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Catherina Narigon
University of Iowa

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DIPHTHONGIZATION OF /U/ IN MIDWESTERN AMERICAN ENGLISH

by

Catherina Narigon

A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the Linguistics

Jill Beckman
Thesis Mentor

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All requirements for graduation with Honors in the
Linguistics have been completed.

Jill Beckman
Linguistics Honors Advisor

Diphthongization of /u/ in Midwestern American English

Catherina Narigon

1. Introduction

/u/ in Midwestern American English (MAE) is expected to have the typical qualities of [+back, +high, +ATR] attested for high back rounded vowels. However, Jerzy Rubach, Christian Koops, and various other sources have suggested that this vowel may in fact have strayed from these expected characteristics when produced by native Midwestern speakers, although no actual acoustic studies have been conducted. In an attempt to remedy this, I conducted an exploratory survey to gauge the status of /u/ in the Midwest. Although I cannot definitively say why changes to this vowel are occurring, I can claim that monophthongal [u] is actually a very uncommon production of /u/ in the speech of the Midwesterners that I recorded. Rather, a diphthong, which has been characterized as /ɪu/, is the preferred pronunciation.

The data I collected during this survey prove that /u/ as a monophthong is a rarity in the speech of the Midwesterners that I tested. However, there are various perspectives offered in the literature surrounding this topic that make assigning a cause to this phenomenon difficult. Jerzy Rubach (2018), a professor at the University of Iowa, believes that the diphthong seen in these contexts in MAE stems from historical processes that occurred far in the past. Fridland (2000), Hall-Lew (2004), Koops (2010), and other researchers have studied back vowel fronting in various regions of the US. They all have found sound evidence of /u/ fronting in these regions, and note that fronting shifts may be more widespread, but do not specifically discuss MAE or the presence of a diphthong in these contexts.

2. Background

During his time teaching at the University of Iowa, Rubach (2018) noticed an interesting phenomenon taking place in the pronunciation of certain vowels by midwestern speakers. Rubach, who speaks Polish natively, expected words like *do* and *hoop* to be pronounced with [u], a pronunciation that is considered standard in American English. However, Rubach claims that many students seem to have adopted a pronunciation in which the vowel that surfaces is [ɪu].

Rubach theorizes that both historical language processes and elements of the Midwestern dialect play a role in the diphthong's appearance. In Middle English, /y:/, a [+high, -back, +ATR] vowel, was present in many modern /u/ words. In some positions, such as following an alveolar obstruent, /y:/ decomposed into [ɪu] over time. Rubach notes that [ɪ] keeps the [-back] feature of /y:/, while /u/ retains the [+round] feature, which is indicative of this decomposition process (Rubach 2018:2).

Rubach elaborates on how the Old English /y:/ underwent changes into /ɪu/. He notes that the change to /ɪu/ actually occurred historically, but then further changed into /ju:/ in all dialects. This /ju:/ simplified into the standard /u/ that is expected in American English today. However, decomposition in certain dialects, like Midwestern American English, did not behave quite this way. Rather than fully decomposing and simplifying into /u/, Middle English /ɪu/ may have remained in some positions. Rubach mentions that documentations of [ɪu] in Midwestern speech occur as early as the 1930s (Rubach 2018:8).

Rubach relies heavily on research conducted by Kenyon and Knott, who documented that /u/ could surface as [ɪu] in three contexts: following labials, velars, and laryngeals; after stressed syllable coronals, and after liquids. Rubach, however, says that the first and the third contexts now result in surface forms [ju] and [u:], respectively, rather than [ɪu]. The context that remains a motivator for the diphthong is after coronals in stressed syllables. Rubach thinks that it is unlikely that preceding non-coronal sounds would change underlying [u] to [ɪu]. He does note that /ɪu/ seems to occur in words that do not contain a historical motivation for the diphthong, although Kenyon and Knott do not document this (Rubach 2018:28).

In his paper exploring the ongoing process of /u/ fronting in Southern dialects of North American English, Christian Koops (2010:113-122) considers the possibility that wider trends of American English /u/ fronting may have been influenced by similar fronting trends in Southern American English. He notes that /u/ fronting has been documented across the United States as a whole (other researchers have claimed that up to 90% of American English speakers have some degree of /u/ fronting in their speech), and similarly has been documented across English spoken in the South (2010:113). Koops goes as far as to say that, perhaps, various regions are undergoing the same vowel shift, rather than experiencing unique but simultaneous shifts.

However, Koops discards this potential hypothesis in favor of one that supports two fronting shifts that came about separately (2010:115).

To uncover more information about the fronting process, Koops investigated speakers of Southern American English from the Houston area. The fronting characteristics seen in these speakers occurred in the nucleus of the vowel, while the offset of the vowel retained or approximated the qualities expected in a pure /u/ vowel. Koops also notes that some fronted /u/ vowels appear monophthongal, while some resemble diphthongs (2010:115). Koops cites research done in other areas of the United States, such as California and Philadelphia, that transcribe the resulting fronted vowel as /ɪu/ and /ɪu/, respectively. Koops also provides an example from 1996 in which an Iowan produced fronted [u] (2010:114).

Koops also compares the differences in vowel quality between older and younger speakers. Although speakers of all ages showed evidence of /u/ fronting, younger speakers had more extreme fronting (2010: 15). Younger speakers were more likely to have vowels that were front for the entire duration of the vowel. Additionally, their F1 values showed evidence of lowering, and many produced a vowel whose F1 offset was more similar to /o/ than to /u/ (2010:16).

Through comparing word-final /u/ to /u/ in other positions, Koops theorizes that there are two distinct fronting shifts co-occurring (2010:117). Non-Houston speakers (still Southern, however) may have more extreme /u/ fronting than speakers from Houston. Koops also remarks that the coronal consonants in /tu/ and /du/ result in more extreme fronting than non-coronal sounds, using /bu/ as a comparison (2010:119). Koops recognizes that similar fronting trends are happening in different parts of the US, but thinks that the Southern fronting shift is unique in its origin from other fronting shifts (2010:120).

Valerie Fridland (2000:267-285) writes about the various kinds of vowel shift that have been documented in the South, and delves into the intricacies of the shifts. She conducted a study using 25 participants from different socioeconomic class and age groups (2000:271). She produced waveforms of various vowels produced by these participants, and used a variety of programs to plot and measure the resulting vowel measurements (2000:272). These

measurements were then compared to a vowel deemed stable for the speakers to rank the degree of shift that the various vowels had undergone (2000:274).

She notes that there is a front shift, a back shift, and separate changes happening in diphthongs (2000:269-270). /u/, part of the back vowel shift, undergoes fronting. According to research done by Fridland, the fronting is often very noticeable, and may cause the vowel (or portions of the vowel) to more closely resemble a front vowel than a back vowel (2000:269). Furthermore, she notes that according to previous studies, the fronting of /u/ began earlier than the fronting of other back vowels. Other research, according to Fridland, suggests that this shift may have begun at least 50 years before shifts affecting front vowels (2000:270).

Lauren Hall-Lew's 2004 study of Northern Arizona Vowels resulted in findings that were similar to Fridland's. She noted that in Northern Arizona, /u/ was often fronted, which she attributed to the influence of surrounding Southern regions (2004:1). She also asserts that ranchers and rural individuals will have more extreme fronting in both /uw/ and /ow/, as she transcribes them, due to the presence of the stereotypical 'Southern' accent used by these individuals (2004:1). Previous researchers, including Labov, had hypothesized that Arizona and surrounding areas were not part of the region where the Southern shift is taking place, but Hall-Lew is not as sure (2004:3).

Hall-Lew collected the data used in her study through casual interviews. She did also include a word list, but notes that it is not as pertinent to her results as the interviews themselves were (2004:5). Previous studies have noted that /uw/ is fronted when it follows non-liquid consonants (2004:6). Hall-Lew additionally found that /uw/ was more likely to be fronted when it followed a coronal consonant (2004:9). /ow/ is often fronted in contexts that /uw/ is fronted, but /uw/ fronting is more widely attested (2004:7). Based off of other documentations, Hall-Lew believes that the fronting of back vowels in the West began after 1950 but before 1970 (2004:7).

Hall-Lew's results showed that the younger the speaker, the more fronted /uw/ was (2004:15). Speakers who were 55 years old and younger consistently fronted /uw/ (2004:23). She also found that while women are ahead of men in some shifts, men and women seem to exhibit the same amount of fronting in /uw/ (2004:16). /uw/ fronting in Northern Arizona also may be influenced by socioeconomic status, and higher class individuals seem more likely to have higher

levels of /uw/ fronting (2004:20). Hall-Lew notes that back vowel fronting is found in many other regions of American English, but not in all of them. It is therefore hard, without more research, to say how related these trends are (2004:26).

