

Comparison of vowel acoustics in children from the Northern, Midland, and Southern regions of
the United States

Undergraduate Research Thesis

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By

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ABSTRACT

This project examines the development of children's regional dialect vowel systems through a comparison of the acoustic properties of vowels produced by 4-11 year olds from the Northern, Midland, and Southern regions of the United States. The Northern dialect is characterized by the Northern Cities Vowel Shift (NCVS), which involves raising of the vowel /æ/. The Midland dialect is characterized by the fronting of high-back vowels and by the Canadian Shift, in which /æ/ is retracted. The Southern dialect is characterized by monophthongization of /aɪ/ in addition to back-vowel fronting. Color names were elicited from 61 children. The first and second formant frequencies of the vowels in these words were obtained to model the participants' vowel spaces and to reveal the developmental trajectory of dialect-specific vowel production within each region. The features I investigated were /æ/ raising/lowering and fronting/backing, /u/ fronting, and /aɪ/ monophthongization. I found that Northerners had the smallest distance between /æ/ and /ɛ/, which is evidence of the NCVS. There was no effect of region on /u/ fronting. Southerners did not produce /aɪ/ monophthongization; further research is needed on this feature. Finally, I did not find clear patterns relating to age. The results of this project suggest future directions for the study of dialect development in children.

INTRODUCTION

Regional dialect in the United States is an established area of linguistic study. The *Atlas of North American English* (Labov, Ash, & Boberg, 2006) is an example of the thorough research that has gone into this subject. However, the emergence of dialect variation in child language is not a well-understood process. Researchers such as Labov (1964) have proposed certain stages in the acquisition of spoken English. The first level is the basic grammar, in which a child learns the general grammatical rules and patterns of English and begins to form a

vocabulary of spoken words. The next level is the vernacular, in which the characteristics of the child's local dialect emerge and eventually become parts of everyday speech; this stage occurs between the approximate ages of five and twelve years (Labov, 1964). The present study examines the development of regional dialect vowel systems in children in the vernacular stage—specifically, 4-11 year olds—through a comparison of the acoustic properties of vowels produced by children from the Northern, Midland, and Southern regions of the United States. A map of these three regions is shown in Figure 1.

The Northern dialect is found in the upper Midwest region of the United States, particularly in Minnesota, Wisconsin, and Michigan. This dialect is characterized by the Northern Cities Vowel Shift (NCVS; Hillenbrand, Getty, Clark, & Wheeler, 1995; Labov, 1998). The NCVS is a chain shift in which low vowels follow a clockwise rotation. A schematic of the shift is shown in Figure 2 (Clopper, Pisoni, & De Jong, 2005). A prominent feature of the Northern dialect is the raising and fronting of /æ/, which is often the first phonetic change in the NCVS as well as a somewhat stereotyped feature perceived by speakers of other dialects (Jacewicz, Fox, & Salmons, 2011; Campbell-Kibler, 2012).

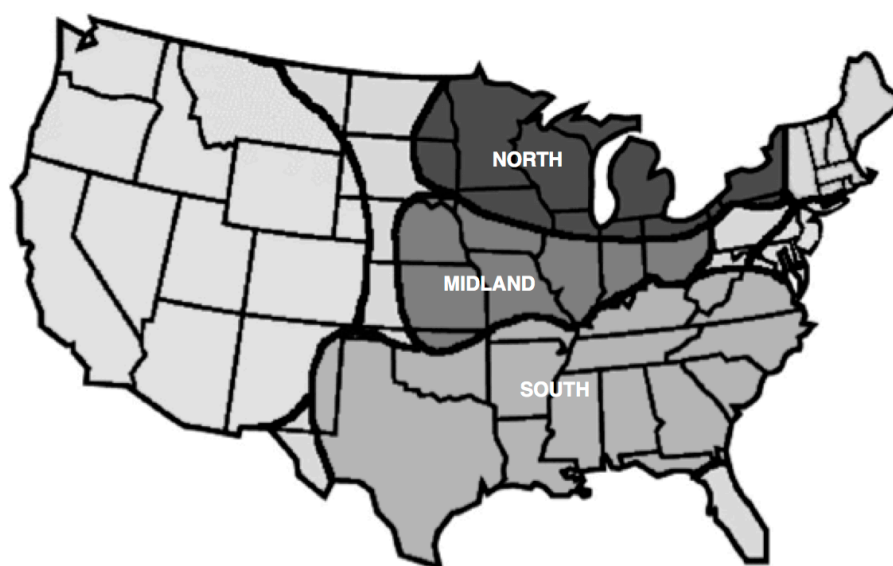


Figure 1. Map of the Northern, Midland, and Southern dialect regions of American English.

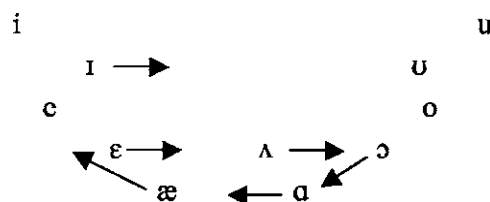


Figure 2. Diagram of the Northern Cities Vowel Shift. From Clopper et al. (2005).

The Midland dialect is found in the lower Midwest, such as central and southern Illinois, Indiana, and Ohio. This dialect is generally described by its absence of any systematic shift. However, we do have evidence of characteristic Midland features, such as the low-back merger—in which the vowels /*ɑ*, *ɔ*/ are no longer distinct—and the fronting of back vowels, especially /*u*/ (Labov et al., 2006). The low-back merger is often called the cot/caught merger because it results in the identical or near-identical pronunciation of these two words. A recent shift that appears to be taking place in the Midland dialect is the Canadian Shift. This shift, initially studied in Ontario by Clarke, Elms, and Youssef (1995), involves a retraction of the vowels /*æ*, *ɛ*, *ɪ*/. Early studies suggested that the shift was brought on by the low-back merger. /*æ*/ retracts to fill the space left by /*ɑ*/, then /*ɛ*, *ɪ*/ follow in a chain shift (Clarke et al., 1995). However, more recent studies have shown different results. Boberg (2005) found evidence in Montreal of a parallel retraction of /*æ*, *ɛ*, *ɪ*/. In this pattern, the three vowels move roughly simultaneously, instead of /*ɛ*, *ɪ*/ moving in response to /*æ*/. The parallel pattern was supported by Jacewicz et al. (2011), who observed the shift occurring without the presence of the low-back merger. A diagram of the Canadian Shift as reported by Boberg (2005) is shown in Figure 3. It is also important to note that Jacewicz et al. (2011) saw evidence of this shift in the Northern, Midland, and Southern regions of the United States. It is not exclusive to Canada; instead, it can be seen throughout North America. Additionally, /*æ*/ backing can be found in a similar shift that

has been studied in California. In this dialect, /æ/ is lowered and retracted, back vowels are fronted, and the low-back vowels /ɑ, ɔ/ are often merged (Hinton et al., 1987; Hagiwara, 2006). Both of these shifts involve /æ/ retraction, centralization of /ε, ɪ/, and at times the low-back merger. Therefore, the pattern of /æ/ backing is often referred to as the California Shift instead of the Canadian Shift.

