Linguistic Portfolios

Volume 12 Article 13

2023

ACOUSTIC PHONETIC VERIFICATION OF CANADIAN RAISING OF /AI/ AND /AU/ IN MINNESOTA ENGLISH

Ettien Koffi
St. Cloud State University

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ETTIEN KOFFI

ABSTRACT

The diphthongs [aɪ] and [aʊ] are produced respectively as [ʌɪ] and [ʌʊ] by Canadians. This pronunciation was first mentioned in a primer in Canada in 1890. Joos drew scholarly attention to it in a seminal paper in 1942. It was later dubbed "Canadian Raising" by Chambers (1973). Vance (1987) contends that /aɪ/-raising was heard in Fergus Falls, MN, as far back as 1930s, but said nothing about the occurrence of /aʊ/-raising. The goal of this paper is to discuss the status of Canadian Raising in Minnesota English. Two separate experiments were conducted in which 18 Minnesotans produced 40 words embedded into the elicitation sentence, <I will say _______, again>. The findings discussed in this paper are based on 2,160 measured tokens (40 words x 18 participants x 3 correlates (F1, F2, F3)). Just Noticeable Difference (JND) thresholds in the frequency domain are summoned to evaluate the type of Canadian Raising found in Minnesota English.

Keywords: Canadian Raising, Minnesota English, [ɑɪ]-Raising, [ɑʊ]-Raising, Tyranny of Averages

1.0 Introduction

When Minnesotans travel outside of the Inland North dialect area of the USA, people readily mistake them for Canadians. This misidentification is due to the way Minnesotans produce some of their vowels (Lopez-Backstrom (2019) and Lopez-Backstrom and Koffi (2020)). Naturally, one can surmise that the Canadian way of pronouncing the vowels [ɑɪ] and [ɑʊ][1] has permeated the speech of Minnesotans. The current study purposes to verify instrumentally if, and to what extent, **Canadian Raising**, henceforth **CR**, has infiltrated Minnesota English. The investigation is carried out in two main installments that are centered around two experiments. The first involves [ɑɪ]-raising, while the second is devoted to [ɑʊ]-raising. Since Vance (1987) found phonological evidence for [ɑɪ]-raising, we do not devote as much attention to it as we do for [ɑʊ]-raising because nothing has been written about how Minnesotans produce it.

2.0 Succinct Literature Review

It is not my intention to bore the reader with an extensive literature review. Suffice it to say that mentions of CR in Canada and elsewhere abound. Dailey-O'Cain (1997:107) reports that CR was first noted in a primer in 1890. Joos (1942) was the first to bring scholarly attention to it. Chambers (1973) was the one who nicknamed it "Canadian Raising." In his 1989 and 2006 papers, Chambers noted that CR has been found in different localities in the USA. Labov et al. (2006:221) list publications that have found CR in the US. For example, Dailey-O'Cain (1997) found CR in Grand Rapids, Michigan. Carmichael (2020) has found traces of it in New Orleans. Outside of the North American continent, Milroy (1996) and Britain (1997) have found CR in Great Britain. In other words, CR is not found only in Canada, but elsewhere.

[1] By convention, the square brackets […] represent phones, the angle brackets <…> represent graphemes, and the slashes /…/ represent phonemes. The first two conventions are used throughout the paper.

2.1 Canadian Raising in Minnesota

If CR is found as far south as New Orleans, it goes without saying that it will be found in Minnesota, a state that abuts Canada. Indeed, the Minnesota evidence comes from Vance (1987). He gives an earwitness account of CR. He is a good earwitness because he was born in Minneapolis in 1951 and lived here until age 12. He recounted using it himself and hearing his friends use it. More importantly, he heard CR in the speech of his mother who was born in Fergus Falls in northern Minnesota in 1930, before moving to Minneapolis in 1947 when she 17. However, Vance is not an ordinary earwitness. He is also a linguist. So, he collected 504 words to test for the evidence of CR in the form of [ɑɪ] raising to [ʌɪ]. He found that in 446 of the test items (88.49%), CR obtained (Vance 1987:204). Based on the evidence provided by Vance, it can be surmised that [ɑɪ]-raising has been going on in Minnesota English since at least 1930. Vance's evidence for the existence of CR is impressionistic, which means that he listened to the data with his naked ear and came to the conclusion that [ɑɪ]-raising occurred in Minnesota. Even though this is a valid method of inquiry, the need has arisen for an instrumental validation of Vance's findings. I assigned the topic of [ɑɪ]-raising to Nick Woolums for his senior undergraduate thesis. His findings were published in 2012. However, since he collected data from only four participants, his findings, though illuminating, are not generalizable. I now have a large enough dataset for the verification of CR in Minnesota. It is worth noting that neither Vance nor Woolums investigated [ɑʊ]-raising. This paper is the first to verify the occurrence or lack thereof of [ɑʊ]-raising in Minnesota.

2.2 Participants and Data Collection[2]

When my family moved to Saint Cloud, in Central Minnesota in 2000, my son picked up BMX racing. So, our house was teaming with preteens and teenagers. I noticed that all of them pronounced <bike> as [bʌɪk], seldomly as [bɑɪk]. This was my first exposure to CR. On the racetrack, I began paying attention to their parents and other people. It was quite clear that [ʌɪ] and [ɑɪ] were in free variation in adult speech but the younger kids produced mostly [ʌɪ]. Pretty soon, I noticed that the <ice> in <ice cream> was pronounced as [ʌɪs], not as [ɑɪs]. Nowadays, [ɑɪ]-raising to [ʌɪ] is the preferred pronunciation of most Minnesotans.

In fall of 2020 and 2021, I began collecting data from the students who enrolled in my Introduction to Linguistics course. The university had mandated that courses taught satisfy one of the six dimensions of Our Husky Compact. The fourth dimension calls for "Integrating Existing and Evolving Technologies." This was the perfect opportunity for students to use Praat to verify aspects of their pronunciation. They recorded themselves reading a list of words embedded in the carrier sentence <*I will say _________, again*> (see Appendices A and B). The recordings took place well before the students began the phonetics and phonology chapters in Fromkin et al. (2017), *An Introduction to Language*, 11th edition. We spent two class periods on extracting various measurements of the vowels [ɑɪ] and [ɑʊ]. The data from 2020 is referred to as Experiment 1 and the one for 2021 as Experiment 2. Since the course is at an introductory level, it enrolls many students with a wide variety of backgrounds, nationality, and states. The data reported in the two experiments are only from students who were born and raised in Minnesota.

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[2] The participants in this study come from the Twin Cities of Minneapolis and Saint-Paul all the way to the Canadian border. The data does not include participants from extreme southern Minnesota, i.e., those who live close to the Iowa or the South Dakota borders.

