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An acoustic description of vowels spoken by speakers with Cajun ethnicity in Southern Louisiana

Ali Beslin
Louisiana State University and Agricultural and Mechanical College

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AN ACOUSTIC DESCRIPTION OF VOWELS SPOKEN BY SPEAKERS WITH CAJUN ETHNICITY IN SOUTHERN LOUISIANA

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Arts

in

The Department of Communication Sciences and Disorders

by

Ali Elizabeth Beslin
B.A., Louisiana State University, 2011
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ABSTRACT

This study aimed to provide selected acoustic data for vowels of one portion of the southern region (Southern LA) in recognition that a variety of Southern dialects have not been recognized on the American English dialect map. To examine dialectical variations in vowel acoustics, this study included a relatively greater number of acoustic parameters including: vowel duration, F1 and F2 from the temporal midpoint of the vowel, trajectory length, and F2 slope. Ten participants between the ages of 18 to 24 were selected from the Southern Louisiana dialect region. Speech stimuli, which have been used in prior research regarding dialect, included words containing 16 American English vowels in /hVd/ context (Hillenbrand, 1995). Each stimulus was produced five times in a row, which results in analysis of a total of 800 vowels (10 speakers, 16 vowels, and 5 repetitions). Based on a general comparison between data from Southern Louisiana dialect speakers and previously reported data from Upper Mid-Western dialect speakers, it can be inferred that there are differences in temporal and spectral measures between these two dialects. This provides a basis for direct comparison of Southern Louisiana dialects to other dialects to determine which parameters are most sensitive to dialect and how these might impact vowel production and perception.
INTRODUCTION

Historically, studies in the field of Communication Sciences and Disorders have mostly included speakers of northern American English (Josephs et al., 2012; Hustad, 2008; Baylor, Burns, Eadie, Britton, & Yorkston, 2011; Martin, Schwartz, & Kohen, 2006). While research regarding dialectal variation in the field of Communication Sciences and Disorders is well-recognized (McLeod, 2007; American Speech-Language-Hearing Association [ASHA], 1983), it remains important to include a variety of dialects across all aspects of the field to account for the normal variation within healthy speakers prior to identifying parameters of speech and language specific to speakers with communication disorders. Dialects are also commonly studied by sociolinguists; however, measures used in this research often do not translate into clinical practice (Thomas, 2001; Wolfram & Ward, 2006; Lanehart, 2001). For example, the current acoustic model of speech intelligibility for individuals with dysarthria (a type of motor speech disorders secondary to diverse neurological impairments) was constructed mostly, if not exclusively, by investigating North American English speakers (Kim, Kent, & Weismer, 2011). Very rarely have dialects other than northern American English been considered in regards to speech acoustics. However, it has been reported that regional, ethnic, and social dialects are integral parts of speech perception, especially perceived speech intelligibility (Clopper, Levi, & Pisoni, 2006). Therefore, it is important that characteristics of dialects other than northern American English be identified so that we can further understand the impact that those characteristics may have on certain aspects of speech perception.

Just as speech parameters including vowel quality have been reported to vary across languages, differences in vowel quality can also occur across dialects of the same language (Miller, Mondini, Grosjean, & Dommergues, 2011). Considering the variation in speech
parameters across dialects, it is important that the range of variation between dialects be examined in order to consider this variation in future studies in the field of Communication Disorders. In particular, information provided by studying a variety of dialects may be useful in the construction of a new acoustic model of speech intelligibility which should include multiple dialects of American English. This new model is necessary considering the current model fails to incorporate dialectical diversity and the impact that this diversity may have on perceived speech intelligibility. Identifying dialectical differences may promote the creation of new assessment measures that are sensitive to multiple dialects and also provide education regarding the characteristics of multiple dialects so that these characteristics are not considered a communication disorder.