I am carrying out this survey because several hypotheses about realizations of /u/ in MAE exist, but none are based on tangible acoustic phonetic evidence. This exploratory survey of MAE vowel fronting/diphthongization is my attempt to see what actually is occurring in MAE speech. The main purposes of this preliminary study were to answer the following set of questions: Do MAE vowels follow the same trends as vowels shifting in other parts of the US? Is there evidence of fronting or of diphthongization in these vowels? Do homophones containing this vowel vary in a significant way, and if so does that lend support to Rubach's theory? Do my data align with any of the hypotheses?

My original hypothesis was that some vowels would be fronted, but that overall I would find monophthongal realizations of /u/. I thought that perhaps Rubach's characterization of the vowel was due to Polish being his native language, and that the perception of native Polish speakers differed from the perception of native English speakers. However, as I listened more to the vowels that people around me produced, I heard more and more of what Rubach stated he had heard: what sounded like a front vowel after the consonant preceding /u/, and then a vowel that sounded like /u/. The front part was often so brief that I wouldn't notice it without focusing very intently. More often than not, I heard a vowel that was not [u] in contexts where I would have expected to find /u/. Rubach absolutely was correct in saying that something was afoot. Through this survey, I am hoping to answer my own questions about this interesting and rather unexpected vowel.

3. Methodology

Four female speakers and three male speakers participated in this study. Three of the females (Chandra, Eden, and Maggie) and all three males (Colton, Yanni, and Sam) are between 20 and 23 years of age. Linda, the other female speaker, is 50 years old. All seven speakers learned to speak English in the Midwest, and currently live in the Midwest. Yanni learned Greek during the formative period in his language development alongside English, and speaks Greek to

his parents, but considers English his L1. The participants were told that they were taking part in a study about the English language, but were not given any specific details about what I was testing for. The participants were given a list of forty words--17 test words and 24 filler words--and were given instructions to read the words at a pace comfortable to them. Chandra, Shiloh, and Colton have all taken linguistics classes, but given the nature of this study and that they did not know what I was testing for, I do not believe that their linguistic knowledge had any effect on their individual results.

The participants were recorded as they read the list. Each participant was recorded twice through in order to account for any odd pronunciations. However, Maggie is the only speaker whose recordings were both usable after being entered into Praat as I had not fully learned the settings on the recorder. After the recordings were gathered, Praat software was used to segment the recordings into intervals containing the test words. These intervals were then extracted and saved as separate .WAV sound files. Praat was also used to create spectrograms of the test words, and to measure the first and second formant values of the vowels in the test words.

The average F2 value for each test vowel was calculated and entered into Excel. 'Pool', one of the original test words, was excluded from the rest of the survey when none of the participants produced [u] or some variation of [u] in this word. This left 16 test words per speaker, and 128 average F2 values. These values were then color-coded based on this average and on how the formants appeared in the spectrograms. Red was used to denote strong diphthongs, orange was used to denote diphthongs that were less extreme, yellow was used to denote diphthongs that varied 500 Hz or less over the vowel's duration, and green was used to denote monophthongs. Excel and Praat were also used to create tables for vowel duration, onset and offset F2 values, and F1 values.

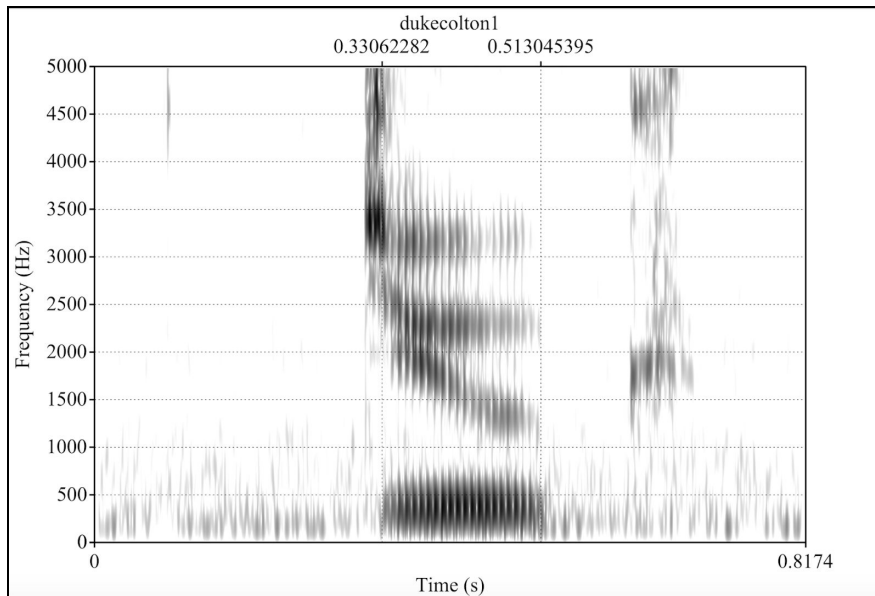
4. Results and Discussion

The color-coding revealed a surprising trend: diphthongs are very prevalent in environments where /u/ is expected to surface. Of the 128 values, only 8 were color-coded green to indicate monophthongs. The other 120 productions of /u/ contained some degree of

diphthongization. Even words without extreme formant movement across the vowel were fronted to some degree.

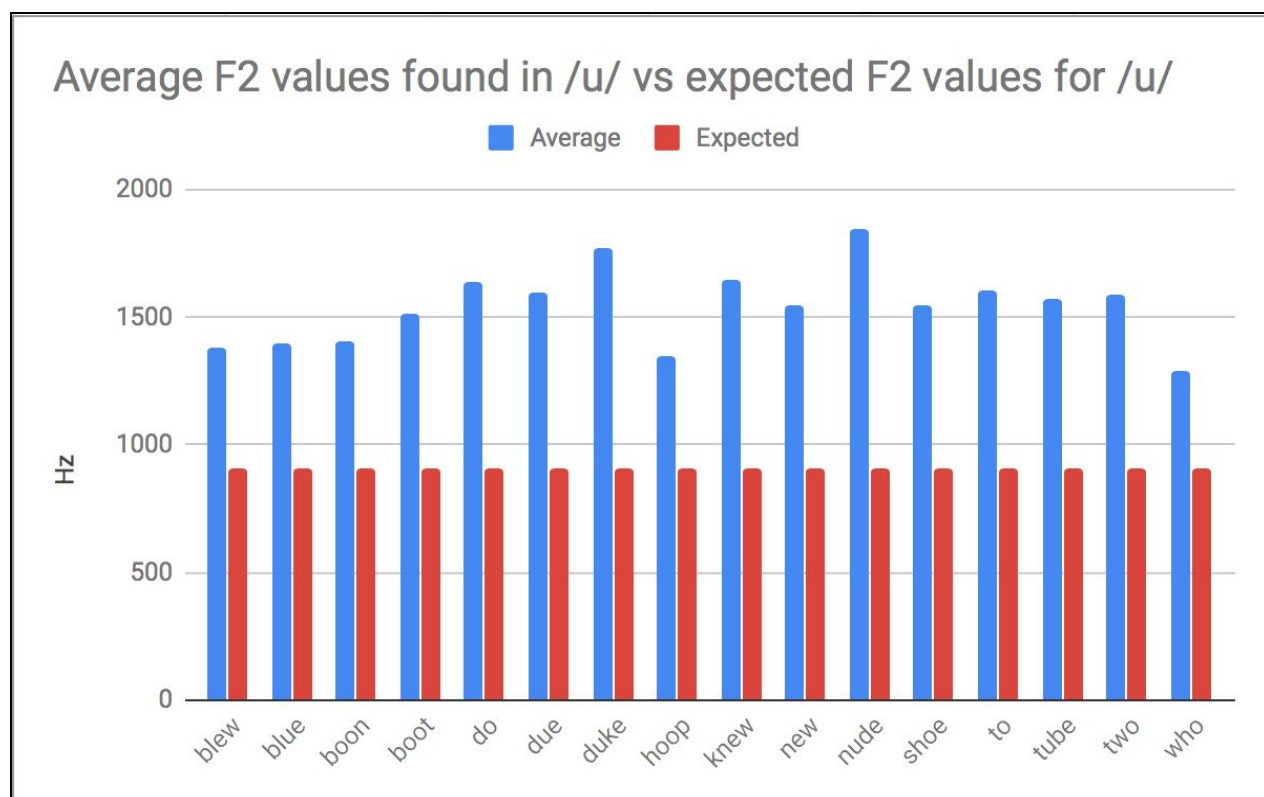
The fronting and diphthongization in the test words was immediately evident. As seen in Figure 1, the F2 of the vowel in /duk/ for this Colton's production of /duk/ is dynamic over the duration of the vowel, and the F2 value lowers by nearly 1000 Hz over the course of the vowel.

