, but then almost completely disappears in the 1990s.

The male population in Table 13 shows a general trend of strengthening the NCS.

Northern Michigan

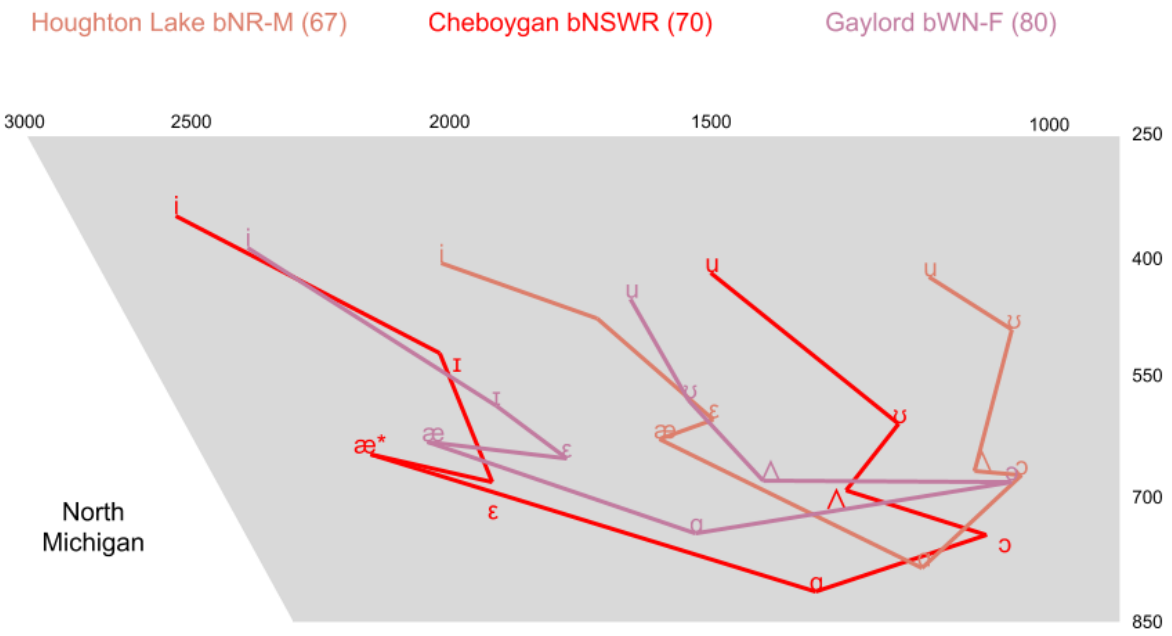
Northern Michigan has only a cursory place in this current study, gathering three representatives from only the Middle Age-Group (1960-1980). The data is further weakened in that two of the participants moved during the period prefaced by the study, and are thus represented both here and in the West Michigan data. In defence of this decision, I must note that existing beyond the urban centers of the state, the main highways that provide access to the area funnel from both sides of the southern regions, resulting in a place where both areas meet representing a convergence of these two lects over the speech of Northern Michigan. While this certainly deserves closer treatment in the future than what is provided here, I believe that the data

I provide is important enough to provide a cursory glimpse at how linguistic phenomena work in areas beyond their prescribed regions.

Upon inspection of the data from the participants in Figure 12, the 'cot/caught' merger can be immediately dismissed, as is the case in all the other regions of the Lower Peninsula.

Figure 12

Northern Michigan Vowel Chart



The oldest of the participants, born in the late 1960s shows /æ/ at Quadrant 2, and the two younger participants show definite Quadrant 3 position above and in front of /ɛ/. All the participants show some evidence of /ɑ/ fronting, but it is weakest in the oldest participant and strongest in the youngest participant. There is possibly /ɔ/ lowering in the middle participant

from Cheboygan, but not in the oldest or youngest ones. There is no easily identifiable /ɛ/ backing in any of the participants.

The fronting of /u/ progresses in the expected manner, increasing as time goes on. There is also the apparent fronting of /ʌ/ in a similar progression as /u/. Although /ʊ/ has been seen to follow /u/ as it advances in other sets, the central position of /ʌ/ is very clear here. While this phenomenon can be seen in both the East and West as well, the trend is less easy to identify. Moreover, although /u, ʊ, ɑ/ are fronting, /ɔ/ does not, which makes it less likely that the entire back system is moving forward. Instead, /ɔ/ becomes more dramatically sundered from the rest of the back vowel system as time progresses in the population.

In summary of the Northern Michigan results, all participants have a cursory introduction to the NCS as seen by the /æ/ fronting and eventual raising. Whether the absence in the oldest participant is due to age, geography, or other demographic factors (gender is often prevalent in such divisions, and the oldest participant is the only male in the set) cannot be determined. In North America, during times of linguistic change women are often apt to lead these changes even if it is not wholly predictable in relation to other social factors (Labov, 1990). It is evidential then, that by this time the region is undergoing some change, or at least that it is not necessarily precluded from change on the basis of less change in the male participant.

The fronting of /ɑ/ further confirms that NCS started in the region, though without a younger population it is impossible in the bounds of this study alone to determine whether continuation or regression is occurring in the present region.

Additionally, the fronting of /u/ can be seen following similar progressions, though whether the advanced centralization of the two younger participants is due to progression of that

change in Northern Michigan or due to their time in West Michigan remains to be determined. Finally, there is the fronting action of /ʌ/ towards the central vowel space.

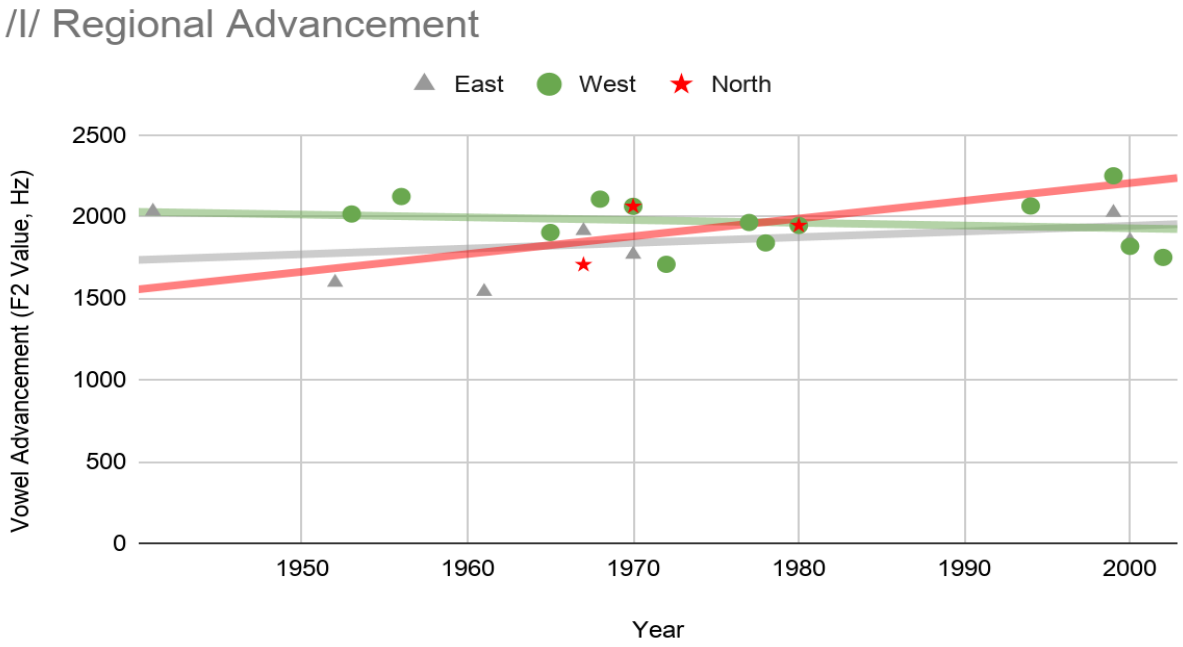
Other Phenomena Observed

Advancement of /ɪ/

Previous study of the region expects Michigander positioning of /ɪ/ to be advanced from 1410-1837Hz, or from 1837-1433Hz. This is often attributed as a late stage indicator of the NCS when significantly backed such as in the initial range listed (Labov et al., 2006). East Michigan shows an average F2 of 1898Hz, while West Michigan shows an average F2 of 1966Hz, and Northern Michigan at 1905Hz. As a whole, none of these are indicative of an NCS position.

Across the Age-Groups from oldest to youngest, East Michigan pulls 1814, 1741, and 1965Hz. West Michigan exhibits 2052, 1933, and 1988Hz. None of the Age-Group averages are indicative of any NCS backing or those recorded by previous study. Figure 13 shows, that in all regions, the position of /ɪ/ appears to be stable, or slightly fronting rather than backing over time.

Figure 13



Reorganization of /æ/

The open-front vowel of /æ/ inhabits a special position in the Inland North with its role as the initiating vowel of the Northern Cities Shift. Because of this, it is one of the most dynamic vowels noted in this study, and is of particular importance on that account.

There are four phenomena where /æ/ is concerned. The first is its role in the NCS, where it is fronted and then raised, or subsequently lowered and backed in instances where the shift is reversing. The second is the raising of pre-nasal /æ/ such as in words like “can” ([ˈkʰæ̃ːn]). This results in the third phenomenon of an allophonic split in positioning between oral and pre-nasal /æ/ among those for whom /æ/ has begun to reverse its Northern Cities positioning (Hillenbrand, 2003). The final phenomenon is the diphthongization of /æ/.

The raising and fronting of /æ/, as well as its reversal has already been addressed above. In East Michigan /æ/ reversed its fronted and raised state over time from Quadrant 3 back to Quadrant 2, where it remains in front of /ɛ/ but not above it. In West Michigan, /æ/ has risen from Quadrant 1 to 3 before reversing back to Quadrant 2 in female speakers, while the male speakers have furthered the fronting and raising to Quadrant 3 over time.

Tables 14 and 15 portray how the different F1 values of words among participants vary within the set of that participant. Lighter shaded cells represent lower F1 values and therefore are indicative of a higher placement of /æ/.