Experiment 1 has 10 native Minnesotans and Experiment 2 had eight. I note in passing that since Atal (1972), it has been known and widely accepted that acoustic phonetic data from 10 participants or more is deemed representative of the speech community. Furthermore, Himmelmann and Ladd (2008) note that data from eight participants is generalizable to the entire community. Hualde et al.'s (2017) study that was published in the *Journal of Phonetics* had 17 participants, one less than the participants in this paper. All this is to say that the findings of this study are generalizable to Minnesotans who are 25 years old or younger. All 18 participants were 18 years old or older at the time of the study, but none was older than 25. They all consented for me to use their data by signing an IRB-approved consent form. Given the age of the participants, it can be said that the pronunciation patterns described here represent that of Gen Zers.[3] The participants produced a total of 2,160 tokens, that is, (40 words x 18 participants x 3 correlates).

2.3 The Methodology

The methodology used in both experiments is as follows. The students in each experiment downloaded Praat on their own laptop computers and recorded themselves reading the test words. A wide variety of devices were used. Some students had Windows operating systems, while others had Apple computers. The use of diverse recording devices and processing systems is not expected to affect the results in any measurable way because these devices and systems met ISO specification for audio products. The students and I met in the acoustic phonetic lab during class time, and I supervised the manual extraction of all the data. The Praat Textgrid annotation procedure that was followed is illustrated by Figure 1:

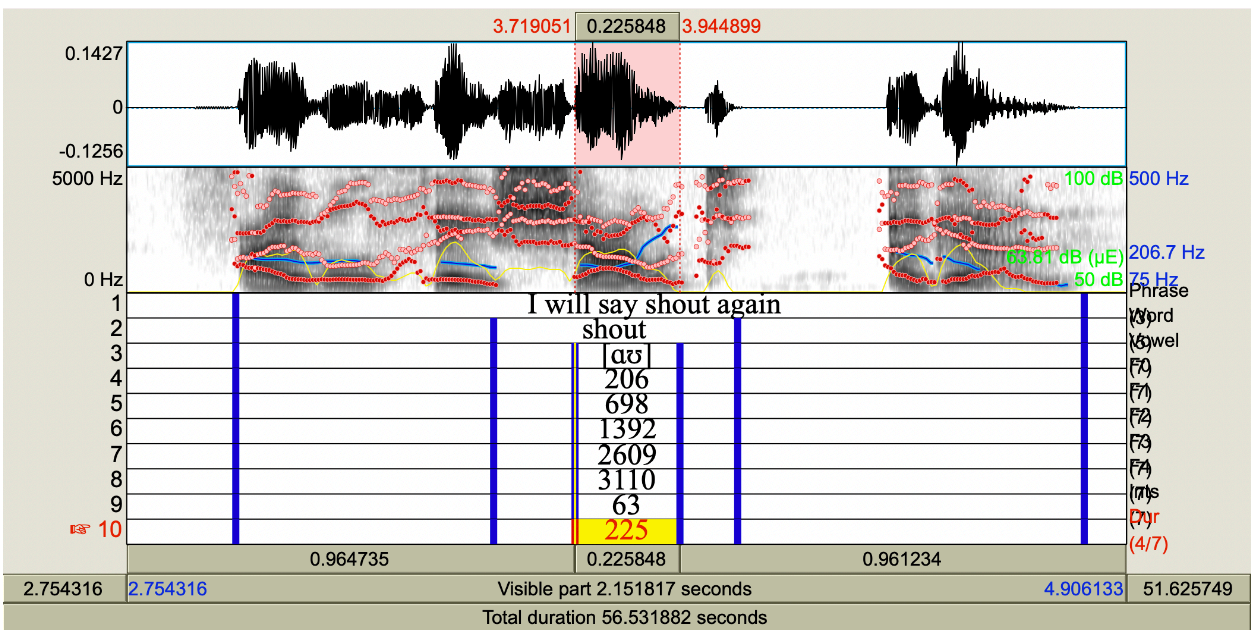

Figure 1: Feature Extraction and Annotation

We extracted seven correlates for each diphthong: F0, F1, F2, F3, F4, intensity, and duration. No attempts were made to measure F1 and F2 glides separately, as was the case in Woolums (2012). The focus here is on the acoustic phonetic behavior of the entire nucleus, from

[3] More information about this age group is available at: https://www.pewresearch.org/topic/generations-age/

the beginning to the end, as shown by the boundary markers in the annotated textgrid. The amount of data collected this way was quite large, that is, 5,040 tokens (40 words x 18 participants x 7 correlates). However, for the verification of CR, we focus only on 2,160 tokens (40 words x 18 participants x 3 correlates, that is, F1, F2, and F3).

2.4 The Interpretive Psychoacoustic Framework

The acoustic correlates of F1, F2, and F3 were extracted because they provide articulatory information about mouth aperture, tongue movement, and lip position. The interpretations of the significance of these measurements are based on tried and true Just Noticeable Difference (JND) thresholds derived from nearly 100 years of experimentations. JNDs help to gauge acoustic phonetic facts "in an understandable way" (Fastl and Zwicker 2007:VII). When JNDs are used, they obviate the need of complex statistical analyses because, for a JND to be considered valid, it must clear at least 75% of correct responses (Stevens 2000:225; Houtsma 1995:271). Koffi (2021) has devoted considerable attention to the history and use of JNDs. Consequently, they are stated and used here without further explanation.[4]

Canadian Raising on the F1 Bandwidth

CR is said to have taken place if and only if there is a difference of ≥ 60 Hz between [ɑɪ] and [ʌɪ] on the F1 frequency bandwidth.

In assessing whether CR obtains or not in any given dialect, F1 is considered the most robust correlate for three reasons. First, according to Ladefoged and Johnson (2015:207), F1 alone contains 80% of the acoustic energy found in vowels. A similar statement is found in Kent and Read (2002:33). Secondly, the proponents of feature hierarchy rank height as the most important feature of vowels (Ladefoged 2006:271-2). Thirdly, Labov et al. (2006:221-2) used the JND of ≥ 60 Hz as incontrovertible evidence for vowel raising. If an acoustic distance of ≥ 60 Hz is found between two different pronunciations of [ɑɪ] or [ɑʊ], then it can be stated categorically that CR has taken place.

Canadian Raising on the F2 Bandwidth

CR is said to involve concomitant fronting, centralization, or backing if and only if there is a difference of ≥ 200 Hz between [ɑɪ] and [ʌɪ] on the F2 frequency bandwidth.

Canadian Raising on the F3 Bandwidth

CR is said to involve concomitant lip rounding or unrounding if and only if there is a difference of ≥ 400 Hz between [ɑɪ] and [ʌɪ] on the F3 frequency bandwidth.

The JNDs of F2 and F3 are provided to investigate any articulatory gesture that may occur concomitantly with CR. The presence or absence of accompanying gestures is not a prerequisite for CR. In other words, F2 and F3 play a lesser role in the verification. The determinative

[4] Rabiner and Juang (1993:152) list slightly different set of JNDs. The JND of F1 is 62 Hz, that of F2 is 158 Hz, for F3, the JND is 355 Hz, while the JND of F4 is 480 Hz. It is important to keep in mind that the differences between these JNDs and those used in the paper do not amount to much on the 1/3 frequency bandwidth which is universally accepted as being a faithful replicate of how the naked ear processes frequency data.

threshold is the JND of ≥ 60 Hz. If a difference of 40 Hz or 50 Hz is found, this can be taken as a sign of incipient CR.