Fig. 1. /duk/ produced by Colton



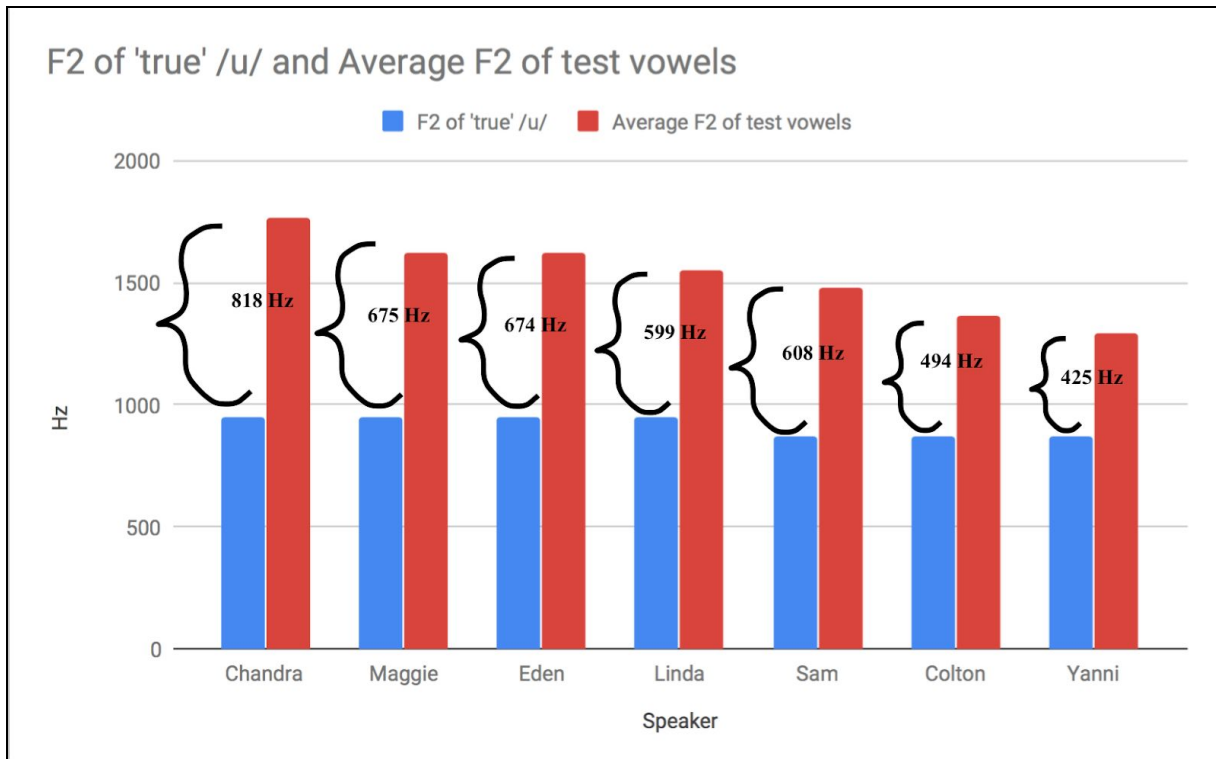
/u/ is standardly characterized as having an average F2 measurement of 870 Hz for male speakers and 950 Hz for female speakers in American English (Peterson & Barney 1952). Age, vocal tract length, and other variables can lead individual speakers to have formant values that are higher or lower than expected averages. This individual variation is expected to some degree, and so slight deviations from expected average formant values are not always indicative of some factor or process imparting changes upon the vowel. However, Figure 2 shows the average F2 value for each test word in blue, and the value standardly expected for /u/ in red. The expected value used is 910 Hz, which is the average of the expected value for male speakers and the expected value for female speakers. The average F2 of the test vowels was substantially higher than the expected F2 of /u/ in all 16 test words.

Fig. 2. Average F2 values vs expected F2 values per test word



The F2 onset for most test vowels, regardless of context, was much higher than would be expected for standard monophthongal /u/. In fact, many speakers had F2 onsets of well over 2000 Hz, and this high value persisted far into the duration of the vowel. Figure 3 shows the average F2 of all of the test vowels per speaker. The average F2 per speaker, in red, appears next to the expected values of /u/ for women and men in blue. The numbers inside the brackets above each speaker indicate the difference, in Hz, between the actual F2 average found and the expected F2 values. The speaker with the lowest overall F2 average, Yanni, still had an average F2 value for /u/ that was 425 Hz higher than the value documented by Peterson and Barney.

Fig. 3. Average F2 of /u/ per speaker



A majority of the test vowels contained what appears to be a diphthong that begins with a front vowel and then becomes a back (or more back) vowel over the course of the vowel's duration. Some test items contained a monophthong that was more front than /u/ is expected to be. Rubach hypothesizes a diphthong that goes from front to back over the duration of the vowel, but expects to see the diphthong ending in a standard, back /u/. The vowels seen in this study generally do not have offsets that are as back as standard monophthong /u/ is expected to have.

While diphthongs and fronting were both seen in abundance in my survey, the nature of the diphthongs varied. Some speakers had gradual F2 movement that was fairly linear over the duration of the vowel (see fig. 1). However, some speakers had F2s that rapidly fell after the vowel onset, or that rapidly fell closer to the offset of the vowel. Figures 4 and 5 show a contrast in the movement of F2 over the course of the diphthong.

Fig. 4. /nud/ produced by Colton

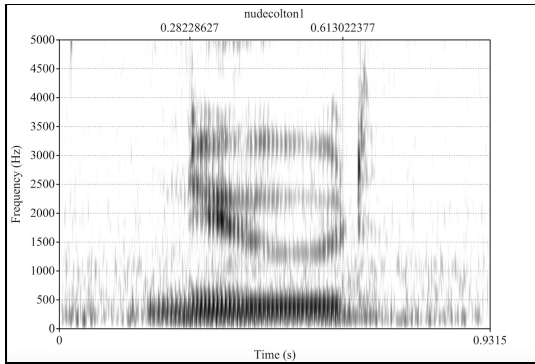


Fig. 5. /du/ produced by Chandra

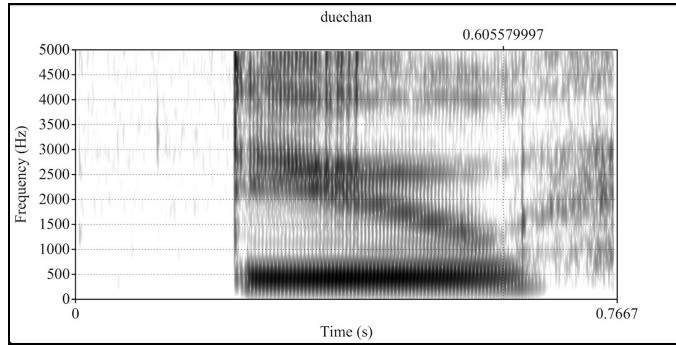
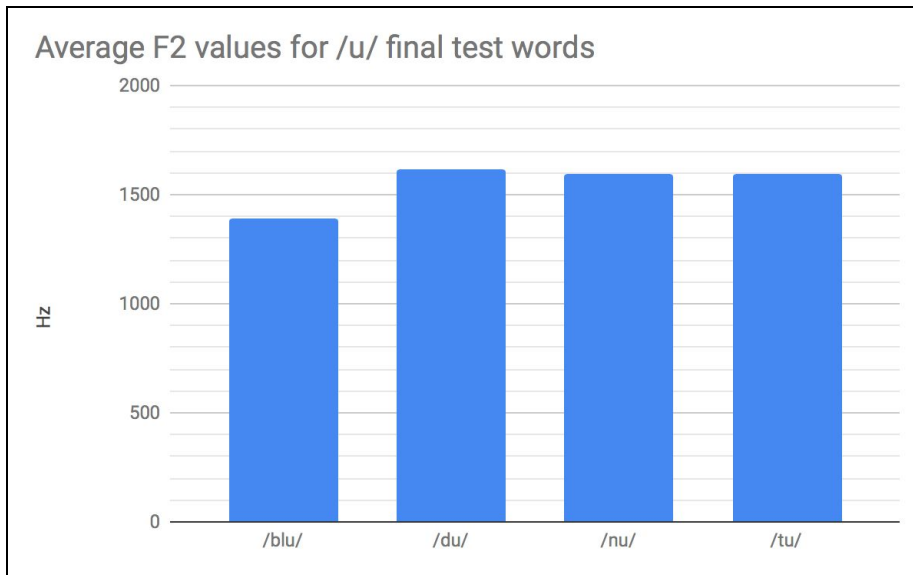


Figure 6 shows the average F2 values of all speakers for words in which /u/ occurred word finally. Based on the expected F2 values for this vowel given by Peterson & Barney (1952:183), for men and women combined we would expect to see a value around 910 Hz for monophthongal /u/. However, even the word with the lowest F2 value for this environment, /blu/, has an F2 that is over 300 Hz above this expected value.