The Southern dialect is found in the southern region of the United States, ranging from Texas to Virginia. This dialect is characterized by monophthongization of the traditionally diphthongal vowel /aɪ/ as well as back-vowel fronting, primarily with /u/ and /o/ (Labov, 1998; Clopper et al., 2005). In /aɪ/ monophthongization, the glide of the vowel is deleted, so it only has one target (Jacewicz et al., 2011). The specific conditions for /aɪ/ monophthongization vary throughout the South. It may occur before obstruents for some speakers or only before voiced consonants for other speakers (Labov et al., 2006). Back-vowel fronting is a feature of the Southern Vowel Shift. The vowels /i, ɪ/ and /e, ε/ also reverse positions in this shift (Labov, 1998; Labov et al., 2006). The fronting of back vowels is found in other dialect regions of the United States, such as in the previously mentioned Midland dialect. However, the South shows this pattern to the strongest degree; the Northern dialect shows the least amount of back-vowel fronting (Clopper et al., 2005; Labov et al., 2006).

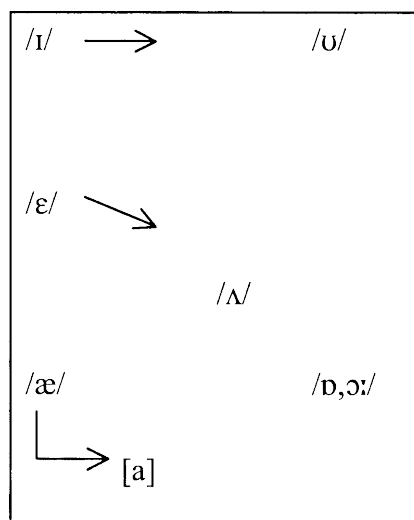


Figure 3. Schematic of the Canadian Shift. Note that the low-back merger need not be present. From Boberg (2005).

Previous research has established the existence of distinctive regional dialects in adults, but we still do not know much about the development of these dialects in children. The goals of this study were to identify evidence of these dialectal differences in children's speech through analysis of the acoustic data. I chose to focus on the age range of 4-11 years because this range is representative of the vernacular stage of language development as described by Labov (1964). I hoped to provide more insight into the process of dialect emergence through this project. The features that I examined were /u/ fronting, changes in /æ/ height and frontness, and /aɪ/ monophthongization. I expected to find /u/ fronting in Midlanders and especially Southerners. Evidence of /aɪ/ monophthongization was also predicted for Southerners. I expected to see /æ/ raising in Northerners because it is a significant feature of the NCVS. Finally, there was a potential for /æ/ lowering and backing as a result of the Canadian Shift, which was most likely to occur among Midlanders (Jacewicz et al., 2011). I predicted that these features of regional dialects would be more distinct in the older children than in the younger children. Older children

have been speaking for a longer amount of time and, as noted by Labov (1964), are more in tune to the social norms of their peers, such as patterns of language. The acoustic evidence and range of ages will give an indication of how and when dialectal features develop over time.

METHODS

MATERIALS

The data for this project were collected from February to August of 2016 in an experiment at the Center of Science and Industry (COSI), an interactive museum in Columbus, Ohio. The experiment, called Speech Olympics, was part of a collaborative project that focused on regional dialect in terms of speech production and perception in both children and adults. Research assistants from the Ohio State University, including myself, recruited visitors to COSI for the experiment and brought them into the Buckeye Language Network lab. All participants were monolingual speakers of American English and did not disclose any speech or hearing disorders.

The Speech Olympics experiment was conducted on a Windows 7 desktop computer. Participants wore an Audio-Technica ATH-770COM headset microphone that recorded their speech in the program Audacity with a sampling rate of 44.1 kHz. The recording was saved as a .wav file at the end of the experiment. There were four different parts in the experiment. The data in this project came from the first part, which was a color-naming task. This task provided a sample of each participant's speech production. Color blocks were presented on the screen; the presentation was controlled by E-Prime. Participants said the name of the color out loud then clicked the mouse to proceed to the next color block. The research assistant running the experiment often clicked the mouse for child participants. The stimulus colors were red, orange,

Color Word	Target Vowel	Measurement(s)	Dialectal Feature(s)	Expected Result	Expected Region(s)
red	ɛ	/æ/-/ɛ/ distance, angle	NCVS	smaller dist, angle	North
			Canadian Shift	larger dist, angle	Midland
black	æ	/æ/-/ɛ/ distance, angle	(see above)		
		/æ/-/i/ distance	NCVS	shorter distance	North
			Canadian Shift	longer distance	Midland
blue	u	/i/-/u/ distance	/u/ fronting	shorter distance	Midland, South
green	i	/æ/-/i/ distance	(see above)		
		/i/-/u/ distance	(see above)		
white	aɪ	/aɪ/ trajectory length	/aɪ/ monophthongization	shorter length	South

Table 1. Summary of target vowels, measurements, and expected results from this analysis.

yellow, green, blue, purple, pink, black, white, and brown. The target vowels in my analysis were /ɛ/ as in “red,” /i/ as in “green,” /u/ as in “blue,” /æ/ as in “black,” and /aɪ/ as in “white.” A preview of the measurements and expected results from this analysis is shown in Table 1.

The colors were presented in a random order for each participant. Because the stimuli only included the color blocks, young children who were not skilled at reading could still perform the experiment. Therefore, this study could illustrate the emergence of dialectal features at an early age and compare the speech of young children to that of adults, showing the development of dialect over time. Additionally, the participants were not influenced by hearing someone else say the color names. If someone had spoken the words first, participants could have altered their typical pronunciation to match that of the speaker. Their speech would not have accurately represented their dialectal features. We avoided this issue in our experimental setup.

There were three additional tasks in this experiment; in the first, participants listened to clips of speech in noise and tried to identify the words they heard. The order of the final two tasks varied depending on the condition of the experiment. In one task, participants listened to

recordings of different talkers reading the same sentence and rated each talker as to the degree to which she sounded like she was “smart,” “friendly,” or “from Ohio.” The other task involved making groups of talkers who sounded like they shared a regional background. The talkers in all three of these parts were adult females from the North, Midland, South, and Mid-Atlantic dialect regions. These three tasks focused on the participants’ comprehension of and attitudes toward different dialects. Once they had finished all of the tasks, participants were debriefed on the experiment. Children were also offered stickers in between the different stages of the experiment to help keep them engaged and motivated.

TALKERS

For this project, I analyzed the color-naming data from 61 child participants. Of the 61, 26 were boys and 35 were girls. There were 16 4-5 year olds, 10 6-7 year olds, 12 8-9 year olds, and 23 10-11 year olds. Furthermore, 20 of the children were from the Northern dialect region, 29 were from the Midland, and 12 were from the South. Table 2 provides the distribution of participants in each age and regional dialect group. Since the data were collected prior to the start of this research project, I did not have control over the demographics of the available participants. Instead, I selected specific participants that met the desired criteria. I first narrowed down the age range to look only at 4-11 year olds. As discussed above, this age range corresponds to the emergence of local dialect in children’s speech (Labov, 1964). Examining these ages would therefore show the development of dialectal features over time.