The current study aims to examine dialectal effect on vowels in recognition of the potential contributions of vowels on perceived speech intelligibility (Neel, 2008). It has been reported that multiple aspects of vowel production are highly correlated with overall speech intelligibility in healthy (Bond & Moore, 1994; Bradlow, Torretta, & Pisoni, 1996; Hazan, & Markam, 2004) and disordered speech (Trost & Canter, 1974; Haley, Bays, & Ohde, 2001; Liu, Tsao, & Kuhl, 2005). Overall speech intelligibility has been shown to be affected by measures of vowel duration, acoustic vowel space, fundamental frequency range, and second formant frequency range (Bond & Moore, 1994; Bradlow, Torretta, & Pisoni, 1996; Hazan, & Markam, 2004).

Given that the characteristics of vowels that have an impact on overall speech intelligibility (e.g., F1, F2, and vowel duration) are similar to the differences in the characteristics of vowels across dialects (Kain et al., 2007; Kent et al., 1989; Kim, Kent, Weismer, & Duffy, 2009; Clopper & Pierrehumbart, 2008; Fox & Jacewicz, 2009), it is important that researchers are aware of the variety in acoustic measures across dialects. It is especially important to be aware of
these differences when conducting research involving speakers of different dialects so that the variation that is attributed to a particular dialect is not mistaken as a characteristic specific to disordered speech. In this sense, the proposed study is significant.

The overall purpose of this study is to determine the acoustic characteristics of vowels of Southern Louisiana dialect speakers as a first step prior to examining the differences between this population and speakers of Northern dialect. Louisiana dialect was of specific interest for this study considering the lack of data on this dialect in past research and the perceived differences within Southern dialects and within the state of Louisiana. These results are expected to determine the acoustic characteristics of vowels for Southern Louisiana dialect speakers. No prior studies have reported on Louisiana dialect, so this dialectical group has not been included on the American English dialect map. This study aims to provide characteristics of this dialect to be included on the American English dialect map in the future. In terms of clinical application, the future study regarding diversity across Northern and Southern English dialects may provide different acoustic predictors of speech intelligibility; so, in this sense, a better understanding of vowel features from various dialect regions is important. Accordingly, the following questions are raised.

**Research Questions**

1. What are the temporal characteristics of vowels produced by speakers of Southern Louisiana dialect?

2. What are the spectral characteristics (F1 and F2) of vowels produced by speakers of Southern Louisiana dialect?

3. What are the trajectory characteristics of vowels produced by speakers of Southern Louisiana dialect?
These questions are posed under the assumption that some, if not all, of the acoustic measures of vowel duration, F1, F2, and F2 slope will be affected by dialect.
LITERATURE REVIEW

Acoustic Characteristics of Vowels

2.1 Temporal Characteristics

According to House (1961), vowel duration provides information regarding vowel production and may also contribute to the listener’s perception of vowels. He stated that vowel duration varies depending on the manner in which a vowel is produced (e.g., tense versus lax). It has been hypothesized that decreased vowel duration for lax vowels may be caused by a reduction in vocal effort or decreased articulatory movement required for the production of lax vowels compared to the production of tense vowels (House, 1961). Therefore, measures of vowel duration may be useful in inferring the amount of articulatory movement or amount of vocal effort used to produce a specific vowel.

In addition to providing information regarding vowel production, vowel duration also plays a role in perceptual vowel identification and overall speech intelligibility (Mok, 2011; Ferguson & Kewley-Port, 2007; Lindblom, 1963). Lindblom (1963) conducted a study investigating the contributors to vowel reduction for short or lax vowels. He reported that vowel duration was a key determinant in whether a speaker would undershoot articulatory placement of a target vowel. This is important because articulatory undershoot plays a role in decreasing perceived speech intelligibility (Tjaden, Rivera, Wilding, & Turner, 2005). Similarly, Ferguson and Kewley-Port (2007) found that vowel duration was greater for speech that was perceived to be clear when comparing sentences produced in a conversational manner with sentences that were directed to a person with a hearing loss.