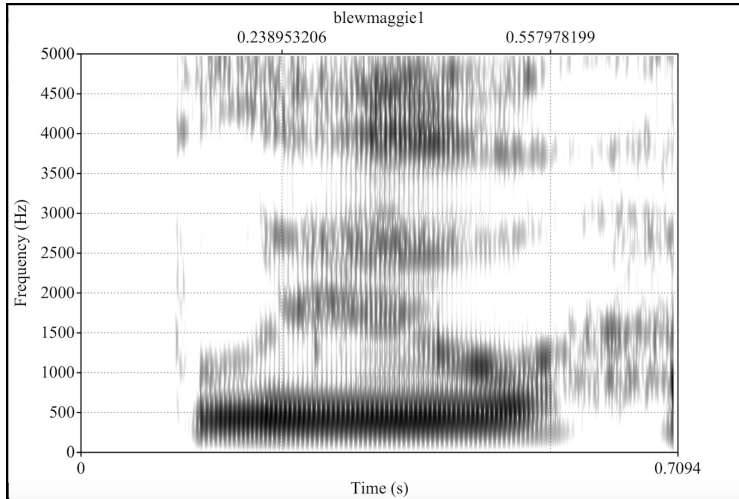
Fig. 6. Word final F2 values



The five test words with the lowest average formant measurements (for all speakers) were *who* (1291.4 Hz), *hoop* (1345.8 Hz), *blew* (1380.1 Hz), *blue* (1400 Hz), and *boon* (1403.9 Hz). Both /bʌs/ likely elicited values that were relatively low for the test words because of the /ʌ/. One of the distinguishing features of /ʌ/ is a very low F2. Recasens (1990) notes a vowel following a [+back] sound usually has a lower F2 than a vowel following a [-back] sound

(1990:146). Figure 7 is one of Maggie’s productions of /bʌu/. The F2 for the /t/ portion of the word is very low, and raises as it transitions into the vowel.

Fig. 7. /bʌu/ produced by Maggie



/hu/ and /hup/ contained the lowest overall F2 values, on average. Figures 8 and 9 show spectrograms of Sam and Chandra producing /hup/. Sam produced a vowel that resembles a monophthong. His F2 was slightly higher than Peterson and Barney’s expected F2 value of /u/, but this deviation from the expected value is slight enough that it can be attributed to individual variation. Chandra, however, had a diphthong with an F2 that fell by over 1000 Hz over the duration of the vowel. *Hoop* may be a test word with a low average F2 compared to the other test words, but it did still show evidence of a diphthong in several of the speakers. However, *hoop* was the first test words that participants read, and the second word overall on the word list. Participants with a monophthong in this test item may have unintentionally enunciated the first several words slowly and carefully before slipping into casual speech for the rest of the word list.

Fig. 8. /hup/ produced by Sam

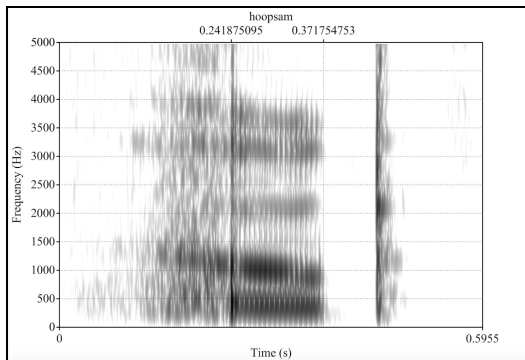
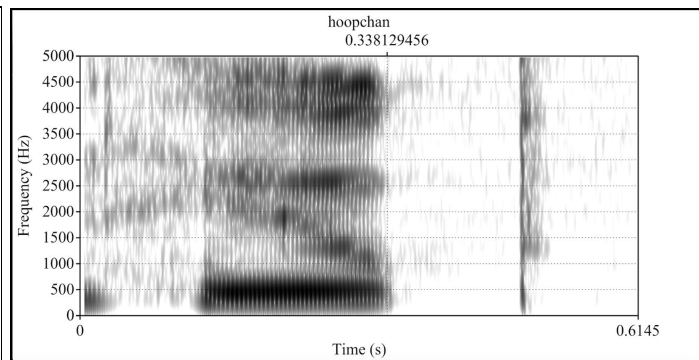


Fig. 9. /hup/ produced by Chandra



The five test words with the highest average formant measurements (for all speakers) were *nude* (1847.1 Hz), *duke* (1771.8 Hz), *knew* (1644.8 Hz), *do* (1638.6 Hz), and *to* (1604 Hz). These values are much higher than would be expected for a ‘true’ /u/. /nud/, in particular, had an average F2 of 1950.2 Hz for female speakers, which is 1000 Hz above the expected F2 value for /u/. The words with the highest average F2 values overall contained very evident and visible diphthongs. For example, Sam had an F2 onset value of 1977 Hz for *do*, and Yanni had an onset value of 1980 Hz for *duke*. These values are much higher than the expected value of 870 Hz for the F2 of /u/ in males. Figures 10 and 11 show the spectrogram of *do* for Eden and Maggie, respectively. Both contain strong diphthongal movement.

Fig. 10. ‘do’ produced by Eden

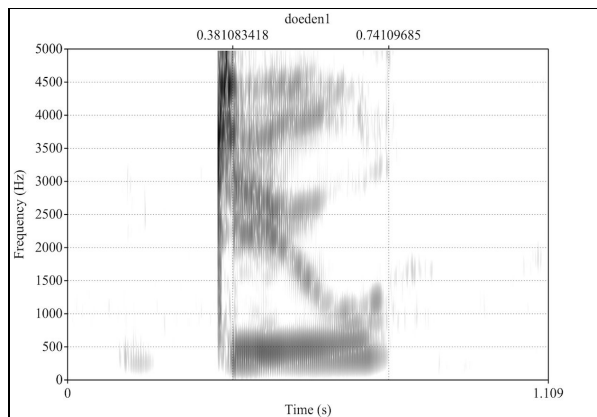
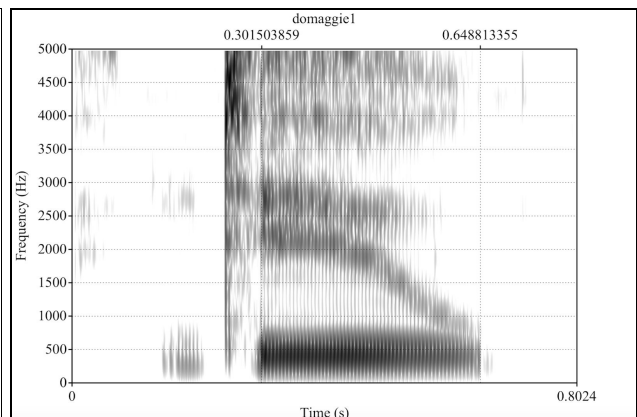


Fig. 11. ‘do’ produced by Maggie



These findings align, in many ways, with Rubach’s assertion that coronal sounds preceding /u:/ result in /ɪu/. The frontness at the onset of the vowels is most apparent in alveolar initial words such as *duke* and *due* (Rubach 2018). Although the words with the most fronted and most diphthongal iterations of /u/ were coronal initial, extreme fronting and diphthongal formants were seen in words that were not coronal initial. The findings deviate from Rubach’s prediction that /ɪu/ would be very unlikely to follow non-coronal sounds. For example, diphthongal vowels and non standard productions of /u/ occur after [h] as seen previously in figure 6.