2.5 Acoustic Phonetic Findings from Earlier Studies

The use of the JND of ≥ 60 Hz means that we rely only on acoustic phonetic measurements for the verification of CR. Unfortunately, most of the studies of CR are impressionistic by nature. It means that researchers collected data, listened to them with their naked ears, and determined if CR applied or not. This is the type of study that Dailey-O'Cain (1997) conducted. She recruited 30 participants from Ann Arbor, Michigan, who read 140 words (62 containing [ɑʊ] and 63 [ɑɪ]) and 15 distractors. Her dataset contained 11,117 tokens: 7,038 tokens for [ɑɪ] and 4,139 tokens for [ɑʊ]. She found that [ɑɪ]-raising occurred 88% of the time, while [ɑʊ]-raising was found only 22% of the time (p.110). She tried to validate her assessment of [ɑʊ]-raising with F1 and F2 measurements. However, her data is unusable because she made her determination by comparing [ɑʊ] with [ɑ]. In my considered opinion, doing so is tantamount to comparing apples and oranges because [ɑ] and [ɑʊ] are two different phonemes in English.

Carmichael (2020) conducted a sociophonetic study of [ɑɪ] and [ɑʊ] -raising in New Orleans. She provided the following measurements on page 558 of her paper:

[ɑʊ] + [-voice, cons]	**F1**	**F2**	**[ɑʊ] + [+voice, cons]**	**F1**	**F2**
Men (Average)	672	1298	Men (Average)	696	1353
Women (Average)	808	1591	Women (Average)	814	1700

Table 1A: CR in Carmichael (2020)

She wanted to use the JND of ≥ 60 Hz to verify [ɑʊ]-raising in New Orleans, but she quickly realized that it did not provide the results that she expected. So, she abandoned this verification method for one that was more amenable to her anticipated conclusions. If we go strictly by the tried-and-true JND of ≥ 60 Hz, we see that [ɑʊ]-raising does **not** occur in the population that she investigated because the acoustic distance between males for [ɑʊ] (696 Hz) and [ʌʊ] (672 Hz) is merely 24 Hz for males. For females, the distance between [ɑʊ] (814 Hz) and [ʌʊ] (808 Hz) is only 6 Hz. The F2 differences of 55 Hz for males and 109 Hz for females also reveal that the amount of fronting is below the JND of ≥ 200 Hz. Again, F2 does **not** show that [ɑʊ]-raising occurs in New Orleans. Yet, she reported on page 559 that 9 of the 57 participants (15.78%) had [ɑʊ]-raising in their speech. It is unclear why she ultimately concluded that [ɑʊ]-raising occurs in New Orleans even though the acoustic phonetic data and the number of participants who produced it indicate otherwise. If only 15.78% of the participants actively produce it, it means that this pronunciation is not attested among 84.22% of the participants. A more logical conclusion would have been to say that this is an emergent pronunciation.

Very few studies of CR provide F1 and F2 measurements. Many authors make their determination about the status of CR on impressionistic grounds. These phonological studies need to be augmented by acoustic phonetic data if CR is to be verified reliably. Unfortunately, it is hard to come across acoustic phonetic measurements for CR. I have combed through dozens and dozens of published papers, but to no avail. I was about to despair when I came across Hualde et al. (2017:22) who provide F1 and F2 measurements from Chicago on which JND tests can be applied. Their study enrolled 17 college students, 10 females and 7 males, born and raised in or around

Chicago. Table 1B displays the mean measurements from their study. They provided other measurements, but we are interested in only those of [ɑɪ] before voiceless and voiced consonants.

N0	Participants	F1 [ɑɪ]+ [-voice, +cons]	F1 [ɑɪ] + [+voice, + cons]	Difference
1.	Females	854	1021	167
2.	Males	685	771	86
	Participants	**F2 [ɑɪ] + [-voice, +cons]**	**F2 [ɑɪ] + [+voice, + cons]**	**Difference**
1.	Females	1717	1590	127
2.	Males	1405	1320	85

Table 1B: CR in Chicagoland (Hualde et al. 2017)

Hualde et al.'s measurements indicate that females raise [ɑɪ] twice as much as their male counterparts. The F1 differences for female and male speakers are respectively 167 Hz and 86 Hz. Since these F1 measurements are higher than the JND of ≥ 60 Hz, we conclude that [ɑɪ]-raising occurs in Chicagoland.

The F2 differences are 127 Hz for females and 85 Hz for males. Both measurements are below the JND of ≥ 200 Hz. We conclude, therefore, that [ɑɪ]-raising in Chicago is not accompanied concomitantly by fronting. The lack of fronting may be an indication that [ɑɪ]-raising in Chicago is different from the one found in Canada. Chambers (2006:115) contends that CR in Canada involves both raising and fronting. However, the extent of fronting mentioned by Chambers must be taken with a grain of salt because he provided no acoustic phonetic measurements to support his claims. The data in Figures 4 and 5 (pages 114 and 115 of his paper) are those of F1, which is not a measure of fronting, but of mouth aperture (raising).

One must note in passing that Chicago is 409 miles south of Minneapolis. If CR is spreading from Canada southward into the USA, we can assume that it would have gone through Minnesota first since it is closer to Canada before reaching Chicago. To verify this hypothesis, we turn to Woolums' (2012) study that provides us with [ɑɪ]-raising measurements from Saint Cloud, a town in central Minnesota, about 70 miles north of the twin cities of Minneapolis and Saint Paul. His findings are displayed in Table 1C, including the words that he used to elicit the data.

[ɑɪ] - [+voice, cons]	F1	F2	[ɑɪ] + [-voice, cons]	F1	F2
hide	815 Hz	1979	height	650 Hz	2162 Hz
hibernation	738 Hz	1913	hyper	668 Hz	2123 Hz
lies	732 Hz	1907	lice	611 Hz	2031 Hz
lied	770 Hz	1890	light	637 Hz	1997 Hz
Average	**763 Hz**	**1922 Hz**	Average	**641 Hz**	**2078 Hz**
Standard Deviation	38	39	Standard Deviation	23	77

Table 1C: CR in Saint Cloud, Minnesota (Woolums 2012)

When the JND of F1 of ≥ 60 Hz is applied to Woolums' data, we see that an acoustic difference of 122 Hz separates [ɑɪ] (763 Hz) from [ʌɪ] (641 Hz). In other words, [ɑɪ] is raised to [ʌɪ] before voiceless consonants. The JND of F2 shows that [ɑɪ]-raising does not show a concomitant fronting gesture because the acoustic distance of 156 Hz between [ɑɪ] (1922 Hz) and [ʌɪ] (2078 Hz) is below the threshold of ≥ 200 Hz. Since Woolums' study was meant to be an exploratory pilot study with only four participants, his findings are not generalizable, hence the need to conduct two new experiments to verify the existence of CR in Minnesota.