Next, I classified the participants into regions based on the cities where they had lived. In order to maximize the available data, participants who had lived within one region for all but 16 months of their lives or less were still considered to be from that particular region. For example, I included a nine-year-old girl who lived in Arizona (Western dialect region) for the first year of

Region	Number and Gender	Age Range (years)
North	2 M, 2 F	4-5
	1 M, 2 F	6-7
	1 M, 3 F	8-9
	4 M, 5 F	10-11
Midland	5 M, 3 F	4-5
	1 M, 4 F	6-7
	1 M, 5 F	8-9
	4 M, 6 F	10-11
South	3 M, 1 F	4-5
	0 M, 2 F	6-7
	0 M, 2 F	8-9
	4 M, 0 F	10-11

Table 2. Numbers of talkers in this study by region, age, and gender.

her life, then moved to Ohio (Midland); she was labeled as a Midlander. In this case, the child was likely too young to have received lasting influences from the speech community in the West; as mentioned, local dialect does not typically emerge in children's speech until about 5 years of age (Labov, 1964). I also included an eight-year-old girl who had just moved to Ohio from Virginia. I classified her as a Southerner, anticipating that her speech would not have changed significantly in the short time she had lived in a different region. Participants who had lived in different regions for longer than 16 months were not included in this study. The data set contained far more Midlanders than Northerners or Southerners as a result of COSI's location in the Midland region. For this reason, I used all of the available Northern and Southern participants and then chose Midlanders to match each participant's age and gender. I also looked at the children's ages in months so that I could match them more closely. This pairing ensured that the data were as balanced as possible across the factors of region, age, and gender. Comparisons of the data would thus remain as unaffected as possible by unevenness in these factors.

ANALYSIS

In the analysis of these data, I first used the program Praat to isolate the portion of the .wav files containing the color words. I made a textgrid for each file with a tier for the whole word and a tier for the word's stressed vowel. My primary cue for segmenting each vowel was the waveform. I identified the periodic pattern in the middle of the vowel and found where this periodicity suddenly changed or dropped considerably in amplitude as a result of a preceding or following consonant. The word "orange" does not have an initial consonant, so I measured from the onset of voicing in the waveform. The word "blue" does not have a final consonant, so I measured until the offset of voicing. All of the words except "purple" had liquids surrounding the target vowel, which often made the waveform transitions less clear. In these cases, I used the spectrogram as a secondary cue. For example, /ɹ/ causes lowering of the third formant, so the spectrogram shows a transition in F3 between /ɹ/ and a vowel. The midpoint of this transition was used as the onset or offset of the vowel. I also listened to the sound files as an additional check on my segmentation of the vowels. Figure 4 shows sample waveforms, spectrograms, and textgrids for the words orange, blue, and red.

The next step in my analysis was to collect the formant measurements. I used Praat to read in each sound file with its associated textgrid and used Praat's implementation of the Burg algorithm to estimate the first three formants. The maximum formant was set to 6000 Hz, with a maximum of five formants, since these settings were appropriate for my data. Each vowel in the sound file was extracted, and the difference between its onset and offset times was calculated for its duration. Praat then extracted the formant values from the Burg analysis at 30, 40, 50, 60, and 70% of the vowel's duration. The formant values and time measurements were written to a text file. I included multiple points because vowels are not static. Instead, their formant frequencies

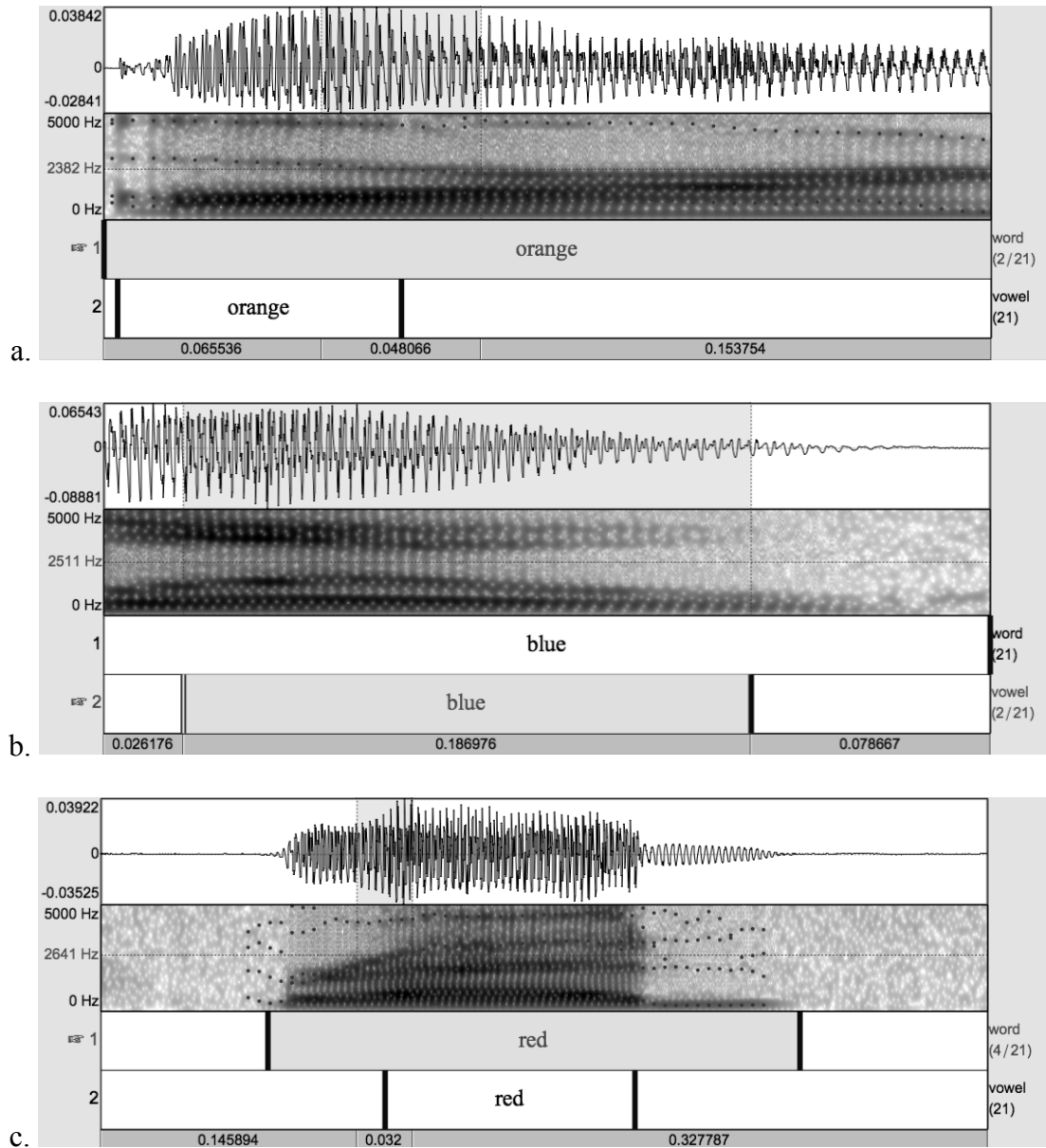


Figure 4. Waveform, spectrogram, and textgrid for (a) orange, (b) blue, and (c) red. The upper tier of the textgrid segments the entire word, and the lower tier segments just the target vowel.

change over time. Studies have shown that measurements over the duration of a vowel provide a better representation of its formants than just a single measurement (Hillenbrand et al., 1995). Having multiple points allows us to examine the trajectory of the vowel. The more-detailed formant changes in these trajectories with five points may also show dialectal features that would

not be seen with fewer measurement points (Fox & Jacewicz, 2009). Additionally, transitions from consonants impact the formant behavior of the vowel (Fox & Jacewicz, 2009). I chose measurement points that were not too close to either end of the vowel in order to avoid the effects of surrounding consonants, especially liquids.