5. Implications of Phonetic Environment

Daniel Recasens (1997) conducted a study about about consonant-vowel coarticulation that helped to inform me about patterns in my spectrograms. From this study, Recasens was able

to make many generalizations and draw conclusions about the production of high vowels in different environments. For example, the vowel in /dud/ is more similar to /i/ than the vowel /u/ produced in isolation is (Recasens 1997:144). This example in particular mirrors the frontedness that is present for all of my participants at the onset of the test vowel in /nud/.

/u/ in particular, compared to other back vowels, varies in degree of fronting. Recasens notes that /u/ is often characterized as a more rounded vowel than other round vowels. He states, “It can be hypothesized that speakers do not care much about the precise location of the lingual constriction because the spectral properties of [u] are already accounted for by the lip rounding gesture (Recasens 1997:144).” /u/’s ability to vary, based off of Recasens’ hypothesis, offers possible explanation for the spectrum of vowel qualities seen from word to word and from speaker to speaker in this survey.

The coarticulation effects of fricatives on high vowels was also covered. Different fricatives can cause vowel fronting to varying degrees. For example, /u/ followed by /s/ is a more fronted vowel than /u/ followed by /f/. Recasens found that fricatives /s/ and /ʃ/ also result in a more fronted /u/ than stop consonants such as /t/ do. This possibly can be attributed to the fact that /s/ and /ʃ/ are produced with some semblance of lip rounding while [t] is not (Recasens 1997:144). A comparison of F2 measures found that the F2 values for /u/ were higher when produced in a /C₁uC₂/ syllable when C surfaced as a nasal, [s], or [ʃ] than when C surfaced as [p], [t], [k], or [ʔ] (1990:146).

Recasens’ study was conducted using Catalan, and so his findings are not influenced by any of the ongoing American English vowel shifts (144). All of the conclusions that Recasens draws about /u/ assume a standard [+back, +ATR, +high] vowel that surfaces as ‘true’ [u] in isolation. In a speaker system without diphthongization or vowel shifting, Recasens would expect the F2 of the vowel in ‘shoe’ to be higher than the F2 of the vowel in ‘to’ or ‘two.’ However, I found an average F2 of 1545.1 Hz for ‘shoe’ in my participants, and F2s of 1604.8 and 1586.6 for ‘to’ and ‘two,’ respectively. Both male and female speakers, separately, mirrored these results. The average F2 of the female speakers was 1586.4 for /shu/ and 1641.8 for /tu/, while the average F2 for males was 1476.3 for /shu/ and 1543 for /tu/.

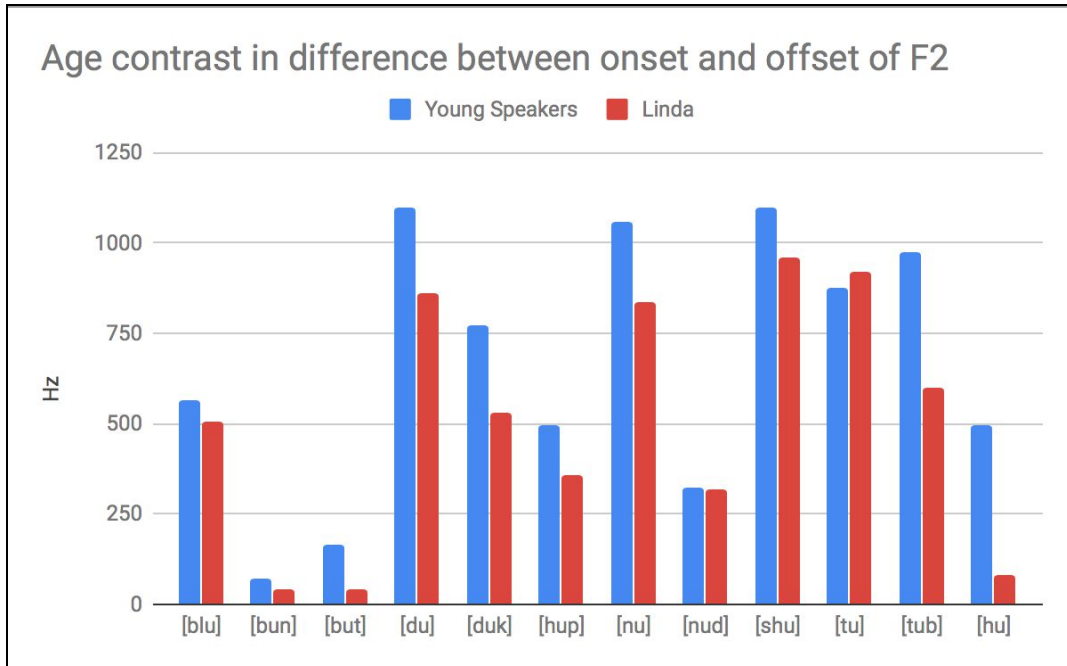
If the phonetic environment alone was responsible for formant changes in my test vowels, I would expect the data from my survey to align more closely with the trends found by Recasen. In a dialect without fronting or diphthongization, preceding and following consonants would likely be responsible for any formant changes seen over the duration of a vowel. However, the results from my survey stray far from Recasen's findings about the effects of consonants on vowels. This is strong evidence that factors outside of the immediate phonetic environment are responsible for the variety of surface forms of /u/ found in this survey.

6. Age

Hall-Lew and Fridland discussed age as a variable for the degree of /u/ fronting. They both documented evidence that older speakers have less extreme fronting of back vowels than younger speakers do in the regions they tested. I investigated whether or not my data aligned with these documentations by comparing Linda's vowels to the vowels produced by the younger speakers that I tested. Her average F2 for all test words was 1548.8, which is 125.5 HZ less than the overall average for the young female speakers, and 169.8 HZ more than the average for the male speakers.

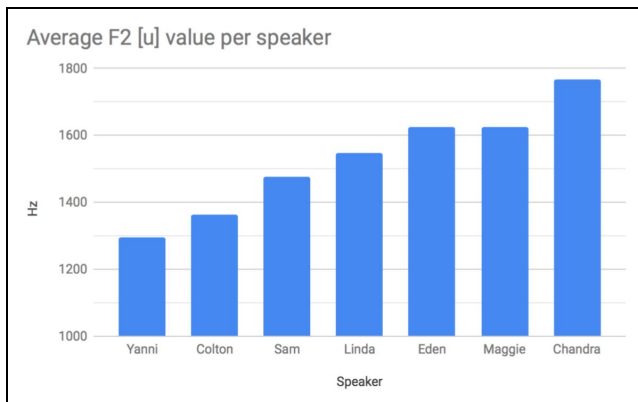
Figure 12 below shows the difference between the onset and offset F2 values for the test vowels in each form (homophones have been combined because, as I will cover, the differences between the vowels produced in these items were effectively negligible). Both the young females and young males' values are averaged together, and are compared to Linda's values. These calculations are based on the onset and offset, rather than the highest and lowest F2 values over the duration of the vowel. Many words experienced an uptick in F2 at the end of the vowel due to coarticulation or to the individual speaker. This graph does not fully encompass how extreme the fronting in these cases was.

Fig. 12. Variation of F2 based on age



If fronting or diphthongization was not taking place, we would expect to see Linda produce results that are more similar to the other female speakers than to the male speakers. However, Linda is positioned between the two groups. Figure 13 below shows the average F2 of /u/ per speaker in my survey. If Linda’s speech contained the same amount of fronting and diphthongization as the other participants, we would expect to see her average values be slightly closer to the averages of the other female speakers. Given that her average F2 was over 1500 Hz, Linda certainly does produce a fronted or diphthongized /u/, even if the shift is lesser in her speech than in the speech of the younger speakers.

Fig. 13. Average F2 per speaker



In many test items, Linda had a much lower second formant value for her vowels than the average of the other females. In *boon* and *boot*, notably, her second formant values were 338 Hz and 598 Hz less than the average for the younger females. Figure 14 is the spectrogram for Linda's production of /but/. Her F2 remains fairly static for the duration of the vowel, and looks very much like a monophthong rather than a diphthong.