3.0 Experiment 1

The 17 words of Experiment 1 are mostly taken from Fromkin et al. (2017: 2017:258-9, Exercise 8). This is the textbook that I use in the Introduction to Linguistics course. The point of this exercise is to help students verify for themselves if they implement CR in their speech. The pronunciation of [ɑɪ] as [ʌɪ] before voiceless consonants is so widespread that it has been featured continuously in Fromkin et al. as a phonology problem since 1978. Even so, there is still some controversy as to whether or not /ɑɪ/ is raised before rhotics. Vance (1987:200) claims that it is, but others have reservations. Various attempts have been made to explain away why CR may or may not apply in <higher> and <hire> (Onisson 2010:62). Morphological and syllabification arguments have been put forth to account for hard to explain cases. Dailey-O'Cain (1997:114) attributes variability in CR before [r] and in other phonological environments to speech style and informality. Such phonologically-inclined explanations ignore the fact that there is a great deal of interspeaker variability as to how rhotacized [ɹ] is produced. For example, Ladefoged (2006:224) notes that 60% of native speakers produce [ɹ] with the tip of the tongue up, 35% produce it as a bunched [ɹ], with the tip of the tongue down, while the remaining 5% have their tongue in an intermediate position. These articulatory gestures may explain why [ɑɪ]-raising before rhotics is still a difficult issue to resolve. In the investigation of CR in Experiment 1, [ɹ] is included among voiced consonants. Hence, the phonological environment to which we pay attention is [ɑɪ]-raising before [± voice] consonants.

3.1 F1 Measurements and Findings

The participants in Experiment 1 are 3 males and 7 females. Gender data is reported separately but the analyses are based on the combined averages, unless a separate analysis is warranted. Moreover, the focus is as much on interspeaker variability as it is on the arithmetic means.

N0	Vowels	F1 [ɑɪ] + [-voice, +cons]	F1 [ɑɪ] + [+voice, + cons]	Difference
1.	Speaker 1F	543	678	135 Hz
2.	Speaker 2M	580	742	162 Hz
3.	Speaker 3M	583	555	28 Hz
4.	Speaker 4F	520	671	151 Hz
5.	Speaker 5F	578	743	165 Hz
6.	Speaker 6F	559	658	99 Hz
7.	Speaker 7F	705	813	108 Hz
8.	Speaker 8F	652	802	150 Hz
9.	Speaker 9F	563	667	104 Hz
10.	Speaker 10M	403	629	226 Hz
	Female Mean	*588*	*718*	*130 Hz*
	Male Mean	*522*	*642*	*120 Hz*
	Combined Means	**568**	**695**	**127 Hz**
	St. Deviation	79	79	

Table 2: F1 Values of [ɑɪ]-Raising

The combined arithmetic means indicate that there is a difference of 127 Hz on the F1 frequency bandwidth between when [ɑɪ] occurs before a voiced consonant (695 Hz) and when it occurs before a voiceless one (568 Hz). Since the difference is more than twice the JND of ≥ 60 Hz, we conclude that the speakers whose data is analyzed here implement CR in their speech. The interspeaker variability analysis supports this conclusion, revealing that 9 of the 10 participants (90%) implement CR in their speech. The only exception is Speaker 3M.

It is worth noting that all 7 female speakers (100%) implement CR in their speech. The magnitude of the raising in this study is almost identical with Woolums' exploratory findings. In his data in Table 1C, we see that the distance between [ɑɪ] (763 Hz) and [ʌɪ] (641 Hz) is 122 Hz. We conclude, therefore, that [ɑɪ]-raising occurs in Minnesota English. Both of these results confirm what Vance (1987:204) reported 35 years ago, namely that CR occurred frequently and pervasively in the speech of Minnesotans. In the 504 items he investigated, he found that CR occurs in 446 of them. The percentage of 88.49% of occurrence is similar to the 90% of the participants in Table 2 who produce CR.

3.2 F2 Measurements and Findings

Ordinarily, phonological studies of CR do not investigate F2. As a result, we do not know how much fronting, centralization, or backing occurs with it. However, when F2 data is provided, as in Table 3, we can address these issues with confidence.

N0	Vowels	F2 [ɑɪ] + [-voice, +cons]	F2 [ɑɪ] + [+voice, + cons]	Difference
1.	Speaker 1F	2232	1870	362 Hz
2.	Speaker 2M	1810	1551	259 Hz
3.	Speaker 3M	1803	1725	78 Hz
4.	Speaker 4F	1830	1801	29 Hz
5.	Speaker 5F	2163	1856	307 Hz
6.	Speaker 6F	1992	1861	131Hz
7.	Speaker 7F	2233	1917	316 Hz
8.	Speaker 8F	2082	1804	278 Hz
9.	Speaker 9F	1840	1641	199 Hz
10.	Speaker 10M	1945	1504	441 Hz
11.	*Female Mean*	*2053*	*1821*	*232 Hz*
12.	*Male Mean*	*1852*	*1593*	*259 Hz*
	Combined Means	**1993**	**1753**	**240 Hz**
	St. Deviation	174	142	

Table 3: F2 Values of [ɑɪ]-Raising

The combined arithmetic means show that [ɑɪ] is more fronted before voiceless consonants than before voiced ones. The acoustic difference of 240 Hz between [ʌɪ] (1993 Hz) and [ɑɪ] (1753 Hz) is greater than the JND of ≥ 200 Hz. Therefore, we conclude that fronting is a robust concomitant articulatory gesture. Furthermore, the interspeaker variability analysis reveals that seven of the 10 participants (70%) front [ʌɪ] significantly. We could even incorporate Speaker 9F among the seven participants who front their [ɑɪ]s before voiceless consonants because her F2 is only 1 Hz shy away from the JND. If so, then it can be argued that 80% of the participants front [ɑɪ] to [ʌɪ] before voiceless consonants. That fronting should occur along with raising is hardly surprising since [ʌ] is ordinarily classified as a central vowel, while /ɑ/ is a back vowel. The data shows that CR in Minnesota is accompanied by fronting, just like it is in Canada. However, as noted in 2.5, CR in Chicago does not involve concomitant fronting, whereas the one in Minnesota does. In other words, Minnesota has adopted CR wholesale, as it is produced in Canada. This is not surprising, given the proximity of Minnesota and Canada.

3.3 F3 Measurements and Findings

By providing F3 measurements, we can also verify if lip positioning is an acoustically robust correlate. For lip position to be relevant, there must be an acoustic difference of ≥ 400 Hz between [ɑɪ] and [ʌɪ]. Let's see what Table 4 reveals in this respect.

N0	Vowels	F3 [ɑɪ] + [-voice, +cons]	F3 [ɑɪ] + [+voice, + cons]	Differences
1.	Speaker 1F	3018	3032	14 Hz
2.	Speaker 2M	2526	2545	19 Hz
3.	Speaker 3M	2656	2587	69 Hz
4.	Speaker 4F	2997	3098	101Hz
5.	Speaker 5F	2512	2757	245 Hz
6.	Speaker 6F	2798	2653	145 Hz
7.	Speaker 7F	2913	2794	119 Hz
8.	Speaker 8F	3067	3009	58 Hz
9.	Speaker 9F	2644	2583	61 Hz
10.	Speaker 10M	2599	2566	33 Hz
11.	*Female Mean*	*2849*	*2846*	*3 Hz*
12.	*Male Mean*	*2699*	*2682*	*17 Hz*
	Combined Means	**2773**	**2762**	**11 Hz**
	St. Deviation	212	212	

Table 4: F3 Values of [ɑɪ]-Raising

The combined arithmetic means show that there is only a difference of 11 Hz between [ʌɪ] (2773 Hz) and [ɑɪ] (2762 Hz). Since 11 Hz is very far from the JND of ≥ 400 Hz, we conclude that lip positioning does not matter in CR. In fact, the interspeaker variability analysis shows that F3 is not robust correlate for any of the participants.