Table 14: Relative Height of /æ/ for Speakers in East Michigan (darker = lower)

Word	past	have	bat	mat	bath	has	back	knack	cash	**fan**	**tab**	**dam**	**ram**	nap	**plant**	**sand**	pal	ask	sat	laugh
FR	633.844	670.5465	659.801	750.0453	677.013	616.82	644.0818	685.1316	657.7859	494.295	630.579	749.7709	370.525	492.6624	877.5	825	636.7	720.1265	731.9946	727.357
MS	492.5629	601.157	519.9577	542.982	520.1077	524.801	577.7568	462.0685	512.5387	353.87	508.631	300.156	450.0538	396.104	796.9259	490.672	533.337	523.3306	569.171	649.424
MU	665.431	759.6928	716.196	1006.6197	698.068	597.425	758.901	780.5179	725.0079	614.2039	579.8199	438.845	562.6	751.5495	693.8	680.7	792.2535	781.449	794.7497	641.4
FS	687.8718	614.272	821.7677	744.119	781.6304	598.609	788.8916	773.3177	681.387	611.524	680.2295	574.3995	607.059	731.8138	670.762	516.891	549.8219	744.9338	782.505	699.835
MR	787.1105	718.983	924.556	982.5909	776.9946	924.3527	918.953	989.638	770.717	543.9115	714.485	465.1345	623.531	655.142	737.225	540.37	606.829	773.987	867.552	934.7985
MS	825.625	890.5927	842.5546	892.7319	807.921	897.778	855.0928	925.854	838.7077	465.0425	840.0653	580.7627	492.6645	661.7397	453.935	562.996	845.299	876.424	791.1428	863.3858
FU	974.573	909.829	812.171	1070.7135	800.695	926.685	861.969	979.204	920.382	658.7838	795.3045	601.732	725.8357	880.598	759.473	657.753	972.9885	866.528	838.17057	873.7926
MR	621.3188	711.209	665.7939	683.6646	663.789	615.14	629.038	683.0488	597.815	556.3276	558.4517	487.8107	566.6827	580.9116	566.027	513.3535	693.506	690.1646	587.318	711.227
FU	986.1569	864.04108	914.326	584.7078	846.782	917.9886	911.50497	489.439	930	371.4926	471.6439		458.1756	548.286	420.4748	439.1946	817.433	924.809	861.6039	871.2778

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

Table 15: Relative Height of /æ/ for Speakers in West Michigan (darker = lower)

Word	past	have	bat	mat	bath	has	back	knack	cash	**fan**	**tab**	**dam**	**ram**	nap	**plant**	**sand**	pal	ask	sat	laugh
MR	647.253	603.7115	720.115	791.6206	700.856	581.374	747.637	627.7188	634.909	461.675	551.3936	479.748	456.345	682.584	609.2676	590.308	744.1389	693.4055	720.752	708.998
FS	930	838	864		773.1906	825	825	681	877	680	694	707	863.903	877.5	903	930	851.3	851.3	811.9	954.5547
FU	780.969	749.88	771.505	799.1476	763.314	804.8315	820.4698	820.401	727.3847	762.102	759.8137	624.836	722.1279	814.36	828.4455	750.897	785.817	834.6047	777.937	808.2806
MR	616.4487	598.7335	596.5348	638.52	599.1976	628.088	632.223	609.4788	659.764	465.796	541.6787	320.6955	444.9989	719.0225	368.6608	351.1679	614.8418	692.472	670.281	670.6918
FR	887.7658	926.1998	708.031	646.1406	708.441	840.0785	665.179	664.771	772.4537	616.666	698.2888	399.889	453.038	696.9885	667.012	650.191	671.1847	857.5079	865.818	796.108
FRS	703.871	671.1905	712.58	692.122	715.5248	677.5179	638.899	652.2265	654.4055	565.3735	665.052	529.8966	538.151	651.8006	563.9506	514.5409	701.2515	600.451	755.4955	772.794
MU	706.901	656.7639	659.1357	741.9158	740.611	616.4699	671.761	705.702	621.5025	404.276	609.341	553.4	668.7046	684.746	528.866	517.0948	675.9807	621.6969	663.685	689.489
FR	687.9826	794.0218	726.841	709.5035	749.487	729.925	752.082	705.581	720.6155	592.1597	702.6386	481.588	405.1869	739.7846	666.328	532.407	752.7727	779.7477	782.99	809.691
MU	825.854	793.217	761.368	819.96	715.1389	779.1279	742.155	749.555	779.6276	703.948	774.5326	566.3387	576.1637	767.8215	712.9957	725.2195	782.733	767.139	827.6565	775.408
FS	711.992	677.1826	706.303	706.1586	704.337	652.942	658.0929	644.548	624.631	491.8369	553.16	403.23	527.255	621.49	579.3835	569.659	550.6689	703.0455	684.2277	654.578
FS	838.758	878.31	855.225	865.2538	851.253	821.579	739.239	868.628	810.506	687.511	894.7696	660.564	699.5048	833.433	679.412	758.4496	974.421	970.2888	840.84	892.6527
FR	1144.231	1109.1765	1072.43	1211.8489	809.8319	927.275	981.43	1019.666	1116.5819	789.167	934.2227	791.4688	925.766	1037.2246	876.856	777.918	1046.753	1094.5267	1101.288	1098.793
MS	639.0059	610.7479	648.835	720.2955	661.8029	596.731	646.779	642.0399	568.905	520.9839	565.127	537.256	610.511	584.7618	551.5376	501.133	663.3076	620.5519	588.646	719.9439
MS	756.324	629.1265	661.38	642.784	614.433	594.293	718.5085	680.866	743.088	499.3359	642.6898	489.103	533.3638	621.46	589.3949	515.897	684.39	750.5676	607.58	655.2435

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

Table 16 clearly demonstrates the higher positioning of /æ/ before nasals (such as in “fan, tab, dam, ram, sand”), resulting in a difference of height greater than 100Hz. Thus, this vowel is written as [æ̰] in a pre-nasal environment.

Table 16

Height of /æ/ Before Oral/Nasal Coda

	Oral Coda F1	Nasal Coda F1	Difference between Oral and Nasal Codas
East Michigan	751Hz	601Hz	150Hz
West Michigan	745Hz	615Hz	130Hz

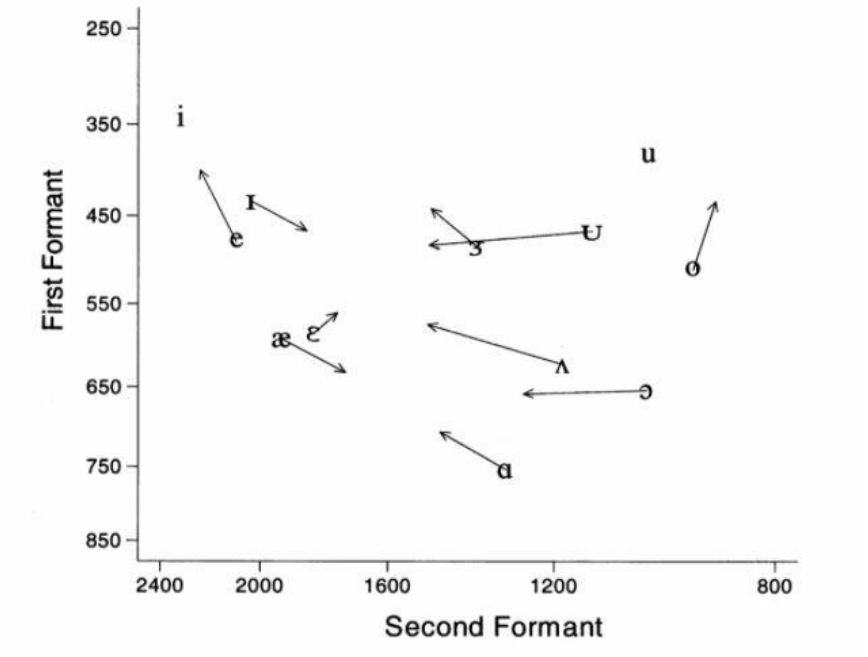
Together, this implies, especially in younger generations, the continued raising of /æ/ in a pre-nasal environment despite most speakers demonstrating a reversal of the NCS fronting and raising. This action is not separable from the NCS in this data, as even those who have /æ/ lowered and backed to its original position still exhibit other signs of the NCS and display this trait of nasal raising. Outside of English however, it is historically common for nasalization of vowels to have the opposite effect, such as in the eleventh-to-thirteenth century lowerings of French ẽ > ã, ĩ > ẽ, and ỹ > œ̃ (Campbell, 2013). This arrangement of lowering /æ/ and raising before a nasal confirms the documentation of /æ/ going under a reorganization and development of an allophonic split (Wagner et al., 2016).

Concerning the diphthongization of /æ/, Hillenbrand's studies on Michigan vowels (1995, 2003) presents diphthongization as a solution adopted by speakers to disambiguate varying forms of the vowel pairs /æ/-/ɛ/, /u/-/ʊ/, and /e/-/ɛ/ (Hillenbrand, 2003). Of these, this study only concerns itself with that of /æ/ and /ɛ/. The spectral-change caused by the diphthongization of these vowels observed by Hillenbrand can be seen in Figure 14. This study did not quantifiably test for the diphthongization of the vowels, but made note of formant shape for /æ/ when visible on the spectrograms while other data was being acquired. Of these, five participants were noted

to have diphthongized /æ/ and belonged to no particular demographic or a particular phonological environment. The oldest participant, born in 1941 was marked as showing no evidence of diphthongization at the time. While this prompts speculation that diphthongization was a process that began in the 1950s, this is as of yet unconfirmable and it is recommended that further analysis using the samples acquired in the course of this study be conducted to more quantifiably evaluate this process. Hillenbrand (1995) demonstrates that vowel duration helps disambiguate /ɑ-ɔ-ʌ/, and /æ-ɛ/, and in the /æ-ɛ/ pair /æ/ shows greater spectral change towards /ɑ/ making it evident that this is a diphthongized element of the pair (Hillenbrand 1995, 2003). The downward direction of F2 in the observations made here confirm these findings.