Fig. 14. /but/ produced by Linda

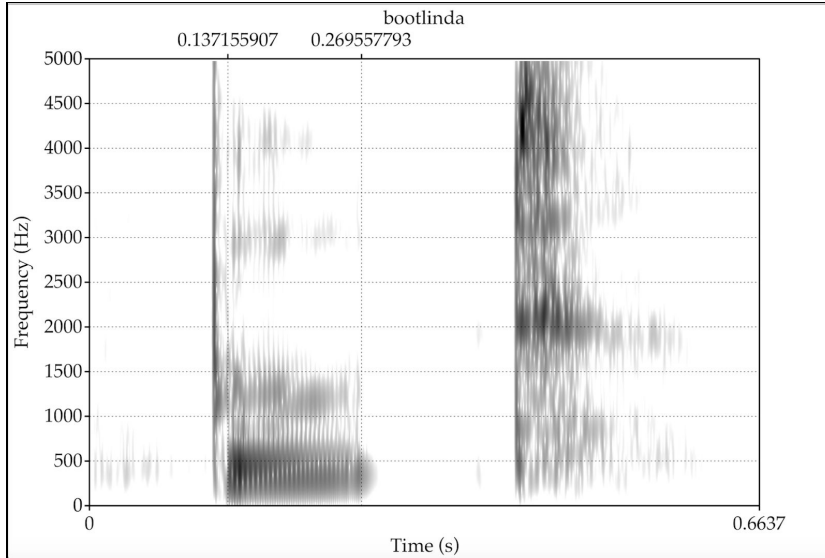


Figure 15 below is a spectrogram of the same test word produced by Chandra. The diphthongal F2 movement seen in Chandra's production of /u/ is similar to what most other young speakers produced for this test word.

Fig. 15. /but/ produced by Chandra

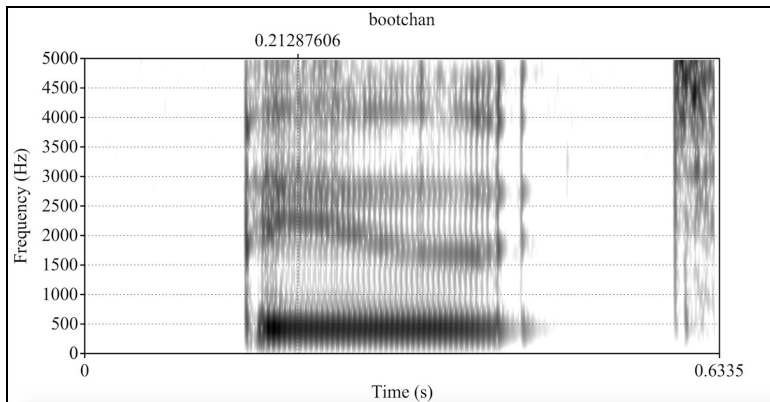


Figure 16 shows Linda's average F2 values for both /bun/ and /but/ compared to the average of the young female speakers and to the individual female speakers. Linda also was the

only speaker, male or female, who produced a monophthong with little to no fronting in both /but/ and /bun/. (Chandra and Yanni each produced a monophthong for one of these test items, but not for both.)

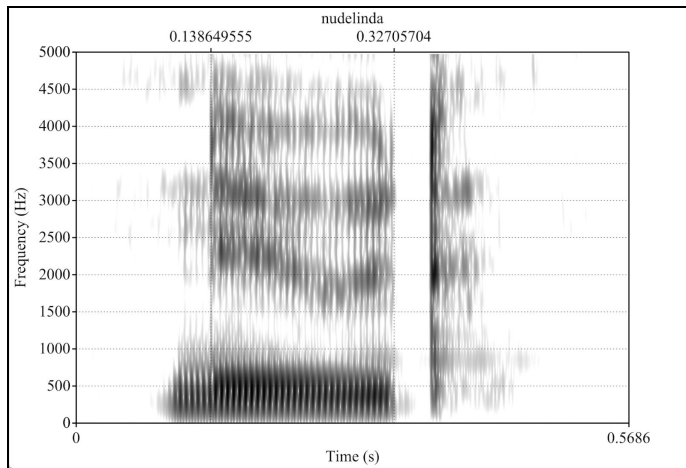
Fig. 16. Younger vs older female F2 values for select test words

	blew	blue	boon	boot
Maggie1	1447	1424	1502	1781
Maggie2	1462	1415	1603	1850
Eden	1452	1567	1300	1798
Chandra	1611	1619	1591	1897
AVERAGE	1493	1533.666667	1499	1831.5
Linda	1448	1632	1161	1233

Boot and *boon* both contained diphthongs in most speakers, but the diphthongs were not as pronounced as the diphthongs in other test items. Figures 9 and 10 show examples of F2s that moved throughout the vowel’s duration, but not to the extent that has been seen in previous figures. Although the movement in Chandra’s F2 in figure 9 is gradual, there is a change of about 500 Hz over the vowel’s duration. Maggie’s F2 in figure 10 rises on the offset, but dips by over 300 Hz during the middle portion of the vowel.

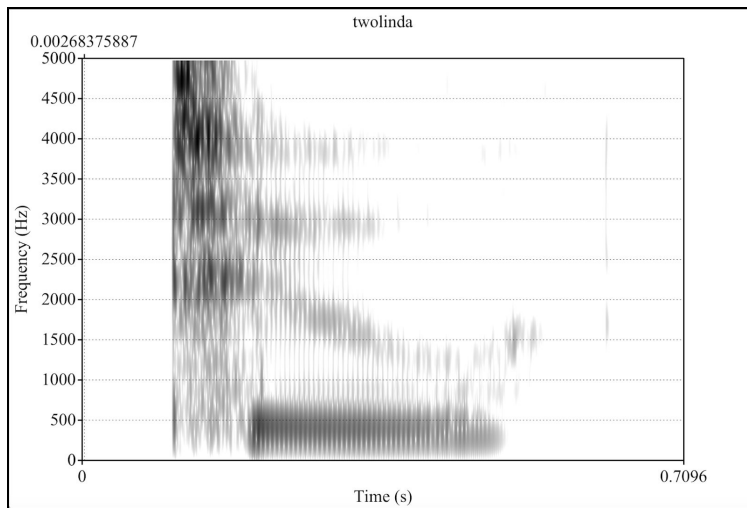
Although /bun/ and /but/ both contain word final alveolars, Linda’s second formant value for *nude* was higher than the values for most of the younger speakers. Figure 17 below is the spectrogram of Linda’s production of /nud/. Her onset F2 for this test word was 2360 Hz. The F2 falls to about 1600 Hz as its lowest measurement before climbing back to around 2000 Hz during the offset.

Fig. 17. /nud/ produced by Linda



Linda's F2 average for /nud/ was high compared to other vowels that she produced, but was comparable to the young speakers. The only test items in which Linda produced a diphthong with more F2 movement than for the other speakers were in *to* and *two*. Figure 18 below shows the spectrogram for Linda's production of *two*, in which extreme movement of the F2 occurs over the duration of her vowel.

Fig. 18. 'two' produced by Linda



Although Linda's F2 values were not always lower than F2 values of the younger speakers, individual variation in pronunciation is expected. Overall, Linda shows less change over the duration of the vowel in test words beginning with [h]. Furthermore, Linda's vowels in [bun], [but], and [hu] change by less than 100 Hz over the duration of the vowels. Compared to

the other speakers, this is relatively minor F2 movement. The other speakers show similar trends for both [bun] and [but], but on average seem to have diphthongal vowels in [hu].

Hall-Lew notes that because /u/ fronting in the south may have started over 50 years ago, shifting trends appear to be stronger in younger speakers than in older speakers (Hall-Lew 2004). Linda's data, compared to the data of the younger female speakers, could be interpreted using Hall-Lew's findings: although fronting or diphthongization is seen in all speakers, it appears to be more extreme in younger speakers. If the southern shift, or a similar shift, is taking place in the midwest presently, it would make sense that younger speakers show stronger shifting trends. If the vowel shift hypothesis is correct, Linda likely acquired language when the vowel shift was relatively new and /u/ fronting was relatively mild. The younger speakers, under this analysis, would have acquired language after /u/ fronting had had the chance to become more extreme.

7. Gender

Hall-Lew investigated gender and socio-economic status as variables in her studies. Although a slight gendered difference was seen for some back vowel shifts, /u/ shifting was consistent in men and women (Hall-Lew 2004:4). Figures 19 and 20 show spectrograms from Chandra and Yanni that are very similar in their fronting. These similar results are representative of the results for all males vs all females in my study. As Hall-Lew concluded, there does not seem to be a distinction in fronting based on gender for the /u/ shift.