3.4 Interim Conclusion

Vance's (1987) phonological findings about [ɑɪ]-raising are confirmed by the acoustic phonetic measurements presented in Experiment 1, which also confirm the results of Woolums' (2012) pilot study. The pervasiveness of CR in Minnesota is due to the fact that Minnesota shares a long border with Canada. According to Vance (1987), this form of CR was adopted in Minnesota as early as the 1930s, if not sooner.

4.0 Experiment 2

Experiment 2 was conducted similarly to Experiment 1, except that it involved eight participants. Whereas [ɑɪ]-raising is sufficiently studied, the same cannot be said for [ɑʊ]-raising. Dailey-O'Cain (1997) is the study that is often cited in this regard. She reported on pages 110 and 116 of her paper that she examined 4,139 tokens for [ɑʊ] and found that it occurred 22% of the time. As noted earlier, her methodology is impressionistic and the F1 measurements that she provided to demonstrate [ɑʊ]-raising are questionable, therefore, not usable (see 2.3). The second study that purports to have studied [ɑʊ]-raising acoustically is Rosenfelder (2007). However, her aggregated measurements are nowhere to be found. Consequently, her data in Figures 6 and 7 on pages 263-5 cannot be used in any meaningful way for verification. The third study is Carmichael (2020). We read on page 557 that she collected 3,851 tokens of [ɑʊ] from 57 participants and found that 9 of them (15.78%) implemented [ɑʊ]-raising. Her study did not pass the JND of ≥ 60 Hz test. So, she resorted to a different method to justify the occurrence of [ʌʊ] in New Orleans.

In this paper, we stick to the JND of ≥ 60 Hz as the acid test for the verification test for [ɑʊ]-raising. Labov et al. (2006:221) used this same JND to verify vowel raising. Six different phonological environments are examined, which are,

1. When [ɑʊ] occurs before voiceless and voiced consonants
2. When [ɑʊ] occurs before voiceless consonants and the rhotacized vowel [ɚ]
3. When [ɑʊ] occurs before voiceless consonants and as singletons ∅ in codaless syllables
4. When [ɑʊ] occurs before voiced consonants and the rhotacized vowel [ɚ]
5. When [ɑʊ] occurs before voiced consonants and as singletons ∅ in codaless syllables
6. When [ɑʊ] occurs before the rhotacized vowel [ɚ] and as singletons ∅ in codaless syllables

4.1 F1 Measurements and Findings

To investigate the possibility of [ɑʊ] raising to [ʌʊ], the pronunciation of [ɑʊ] in the words <*shout, out, about, mouse, mouth, tout, doubt, house, couch, south, pout*> was contrasted with that of <*loud, proud, powder*>. The measurements obtained from the analyses are displayed in Table 5A:

N0	Speakers	F1 [ɑʊ] + [-voice, +cons]	F1 [ɑʊ] + [+voiced, +cons]	Difference
1.	Speaker 11F	736	846	110 Hz
2.	Speaker 12F	704	689	15 Hz
3.	Speaker 13F	732	816	84 Hz
4.	Speaker 14F	660	722	62 Hz
5.	Speaker 15F	536	573	37 Hz
6.	Speaker 16F	717	707	10 Hz
7.	Speaker 17F	545	573	28 Hz
8.	Speaker 18M	644	633	11 Hz
9.	*Female Mean*	*654*	*703*	*49 Hz*
	Combined Means	**652**	**694**	**42 Hz**
	St. Deviation	83	101	94

Table 5A: F1 Values of [ɑʊ]-Raising

The combined arithmetic means indicate that the difference between the two phonological contexts is 42 Hz, which is below the JND of ≥ 60 Hz. This suggests that, though, there is a tendency towards [ɑʊ] raising to [ʌʊ], it is not happening across the board. The interspeaker variability analysis bears it out. Only three participants (Speakers 11F, 13F, and 14F) out of eight (37.5%) raise [ɑʊ] to [ʌʊ] before voiceless stops.

When the phonological environment is changed, and [ɑʊ] before voiceless consonants is compared with [ɑʊ] in words in which a rhotic occurs in the coda, as in <*tower, coward, flower, power, hour*>, the acoustic distance between them rises to 72 Hz, which is higher than the JND of ≥ 60 Hz.

N0	Speakers	F1 [ɑʊ] + [-voice, +cons]	F1 [ɑʊ]+ [ɚ]	Difference
1.	Speaker 11F	736	883	147 Hz
2.	Speaker 12F	704	796	92 Hz
3.	Speaker 13F	732	838	106 Hz
4.	Speaker 14F	660	741	81 Hz
5.	Speaker 15F	536	591	55 Hz
6.	Speaker 16F	717	747	30 Hz
7.	Speaker 17F	545	575	30 Hz
8.	Speaker 18M	644	621	23 Hz

9.	*Female Mean*	*654*	*738*	*84 Hz*
	Combined Means	**652**	**724**	**72 Hz**
	St. Deviation	83	116	

Table 5B: F1 Values of [ɑʊ]-Raising

The higher acoustic difference is a case of the **"tyranny of averages"** because the interspeaker variability reveals that only half of the participants raise [ɑʊ] to [ʌʊ]. In statistics, the tyranny of averages is noted when the arithmetic means skews the data. Because of it, we cannot read too much into the combined means. Yet, there is definitely a discernible pattern. First, the raising among females is 84 Hz, which is 24 Hz higher than the JND of ≥ 60 Hz. Secondly, four of the seven females (Speakers 11F, 12F, 13F and 14F) raise [aʊ] before [ɹ]. Is this because they produce [ɹ] with the tip of their tongue up or is this a genuine case of [ɑʊ] raising to [ʌʊ]? This seems to be a legitimate case of [ɑʊ]-raising because, except for Speaker 12F, the same three participants (Speakers 11F, 13F, and 14F) raise [ɑʊ] to [ʌʊ] in Table 5A.

In Table 5C, we compare [ɑʊ] before voiceless consonants with when [ɑʊ] occurs by itself in codaless syllables, as in <*bow, cow, how, wow*>.