Researchers have used temporal measures of vowels as assessment measures in research for both children and adults with communication disorders. In the adult population, vowel
duration has been used to assess whether or not speakers with aphasia and apraxia of speech
differentiate vowel duration between voiced and voiceless post-vocalic stop consonants when
compared to individuals with aphasia only and healthy controls (Haley, 2004). She found that
many speakers with aphasia and speakers with aphasia and apraxia of speech inconsistently
differentiated or failed to differentiate vowel duration between voiced and voiceless post-vocalic
stop consonants (Haley, 2004). Measures of vowel duration have also been used in the treatment
of dysarthria to improve perceived speech intelligibility (Kain et al., 2007). Kain and colleagues
(2007) were able to improve the speech intelligibility of one speaker with dysarthria by training
her to produce vowels in the same way as a healthy speaker.

In younger populations, vowel duration has been identified as an indicator of perceived
stress for children with developmental apraxia of speech and children with phonological
disorders (Munson, Byjourm, & Windsor, 2003). Vowel duration was also included as one of
the measures used to construct a speech and language classification system for children who
have a diagnosis of cerebral palsy (Hustad, Gorton, & Lee, 2010). Within this study, vowel
duration, in conjunction with vowel space, contributed to most of the variance within the
children studied and led to the construction of a four communication profile groups.

This literature shows the importance of vowel duration to the field of Communication
Disorders and further highlights the need to understand the variability of this measure within the
normal population to better understand the speech of individuals with communication disorders.

2.2 Spectral Characteristics

Researchers extensively use two types of measures for identifying the spectral
characteristics of vowels: steady-state measures and dynamic measures. Steady-state measures
refer to measures taken during the vowel’s stable state (e.g., F1 and F2), while dynamic
measures refer to measures of formant slope and duration (Assman, Neary, & Hogan, 1982). These measures provide information regarding the configuration of the vocal tract and the rate of change in vocal tract configuration, respectively.

The relationship is well established between F1/F2 and tongue placement in the horizontal/vertical dimension. F1 infers tongue height, whereas F2 infers tongue advancement (Stevens, 2000). This allows assumptions to be made regarding tongue placement based on formant frequency values. Subsequently, such measures may be beneficial in inferring differences in speakers who produce vowels with significantly different formant frequency values. These measures are useful to the current study to describe articulatory movements and to begin to identify changes in production that may cause the perception of dialectical differences.

Acoustic vowel space has been used to examine both vowel production and perception aspects of healthy (Tsao, Weismer, & Iqbal, 2006) and disordered speech (Liu, Tsao, & Kuhl, 2005). Acoustic vowel space is derived from F1 and F2 measures of the four corner vowels /Ø, æ, a, u/. These vowels are selected as a representation of the acoustic vowel space of a speaker because they represent the most extreme articulatory positions of vowels; therefore, they also represent the most extreme formant frequency values (Liu, Tsao, & Kuhl, 2005). In terms of vowel production, acoustic vowel space has been used an index of vowel articulation, which infers the movement and coordination of oral-facial structures such as the tongue and jaw (Liu et al., 2005). Therefore, a reduction in acoustic vowel space would signify a reduction in articulatory movement during vowel production. Acoustic vowel space has also been studied as a predictor of perceived speech intelligibility, where a reduction in acoustic vowel space is correlated with a reduction in overall speech intelligibility (Neel, 2008).
Similarly to vowel duration, it has been determined that spectral characteristics of vowels also contribute to perceived intelligibility by aiding in the identification of vowels. Sakayoir and colleagues (2002) reported that F1 and F2 values may be the most essential components for perceptual vowel identification. Furthermore, it has been hypothesized that F2 slope is critical to perceptual vowel identification which may contribute to speech intelligibility (Strange, 1989).