I checked for outliers in the set of measurements by plotting the F2 by F1 vowel space for each participant in the program R. The five measured points of each vowel were connected to each other in the plot and were also in the corresponding color of the word (except that the data points for “white” were plotted in gray). I expected to find a few inaccuracies in the initial data, especially given the high frequencies and unclear voice quality of children’s speech (Lee, Potamianos, & Narayanan, 1999). I visually determined any anomalous points in the plots then returned to Praat to check the sound files and textgrids. I used the Formant Listing query to obtain more accurate measurements for these points. Often, this method yielded more reasonable and expected results and was the only step I needed to take. At other times, Praat had mistakenly identified an additional formant between two of the formants; I ignored these erroneous formants and focused on the remaining values. If there was an issue due to voice quality or background noise in the recording that rendered Praat unable to accurately measure some of the formant values, I manually estimated them from the high-amplitude bands in the spectrogram. There were two relevant formant measurements at each of five time-points in each vowel (I did not include F3 in any of my analyses), approximately ten vowels per participant (a few did not say all the target color words), and 61 participants, for a total of 6,070 formant measurements; I made a total of 124 corrections (2.3%). I confirmed my changes by plotting and visually inspecting each participant’s vowel space again.

Schematics of the calculations that I made to analyze the data are shown in Figure 5. The F1 and F2 measurements were converted from Hertz to the Bark scale (Traunmuller, 1990), which provides a better representation of sound processing in the human ear. In order to estimate back-vowel fronting, a feature of both the Midland and Southern dialects, I looked at the difference in F2 in the word “green” for /i/ and the word “blue” for /u/, since /u/ is a back vowel and /i/ is a front vowel. I used the measurement from the midpoint of each vowel. While the midpoint does not provide information about the trajectory of the vowel, it provides an approximation of the target formant values. The midpoint is also unaffected by transitions with neighboring consonants. For each participant, the F2 of /u/ was subtracted from that of /i/. This distance tells us how far apart the two vowels are; if the distance is smaller, then /u/ is more fronted.

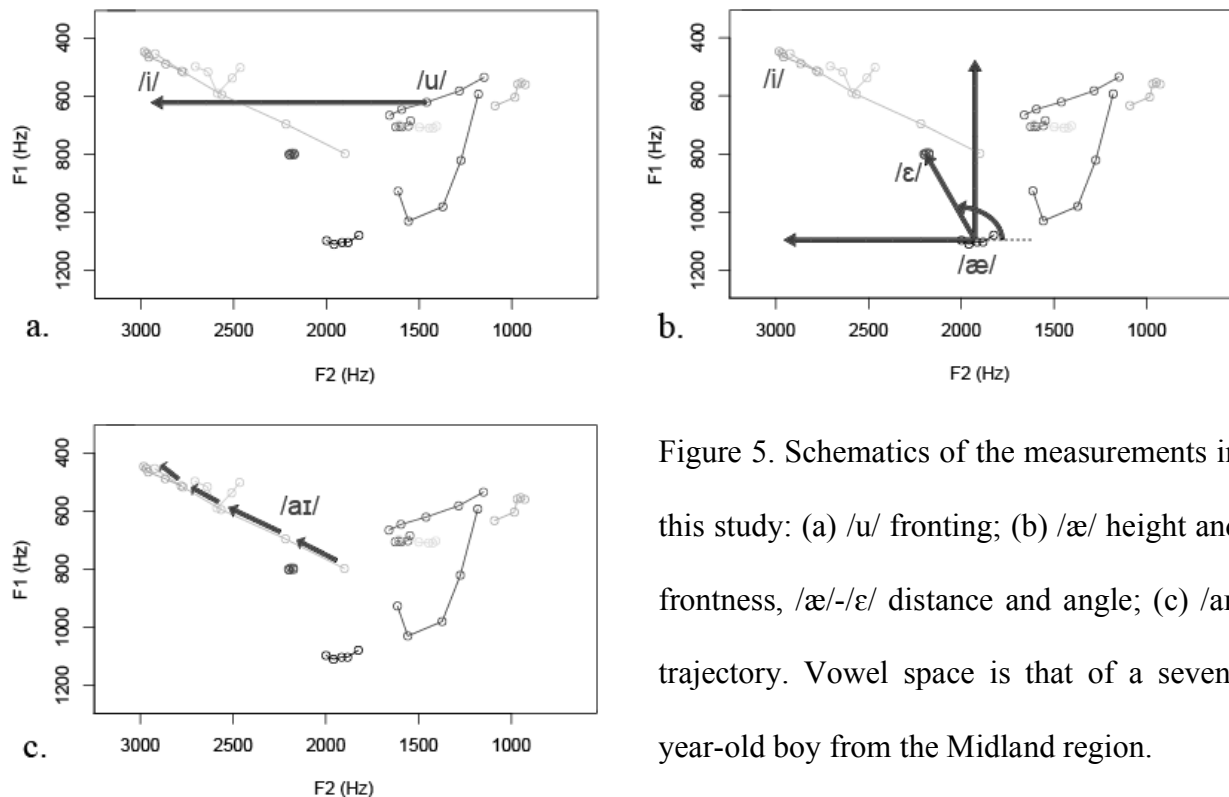


Figure 5. Schematics of the measurements in this study: (a) /u/ fronting; (b) /æ/ height and frontness, /æ/-/ε/ distance and angle; (c) /aɪ/ trajectory. Vowel space is that of a seven-year-old boy from the Midland region.

The next calculations concerned the vowel /æ/ in the word “black.” As discussed above, /æ/ is raised and fronted in the NCVS; in the Canadian Shift, it becomes lowered and backed. The raising of /æ/ in the NCVS also affects the relationship between /æ/ and /ε/. I used the word “red” for the vowel /ε/. To assess these effects, I calculated the /i/-/æ/ F1 distance (height) and the /i/-/æ/ F2 distance (frontness), as well as the angle in degrees and the Euclidean distance between /æ/ and /ε/. These calculations again used the formant values at the midpoint of each vowel. For the F1 distance, I subtracted /i/’s value from that of /æ/, since /æ/ has a higher F1; for the F2 distance, I subtracted /æ/’s measurement from that of /i/, since /i/ has a higher F2. Larger F1 and F2 distances will point towards the Canadian Shift while smaller distances will indicate the NCVS. The angle between /æ/ and /ε/ was measured with /æ/ as the origin and calculated as the inverse tangent of the F2 difference divided by the F1 difference. I added 90 degrees to the output if the F2 difference was less than or equal to zero. A small angle will show evidence of the NCVS because /æ/ and /ε/ will have rotated in a clockwise direction. A large angle will indicate the Canadian Shift because /æ/ will have retracted to a position further away from /ε/. The Euclidean distance will show if the two vowels are becoming more distinct, as in the Canadian Shift, or more similar, as in the NCVS. There were two participants in the data set that did not say the word “black,” so their data were omitted from these calculations.