N0	Speakers	F1 [ɑʊ]+ [-voice, +cons]	F1[ɑʊ]+∅	Difference
1.	Speaker 11F	736	816	80 Hz
2.	Speaker 12F	704	759	55 Hz
3.	Speaker 13F	732	752	30 Hz
4.	Speaker 14F	660	666	6 Hz
5.	Speaker 15F	536	573	37 Hz
6.	Speaker 16F	717	838	121 Hz
7.	Speaker 17F	545	624	79 Hz
8.	Speaker 18M	644	661	17 Hz
9.	*Female Mean*	*654*	*711*	*57 Hz*
	Combined Means	**652**	**704**	**52 Hz**
	St. Deviation	83	94	

Table 5C: F1 Values of [ɑʊ]-Raising

The combined arithmetic means indicate a fair amount of [ɑʊ]-raising (52 Hz), but it is still below the JND of ≥ 60 Hz. The female raising mean is 57 Hz, which is only 3 Hz shy of the JND. This is an indication that the presence of voiceless consonants is a favorable environment for [ɑʊ]-raising to occur even though the raising is still below the JND of ≥ 60 Hz. The interspeaker variability analysis shows that three of the seven participants (42.85%) raised [ɑʊ] in this phonological environment.

When [ɑʊ] occurs before a voiced consonant and is compared with [ɑʊ] that occurs before the rhotic [r], we see that the acoustic distance between them is only 30 Hz, which is below the JND of ≥ 60 Hz. Only Speaker 12F produces the two types of [ɑʊ] differently. The remaining seven speakers produce them the same.

N0	Speakers	F1 [ɑʊ] + [+voice, +cons]	F1 [ɑʊ] + [ɚ]	Difference
1.	Speaker 11F	846	883	37 Hz
2.	Speaker 12F	689	796	107 Hz
3.	Speaker 13F	816	838	22 Hz
4.	Speaker 14F	722	741	19 Hz
5.	Speaker 15F	573	591	18 Hz
6.	Speaker 16F	707	747	40 Hz
7.	Speaker 17F	573	575	2 Hz
8.	Speaker 18M	633	621	12 Hz
9.	*Female Mean*	*703*	*738*	*33 Hz*
	Combined Means	**694**	**724**	**30 Hz**
	St. Deviation	101	116	

Table 5D: F1 Values of [ɑʊ]-Raising

Table 5E also shows no difference between when [ɑʊ] occurs before voiced consonant and when it occurs by itself in codaless syllables. The arithmetic mean of 10 Hz that separates them is well below the JND of ≥ 60 Hz. The interspeaker variability analysis reveals again that three participants (Speaker 12F, 13F, and 16F) raise [ɑʊ] to [ʌʊ], but the five remaining speakers produce them the same.

N0	Speakers	F1[ɑʊ] + [+voice, +cons]	F1[ɑʊ]+∅	Difference
1.	Speaker 11F	846	816	30 Hz
2.	Speaker 12F	689	759	70 Hz
3.	Speaker 13F	816	752	64 Hz
4.	Speaker 14F	722	666	56 Hz
5.	Speaker 15F	573	573	0 Hz
6.	Speaker 16F	707	838	131 Hz
7.	Speaker 17F	573	624	51 Hz
8.	Speaker 18M	633	661	28 Hz
9.	*Female Mean*	*703*	*711*	*8 Hz*
	Combined Means	**694**	**704**	**10 Hz**
	St. Deviation	101	94	

Table 5E: F1 Values of [ɑʊ] Raising

Finally, we examine the acoustic behavior of [ɑʊ] before rhotic and [ɑʊ] codaless syllables. The arithmetic means indicate that the pronunciation of [ɑʊ] does not change in these two phonological environments. The distance of 20 Hz is below the JND of ≥ 60 Hz.

N0	Speakers	F1 [ɑʊ] + [ɚ]	F1[ɑʊ]+∅	Difference
1.	Speaker 11F	883	816	67 Hz
2.	Speaker 12F	796	759	37 Hz
3.	Speaker 13F	838	752	86 Hz
4.	Speaker 14F	741	666	75 Hz
5.	Speaker 15F	591	573	18 Hz
6.	Speaker 16F	747	838	91 Hz
7.	Speaker 17F	575	624	49 Hz
8.	Speaker 18M	621	661	40 Hz
9.	*Female Mean*	*738*	*711*	*27 Hz*
	Combined Means	**724**	**704**	**20 Hz**
	St. Deviation	116	94	

Table 5F: F1 Values of [ɑʊ]-Raising

The interspeaker variability analysis reveals that half of the participants raise [ɑʊ] to [ʌʊ] while the other half do not.

4.1.1 Interim Conclusion

The investigation has so far revealed that there is a slight tendency towards [aʊ]-raising in Minnesota. In three instances, the raising is higher than 40 Hz. In every phonological environment, there are three to four participants who implement [ɑʊ]-raising, except in Table 5D. The findings paint an accurate picture of a change in progress that for now affects only about 37.5% of Minnesotans. The main phonological environments that favor [ɑʊ]-raising are before voiceless consonants, before rhotics, and in codaless syllables.

4.2 F2 Measurements and Findings

Measurements on the F2 frequency bandwidth are auditorily perceptible if the distance between [ɑʊ] and [ʌɪ] is ≥ 200 Hz. The pronunciation with the greater F2 value is considered more fronted than the one with the lesser value. When the data is cross-tabulated as displayed in Tables 6A through 6F, we see that none of the arithmetic means reach 200 Hz. The interspeaker variability analyses also indicate that only Speaker 18M produced [ɑʊ] differently in Tables 6B, 6D, and 6F. When [ɑʊ] is followed by [ɹ], he retracts his tongue more strongly. This is an indication that this speaker is most likely one of the 35% of Americans who, according to Ladefoged, adopts a bunched [r] pronunciation. The data from the remaining participants show that there is no F2 difference in the pronunciations of [ɑʊ] and [ʌɪ].

N0	Speakers	F2 [ɑʊ]+ [-voice, +cons]	F2 [ɑʊ]+ [+voiced, +cons]	Difference
1.	Speaker 11F	1451	1384	67 Hz
2.	Speaker 12F	1438	1300	138 Hz
3.	Speaker 13F	1368	1343	25 Hz
4.	Speaker 14F	1538	1544	6 Hz
5.	Speaker 15F	1334	1151	183 Hz
6.	Speaker 16F	1507	1473	34 Hz
7.	Speaker 17F	1442	1353	89 Hz
8.	Speaker 18M	1413	1323	90 Hz
9.	*Female Mean*	*1440*	*1364*	*76 Hz*
	Combined Means	**1436**	**1358**	**78 Hz**
	St. Deviation	78	117	

Table 6A: F2 Values of [ɑʊ]-Raising

N0	Speakers	F2 [ɑʊ]+ [-voice, +cons]	F2 [ɑʊ]+ [ɚ]	Difference
1.	Speaker 11F	1451	1441	10 Hz
2.	Speaker 12F	1438	1431	7 Hz
3.	Speaker 13F	1368	1303	65 Hz
4.	Speaker 14F	1538	1628	90 Hz
5.	Speaker 15F	1334	1236	98 Hz
6.	Speaker 16F	1507	1337	170 Hz
7.	Speaker 17F	1442	1278	164 Hz
8.	Speaker 18M	1413	1001	412 Hz
9.	*Female Mean*	*1440*	*1379*	*61 Hz*
	Combined Means	**1436**	**1331**	**105 Hz**
	St. Deviation	78	181	