Formant frequencies (especially F1 and F2) have been studied extensively in prior research with individuals with a variety of communication disorders. For example, F1 and F2 values were used to determine differences between healthy speakers and speakers who have had a glossectomy (Kazi et al., 2007). Results from this study showed that F1 and F2 values were significantly different between healthy male and female speakers but were not significantly different between male and female speakers who had a glossectomy. Results also showed that significant differences were seen for F2 and F3 values when comparing healthy female speakers to female speakers who had a glossectomy; however, only F1 values were significantly different for male speakers who had a glossectomy compared to healthy male speakers. Laures-Gore and colleagues (2006) aimed to identify the acoustic-phonetic characteristics of speech in individuals with foreign accent syndrome and found that speakers with foreign accent syndrome had a normal F1/F2 patterns. In another instance, Kim, Kent, and Weismer (2011) aimed to isolate acoustic variables associated with speech intelligibility in speakers with dysarthria. They found that F1 and F2 values used to calculate acoustic vowel space along with three other variables were significantly correlated to speech intelligibility. Finally, Campisi, Low, Papsin, Mount, and Harrison (2006) used F1 and F2 as two of the acoustic variables to identify differences between children who are profoundly deaf and normal hearing children.
Just as temporal analysis is used frequently in the field of communication disorders, the literature mentioned above acknowledges the role of formant frequencies to this field as well. Therefore, it is reiterated that these measures be studied in a variety of healthy populations to understand their variability so as to gain a better understanding of how the speech of clinical populations differs from the speech of healthy individuals. This understanding should be a guide for the creation of new assessment and treatment measures for clinical populations.

The dynamic measure of F2 slope has also been used as a variable for identifying predictors of speech intelligibility (Kent et al., 1989; Kim, Kent, & Weismer, 2009). Additionally, it has been used to track disease progress in speakers with dysarthria as well as to differentiate mild-moderate dysarthria from healthy speech (Rosen, Goozee, & Murdoch, 2008; Yunusova, Green, Greenwood, Wang, Pattee, & Zinman, 2012). It has also been employed as a measure to determine a difference in phonatory behavior for individuals with muscle tension dysphonia when compared to healthy speakers (Dromey, Nissen, Roy, & Merrill, 2008).

Trajectory length was chosen as a variable for this study because relatively recent studies have shown that it is sensitive to dialect variations and particularly vowel trajectories which deviate from a linear pattern (Fox & Jacewicz, 2009; Jacewicz, Fox, & Salmons, 2011). Primarily because of the short history of this parameter, few studies have examined trajectory length in diverse dialects. This study aims to contribute to the research utilizing this measure to provide information regarding formant trajectories across the entire vowel duration in addition to F2 transition duration and transition extent (F2 slope).

**Effect of Dialect on Acoustic Characteristics of Vowels**

A few studies have examined the effect of multiple regional dialects on acoustic characteristics of vowels. This literature has shown significant differences between speakers of
Southern and Northern dialects (Clopper & Pierrehumbart, 2008; Fox & Jacewicz, 2009). Clopper and Pierrehumbart (2008) reported spectral reduction in vowels produced by speakers of Southern dialect and significant differences for F2 values of the vowels /a/ and /æ/. Fox and Jacewicz (2009) also acknowledged the effect of regional dialect on acoustic characteristics of vowels by reporting significant differences between measures of vowel duration and trajectory length for the vowels /ɪ, ɛ, e, æ, a/. While the aforementioned literature reported on the effects of dialect on adult speakers, Jacewicz, Fox, and Salmons (2011) also acknowledged that the effects of dialect on vowels is significant in children as well as adults. These results suggest that regional dialect has an effect on multiple acoustic parameters of vowels though supporting literature is limited.

Though there has been some research regarding dialect differences between Northern dialect, Southern dialect, and Midland dialect speakers, this research does not address the potential variety within each of these regions. The dialect regions included in the American dialect include a large area in each region (Figure 1). For example, studies of Southern dialect have only included speakers from North Carolina, Kentucky, and Texas (Clopper & Pierrehumbert, 2008; Fox & Jacewicz, 2009; Jacewicz, Fox, & Salmons, 2007; Jacewicz, Fox, & Salmons, 2011). Given the limited number of Southern areas included in dialect research, this study aims to contribute to the current research by including Louisiana, an unstudied area and to potentially highlight the amount of variability that exists within the south. The need to determine the amount of variability is especially highlighted by the large amount of perceived variability that exists within the state of Louisiana alone.
Figure 1. Illustration of the American Dialect Map (Delany, 2000).
METHODS

Participants

Ten female participants were selected for this study from undergraduate classes in the Department of Communication Sciences and Disorders at Louisiana State University. All participants in this study were Caucasian females 18 to 24 years of age in order to control for the effects of gender, age, and dialects other than those of interest (e.g., African American English) on acoustic parameters of the speech sample. Differences in vocal tract size and shape between different gender, race, and age groups impact the acoustic characteristics of speech; therefore, only Caucasian females were selected for this study.