Fig. 19. /blu/ produced by Chandra

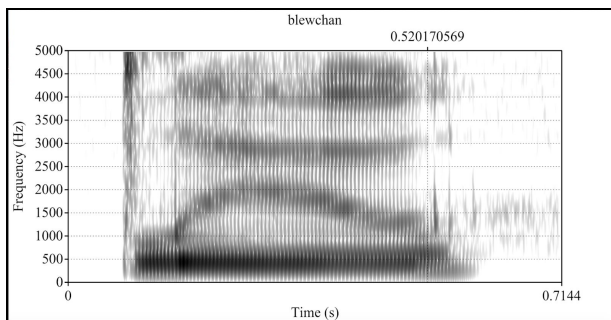
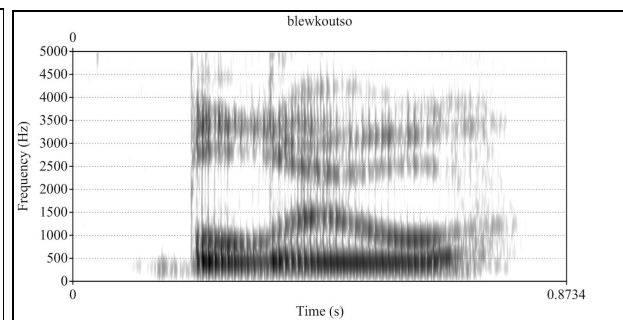


Fig. 20. /blu/ produced by Yanni



8. L2 effects

One participant, Yanni, grew up learning English and Greek simultaneously. He now only speaks Greek when at home with his parents, who are Greek immigrants, and considers English to be his L1. He is, however, still fluent in Greek. He showed the least overall diphthongization in this survey compared to the other participants. I asked him about Greek phonetics (after recording his word list), and he told me that in Greek, diphthongs are not common and wouldn't be expected to alternate with /u/, which occurs in Greek strictly as a monophthong. Anna Sfakianaki (2002) conducted a study about the acoustic properties of Greek vowels. Her study found that [i] and [u] are very distinct from each other, and never overlap (Sfakianaki 2002:384). She also found that the average F2 value for /u/ in Greek is 921 Hz for male speakers (Sfakianaki 2002:387). Sfakianaki concluded that the formants of Greek vowels in native Greek production are similar to the formants of their counterpart English vowels in native English production (Sfakianaki 2002:393). Although she says this, she does not take vowel shifting or back vowel fronting into account at any point in her paper.

Although Yanni thought he would produce monophthongs rather than diphthongs, he shows evidence of a diphthong in many contexts. In a few instances, he had a vowel that more closely resembled a monophthong than a diphthong, but other times had a very pronounced diphthong. Figure 21, below, is an example of an instance in which Yanni produced a vowel that resembled a diphthong more so than it resembled a monophthong.

Fig. 21. /du/ produced by Yanni

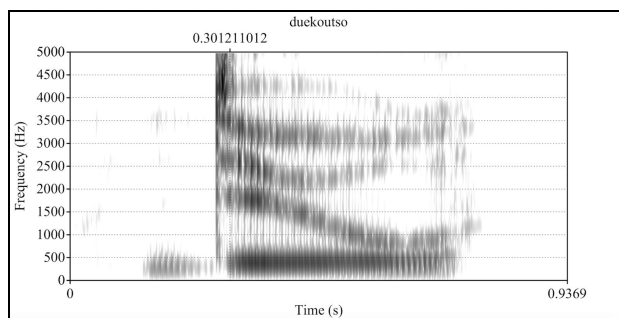
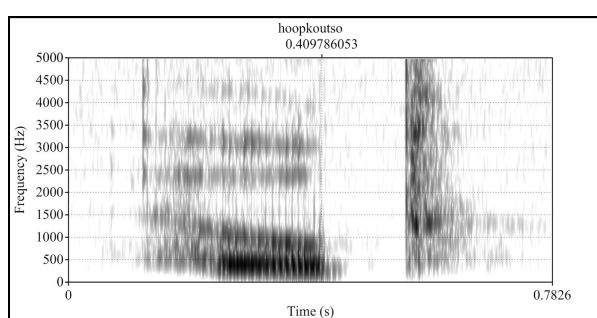


Fig. 22. /hup/ produced by Yanni



Yanni did produce two vowels that were more monophthongal than diphthongal in his recording. The vowel he produced in /hup/, pictured above in figure 22, had an average F2 value of 885 Hz, which is very close to the expected F2 value of /u/ found by Peterson and Barney. This was the only test vowel produced by any of the speakers throughout the survey whose

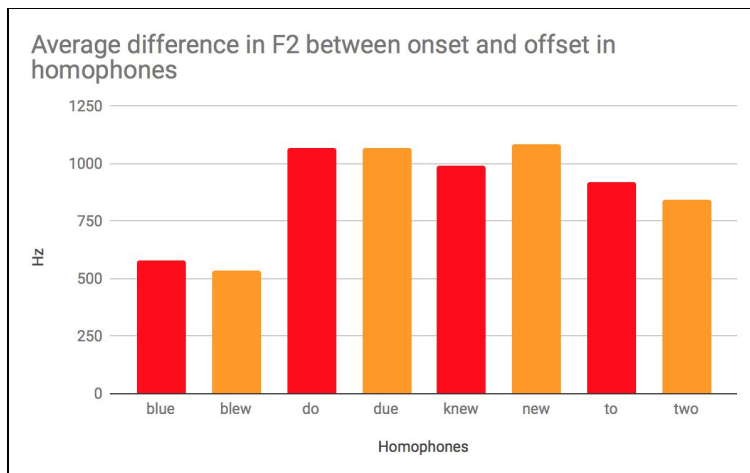
values aligned with Peterson and Barney's expected values. The other monophthong that Yanni produced appeared in /but/, but the average F2 for his test vowel in this item was 1119 Hz. He produced the other fourteen test words with a diphthong. Prior to his analyzing his recordings, I expected to see vowels that more closely resembled monophthongs in his speech. I thought that the monophthongal nature of /u/ in Greek would inhibit the vowel from surfacing as a diphthong, especially given that he learned Greek during the formative period for language acquisition. However, it seems possible that because Yanni learned MAE and currently speaks MAE much more frequently than he speaks Greek, a diphthong occurs in his English.

After analyzing his data, I became aware of how interesting it would have been to record him producing Greek words containing /u/ for comparison, but was unable to. If Yanni were to show evidence of fronting/diphthongization in Greek as well as in English, I believe it would point to the back vowel shift rather than to historical processes. If a shift occurred in the language Yanni speaks most frequently, it makes logical sense that a shift that occurs without the speaker's knowledge would seep into that person's other languages as well. However, if Yanni only produced diphthongs and fronted back vowels in English rather than in Greek, I believe it would point to Rubach's theory. The historical processes at play occurred historically in English and not in Greek. Given Sfakianaki's analysis, I also am curious as to whether or not native Greek speakers who acquire MAE as an L2 would produce their vowels with fronting, or if a diphthong would surface.

9. Homophones

Rubach hypothesizes that homophones with different historical derivations will be pronounced the same way (Rubach 2018). This means that if a speaker has [ɪu] as the surface vowel in a word that is part of a homophone pair, they will have [ɪu] surface in the other word even if one of the words does not have historical motivation for the diphthong. The homophone pairs present in the test words were not notably distinct from each other, as per Rubach's hypothesis. Figure 23 below illustrates how similar, on average, the F2s of the homophone pairs were.

Fig. 23. F2 values in homophone pairs



Rubach’s discussion of the diphthong explains why many of these pairs are produced incredibly similarly by most speakers (Rubach 2018:1). *Due*, historically, contained the correct phonetic environment for processes such as palatalization and decomposition while *do* did not. This eventually led to some form of present-day *due* that contained /ɪu/, while *do* contained /u/. However, the diphthong eventually began to apply outside of words that underwent the historical processes that led to the diphthong, which is why a diphthong appears in *do* as well. Figures 24 and 25 are Eden’s productions of *do* and *due*, respectively.