I also investigated /aɪ/ monophthongization by measuring the trajectory length of the vowel /aɪ/ in “white” for each participant. Trajectory length shows the changes in formant frequency throughout the course of the vowel (Fox & Jacewicz, 2009). I calculated the sum of the Euclidean distances between each consecutive point in a participant’s trajectory using the trajectory length formula from Fox and Jacewicz (2009). Shorter trajectories will provide

evidence of /aɪ/ monophthongization, since a monophthongal vowel only has one vowel target instead of two. I expected to find shorter trajectories in the Southerners' speech.

I used analysis of variance (ANOVA) to check for significant differences in these data. The independent variables in each analysis were region, age, and gender. These factors do not vary within participants, so I used ANOVA without repeated measures. Since there were multiple factors, the ANOVA included the main effects of region, age, and gender individually as well as their interactions. I ran these ANOVAs in R using the `anova` function. The levels for region were North, Midland, and South; the levels for age were 4-5, 6-7, 8-9, and 10-11 year olds; and the levels for gender were boys and girls. I continued to group the participants' ages into four pairs because that is how participants were recruited for the experiment.

RESULTS

As an overview of the results, Figure 6 shows the combined vowel spaces of all speakers by region. The plots were made in the style of Peterson and Barney (1952). The diphthongs /aɪ/ as in “white” and /aʊ/ as in “brown” were omitted because they have two vowel targets and cannot be accurately represented by a single point. Only the midpoints of the remaining eight monophthongs were plotted. Ellipses were then hand-drawn to include at least 80% of the tokens. These plots show the approximate positions of the vowels in the F1 by F2 space that are typically produced by speakers from each region. The position of /u/ as in “blue” relative to /i/ as in “green” is about the same for each region. It appears that /u/ is fronted in all three regions. The ellipse for “blue” is aligned with that for “black,” which has the front vowel /æ/. Additionally, there is more overlap of the ellipses for “red” and “black” among Northerners, indicating that the vowels /æ/ and /ɛ/ are more similar for these speakers than for the speakers from other regions.

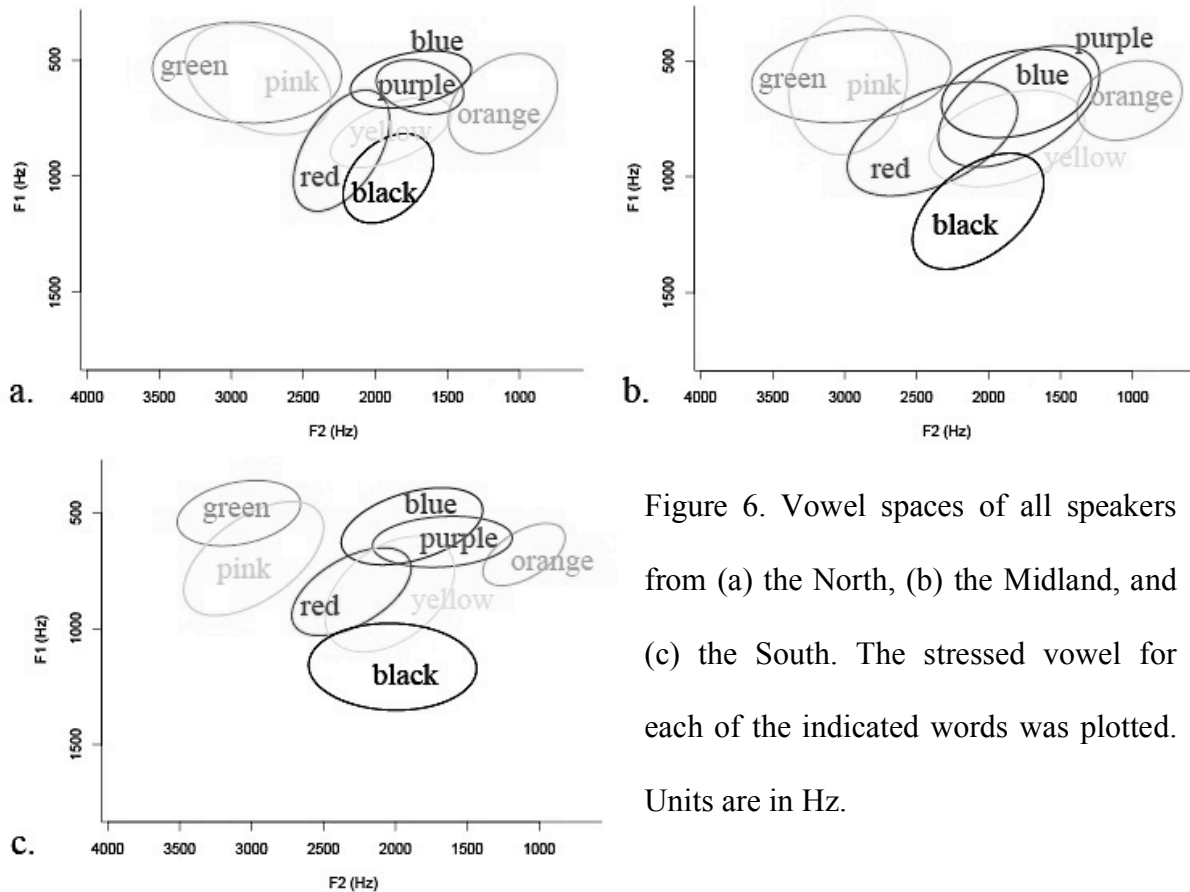


Figure 6. Vowel spaces of all speakers from (a) the North, (b) the Midland, and (c) the South. The stressed vowel for each of the indicated words was plotted. Units are in Hz.

The ANOVA for the Euclidean distance between /æ/ and /ε/ revealed a main effect of region [$F(2, 38) = 4.09$, $p = 0.025$]. Figure 7 shows a graph that compares the mean distance for each region. On average, the distance between /æ/ and /ε/ was the shortest for the Northern speakers. There was a significant difference between Northerners and Midlanders [$t(45) = -2.50$, $p = 0.016$] as well as between Northerners and Southerners [$t(29) = -2.65$, $p = 0.013$]. The difference between the Midlanders and Southerners was not significant [$t(38) = -0.52$, n.s.]. There were no other main effects or interactions for /æ/-/ε/ Euclidean distance. The short distance found in Northern vowels suggests evidence of the NCVS. In order to investigate the effect further, I then analyzed the F1 and F2 differences between /æ/ and /ε/. These calculations showed whether or not /æ/ was raised or fronted in comparison to /ε/. The F1 and F2 differences had already been extracted for the Euclidean distance, so I used the absolute value of these