Participants were selected based on their hometown. Those included in the Southern Louisiana dialect group were native to Lafayette, Louisiana (25 mile radius). The experimenter, a native speaker of Southern LA dialect, subjectively determined if the speaker’s sample was characteristic of the dialect being studied. A brief case history was collected to determine if the participant had any past or current history that would affect speech and language skills including neurological conditions or communication disorders. Participants were not recruited for this study for reasons including a history of speech or language disorders and speaking English as a second language.

In recognition of the potential dialectical variability within the region selected, an analysis of the languages spoken in the region was performed. After recording, participants were also asked to fill out a survey regarding their proficiency in speaking French or Cajun French as well as their family history of language use (Dubois & Melancon, 1997; Appendix A). This survey was used to describe the participants’ cultural and linguistic backgrounds as well as their French language abilities (Table 1). Participants four and seven did not respond to the survey, so there is no data to report on their proficiency in French or Cajun French.
Participants were selected from Lafayette Parish, an area that has been recognized in prior research (Dubois & Horvath, 1998; Dubois & Melancon, 1997). In Lafayette Parish, 13.72 percent of 176,051 people are speakers of French. The percentage of French speakers in Lafayette Parish is considerably higher than that of the state of Louisiana where only 3.19 percent of people speak French (Modern Language Association, 2005). All participants reported that the elders in their family are able to speak both Cajun French and English where younger generations speak English only. All participants except participant two demonstrated some ability to speak French. Visual inspection of the data revealed that the data collected from participant two was similar to that of all other speakers. Since this participant was not an outlier, she remained in the sample population.

Informed consent was obtained from all research participants and appropriate approval from the Institutional Review Board at Louisiana State University. The researcher analyzing the speech samples is certified by the National Institute of Health Office of Extramural Research and participated in the “Protecting Human Research Participants” training course.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Bilingualism/Heritage</th>
<th>French Speaking Ability</th>
<th>Family History</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>5</td>
<td>b, c, c</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>10</td>
<td>c, c, c</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td>b, c, c</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>3</td>
<td>b, c, c</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>2</td>
<td>b, c, c</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>9</td>
<td>b, c, c</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>5</td>
<td>b, c, c</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>5</td>
<td>b, c, c</td>
</tr>
</tbody>
</table>
**Procedures**

Vocal recordings were made individually in the laboratory setting. Each speaker read the stimulus items from a list (Appendix B) printed in 16-point font on 8 ½ x 11” paper, which included the 16 target vowels of the study in /hVd/ context (Hillenbrand, 1995). These recordings were used for later acoustic analysis. Each speaker was assigned a number to protect confidentiality. Speech samples were recorded in a double-walled sound booth using a Perception 120 (AKG) microphone and Praat 5.3.20 software (Boersma & Weenik, 2012) on a Dell Optiplex 750 desktop computer. Participants were engaged in a 10-minute casual conversation regarding the purpose of the study prior to recording the experimental stimuli. After the 10-minute conversation, participants were asked to read the list of 16 words (Appendix B). The list of stimuli was read twice by each participant allowing for the experimenter to make corrections to the speaker’s production of the stimuli after the first trial. For the second reading of the stimulus items, each stimulus was read aloud five times prior to moving on to the next item.

**Analyses**

TF32 software (Milenkovic, 2001) was used to separate each speech sample into audio clips of each of the 16 target vowels and was also used to complete acoustic analysis. This computer program was chosen for analysis because this program provides a user-friendly function for manual correction of formant trajectories when needed. Manual corrections were carefully made to the formant frequency structures prior to measurements in order to eliminate possible algorithm-generated errors of the program.