Figure 14

Spectral-change patterns in Hillenbrand (1995)



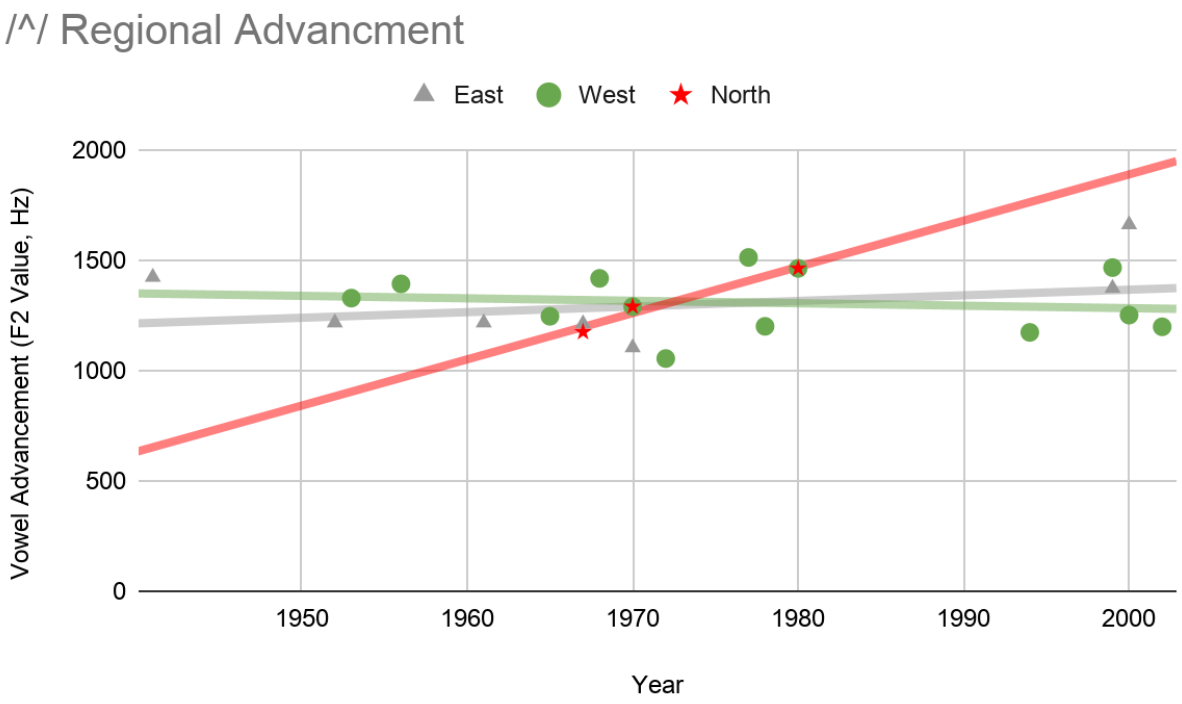
Note. The vowel represents the initial position of the vowel at 20% duration, the tip of the arrow at 80% vowel duration.

Advancement of /ʌ/

The fronting of /ʌ/ is a characteristic of the Midland Region of North American English, the region immediately south of Michigan and the Inland North. In terms of states bordering Michigan, this consists of Ohio and Indiana. Other instances of /ʌ/ fronting are found - but with less consistency as in the Midland Region - in the South. This phenomenon is not however expected in the Inland North. Fronted /ʌ/ vowels in the Midland Region range in F2 values of 1433-1907Hz, the most extreme cases being 1539-1907Hz within that range. Labov rather lists Michigan /ʌ/ at a 1095-1433Hz range (Labov et al., 2006).

East Michigan on average exhibits an F2 value for /ʌ/ at 1266Hz, split at 1320, 1178, and 1288Hz across Age-Groups. West Michigan averages at 1290Hz, with 1349, 1312, and 1272Hz across Age-Groups. Northern Michigan averages at 1309Hz. In these instances, Michigan speakers observe across all groups the expected values, many of which are somewhat backed due to the NCS with the youngest Age-Group behind that of the eldest. The advancement can be observed through time divided by region below in Figure 15.

Figure 15

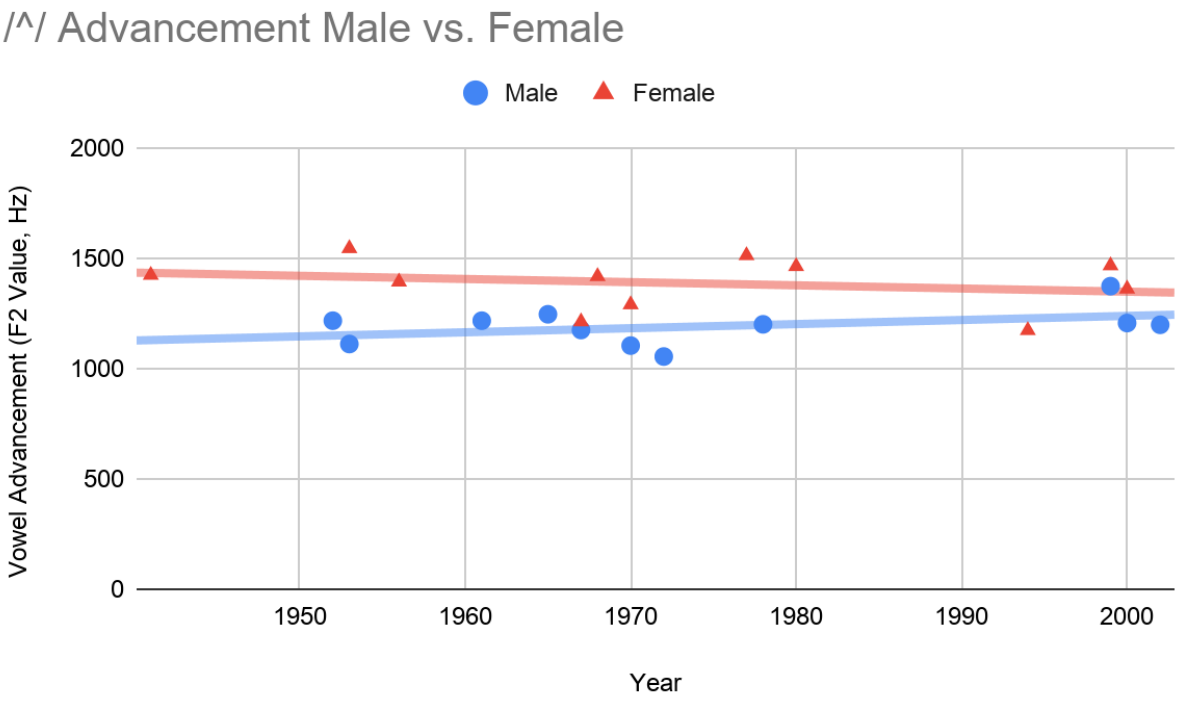


One notable item is that more fronted forms appear in female speakers than in male, and can be seen as far back as 1941 and as recently as 2000. All but two female speakers tested in the study exhibit /ʌ/ fronted in excess of a range of 1289-1325Hz which correspond to the average F2 position of the vowel across the study and the halfway point between the maximum and minimum F2 values recorded. This coincides with the observation in the Inland North that usually it is the female population that first adopts new speech features, such as in this advancement of /ʌ/. The two exceptions to this observation are from the same household. No male speakers were observed with this fronting.

This phenomenon can be identified as the fronting of /ʌ/ rather than the fronting of the entire back vowel system as demonstrated that speakers with a more fronted /ʌ/ do not exhibit a fronting of /ɔ/. These two vowels are usually paired, as they are both open-mid back vowels and

differ only in that /ɔ/ exhibits lip rounding and /ʌ/ does not. Thus, to see such a dramatic separation of the two vowels as seen in Figure 12, it is highly indicative that that fronting of /ʌ/ is independent of the rest of the back vowel system. Figure 16 demonstrates a consistently fronted /ʌ/ in female speakers in comparison to male speakers, though male speakers may be gradually following this pattern.

Figure 16



Fronting of /u/

The fronting of the close-back vowel /u/ is widespread throughout the United States, and is usually accompanied by an allophonic split. The first allophone is /Tu/, representing the vowel after coronal sounds. Its counterpart /Ku/ represents /u/ after non-coronal sounds. *The Atlas of*

North American English (ANAE) divides these sounds into four colour coded stages as seen below in Table 17:

Table 17

ANAE *Levels of /u/ Advancement*

	F2 /Tu/ (Hz)	F2 /Ku/ (Hz)
Red	1950-2280	1620-2000
Yellow	1800-1950	1410-1620
Green	1590-1800	1200-1410
Blue	1110-1590	810-1200

Michigan is shown in *ANAE* possessing /Tu/ the most commonly at level green, followed by yellow, and then blue. /Ku/ occurs most commonly at the blue level and then at green. This suggests mild advancement of /u/, primarily following coronal sounds (Labov et al., 2006).

The below Tables 18 and 19 display, in chronological order, the relative advancement of /u/ in East and West Michigan with green corresponding with a more backed /u/ and red associated with a more fronted /u/. For each table, the minimum value on that table corresponds with green, the maximum with red, and the halfway point between these represented by yellow.

Table 18: Relative Advancement of East Michigan /u/

	moot	fool	room	tool	soon	boon	shoot	food	loot	suit	doom	root	nuke	whose	coop	booth	stoop	boot	soup	tomb
FR	1406.875	943.8969	1192.0668	1123.623	1501.125	1127.1652	1600.149	1188.621	1329.367	1514.3887	1434.072	1328.0027	1605.4336	1127.9929	1181.8258	1118.457	1386.6007	1074.439	1371.1868	1230.0649
MS	1570.5878	827.84	1001.931	955.7265	1529.4209	983.0689	1771.1597	1151.1027	1492.031	1549.6795	1030.624	1111.487	1565.1795	1087.6999	1036.735	1093.8125	1579.6208	1139.899	1484.7967	1066.1518
MU	1178.604	986.3328	1252.2285	751.0176	1460.21	1236.7228	1461.3049	1186.2587	1349.1999	1516.6037	1504.143	1290.671	1544.673	1248.417	1170.3636	1221.6148	1440.782	1301.0818	1407.9526	1362.9916
FS	1325.1685	2936.3569	1297	961.4919	1687.7405	1272.406	1346.997	1258.4746	1264.945	1758.065	1834.044	1293.541	1935.003	1248.3296	1202.854	1255.3548	1662.296	1315.7299	1376	1327.7548
MR	908.3589	603.8	1127.175	1112.357	995.694	1211.2806	1739.2485	981.8569	1272.519	920.307	1160.3719	1026.072	1933.037	961.97	1030.2097	1070.6537	1730.985	988.9869	1616.996	1165.262
MS	1105.8218	2609.154	2032	2543.2416	2202.2316	1130.489	2177.682	1179	1271	2023.5779	2255.5149	1940.22	2070.619	2240.3318	930	1127	2250.2379	1035	2149.039	2400
FU	1457.4507	902.1925	1224.947	919.542	1995.2026	1258.8968	1990.8578	1473.294	1874.7336	2045.0655	1112.4005	1665	1984.32	1887.0037	1118.5408	1375.138	2093.248	1855.669	1958.8329	1893.591
MR		854.884	1412.278	934.863	2215.6906	1256.012	2222.4386	1393.003	1901.6	1733.8877	2148.0959	1674.158	2234.5488	1217.118	1387.605	1341.8956	1888.7077	1384.9485	1866.6605	1421.121
FU	1325.1685	2936.3569	1297	961.4919	1687.7405	1272.406	1346.997	1258.4746	1264.945	1758.065	1834.044	1293.541	1935.003	1248.3296	1202.854	1255.3548	1662.296	1315.7299	1376	1327.7548

Note. The comparisons are made relative to the entire data set. The minimum value is green, the maximum value red, with yellow 50% of the way between.