Fig. 24. ‘do’ produced by Eden

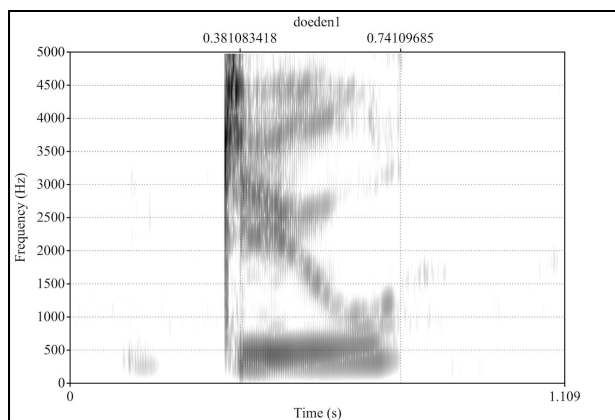
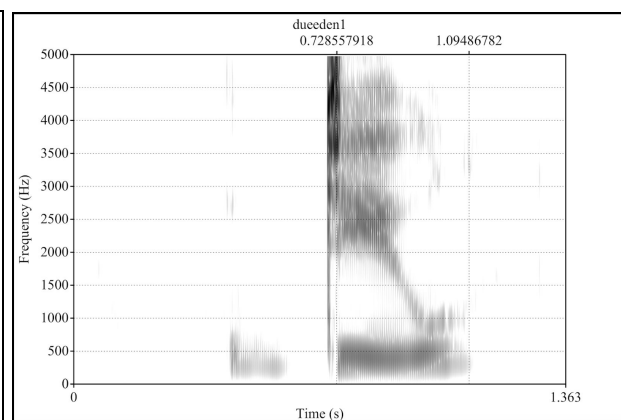


Fig. 25. ‘due’ produced by Eden



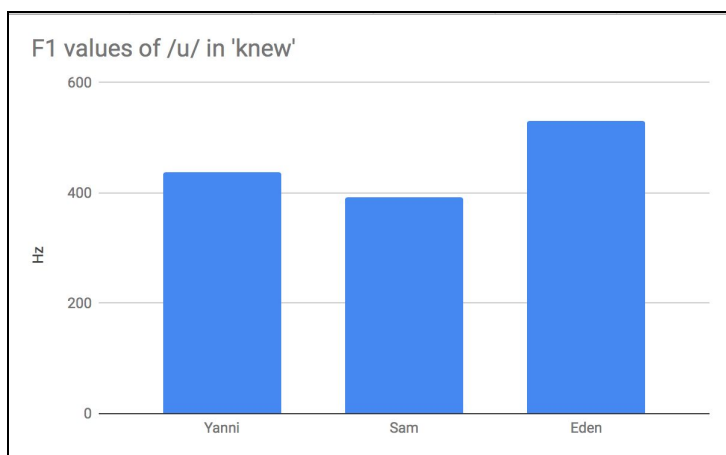
These spectrograms show that Eden produces both *do* and *due* with vowels that are extremely similar. However, if I had found that *due* had a substantially more pronounced diphthong than *do*, and had seen similar trends in my diphthong pairs, the evidence would actually back up Rubach’s theory of historical processes more strongly. Differences in F2

movement and overall values across homophone pairs would likely be attributed to historical derivations. There would be no reason for a currently ongoing shift to affect *due* differently than *do*, especially because most speakers perceive these words as sounding the same. However, the fact that *due* originated separately from *do* and underwent different historical processes and changes would be a reason for differences between the two words to appear on a spectrogram. Because such differences are not seen, it is impossible for me to say whether or not historical processes are responsible for the fronting, especially given the limitations of this survey.

10. Lowering

Fridland found that lowering seems to go hand-in-hand with fronting, especially for rounded back vowels (Fridland 2000:297). I compared the F1 of test vowels that I had recorded with the expected values to see if this pattern was likewise occurring in MAE. According to Peterson and Barney (1952), the expected F1 of monophthongal [u] for male speakers is 300 Hz, and for females is 370 Hz. However, many speakers had several instances in which the F1 for certain test items was substantially above this. Yanni's F1 values hovered around 380 Hz, which shows evidence of slight lowering. Some speakers showed evidence of lowering in SOME of the test items. For example, Eden's average F1 value for 'due was 371 Hz. However, her F1 for *knew* was 531 Hz which is indicative of substantial lowering in this production. Figure 26 shows Eden's high F1 value for /nu/, along with two other speaks whose F1 values were high for the same test word. Yanni's F1 for /nu/ was 437 Hz.

Fig. 26. F1 values for /nu/



The possible lowering was not nearly as extreme or apparent as the fronting of [u]. Some speakers did not exhibit any signs of lowering. Maggie produced most of test vowels with an F1 that was under 400 Hz, which is very near the standard for this vowel. Koops, as well, noted that portions of diphthongs in the expected place of monophthongal /u/ may be lowered, and the results seen in *knew* illustrate that this may sometimes be the case (Koops 2010:114). However, many test words appear to contain a vowel that remains high throughout its duration, and only varies in frontness.

11. Vowel duration

Vowel duration does not seem to be tied to the presence or severity of the diphthong. The duration of the test vowels ranged from 150 msec-440 msec seconds with no apparent patterning of vowel duration to particular test words. The vowel in *blue* produced by Eden lasted only 170 msec, while Maggie's vowel for the same word lasted 430 msec. Although the duration of their vowels was notably different, their average F2 values for 'blue' were within 100 Hz of each other. The individual speakers also varied widely in the duration of the test vowels. None of the literature discussed in this survey investigated vowel duration. However, if diphthongs regularly lasted for 100 msec or more longer than monophthongs, I believe I would have been able to use vowel duration to help categorize the degree of diphthongal activity that various vowels the speakers produced.

12. Historical Analysis

Rubach's hypothesis that /ɪu/'s presence can be traced to the historical form /y:/ largely aligns with the data found in the survey. Some of the generalizations from Rubach are especially interesting compared to my data. Rubach noted that while a stressed coronal preceding /u/ could garner either [u:] or [ɪu] as the resulting vowel, "[ɪu] is the dominant pronunciation (Rubach 2018:11)." My data did not contradict this, but I didn't see any variation between the monophthong and the diphthong in any of my speakers for test words in which a coronal preceded /u/.

Rubach also generalizes that /ɪu/ is no longer an option after [r] and [l], although it was once historically. He instead expects [u:] to surface in these environments (Rubach 2018:11). Although /ɪu/ could monophthongize to either [ɪ] or [u] in these environments, only [u:] is expected in these positions (Rubach 2018:26). However, all participants showed diphthongal tendencies after both *blue* and *blew* although /u:/ is Rubach's expected vowel following a liquid.

If Rubach is correct, the fronting and diphthongization are not part of ongoing US fronting shifts. This could help distinguish the places where shifts are NOT taking place. Fridland predicted that although many regions are experiencing relatively new fronting shifts, not all are. However, if Rubach is correct, it seems strange that Linda's F2 values and other measurements were different from those seen in the younger speakers.

Another interesting possibility is that both Rubach's hypothesis and back vowel fronting are co-occurring. Linda's fronting and diphthongization, as an older speaker, could be due to historical processes and the more extreme fronting seen in the younger speakers could be additional shifting on top of the already present diphthong. There is no phonetic reason why these two separate processes could not both be at play.

13. Discussion about Survey

This survey proves that monophthongal /u/ seems to be an uncommon vowel for the speakers in the contexts that I tested, but much about the presence of this diphthong is still shrouded in mystery. What realization (or realizations) of /u/ appear in polysyllabic words? I only tested words in isolation, which has been seen to produce results that are somewhat artificial compared to natural speech. What results would I see if I tested /u/ produced in casual speech or sentential contexts? What other social factors, if any, are playing a role? Are other vowels in MAE also exhibiting diphthongal tendencies, and if so, what does that mean?

In order to gain a better understanding of this vowel, I think a more expansive study would be necessary. Fridland and Hall-Lew, in their preliminary studies, used as few as 5 people to draw conclusions about city or state dialects. I only used 7 participants, of which only one varied in age from the other speakers. I think a more adequate number of subjects would be at least 50 per region, varying in age and gender. In order to answer Koops' question about the

relatedness of the ongoing vowel shifts, speakers from regions across the country would have to be compared.

14. Conclusion

Spoken language often deviates from idealized and generalized standards. Peterson and Barney's vowel formant measurements have long been heralded by linguists as standard measurements of American English vowels. However, the qualities of /u/ produced by MAE speakers vary from this standard in frontness, and actually do not seem to be monophthongal. Spectrographic analysis shows evidence of what appears to be a diphthong in many positions in which monophthongal [u] would be the assumed standard. These unexpected qualities of MAE /u/ may be attributed to historical language processes, or to vowel shift(s) currently underway in the United States. Without a more involved study, it is impossible to prove or disprove any existing theories regarding this phenomenon. Regardless of its origin, monophthongal [u] as a surface form is a rarity in a dialect that seems to favor the diphthong [ɪu].

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