For each excised vowel’s audio file, acoustic measures were taken of five acoustic characteristics of vowels: 1) vowel duration, 2) F1 at the temporal midpoint, 3) F2 at the
temporal midpoint, 5) F2 transition duration (transition was defined as the time interval during which formant trajectories exhibit greater than 20Hz change from 20ms (Weismer et al., 1998; Kim et al., 2009)), 6) F2 transition extent using TF32 (Milenkovic, 2001), and 7) trajectory length. F2 slope was derived from measures of F2 transition and F2 extent. Trajectory length was calculated using procedures outlined the study by Fox and Jacewicz (2009). F1 and F2 values were obtained from 20%, 35%, 50%, 65%, and 85% of the total vowel duration. These values were then inserted into the following formula:

\[ VSL_n = \sqrt{(F1_n - F1_{n+1})^2 + (F2_n - F2_{n+1})^2} \]

The overall trajectory length was then obtained as a sum of the trajectories of the four vowel sections (Fox & Jacewicz, 2009). Five vowels were chosen for this parameter (/ju, e, aɪ, ao, ɔɪ/) because it was reported that this measure was most sensitive to diphthong or diphthongized vowels (Fox & Jacewicz, 2009).
RESULTS

The results of this study are discussed in terms of temporal analysis, spectral analysis, and trajectory measures. Temporal analysis included vowel duration solely, while spectral analysis included the following parameters: F1 and F2 values. Trajectory measures included F2 slope and trajectory length. Portions of the data were compared with previous research to examine whether or not there was a general pattern among dialects. Only descriptive comparisons were made between this data and prior research considering no statistical analyses were conducted.

Temporal Analysis

Mean measurements of vowel duration for the /hVd/ context were collected and are displayed in Table 2. The averages shown in the table are based on measurements of three tokens of each Southern Louisiana speaker for each vowel. The first and fifth token of each speaker’s sample were excluded to account for the impact of beginning and ending effects of speech on the selected acoustic parameters. Mean values of vowel duration were compared to those reported in a previous study which used the same /hVd/ context (Figure 2; Hillenbrand et al., 1995).

![Graph showing mean vowel duration (ms) of speakers from Southern Louisiana and the Upper Mid-West (when available).](image-url)
Analysis of Southern Louisiana data revealed slightly longer vowel durations for low vowels (/æ, ɔ, ɑ/) when compared to high vowels (/i, ɪ, o, u/). Similarly, greater vowel durations were noted for diphthongs or dipthongized vowels (/aɪ, aʊ, eɪ, ɔɪ/) when compared to monophthongs (/i, ɪ, o, u, æ, ɔ, ɑ/). There appeared to be no notable difference in vowel duration when comparing front, central, and back vowels.

When compared to Hillenbrand and colleagues (1995), it appeared that vowel duration was generally longer for speakers of Upper Mid-Western dialect. It was also noted that mean vowel duration for Upper Mid-Western speakers followed a similar pattern to Southern Louisiana speakers in that vowel duration was longest for low vowels (/æ, ɔ, ɑ/), shorter for high vowels (/i, ɪ, o, u/), and shortest for mid vowels (/ɛ, ɪ, ʌ/). No steady pattern was observed between vowel durations for front, central, or back vowels.

**Spectral Analysis**

Mean formant frequency measures and standard deviations were derived for each vowel for the three token vowel productions of all speakers (Table 2). The first and fifth token of each speaker’s sample were excluded to account for the impact of beginning and ending effects of speech on the selected acoustic parameters. The values obtained for formant frequency values were then compared to those reported by Hillenbrand and colleagues (1995). His study did not include all English vowels; therefore, this comparison was made with the available data (Figure 3).

Analysis of formant frequency values revealed that F1 values were highest for low vowels and decreased as tongue height increased (mid then high vowels). Similarly, it was determined that F2 values were affected by tongue position within the oral cavity. F2 values
were highest for front vowels and decreased as tongue placement within the oral cavity shifted toward the velum.