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

Table 19: Relative Advancement of West Michigan /u/

	moot	fool	room	tool	soon	boon	shoot	food	loot	suit	doom	root	nuke	whose	coop	booth	stoop	boot	soup	tomb
MR		718.223	1093.557	780.387	1145.1247	954.4498	1256.476	870.8667	1150.816	1290.3047	1049.8379	921.404	1246.376	718.24	1702.235	826.172	1222.129	873.304	974.671	1144.479
FS	1385.6816	1035	1625	1114.159	1506.1617	1135.7049	1736.7546	1478.273	1595.9375	1692.0458	1593.3737	1646.7907	1870.2525	1172.812	1153.7497	1229.386	1843.09	1525.054	1673.9627	1443.5689
FU	995.2656	849.935	1363.647	1034.8867	1732.6279	1156.892	1518.672	1137.8598	1377.24	1603.105	1692.1538	1147.2628	1555.98	928.698	1071.1339	1192.3189	1587.83	1154.7049	1353.1856	1491.807
MR	987.7169	769.879	590.3049	722.034	1215.8335	982.5	1627.268	1000.5559		1669.377	1207.752	1165.6846	1075.0519	1127	1139.2548	989.5487	1280.491	1196.7877	1612	1269.7068
FR	1439.7548	1023.488	1715.006	988.9088	1205.1228	1084.76	1966.472	1400.0108	1503.352	1461.5228	1104.2096	1759.9317	1258.452	1018.8616	1061.4199	1503.0556	2193.6858	1172.843	1572.428	1120.823
FRS	1332.2488	870.334	1409.5779	767.0256	1867.56	1014.364	1592.8235	1595.679	1695.357	1885.6008	2142.321	1604.6998	2183.7016	988.462	1386.1987	1417.0109	2267.706	1258.6149	1682.9466	1384.0358
MU	727.793	749.295	1121.885	972.8675	724.8237	857.925	1133.785	779.5658	1298.6298	1219.601	833.883	1255.556	1482.466	770.663	1018.697	927.251	1400.097	799.2068	1189.084	1077.805
FR	1443.432	899.856	1692.076	1121.981	1339.7746	1569.521	1639.4389	1738.302	1782.485	1978.702	1290.8176	1774.428	2095.7355	1084.939	1189.674	1732.0106	2035.8777	1504.2707	1635.719	1495.4899
MU	1080.8156	876.7105	1219.56	849.636	1617.4855	1082.0896	1635.8328	1096.7545	1317.1615	1464.396	1170.903	1294.8889	1912.898	942.1373	1060.594	1099.4618	1618.901	1072.9025	1242.7146	1267.3507
FS	1866.9466	874.4198	1768.873	1008.7887	1902.274	1575.0288	1877.1076	1689.375	1676.8698		1621.623	1771.1528	2272.3898	1462.92	1847.403	1376.3325	2066.0799	1525.13	1812.3806	1610.5658
FS	1235.6167	700.6186	1660.6786	769.925	2245	1299.2616	1595.2456	1305.0097	1127.482	1143.246	2075	1585.9976	2587.2618	1144.907	1625.9458	1304	1141.6925	1153.895	1461.1846	
FR	1284	898.5895	1999.0416	1074.7466	2308.2885	2064.046	1779.106	1564.653	1934.981	2338.41	2419.921	1942.474	2529.34	1593.049	1491.0389	1612.7788	2464.151	1915.211	2329.272	2427.1817
MS	1392.429	2408.4526	1263.984	939.064	1844.39	1639.561	1809.1399	1453.558		1767.7795	1835.159		2013.0339	1311.0468	1377.4658	1310	1865.1486	1268.3698	1815.258	1739.9629
MS	1282.204	1105.536	1442.9226	1137.07	1571.597	1315.233	1458.4605	1522.4016	1476.1419	1700.6289	1708.2125		1776.028	1346.731	1180.415	1227.7788	1514.116	1345.0735	1347.2709	1322.8228

Note. The comparisons are made relative to the entire data set. The minimum value is green, the maximum value red, with yellow 50% of the way between.

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

Both regions display a fronting of /u/ more advanced for coronal sounds as seen by the alveolar initial consonants of /d, s, l, r, n/ and alveo-palatal <sh>. The prevalence of alveolars is likely due to the alveolar ridge of the mouth being situated at the front edge of the vowel production space, thus a vowel following a consonant produced at this edge is more likely to result in the tongue drawn forward in the mouth to that position while the vowel is being

produced, resulted in a fronted vowel. At a glance, this effect seems strongest in the fricative /s/ and <sh> and the nasal /n/. This is to be expected, as such sounds result in the tongues prolonged position at the consonant's point of articulation before it moves to the vowel's point of articulation, giving the tongue less time to move between these positions and resulting in an even more fronted vowel.

At first, it is surprising that /t/ is one of the least fronted word initial consonants when all the other coronal sounds in the wordlist have a more heavily fronted /u/ when word initial; however, when it is considered that /t/ is aspirated as [t^h], this seems less unusual as it is likely that the brevity of the front articulation of the plosive /t/ (especially compared with the prolonged articulation of fricatives such as /s/) combined with the aspiration provide enough space for the tongue to back properly for /u/, dependent on where the initial position of /u/ is for that speaker. The word 'whose' (/huz/) in the data is a good indication of the unaltered positioning due to its nature as a glottal fricative, meaning neither the tongue nor the lips form any obstruction to the positioning of /u/.

Taking these elements into account, we can find the values in Table 20, which shows the different average values of post-coronal and post-non-coronal /u/. The "/Tu/ [-spread]" represents the post-coronal group of /u/ without the influence of /t/ due to its aspiration in the word initial position in English. The data columns are coloured corresponding to the levels of fronting according to the the *ANAE* study as seen in Table 17.

Table 20

Average Michigan /u/ Advancement

	/Tu/	/Tu/ [-spread]	/Ku/
East Michigan	1557Hz	1607Hz	1275Hz
West Michigan	1529Hz	1597Hz	1225Hz

Tables 18 and 19 as seen above demonstrate how fronted the /u/ in words from the test corpus are related to one another in that region. This identifies which words in a set cause fronting of /u/, and through this the phonological environments for this phenomena can be discerned. In contrast, Tables 21 and 22 seen below demonstrate how the vowels spoken by the participants compare to the parameters set by the *ANAE* study. Instead of the gradients of the tables being based on the maximum and minimum of the data set, the lowest point on the gradient (green) corresponds with the *ANAE* /Tu/ lower bound of 1110Hz, the base requirement for the blue category. The midpoint (yellow) is at 1800Hz corresponding to the border of *ANAE* green and yellow. The highest colour (red) is 1950Hz, the lower bound of *ANAE* red and the highly advanced /u/ fronting.

Table 21: Advancement of East Michigan /u/ in Comparison with ANAE

	moot	fool	room	tool	soon	boon	shoot	food	loot	suit	doom	root	nuke	whose	coop	booth	stoop	boot	soup	tomb
FR	1406.875	943.8969	1192.0668	1123.623	1501.125	1127.1652	1600.149	1188.621	1329.367	1514.3887	1434.072	1328.0027	1605.4336	1127.9929	1181.8258	1118.457	1386.6007	1074.439	1371.1868	1230.0649
MS	1570.5878	827.84	1001.931	955.7265	1529.4209	983.0689	1771.1597	1151.1027	1492.031	1549.6795	1030.624	1111.487	1565.1795	1087.6999	1036.735	1093.8125	1579.6208	1139.899	1484.7967	1066.1518
MU	1178.604	986.3328	1252.2285	751.0176	1460.21	1236.7228	1461.3049	1186.2587	1349.1999	1516.6037	1504.143	1290.671	1544.673	1248.417	1170.3636	1221.6148	1440.782	1301.0818	1407.9526	1362.9916
FS	1325.1685	2936.3569	1297	961.4919	1687.7405	1272.406	1346.997	1258.4746	1264.945	1758.065	1834.044	1293.541	1935.003	1248.3296	1202.854	1255.3548	1662.296	1315.7299	1376	1327.7548
MR	908.3589	603.8	1127.175	1112.357	995.694	1211.2806	1739.2485	981.8569	1272.519	920.307	1160.3719	1026.072	1933.037	961.97	1030.2097	1070.6537	1730.985	988.9869	1616.996	1165.262
MS	1105.8218	2609.154	2032	2543.2416	2202.2316	1130.489	2177.682	1179	1271	2023.5779	2255.5149	1940.22	2070.619	2240.3318	930	1127	2250.2379	1035	2149.039	2400
FU	1457.4507	902.1925	1224.947	919.542	1995.2026	1258.8968	1990.8578	1473.294	1874.7336	2045.0655	1112.4005	1665	1984.32	1887.0037	1118.5408	1375.138	2093.248	1855.669	1958.8329	1893.591
MR		854.884	1412.278	934.863	2215.6906	1256.012	2222.4386	1393.003	1901.6	1733.8877	2148.0959	1674.158	2234.5488	1217.118	1387.605	1341.8956	1888.7077	1384.9485	1866.6605	1421.121
FU	1325.1685	2936.3569	1297	961.4919	1687.7405	1272.406	1346.997	1258.4746	1264.945	1758.065	1834.044	1293.541	1935.003	1248.3296	1202.854	1255.3548	1662.296	1315.7299	1376	1327.7548

Note. Values are only compared within the data of individual speakers. Shading is based on the upper and lower bounds of /u/ advancement set by *ANAE.* The lower bound 1100Hz is represented by green, and the upper bound at 1950Hz by red. Yellow represents the border between the two middle *ANAE* categories at 1800Hz.