Table 6B: F2 Values of [ɑʊ]-Raising

N0	Speakers	F2 [ɑʊ]+ [-voice, +cons]	F2 [ɑʊ]+∅	Difference
1.	Speaker 11F	1451	1372	79 Hz
2.	Speaker 12F	1438	1429	9 Hz
3.	Speaker 13F	1368	1248	120 Hz
4.	Speaker 14F	1538	1379	159 Hz
5.	Speaker 15F	1334	1151	183 Hz
6.	Speaker 16F	1507	1514	7 Hz
7.	Speaker 17F	1442	1341	101 Hz
8.	Speaker 18M	1413	1288	125 Hz
9.	*Female Mean*	*1440*	*1334*	*106 Hz*
	Combined Means	**1436**	**1327**	**148 Hz**
	St. Deviation	78	123	

Table 6C: F2 Values of [ɑʊ]-Raising

N0	Speakers	F2 [ɑʊ]+ [+voice, +cons]	F2[ɑʊ] + [ɚ]	Difference
1.	Speaker 11F	1384	1441	57 Hz
2.	Speaker 12F	1300	1431	131 Hz
3.	Speaker 13F	1343	1303	40 Hz
4.	Speaker 14F	1544	1628	84 Hz
5.	Speaker 15F	1151	1236	85 Hz
6.	Speaker 16F	1473	1337	136 Hz
7.	Speaker 17F	1353	1278	75 Hz
8.	Speaker 18M	1323	1001	322 Hz
9.	*Female Mean*	1364	1379	15 Hz
	Combined Means	**1358**	**1331**	**27 Hz**
	St. Deviation	117	181	

Table 6D: F2 Values of [ɑʊ]-Raising

N0	Speakers	F2 [ɑʊ]+ [+voice, +cons]	F2 [ɑʊ]+∅	Difference
1.	Speaker 11F	1384	1372	12 Hz
2.	Speaker 12F	1300	1429	129 Hz
3.	Speaker 13F	1343	1248	95 Hz
4.	Speaker 14F	1544	1379	165 Hz
5.	Speaker 15F	1151	1151	0 Hz
6.	Speaker 16F	1473	1514	41 Hz
7.	Speaker 17F	1353	1341	12 Hz
8.	Speaker 18M	1323	1288	35 Hz
9.	*Female Mean*	1364	1334	30 Hz
	Combined Means	**1358**	**1327**	**31 Hz**
	St. Deviation	117	123	

Table 6E: F2 Values of [ɑʊ]-Raising

N0	Speakers	F2 [ɑʊ]+ [ɚ]	F2 [ɑʊ]+∅	Difference
1.	Speaker 11F	1441	1372	69 Hz
2.	Speaker 12F	1431	1429	2 Hz
3.	Speaker 13F	1303	1248	55 Hz
4.	Speaker 14F	1628	1379	247 Hz
5.	Speaker 15F	1236	1151	85 Hz
6.	Speaker 16F	1337	1514	177 Hz
7.	Speaker 17F	1278	1341	63 Hz

8.	Speaker 18M	1001	1288	227 Hz
9.	*Female Mean*	*1379*	*1334*	45 Hz
	Combined Means	**1331**	**1327**	**4 Hz**
	St. Deviation	181	123	

Table 6F: F2 Values of [ɑʊ]-Raising

4.2.1 Interim Conclusion

The F2 measurements of [ɑʊ] and [ʌɪ] remain the same regardless of phonological environments. Even Speakers 11F, 13F, and 14F who tend to raise their /ɑʊ/ to [ʌʊ] do not accompany the raising with fronting. Only Speaker 18M produces [aʊ] differently by retracting his tongue when [ɑʊ] is immediately followed by [ɹ]. In other words, F2 is not yet a robust correlate for [ɑʊ]-raising in Minnesota English.

4.3 F3 Measurements and Findings

F3 correlates with lip rounding. When the lips are rounded, F3 values are significantly less than when they are not rounded. The JND of ≥400 Hz helps to gauge the significance of lip position. The six tables displayed in 7A through 7F show that the arithmetic means of [ɑʊ] in the various phonological environments are less than 400 Hz, which means that lip rounding is not a robust acoustic cue. Lip rounding appeared to be a salient cue in only one instance in Table 7E for Speaker 16F. She rounds her lips more when [ɑʊ] occurs before voiced consonants than when it occurs in codaless syllables.

N0	Speakers	F3 [ɑʊ] + [-voice, +cons]	F3 [ɑʊ]+ [+voiced, +cons]	Difference
1.	Speaker 11F	2995	2601	394 Hz
2.	Speaker 12F	2694	2693	1 Hz
3.	Speaker 13F	2651	2296	355 Hz
4.	Speaker 14F	3175	2816	359 Hz
5.	Speaker 15F	2628	2446	182 Hz
6.	Speaker 16F	2717	2490	227 Hz
7.	Speaker 17F	2611	2522	89 Hz
8.	Speaker 18M	2735	2599	188 Hz
9.	*Female Mean*	*2796*	*2552*	*244 Hz*
	Combined Means	**2787**	**2557**	**230 Hz**
	St. Deviation	212	158	

Table 7A: F3 Values of [ɑʊ]-Raising

N0	Speakers	F3 [ɑʊ] + [-voice, +cons]	F3 [ɑʊ]+ [ɚ]	Difference
1.	Speaker 11F	2995	2771	224 Hz
2.	Speaker 12F	2694	2409	285 Hz
3.	Speaker 13F	2651	2499	152 Hz
4.	Speaker 14F	3175	2959	216 Hz
5.	Speaker 15F	2628	2282	346 Hz
6.	Speaker 16F	2717	2546	171 Hz
7.	Speaker 17F	2611	2529	82 Hz
8.	Speaker 18M	2735	2445	290 Hz
9.	*Female Mean*	*2796*	*2570*	*226 Hz*
	Combined Means	**2787**	**2555**	**232 Hz**
	St. Deviation	212	214	

Table 7B: F3 Values of [ɑʊ]-Raising

N0	Speakers	F3 [ɑʊ]+ [-voice, +cons]	F3 [ɑʊ]+∅	Difference
1.	Speaker 11F	2995	2860	135 Hz
2.	Speaker 12F	2694	2673	21 Hz
3.	Speaker 13F	2651	2660	9 Hz
4.	Speaker 14F	3175	2792	383 Hz
5.	Speaker 15F	2628	2446	182 Hz
6.	Speaker 16F	2717	2990	273 Hz
7.	Speaker 17F	2611	2638	27 Hz
8.	Speaker 18M	2735	2748	13 Hz
9.	*Female Mean*	*2796*	*2731*	*65 Hz*
	Combined Means	**2787**	**2733**	**54 Hz**
	St. Deviation	212	181	

Table 7C: F3 Values of [ɑʊ]-Raising

N0	Speakers	F3 [ɑʊ]+ [+voice, +cons]	F3 [ɑʊ]+ [ɚ]	Difference
1.	Speaker 11F	2601	2771	170 Hz
2.	Speaker 12F	2693	2409	284 Hz
3.	Speaker 13F	2296	2499	203 Hz
4.	Speaker 14F	2816	2959	143 Hz
5.	Speaker 15F	2446	2282	164 Hz
6.	Speaker 16F	2490	2546	56 Hz
7.	Speaker 17F	2522	2529	7 Hz
8.	Speaker 18M	2599	2445	154 Hz
9.	*Female Mean*	*2552*	*2570*	*18 Hz*
	Combined Means	**2557**	**2555**	**2 Hz**
	St. Deviation	158	214	