Table 2. Mean vowel duration (ms) and formant frequency values (Hz) for speakers of Southern Louisiana dialect. Standard deviations of each mean are presented in parentheses.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (SD)</th>
<th>F1 (SD)</th>
<th>F2 (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/æ/</td>
<td>260 (48)</td>
<td>1003 (88)</td>
<td>1912 (143)</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>277 (38)</td>
<td>754 (93)</td>
<td>1153 (69)</td>
</tr>
<tr>
<td>/e/</td>
<td>257 (44)</td>
<td>468 (110)</td>
<td>2725 (147)</td>
</tr>
<tr>
<td>/ɛ/</td>
<td>218 (49)</td>
<td>719 (63)</td>
<td>2161 (163)</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>263 (42)</td>
<td>578 (116)</td>
<td>1752 (103)</td>
</tr>
<tr>
<td>/ɨ/</td>
<td>231 (34)</td>
<td>366 (28)</td>
<td>2957 (135)</td>
</tr>
<tr>
<td>/ju/</td>
<td>282 (64)</td>
<td>380 (34)</td>
<td>2308 (251)</td>
</tr>
<tr>
<td>/u/</td>
<td>211 (50)</td>
<td>517 (73)</td>
<td>2416 (103)</td>
</tr>
<tr>
<td>/a/</td>
<td>293 (49)</td>
<td>928 (87)</td>
<td>1618 (169)</td>
</tr>
<tr>
<td>/a/</td>
<td>268 (36)</td>
<td>926 (79)</td>
<td>1393 (90)</td>
</tr>
<tr>
<td>/o/</td>
<td>274 (56)</td>
<td>518 (83)</td>
<td>1411 (208)</td>
</tr>
<tr>
<td>/o/</td>
<td>234 (44)</td>
<td>574 (98)</td>
<td>1744 (132)</td>
</tr>
<tr>
<td>/ao/</td>
<td>291 (49)</td>
<td>949 (73)</td>
<td>1584 (78)</td>
</tr>
<tr>
<td>/u/</td>
<td>257 (53)</td>
<td>409 (54)</td>
<td>1692 (201)</td>
</tr>
<tr>
<td>/ʌ/</td>
<td>223 (40)</td>
<td>738 (91)</td>
<td>1717 (112)</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>291 (5)</td>
<td>551 (114)</td>
<td>1338 (171)</td>
</tr>
</tbody>
</table>

When comparing Southern Louisiana data to data reported by Hillenbrand and colleagues (1995), differences between the mean F1 and F2 values were noted. More specifically, Southern Louisiana speakers had increased mean F2 values for mid vowels, decreased F1 values for high vowels, and increased F2 values for high vowels. Also, Southern Louisiana speakers had lower mean F1 and F2 values for the central vowel /ʌ/. There was no pattern identified between mean F1 and F2 values comparing these two dialects for front or back vowels.
Figure 3. Comparison between F1 and F2 values for the Upper Mid-West region and Southern Louisiana.

**Trajectory Measures**

F2 slope was calculated for all 16 English vowels. Means and standard deviations were derived for all vowels (Table 3). Figure 4 demonstrates an example of F2 trajectories of *hoyped* produced by all ten speakers.

Figure 4. Display of F2 trajectories for the vowel /ɔɪ/ obtained from all participants (30 data points).
Table 3. Mean and standard deviation values of F2 slope (Hz/ms).