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

Table 22: Advancement of West Michigan /u/ in Comparison with ANAE

	moot	fool	room	tool	soon	boon	shoot	food	loot	suit	doom	root	nuke	whose	coop	booth	stoop	boot	soup	tomb
MR		718.223	1093.557	780.387	1145.1247	954.4498	1256.476	870.8667	1150.816	1290.3047	1049.8379	921.404	1246.376	718.24	1702.235	826.172	1222.129	873.304	974.671	1144.479
FS	1385.6816	1035	1625	1114.159	1506.1617	1135.7049	1736.7546	1478.273	1595.9375	1692.0458	1593.3737	1646.7907	1870.2525	1172.812	1153.7497	1229.386	1843.09	1525.054	1673.9627	1443.5689
FU	995.2656	849.935	1363.647	1034.8867	1732.6279	1156.892	1518.672	1137.8598	1377.24	1603.105	1692.1538	1147.2628	1555.98	928.698	1071.1339	1192.3189	1587.83	1154.7049	1353.1856	1491.807
MR	987.7169	769.879	590.3049	722.034	1215.8335	982.5	1627.268	1000.5559		1669.377	1207.752	1165.6846	1075.0519	1127	1139.2548	989.5487	1280.491	1196.7877	1612	1269.7068
FR	1439.7548	1023.488	1715.006	988.9088	1205.1228	1084.76	1966.472	1400.0108	1503.352	1461.5228	1104.2096	1759.9317	1258.452	1018.8616	1061.4199	1503.0556	2193.6858	1172.843	1572.428	1120.823
FRS	1332.2488	870.334	1409.5779	767.0256	1867.56	1014.364	1592.8235	1595.679	1695.357	1885.6008	2142.321	1604.6998	2183.7016	988.462	1386.1987	1417.0109	2267.706	1258.6149	1682.9466	1384.0358
MU	727.793	749.295	1121.885	972.8675	724.8237	857.925	1133.785	779.5658	1298.6298	1219.601	833.883	1255.556	1482.466	770.663	1018.697	927.251	1400.097	799.2068	1189.084	1077.805
FR	1443.432	899.856	1692.076	1121.981	1339.7746	1569.521	1639.4389	1738.302	1782.485	1978.702	1290.8176	1774.428	2095.7355	1084.939	1189.674	1732.0106	2035.8777	1504.2707	1635.719	1495.4899
MU	1080.8156	876.7105	1219.56	849.636	1617.4855	1082.0896	1635.8328	1096.7545	1317.1615	1464.396	1170.903	1294.8889	1912.898	942.1373	1060.594	1099.4618	1618.901	1072.9025	1242.7146	1267.3507
FS	1866.9466	874.4198	1768.873	1008.7887	1902.274	1575.0288	1877.1076	1689.375	1676.8698		1621.623	1771.1528	2272.3898	1462.92	1847.403	1376.3325	2066.0799	1525.13	1812.3806	1610.5658
FS	1235.6167	700.6186	1660.6786	769.925	2245	1299.2616	1595.2456	1305.0097	1127.482	1143.246	2075	1585.9976	2587.2618	1144.907	1625.9458	1304	1141.6925	1153.895	1461.1846	
FR	1284	898.5895	1999.0416	1074.7466	2308.2885	2064.046	1779.106	1564.653	1934.981	2338.41	2419.921	1942.474	2529.34	1593.049	1491.0389	1612.7788	2464.151	1915.211	2329.272	2427.1817
MS	1392.429	2408.4526	1263.984	939.064	1844.39	1639.561	1809.1399	1453.558		1767.7795	1835.159		2013.0339	1311.0468	1377.4658	1310	1865.1486	1268.3698	1815.258	1739.9629
MS	1282.204	1105.536	1442.9226	1137.07	1571.597	1315.233	1458.4605	1522.4016	1476.1419	1700.6289	1708.2125		1776.028	1346.731	1180.415	1227.7788	1514.116	1345.0735	1347.2709	1322.8228

Note. Values are only compared within the data of individual speakers. Shading is based on the upper and lower bounds of /u/ advancement set by *ANAE.* The lower bound 1100Hz is represented by green, and the upper bound at 1950Hz by red. Yellow represents the border between the two middle *ANAE* categories at 1800Hz.

Note. Demographics are listed on the leftmost column, starting with participant sex, Male/Female (M/F) followed by the population density Urban/Suburban/Rural (U/S/R)

As a whole, this study agrees with the observations made concerning the fronting of /u/ in Michigan as found in the *ANAE* data. East Michigan shows more heavily fronted /u/ as a whole, but this is almost exclusively found in constrained coronals.

West Michigan, while none of its /u/ productions are as far forward as in the East, /u/ is more broadly fronted in more phonological environments outside of just coronals, and in the youngest Age-Group there are signs of fronting after almost all consonants (the notable exception being 'tool,' even more so than 'whose'). Also in the youngest Age-Group is a gradual fronting, indicating that West Michigan exhibits a more uniformly fronted /u/, while East Michigan sees a much more heavily fronted /u/ among some post-coronal contexts, but much less so among other phonological environments.

In addition to the coronals noted for causing /u/ fronting, among some but to no particular demographic identifiable here, /f/ also causes considerable fronting of /u/, in some cases in excess of 2900Hz. This follows the same principle as the coronal fricatives, where prolonged articulation towards the front of the mouth results in a failure to return the tongue to a backed position.

This study provides a few hypotheses to the cause of /u/ fronting, but as of yet does not have the full means to test these. The first two are through diffusion, either from the west coast of the United States or from the Midland Region, where the fronted form of /u/ is prevalent (Labov et al., 2006). This phenomenon is very prevalent in North American English, and therefore could arrive from a variety of sources. The West pronunciation has grown in its exposure to the anglophonic continent through popular media, whereas the Midlands are closer

to the Inland North and Michigan with many areas along the Michigan/Ohio border showing more pronounced examples of fronting.

The third proposal is fronting sympathetic to the fronting of /ɑ/ due to the Northern Cities Shift, in which case it would be expected to see strong correlation between the fronting of both vowels in apparent time. In the data presented here, more heavily fronted /u/ can be observed in younger speakers while stronger NCS vowel space occurs in older generations. Unless it is demonstrated that there is a delay between the fronting of /ɑ/ and that of /u/ it remains difficult to sustain this hypothesis under current circumstance. Moreover, it must be demonstrated that /ɑ/ and /u/ move independent from the rest of the back vowel system as noted by the lack of /ɔ/ fronting, which could only be correlated through their position of opposites in vowel height, which is extending their relationship as of yet without evidence to make this proposition a likely relationship.

The fourth and final proposal is that, especially in East Michigan some members of the Middle Age-Group demonstrate a very backed /u/, which might be difficult for the offspring generation of the Youngest Age-Group to distinguish the second formant (which would be low and very close to the first formant). When acquiring their first language, juvenile mammals have been posited to develop acoustic sensitivity for the middle of their range of hearing first, the region of this range from 2000-4000Hz being that which requires the lowest threshold of amplitude for perception. This range happens to be the region wherein we would expect to find the upper boundaries of a possible Second Formant and especially inhabited by the Third Formant (Olsho et al., 1988). Therefore, if more attention is placed to a higher cue of tongue advancement than the low cue provided by their parent generation, this could result in perceiving heavily fronted /u/ and thus the fronting of their own /u/ vowels. It is also of note, that infants

may perceive vowels through slightly different means than adults, and it remains to be seen how this might affect such a hypothesis (Polka et al., 2014). Nonetheless, this would explain why /u/ alone of the back system advances, even while vowels such as /ɑ/ retreat back to their more posterior positions in the vowel space; however, this perception mistake so deeply rooted in the acoustics (and insinuates the re-evaluation of a listener of every formant cue above F1) of the vowel seems to be a rather drastic cause that challenges current understanding of vowel perception, and extensive perception tests of /u/ across generations would be required to give any significant merit to this hypothesis whatsoever.

Regardless of the cause, the representation of /u/ should be discussed. With the cueing environment of post-coronals, the fronting of /u/ presents a clear allophonic change. The appropriate question therefore is what the variation is. As reference, the Quasi-Cardinal Vowels identified by Lindblom (1986) demarcates the bounds of close-vowels in the compilation and are provided in Table 23. The vowel /i/ has a rough F1 value of 255Hz, and an F2 value of 2550Hz. The vowel /u/ by contrast lies around 290, 625Hz. In general, the values identified in this study as seen in Table 24 more closely resemble the Lindblom (1986) demarcations for /ʉ/ at 276, 1256Hz, and /y/ at 263, 2191Hz. All the regional average values found in Table 24 represent a central /ʉ/.

At 50% between /y/ and /ʉ/ values is our border at 1724Hz. Anything in excess is classified as /y/, anything less as /ʉ/. The same boundary between /ʉ/ and /u/ is 941Hz, but this seemed to eliminate too much of what could be easily considered /u/, so the lower bounds of the central vowel were left at Lindblom's 1256Hz. In Table 17, yellow represents all post-coronal values of /Tu/, red coronals without aspirated consonants, and green non-coronal /Ku/ values.

Table 23

Representation of East Michigan Close-Rounded Vowel

	/y/	/ʉ/	/u/
Lindblom	1724-2191Hz	1256-1724Hz	941-1256Hz
	/Tu/	**/Tu/ [-spread]**	**/Ku/**
Region	1557Hz	1607Hz	1275Hz
Eldest Age-Group	1365Hz	1419Hz	1129Hz
Middle Age-Group	1386Hz	1440Hz	1213Hz
Youngest Age-Group	1827Hz	1760Hz	1398Hz

Table 24
Representation of West Michigan Close-Rounded Vowel

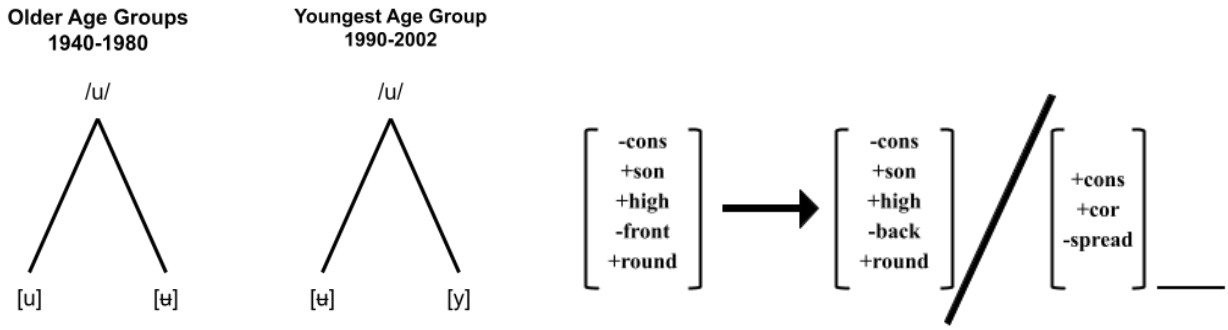
	/y/	/ʉ/	/u/
Lindblom	1724-2191Hz	1256-1724Hz	941-1256Hz
	/Tu/	**/Tu/ [-spread]**	**/Ku/**
Region	1529Hz	1597Hz	1225Hz
Eldest Age-Group	1391Hz	1436Hz	1099Hz
Middle Age-Group	1480Hz	1554Hz	1167Hz
Youngest Age-Group	1734Hz	1807Hz	1396Hz

In both East and West Michigan, the Eldest and Middle Age-Groups both show a non-coronal value of /u/, and a coronal /ʉ/. Likewise both regions have the Youngest Age-Group with a non-coronal /ʉ/ with a fronted coronal variant of /y/.