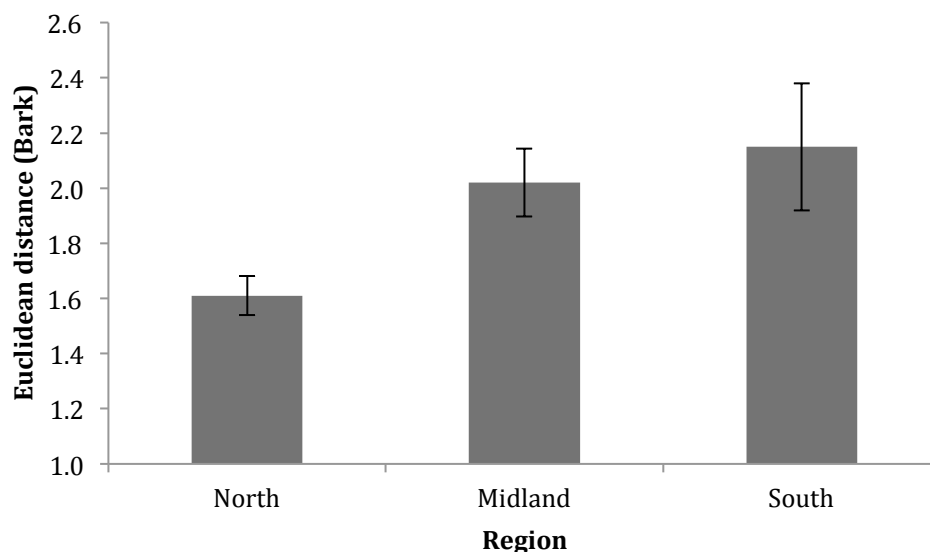


Figure 7. Mean /æ/-/ε/ Euclidean distance by region. The distance is significantly shorter for Northern speakers than for the other two groups of speakers.

calculations for the new distances. The ANOVA for F1 distance revealed a main effect of region [$F(2, 38) = 3.36, p = 0.045$]; the ANOVA for F2 distance showed no main effects or interactions. Northerners had on average the shortest distance; again, the difference between Northerners and Midlanders [$t(45) = -2.07, p = 0.045$] and Northerners and Southerners [$t(29) = -2.31, p = 0.028$] were both significant, but the difference between Midlanders and Southerners was not. [$t(38) = -0.77, n.s.$]. The overlap of /æ/ and /ε/ can be seen in Figure 6(a). The results of this analysis are consistent with /æ/ raising, a feature of the NCVS.

The ANOVA for /æ/-/i/ F2 difference revealed a main effect of age [$F(3, 38) = 3.66, p = 0.021$]. Figure 8 shows a graph of the mean distances for each age group. The 4-5 year olds had the shortest F2 distance on average. This distance was significantly shorter than that of 6-7 year olds [$t(23) = -2.66, p = 0.014$] and 10-11 year olds [$t(36) = -2.77, p = 0.009$], but it was not significantly different from that of 8-9 year olds [$t(24) = -1.71, p = n.s.$]. None of the other

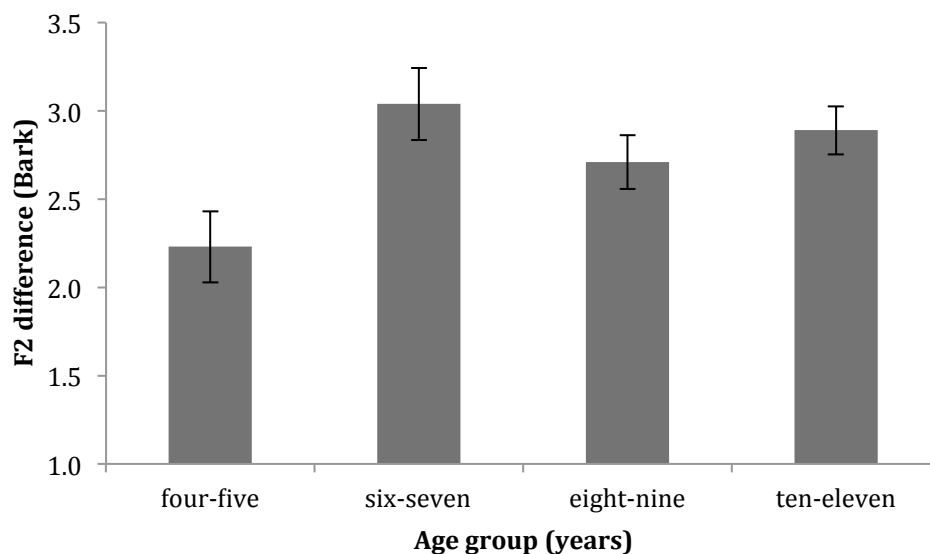


Figure 8. Mean F2 distance between /æ/ and /i/ by age. The distance is generally smaller for 4-5 year olds.

pairwise comparisons were significant [$t(19) = 1.30$, n.s. for 6-7 vs. 8-9, $t(31) = 0.61$, n.s. for 6-7 vs. 10-11, and $t(32) = -0.81$, n.s. for 8-9 vs. 10-11 year olds]. The /æ/s produced by 4-5 year olds were generally the most fronted, while those produced by the older children were the most backed. Vowel spaces comparing 4-5 year olds to the older children are shown in Figure 9. For the 4-5 year olds, all of the front vowels are closer together than they are for the older children.

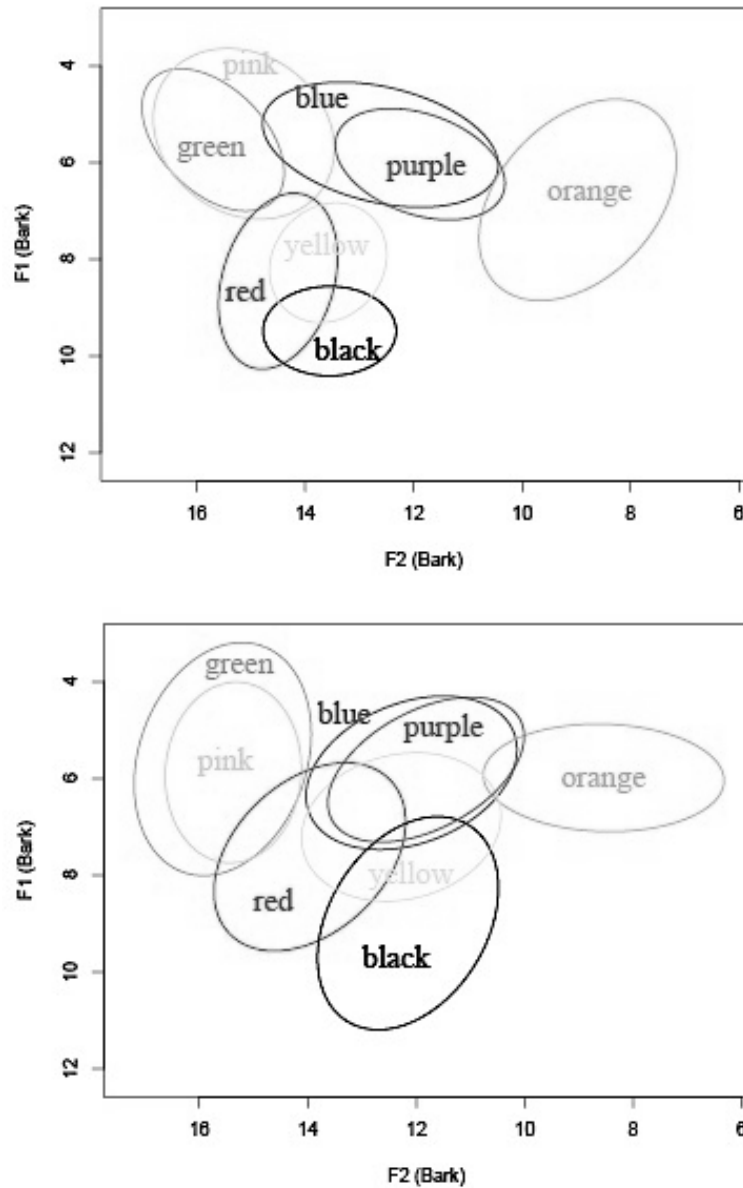


Figure 9. Vowel spaces of all 4-5 year olds (top) and all 6-11 year olds (bottom). Ellipses were drawn by hand to include at least 80% of the vowel tokens. Units are in Bark.