Table 7D: F3 Values of [ɑʊ]-Raising

N0	Speakers	F3 [ɑʊ]+ [+voice, +cons]	F3 [ɑʊ]+∅	Difference
1.	Speaker 11F	2601	2860	259 Hz
2.	Speaker 12F	2693	2673	20 Hz
3.	Speaker 13F	2296	2660	364 Hz
4.	Speaker 14F	2816	2792	24 Hz
5.	Speaker 15F	2446	2446	0 Hz
6.	Speaker 16F	2490	2990	500 Hz
7.	Speaker 17F	2522	2638	116 Hz
8.	Speaker 18M	2599	2748	149 Hz
9.	*Female Mean*	*2552*	*2731*	*179 Hz*
	Combined Means	**2557**	**2733**	**176 Hz**
	St. Deviation	158	181	

Table 7E: F3 Values of [ɑʊ]-Raising

N0	Speakers	F3 [ɑʊ]+ [ɚ]	F3 [ɑʊ]+∅	Difference
1.	Speaker 11F	2771	2860	89 Hz
2.	Speaker 12F	2409	2673	264 Hz
3.	Speaker 13F	2499	2660	161 Hz
4.	Speaker 14F	2959	2792	167 Hz
5.	Speaker 15F	2282	2446	164 Hz
6.	Speaker 16F	2546	2990	444 Hz
7.	Speaker 17F	2529	2638	193 Hz
8.	Speaker 18M	2445	2748	303 Hz

9.	*Female Mean*	*2570*	*2731*	*161 Hz*
	Combined Means	**2555**	**2733**	**178 Hz**
	St. Deviation	214	181	

Table 7F: F3 Values of [ɑʊ]-Raising

4.3.1 Interim Conclusion

The cross-tabulated pieces of evidence show that the participants' lips remain virtually the same in all phonological environments. F3 is a robust correlate only for Speaker 16F in Tables 7E and 7F. Her lips are more rounded when producing [ɑʊ] before voiceless consonants and before [ɹ] than when it occurs in codaless syllables.

5.0 Overall Summary

Experiment 1 shows overwhelmingly that the raising of [ɑɪ] to [ʌɪ] before voiceless consonants is a *fait accompli* in the pronunciation of Gen Zers in Minnesota. This confirms Vance's (1987) phonological analysis in which he found 35 years ago that [ɑɪ]-raising occurred pervasively in Minnesota. The findings reported here also confirm Woolums' exploratory study. Furthermore, they agree with Carmichael's (2020:555) conclusion that "Within the U.S., /ɑɪ/-raising is more common than /ɑʊ/-raising, with some researchers advocating for /ɑɪ/-raising without concomitant /ɑʊ/-raising to be referred to as 'American raising.'"

Experiment 2 shows that [ɑʊ]-raising to [ʌʊ] is afoot in Minnesota but it is still in its infancy. It is found in only 35.5% of the participants' pronunciation. The phonological environments that seem to facilitate its spread are when [ɑʊ] occurs before voiceless consonants, before rhotacized vowels, or when it occurs by itself in codaless syllables. The rate of [ɑʊ]-raising in Minnesota is greater than the one found in Grand Rapids, Michigan (22%), or in New Orleans (15.78%). This also is not surprising since Minnesota shares a long border with Canada. If unforeseen sociolinguistic forces do not impede its spread, it is only a matter of time before [ɑʊ]-raising is fully adopted.

There is something surprising about the differential spread of CR in Minnesota. Assuming that both [ɑɪ] and [ɑʊ] were occurring in Canada simultaneously in 1890 and that [ɑɪ]-raising reached Minnesota in a relatively short period of time, that is, 40 years from 1890 to 1930, one is left wondering why [ɑʊ]-raising to [ʌʊ] is taking so long to be widely adopted. Are there sociophonetic factors that are impeding its spread? Minnesotans are often misidentified by fellow Americans for Canadians (Lopez-Backstrom and Koffi 2020). Is there some reluctance towards a wholesale adoption [ɑʊ]-raising for fear of being completely misidentification for the neighbors to the north? Or could it be that even in Canada, [ɑɪ]-raising started much earlier than [ɑʊ]-raising but by the time both were "discovered," both types of CR had run their course? The latter hypothesis seems more plausible. If so, we expect that in a generation or two, [ɑʊ]-raising will be as pervasive as [ɑɪ]-raising is now.

ABOUT THE AUTHOR

Ettien Koffi, Ph.D. linguistics (Indiana University, Bloomington, IN) teaches at Saint Cloud State University, MN. He is the author of five books and author/co-author of several dozen articles on acoustic phonetics, phonology, language planning and policy, emergent orthographies, syntax, and translation. His acoustic phonetic research is synergetic, encompassing L2 acoustic phonetics of English (Speech Intelligibility from the perspective of the Critical Band Theory), sociophonetics of Central Minnesota English, general acoustic phonetics of Anyi (a West African language), acoustic phonetic feature extraction for application in Automatic Speech Recognition (ASR), Text-to-Speech (TTS), voice biometrics for speaker verification, and infant cry bioacoustics. Since 2012, his high impact acoustic phonetic publications have been downloaded **54,717** times (**37,140** as per Digital Commons analytics), **17,577** (as per Researchgate.net analytics), and several thousand downloads from Academia.edu, as of **February 2023**. He can be reached at enkoffi@stcloudstate.edu.

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Appendix A (Experiment 1)

Read the following sentences as naturally as possible. Do not read them slower or faster than you normally talk.

1. I will say rice, again.
2. I will say bide, again.
3. I will say bite, again
4. I will say wise, again.
5. I will say bribe, again.
6. I will say ripe, again.
7. I will say wives, again.
8. I will say wife, again.
9. I will say dime, again.
10. I will say life, again.
11. I will say nine, again.
12. I will say dike, again.
13. I will say rile, again.
14. I will say dire, again.
15. I will say lice, again.
16. I will say file, again.
17. I will say lives, again.

Appendix B (Experiment 2)

Read the following sentences as naturally as possible. Do not read them slower or faster than you normally talk.

1. I will say shout, again.
2. I will say loud, again.
3. I will say proud, again.
4. I will say our, again.
5. I will say about, again.
6. I will say out, again.
7. I will say mouse, again.
8. I will say mouth, again.
9. I will say vow, again.
10. I will say tout, again.
11. I will say doubt, again.
12. I will say hour, again.
13. I will say a house, again.
14. I will say how, again.
15. I will say couch, again.
16. I will say south, again.
17. I will say pout, again.
18. I will say tower, again.
19. I will say coward, again.
20. I will say bow, again. [as in “to bow down”]
21. I will say flower, again.
22. I will say cow, again.
23. I will say power, again.