It is not incorrect to denote the close-rounded vowel of this variant of English as /u/, as it fills the role of being a close-back vowel to contrast with the close-front vowel /i/ within the system of American English. Vowels are arranged in terms of contrast to one another, and can be viewed as a series of positions at the extremes of articulatory positioning within the vowel space, with gradient forms filling any spaces between. The vowel /u/ is paired with /i/ in a horizontal contrast, and /ɑ/ on a vertical contrast. Therefore, when speaking of the allophonic variation of the coronal and non-coronal forms, one may refer the variation found in the first two Age-Groups as /u/~[ʉ], and among the youngest group /u̟/~[y] (the diacritic beneath the /u/ represents an advanced vowel), but in reference to the positions of vowels in other languages that have /ʉ/ as a gradient form or /y/ at an articulatory extreme, then these same groups should be noted as [u]~[ʉ] and [ʉ]~[y]. The base phonemic forms of the younger and elder vowel spaces are /u/, and only differ in the extent of their allophonic variation, both moving from a base close-backed vowel and advancing to a more fronted variant. This is summarized in Figure 17 where the allophonic variation is seen between the two variants of the close-back vowel system, with the phonemic form at the head of the tree to its allophonic daughters. The second part is a phonological rule that unifies both systems by demonstrating the mutual exchange of distinctive phonetic features in a shared context.

Figure 17

Phonological Representation of Close-Round Vowel Allophony



Discussion

In comparing the different regions and tests together, it can be observed that in East Michigan there is a general trend of a weakening NCS, this regression being stronger in correlation to less population, but is present nonetheless in urban centers. In contrast, West Michigan in this study presents a strengthening NCS vowel space in the more populous regions, but those regions are little documented in this study. While west suburban regions appear to be strengthening their NCS in recent time, rural regions are weakening. While there was no discernable difference between male and female populations in East Michigan, West Michigan presents a distinct contrast, with females being more consistent with each other demonstrating a uniform increase of NCS between the Eldest and Middle Age-Groups, and then a uniform and seemingly sudden abandonment of it on the onset of the Youngest Age-Group. Western males seem to strengthen their NCS, but are much less consistent in this set and are the primary source of ambiguity in the data and the state of West Michigan cities.

As a whole, it can at least be discerned that west female populations and non-urban populations are reversing the NCS at the quickest rate, while east urban areas and west male populations are slower in reversal. Little more can be said definitively about western male or western urban populations in the scope of the participants tested in this study, but as a whole, the state appears to be reversing, starting with non-urban areas where it was weakest to begin with. Western cities may be the exception to this rule in that they may be experiencing a strengthening of the NCS among their speakers, but it remains to be demonstrated clearly. Additional exceptions to this pattern may be found in geographic regions in future study, with regions such as those around Ann Arbor and Lansing being of particular interest. In Roeder 2010, it was reported that "the NCS in Lansing is well advanced and may still be in progress" but was reluctant to conclude if the change was ongoing or not. A group of six Lansing women born 1985-1990 (between this study's Middle and Youngest Age-Groups) display a Q2 /æ/ almost even in height to /ɛ/ and is raised in a nasal environment. Inhabiting a region around 1300Hz, /ɑ/ is mostly back. The other stages have failed to be realized, and /u/ is still back in its realization. For male speakers /æ/ is slightly lower and in a nasal environment is not realized as high, but still inhabits Q2. Male Lansing speakers otherwise display similar vowel positions to their female counterparts (Roeder, 2010). Administering the NCS diagnostics in Table 25 results confirms a strong NCS in the group by passing each diagnostic. The presence of /æ/ in Q2 confirms Roeder's uncertainty on whether this evidence of an advancing or regressing NCS and is impossible to clearly determine without diachronic context.

Table 25

NCS Diagnostics for Lansing found in Roeder (2010)

	Male	Female
Quadrant	Q2	Q2
ae F1<700		
F2e-F2a<375		
F2∧<F2a		
Demographic	Urban Central Michigan	

Wagner et al. (2016) contains samples from speakers born from 1900-90s and provides a large diachronic context for Lansing. A speaker born in 1924 showed a lowered /aæ/, followed by a 1971 born raised /æ/ and then a reversal in participants born in the 1990s. With these two studies providing context in age and gender, I believe it is easier to conclude that Lansing is undergoing slow reversal, and agree with Roeder that this change is led by female speakers. This makes the changes undergone in Lansing slightly more congruent with the West Michigan model of reversal and change than that of East Michigan.

Thus, in comparison to previous literature in the topic, it confirms many general findings such as the reversal and reorganization of the NCS found in Lansing by Wagner et al. (2016) is more widespread in the state, and the positions of /æ/, and /ʌ/ for Michigan as described by the *ANAE* study are correct, /ɪ/ does not show the demonstrated backing of *ANAE* in the region. Whether this is due to the distance in time between these studies is debatable. The *ANAE* is based on data taken in the Teslur Telephone Survey conducted from 1992-1999, while this study was conducted in the summer and autumn of 2020, resulting in a minimum 21 year gap in data (Labov et al., 2006).

The breaking of /æ/ into a diphthong noticed in Hillenbrand (2003) is also noted here, though its nature and extent is not elaborated upon further, but presented here is further commentary on the advancement of the back vowel system noted in the same publication. While /ʊ/ and /ɔ/ do not show notable fronting, /u/ does show noteworthy fronting, and /ɑ/ is largely in recession of its NCS caused advancement (Hillenbrand, 2003). Concerning Roeder (2010), the findings were determined to be congruent with those of the changes in West Michigan found here and we were able to determine that the changes she observed were reversing rather than progressing. I also agree with her assessment that female speakers are the leaders of linguistic change in this region.

The two models of reversal for the Northern Cities Shift is important when examining the mechanisms of language change. The result of there being separate models for East and West Michigan is surprising when considering that the NCS advanced in a single model across the entire area affected by the shift, transmitting between adults and altering their vowels starting with the first stage of the shift (Labov, 2007). Thus, it was expected that like the advancement of the shift, the reversal of the NCS would also follow one model, but instead is observed to be acting over different demographics between geographic regions. It is also possible that because of these two different demographic models, the mechanism of the change (being how the vowels interact and shift in relation to one another) may also vary between models, though I hesitate to posit any variation without a more populous and detailed sample of the speakers within these models.

Conclusions

This study has confirmed the reversal of the Northern Cities Shift in non-urban areas of East Michigan and among West Michigan female speakers. It has also confirmed the allophonic alternation of /æ/~[æ̃] in a pre-nasal environment, as well as confirming the presence of diphthongization of /æ/ identified by Hillenbrand (2003) in Southern Michigan and by Fasold (1996) in Detroit. Especially in some female speakers, mild fronting of /ʌ/ occurs without the fronting of its rounded counterpart /ɔ/. The back vowel /u/ is shown to have in the middle and youngest Age-Groups fronted, with East Michigan speakers showing greater fronting following coronals but less fronted after non-coronals. West Michigan speakers show a more consistently fronted back vowel with less difference between coronal and non-cornonal environments, but with coronals also being less fronted than in East Michigan. The two older Age-Groups have a close-rounded vowel that starts functions as /u/→ [ʉ] /T__, while the younger speakers exhibit /u̟/ → [y] /T__.

Impairment to the conduct of this study is largely due to its narrow timeframe and constraints set on it by the outbreak of the global pandemic in 2020. Due to this, participants were unable to be brought to a linguistics lab or interviewed in a location of the researcher's approval, nor was it possible for designated equipment or programs to be assigned with samples being sent in by a variety of methods removing control over the quality of the audio-data received. Some samples were less clear than others, possibly upsetting the identification and sampling of formant altitudes vital to the conduct of this study; however, unusably unreliable audio recordings were discarded from analysis, mitigating some of these effects. Future research conducted under these conditions should be better equipped to distribute the digital tools needed,

but will again be limited in the control it has over the spaces in which participants record themselves.

The prompting of the wordlist via slideshow was excellent means of acquiring un-enunciated speech, as it progressed quickly enough to avoid careful articulation, but still does not represent natural speech as a dialogue would. This may be a necessary element of the study if it is to compare all identical environments across participants, but further study is required then to complete the sampling in order to account for natural speech.

Also due to prompt delivery method, the progression of a wordlist resulted in the prosody associated with list reading in English, which may have some effect on the height of formants and their interactions with the surrounding consonants. Participants were instructed to avoid such prosody if possible, but achieving this was found to be difficult for many. Placing the sounds into a string of untested words leaving the tested words in the same prosodic position (unmarked as so to the participants) or by repeating all the target words to the each prosodic position may mitigate these effects, but at cost to the efficient use of time and effort for both participant and researcher.

Population size has always been the greatest concern, and while the study has garnered enough participation to merit some assertions, many are far from conclusive and need a larger population in several demographics and as a whole to be more satisfied in the results produced.

Continued work in this project is necessary, both to increase the population size sampled and expand beyond the demographics found within the tested population in order to provide a more clear picture of phonetics and phonology in the Lower Peninsula of Michigan and confirm or dispel the assertions made here about the models of NCS reversal observed. This should include an analysis of the mechanisms of reversal, and see if these vary between the models as

well. In addition to this, the field will see benefit in further study of diphthongization in /æ/ and other potentially ambiguous vowels as identified by Hillenbrand, and can be accomplished with the samples collected by this study and those of any future studies. Similar investigation is needed for the production and perception of the close-rounded vowel of the /u/ system, evaluating the various hypotheses proposed to explain the fronting, including closer investigation on other regions where this change is prevalent and the media through which it may diffuse to the Inland North, as well as perception tests across demographics on the various forms of the close-rounded vowel in relation to the acoustic hypothesis.

Finally, more extensive samples are needed from the Northern Lower Peninsula and from a wider geographic area, as all those found in the study are in towns that are adjacent to I-75 narrowing the potential spectrum of results. Furthermore, in order to complete any survey of Michigan vowels, a survey of the Upper Peninsula and comparison with those of neighboring states and Canada is imperative, and represents a current dearth in our knowledge of North American English.

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Appendix A

Participant Demographic Distribution

Following chart represents all the participants sampled for the conduct of this study. The years listed along the y-Axis represents the year of birth for any participant listed in that row. Along the top are the regional (West, North, South) and population-density environments (rural, suburban, urban) with each regional-density column split between male and female columns. Participants of uncertain or multiple demographics are listed for each applicable classification marked by and asterisk(*).