The ANOVA for /aɪ/ trajectory length showed a main effect of region [$F(2, 40) = 6.31$, $p = 0.004$] and a main effect of age [$F(3, 40) = 3.19$, $p = 0.034$]. Figure 10 shows a graph of the mean trajectory lengths by region as well as a graph by age group. Southerners had the longest trajectories; there was a significant difference between Southerners and both Northerners [$t(30) = 2.33$, $p = 0.027$] and Midlanders [$t(39) = 3.04$, $p = 0.004$]. The difference between the Northerners and the Midlanders was not significant [$t(47) = -0.62$, n.s.]. The 6-7 year olds had

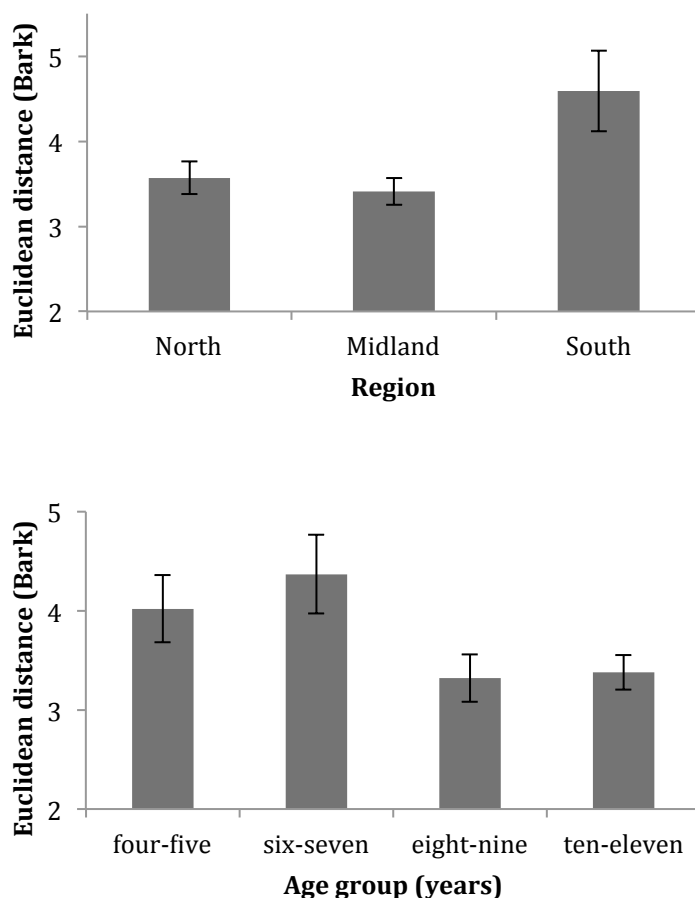


Figure 10. Mean length of /aɪ/ trajectory by region (top) and by age group (bottom). The trajectory length is the greatest for Southerners (top), and for 6-7 year olds (bottom).

significantly longer trajectories than those of 8-9 year olds [$t(20) = 2.34$, $p = 0.030$] and 10-11 year olds [$t(31) = 2.66$, $p = 0.012$]. There was no significant difference between the 4-5 year olds and the 6-7 year olds [$t(24) = -0.66$, $p = \text{n.s.}$]. Although the trajectories of the 4-5 year olds are generally longer than those of the oldest two age groups, there was no significant difference compared to either the 8-9 year olds [$t(26) = 1.56$, $p = \text{n.s.}$] or the 10-11 year olds [$t(37) = 1.82$, $p = \text{n.s.}$]. In my data set, the group of Southerners had proportionally the most 4-7 year olds compared to the other regions, and the group of 4-7 year olds had proportionally the most Southerners compared to the other ages. The overlap of these groups made it difficult for me to tell which variable—age or region—was responsible for the increased trajectory lengths. To better understand these results, I plotted the mean /aɪ/ trajectory length by age and region, shown

in Figure 11. While there was not a significant region X age interaction for the trajectory length [$F(6, 40) = 1.07$, n.s.], Figure 11 shows that it was primarily the Southern 4-7 year olds who had the longest trajectories. Note the large error bars that show the inconsistent nature of these data. A large trajectory length indicates increased diphthongization, which is the opposite of what I expected to find in Southerners.

Finally, the ANOVAs for /u/ fronting, /æ/ height relative to /i/, and /æ/-/ε/ angle showed no main effects of region, age, or gender, nor did they show any interactions between these variables. The lack of regional variation for /u/ fronting suggests that children from all three regions produced /u/s that were roughly equivalent in their F2 position. The lack of significant results for either the F1 distance between /æ/ and /i/ or the angle of rotation, combined with the significance of /æ/-/ε/ Euclidean distance, suggests that the NCVS is still in its early stages. In adults, we would expect /æ/ to be raised and fronted with respect to /i/ and the angle between /æ/

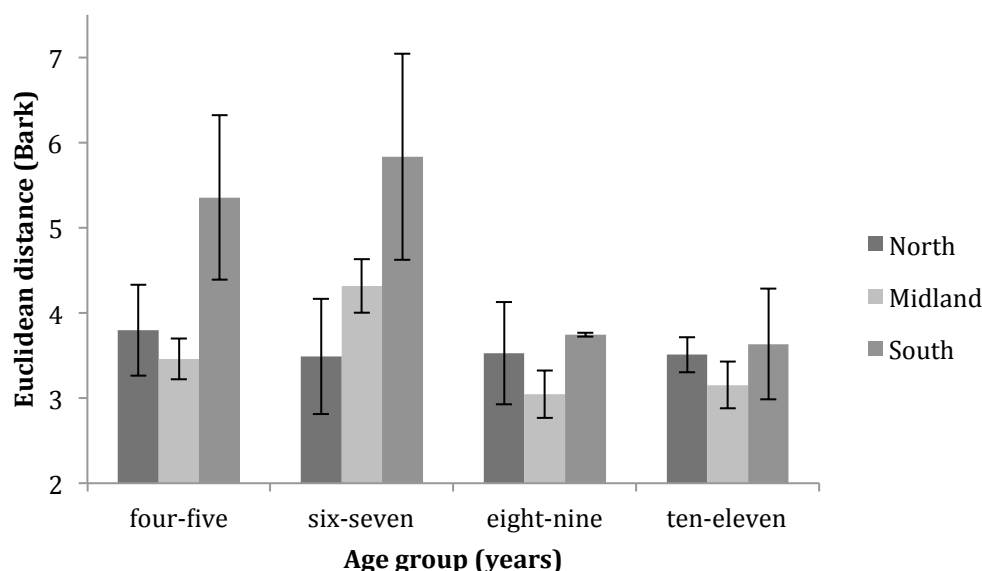


Figure 11. Mean length of /aɪ/ trajectory by age and region. Southern 4-5 and 6-7 year olds generally have the longest trajectory lengths, although there was no region X age interaction.

and /ε/ to be very small. The Northern children's speech showed some features of the NCVS, but the shift was not as extensive as what we usually observe in adults.