Table A1

Distribution of Participants by Age, Region, Population Density, and Sex

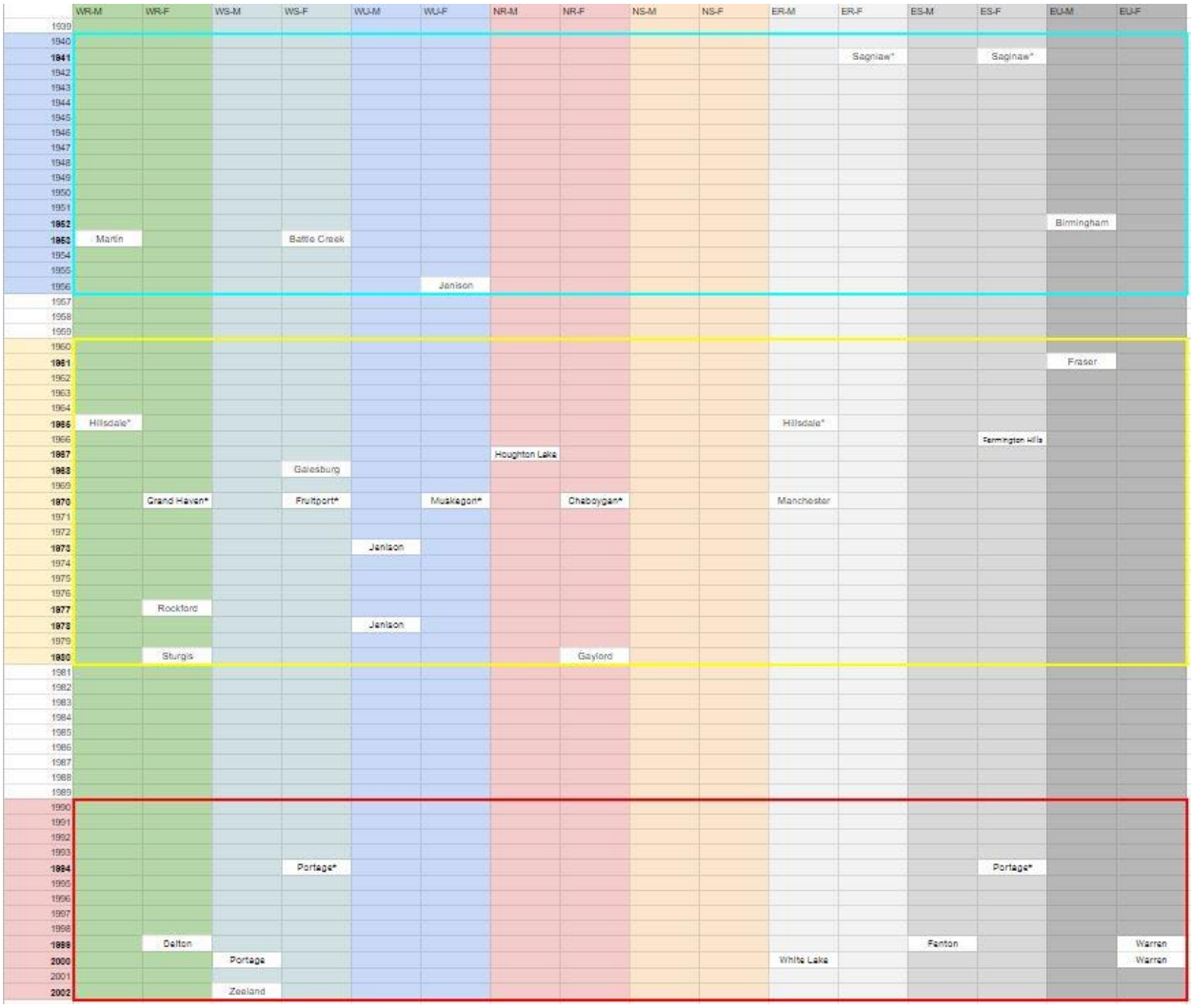


Table A2

Test Population by Region, Age, and Sex

Totals				Age-Group α (1940-1956)			Age-Group β (1960-1980)			Age-Group ɣ (1990-2002)		
N=24		Male	Female	N=5	Male	Female	N=13	Male	Female	N=8	Male	Female
East	**9**	**5**	**4**	**2**	**1**	**1**	**3**	**2**	**3**	**4**	**2**	**2**
West	**14**	**6**	**8**	**3**	**1**	**2**	**7**	**3**	**4**	**4**	**2**	**2**
North	**1 (+2)**	**1**	**(+2)**	**0**	**0**	**0**	**1 (+2)**	**1**	**(+2)**	**0**	**0**	**0**

Appendix B

Word List

The following 175 words were used in the study. Those in bold red (*full, wolf*) were included in the wordlist with which participants were presented but were not used in the final study due to them lacking an identifiable vowel with the moraic nucleus of the word being filled by a syllabic /l/ resulting in [fɬˈ] "full," and [wɬfˈ] "wolf." Note that some words are used to represent multiple environments or in the case of *tawny* contain two vowels [tʰɔːˈniˌ].

Table B1

Oral and Post-Nasal Environments

Minimal Pairs	[i]	**[ɪ]**	**[ɛ]**	**[æ]**	**[ʌ]**	[u]	[ʊ]	**[ɔ]**	**[ɑ]**
x	beat	bit	bet	bat	but	boot	**full**	bought	bot
x	beak	Bic	beck	back	buck	*fool*	book	bawk	Bach
x	seat	sit	set	sat	*cup*	suit	soot	sought	sot
x	*ease*	nick	neck	knack	*duck*	nuke	nook	*cawed*	knock
x	meet	mitt	met	mat	mutt	moot	*rook*	*raw*	*cod*
	steep	kid	pet	bath	puff	coop	put	pause	gosh
	feed	his	step	tab	sub	booth	could	caught	cot
	dear	pig	fed	has	shut	stoop	cook	dog	top
	lead	kiss	mesh	have	fuzz	whose	hood	hawk	mop
	steer	ill	mess	cash	dull	food	hoof*	laud	block
	reed	fish	bell	pal	cull	soup	bush	sauce	rock
	league	dish	red	laugh	lush	shoot	push	all	shot
	leash	fill	leg	past	rub	loot	good	awe	shop
	feet	lip	less	ask	rut	root	**wolf**	awed	odd
	lease	rib	sell	nap	up	tool	look	fought	dock

Table B2

Pre-Nasal Environments

Minimal Pairs	[i]	**[ɪ]**	**[ɛ]**	**[æ]**	**[ʌ]**	[u]	[ʊ]	**[ɔ]**	**[ɑ]**
	gene	rim	wren	ram	rum	room		pawn	John
	team	fin	fen	fan	fun	tomb		fawn	Tom
	deem	dim	den	dam	dumb	doom		dawn	don
	seen	sin	send	sand	sun	soon	woman	lawn	mom
	gleam	pin	pent	plant	punt	boon		tawny	romcom

Appendix C

Cartographic Representations

Figure C1

Map of the Distribution of the EQ Measure in Michigan

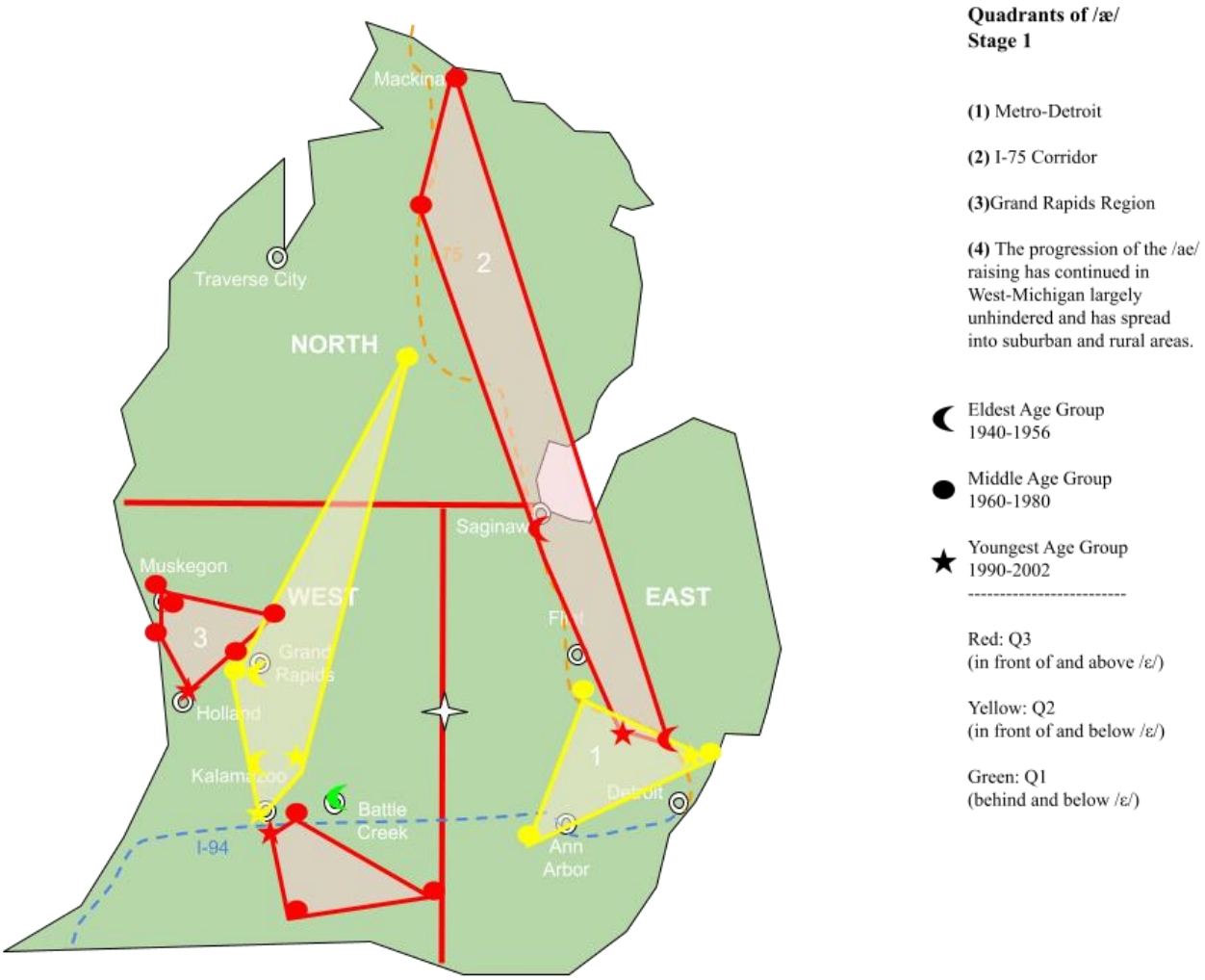


Figure C2

Map of the UD Measure in Michigan

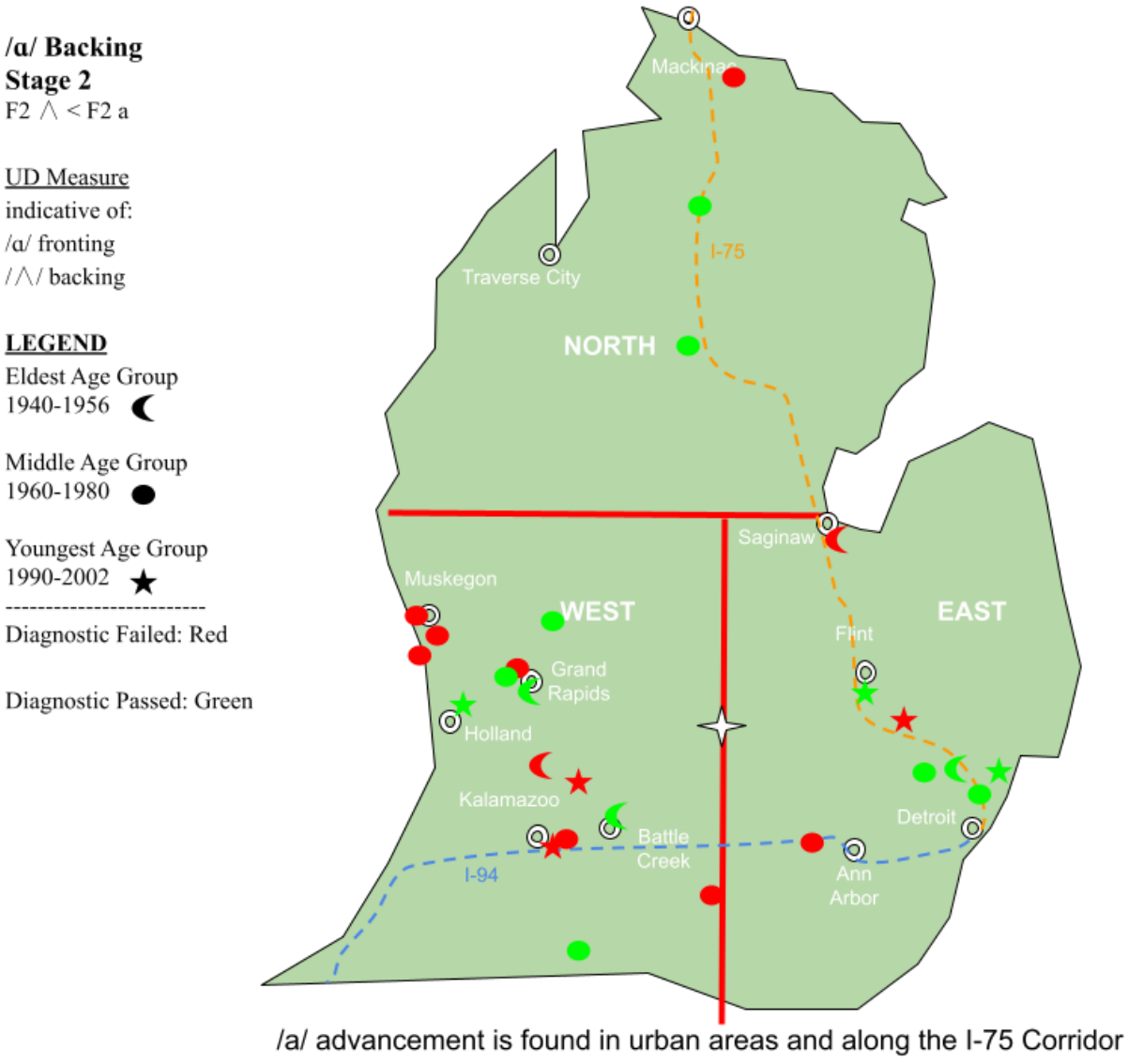


Figure C3

Map of the ED Measure in Michigan

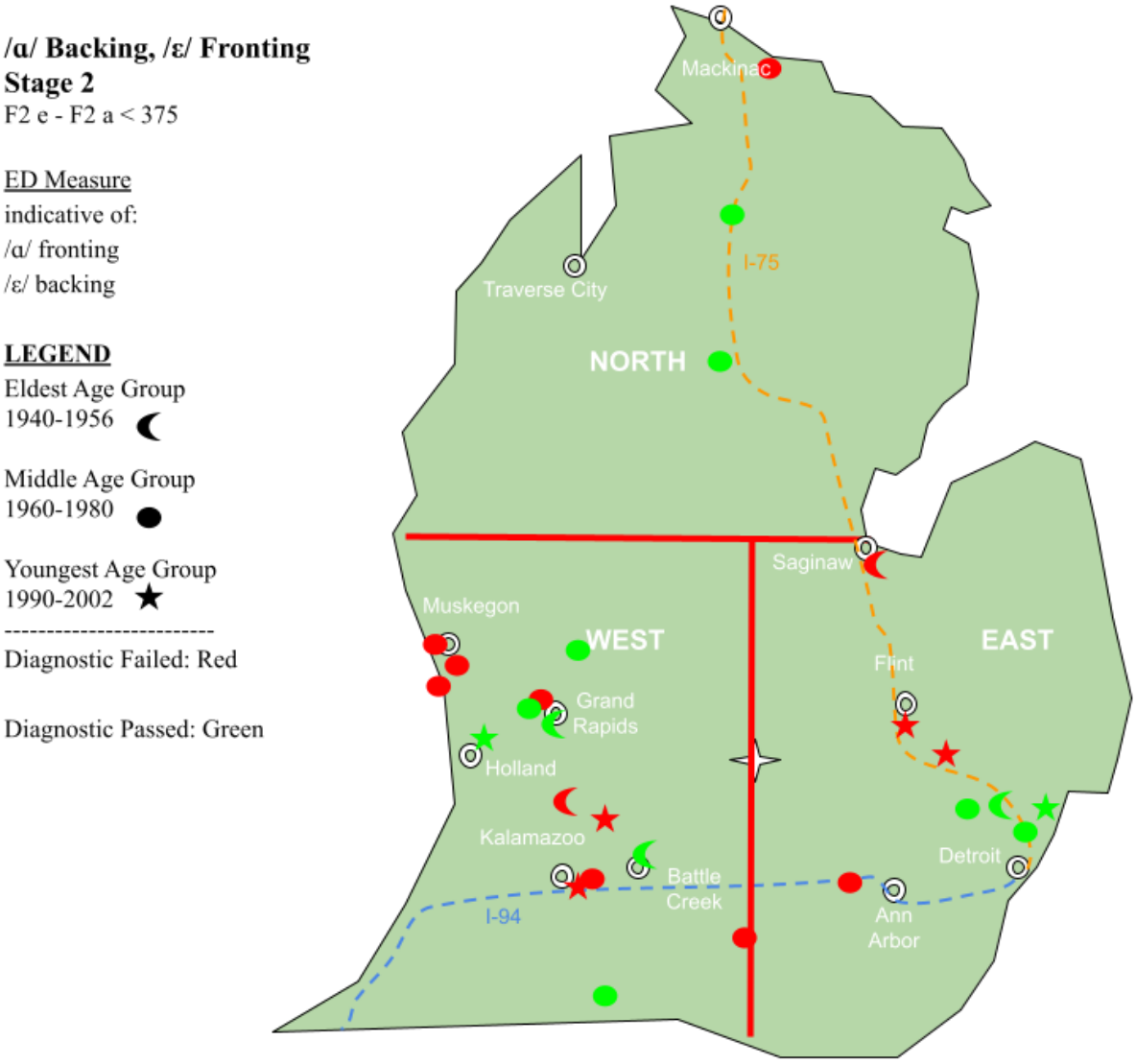
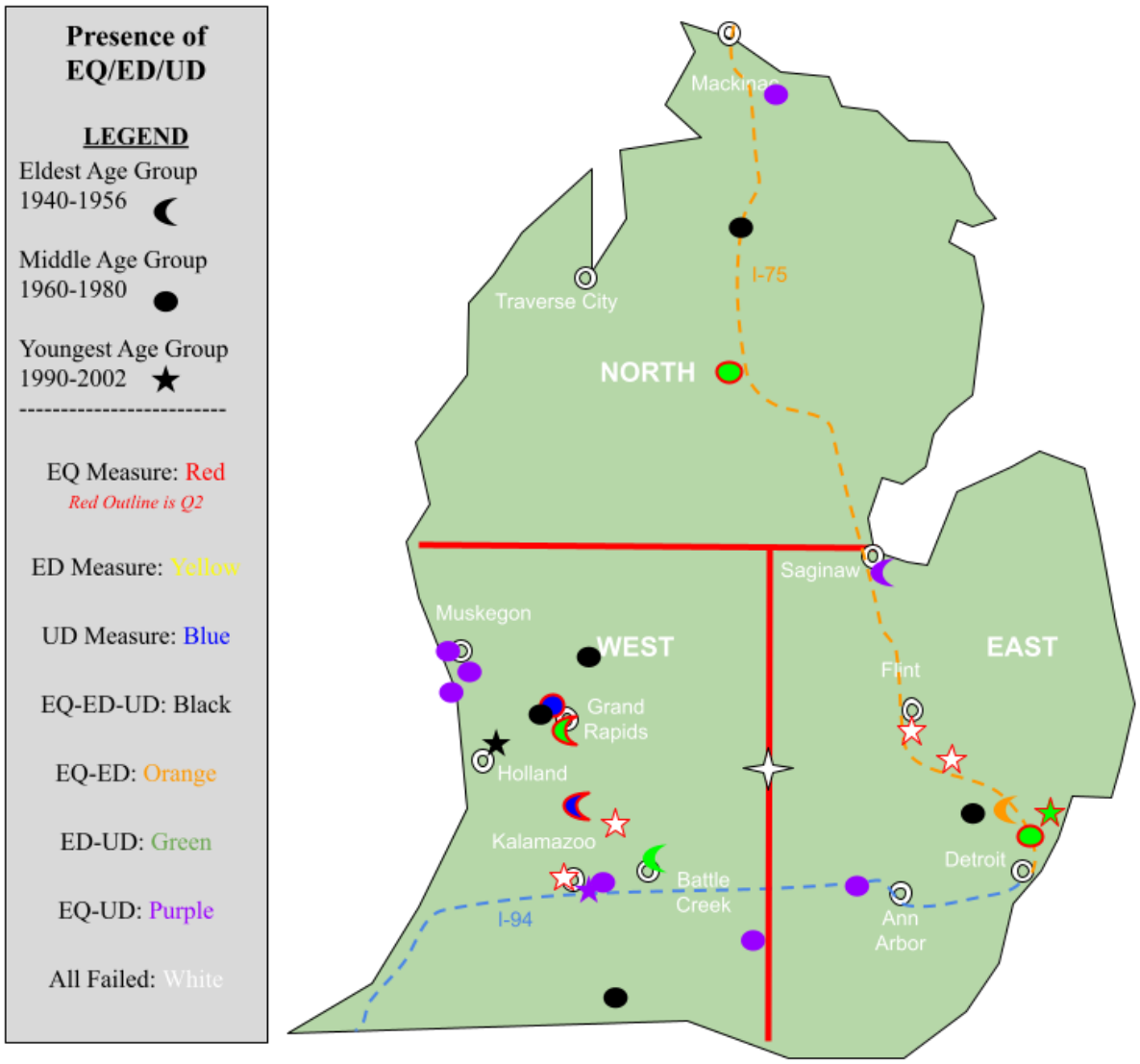


Figure C4

Map of Combined Measures in Michigan



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