DISCUSSION

The results of the /æ/-/ε/ Euclidean distance analysis provide evidence of the NCVS. The distance was significantly shorter for Northerners, as shown in Figure 7. These two vowels are beginning to overlap, as shown in Figure 6(a). The ellipses for “red” (/ε/) and “black” (/æ/) have the greatest intersection compared to the vowel spaces of the other two regions. The overlapping of these two vowels in the F1 by F2 space has been observed by Hillenbrand et al. (1995) in both adult and child speakers from the Northern dialect region. The raising of /æ/ is often the first change to occur in the NCVS. The vowel is raised and fronted to a position similar to that of /ε/. As the low vowels continue to rotate in a clockwise direction, /ε/ is retracted further, which helps to eliminate overlap with /æ/ (Clopper et al., 2005). We would expect to find significant differences in the height and frontness of /æ/ with respect to the high-front vowel /i/ among Northerners as a result of /æ/ raising. However, the present study did not reveal significant results for this measurement. This pattern suggests that /æ/ raising has not yet reached its fullest extent in these Northern children. In order to better understand the significance of /æ/-/ε/'s Euclidean distance, I analyzed the F1 and F2 components individually to determine if raising and/or fronting of /æ/ with respect to /ε/ were present. The results showed a significant difference in /æ/'s height compared to that of /ε/ among Northerners compared to Midlanders [$t(45) = -2.07$, $p = 0.045$] and Southerners [$t(29) = -2.31$, $p = 0.028$]. The F1 distance between the vowels was the shortest for Northerners, which may also suggest that /ε/ is moving lower as /æ/ is shifting. Overall, these results are indicative of the early stages of the NCVS. The shift is still in progress, so not all of its features are fully defined in these children. Furthermore, there was no significant

difference in /æ/-/ε/ Euclidean distance across age groups. This finding implies that all of the Northerners showed /æ/ raising to about the same degree. In order to see effects of age on /æ/ raising, we would need to look at younger ages to see how it emerges as well as older ages to see how its development continues as the NCVS progresses to an adult-like level.

The results for /æ/-/i/ F2 distance were unexpected. The distance was generally shorter for 4-5 year olds than for the other age groups. Region did not have an effect on this outcome, which suggests that it is unrelated to the NCVS or the Canadian Shift. Upon observing the vowel spaces of the 4-5 year olds, I noticed that all of their front vowels appeared to be somewhat on top of each other, at least more so than those of the older children. Vowel spaces of the two age groups are shown in Figure 9. For the older children, the vowels in “green,” “pink,” “red,” “yellow,” and “black” (/i, ɪ, ε, e, æ/, respectively) show a clear diagonal across the vowel space, which is what we expect for adults. These vowels are all rather fronted for the 4-5 year olds. This difference may be a result of differing articulation in young children. Because they generally have smaller mouths and vocal tracts, they might not articulate front vowels in the same way that older children do. Another possible reason for this difference is that the formant calculations were not normalized before analyzing the results (Lobanov, 1971; Clopper et al., 2005). Normalization limits the speaker-inherent factors that affect the vowel space. There could be an effect of vocal tract size that is causing the vowel spaces of young children to appear more compact with their front vowels. Further research is needed to better interpret these results.

The results for /aɪ/ trajectory length also revealed an unexpected effect. I had predicted that Southerners would exhibit /aɪ/ monophthongization; they would have the shortest trajectory lengths. However, I found that both Southerners and 4-7 year olds actually had much longer trajectories compared to the other regions and the older ages, as shown in Figure 10.

Additionally, the group of Southerners contained proportionally more 4-7 year olds compared to the other regions (50% vs. 35% for Northerners, 45% for Midlanders), and the groups of 4-5 and 6-7 year olds contained proportionally more Southerners than the other ages (25% and 20% respectively vs. 17% each for 8-9 year olds and 10-11 year olds). The variables were not entirely orthogonal, so it was difficult to interpret the effects on /aɪ/ trajectory. Therefore, I plotted the mean length of /aɪ/ trajectory by both age and region, even though the ANOVA did not reveal a significant interaction between these variables. As can be seen in Figure 11, the 4-7 year old Southerners primarily had the longest trajectories. The large error bars show that the data was rather varied, which helps explain why the region X age interaction was not significant. The uneven number of subjects in each group probably contributed to the lack of a significant interaction, as well.

The long trajectory length indicates increased diphthongization, which is the opposite of the monophthongization that I expected to find. An explanation for this result is that in different parts of the South, /aɪ/ monophthongization is conditioned by different phonetic environments. As discussed above, this effect may not occur for some speakers when the vowel precedes a voiceless consonant, as is the case for the word “white.” Thus, speakers who do not monophthongize the /aɪ/ in “white” could very well show monophthongization in the word “wide,” where the vowel precedes a voiced consonant. The exaggerated diphthong produced by young children could therefore be a response to monophthongization in a different context. The long trajectory emphasizes the distinction between the monophthongal /aɪ/ of “wide” and the diphthongal /aɪ/ of “white.” /aɪ/ monophthongization may still be developing in these young children, so they may take extra measures to ensure that the contrast between monophthongal and diphthongal /aɪ/ is heard. Older children who have more language experience do not need to

emphasize this contrast. More research is needed to confirm these speculations. Future studies would need to examine more possible contexts for /aɪ/ monophthongization in order to truly understand its development.

While I found evidence of the NCVS in the /æ/-/ɛ/ Euclidean distance and /æ/-/ɛ/ F1 distance, there were no effects or interactions for /æ/-/i/ F1 distance or for /æ/-/ɛ/ angle. I cannot conclude that there was evidence of the Canadian Shift based on these results alone. I will need to make a comparison with adult speakers from the Midland and South. Their vowel spaces can be used as a reference point to see if the Canadian Shift is more developed in the speech of the younger generation. Last, there were no effects or interactions for /u/ fronting. This lack of regional effect either suggests that speakers from all three regions produced fronting to roughly the same degree, or that it is widely variable across regions. After listening to the sound files, I agree with the second option and conclude that /u/ fronting varies throughout the regions. Some Northerners produced fronted /u/s, suggesting that this trend is making its way into the Northern dialect, which has typically been more resistant to back-vowel fronting (Labov et al., 2006; Jacewicz et al., 2011). Midlanders and Southerners also produced both fronted and backed /u/s, and age did not have any significant effect. Therefore, the pattern of /u/ fronting in this study is not predictable by region or age.

In conclusion, this project gave some insight into the development of regional dialect in children. Northerners exhibited the early stages of the NCVS, primarily movement of /æ/ and /ɛ/. Further studies will need to examine an expanded age range to see how this feature develops over time. Southern children between the ages of 4 and 7 years generally had the longest /aɪ/ trajectories, although there was no region X age interaction. These children might be exaggerating the difference between a monophthongal /aɪ/ and a diphthongal /aɪ/ found in a

different phonetic environment. More research is needed to study the different possible contexts of /aɪ/ monophthongization. Finally, there were no effects of region or age on /u/ fronting. Having multiple utterances from each speaker might help explain the variability of this feature, as would data from a wider range of speakers. This study has suggested directions for future research into the emergence of dialect variation.

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