<table>
<thead>
<tr>
<th>Vowel</th>
<th>F2 Slope</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>/æ/</td>
<td>3.23</td>
<td>2.83</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>5.87</td>
<td>1.28</td>
</tr>
<tr>
<td>/ʌ/</td>
<td>3.8</td>
<td>1.3</td>
</tr>
<tr>
<td>/e/</td>
<td>3.41</td>
<td>1.81</td>
</tr>
<tr>
<td>/ɜ/</td>
<td>4.3</td>
<td>1.91</td>
</tr>
<tr>
<td>/i/</td>
<td>3.83</td>
<td>2.4</td>
</tr>
<tr>
<td>/u/</td>
<td>4.11</td>
<td>1.28</td>
</tr>
<tr>
<td>/ɪ/</td>
<td>3.98</td>
<td>1.63</td>
</tr>
<tr>
<td>/o/</td>
<td>4.8</td>
<td>1.89</td>
</tr>
<tr>
<td>/ɑ/</td>
<td>5.04</td>
<td>1.42</td>
</tr>
<tr>
<td>/ʌ/</td>
<td>3.77</td>
<td>1.8</td>
</tr>
<tr>
<td>/aʊ/</td>
<td>6.51</td>
<td>2</td>
</tr>
<tr>
<td>/ɑʊ/</td>
<td>3.63</td>
<td>1.25</td>
</tr>
<tr>
<td>/ju/</td>
<td>5.49</td>
<td>2.1</td>
</tr>
<tr>
<td>/eɪ/</td>
<td>3.58</td>
<td>1.62</td>
</tr>
<tr>
<td>/ɔɪ/</td>
<td>8.37</td>
<td>2.19</td>
</tr>
</tbody>
</table>

F2 slope values were found to be slightly greater for diphthongs or diphthongized vowels (/ju, ɔɪ, ar, aʊ, et/) when compared to monophthongs; however, this was not statistically significant ($t=-2.52$, $p=0.08$, df= 13). Statistical significance may increase as more participants are included within the sample. Greater F2 slope values for diphthongs were predicted considering diphthongs require a more extensive degree of movement of the articulators from the articulatory placement of one vowel to another for vowel production. Thus, transition duration and transition extent were both predicted to be greater leading to greater F2 slope values. Analysis of F2 slope also suggests that there is a moderate amount of variability within each speaker as evidenced by visual inspection of Figure 4. Variability within the sample could be related to variability of vowel duration considering vowel duration potentially has an impact on F2 slope (e.g., the longer the vowel duration, the shallower the slope). This suggests that there is potential for significant amounts of variability within each dialect as well as across dialects.
In addition to F2 slope, trajectory length, used by Fox and Jacewicz (2009) was calculated for five vowels: hayed, hoyed, hide, how’d, and hewed (Figure 5). Means and standard deviations of trajectory length are shown in Table 4.

![Box and whiskers plot of trajectory length (Hz)](image)

Figure 5. Box and whiskers plot of trajectory length (Hz) for how’d, hoyed, hewed, hide, and hayed. Median values are depicted by black lines and outliers in the 5th and 95th percentile are depicted by black dots.

Table 4. Mean and standard deviation values of trajectory length (Hz).

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>/æt/</td>
<td>788.08</td>
<td>330.85</td>
</tr>
<tr>
<td>/əʊ/</td>
<td>644.85</td>
<td>178.94</td>
</tr>
<tr>
<td>/ju/</td>
<td>717.98</td>
<td>240.25</td>
</tr>
<tr>
<td>/ɛı/</td>
<td>294.11</td>
<td>94.47</td>
</tr>
<tr>
<td>/əʊ/</td>
<td>1364.45</td>
<td>207.95</td>
</tr>
</tbody>
</table>

Table 5. Mean values comparing trajectory length (Hz) of Southern Louisiana dialect and data from Fox and Jacewicz (2009).

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Southern LA</th>
<th>North Carolina</th>
<th>Wisconsin</th>
</tr>
</thead>
<tbody>
<tr>
<td>/æt/</td>
<td>788</td>
<td>643</td>
<td>427</td>
</tr>
<tr>
<td>/ɛı/</td>
<td>341</td>
<td>936</td>
<td>1092</td>
</tr>
</tbody>
</table>
Analysis of trajectory length revealed that it was shortest for the vowel /eɪ/ and longest for the vowel /ɔɪ/. When compared to data from Fox and Jacewicz (2009) differences were seen for both Northern (Wisconsin) and Southern (North Carolina) dialects. This suggests that not only are differences present between dialect regions, but also that there are differences within dialect regions considering the differences identified between Southern Louisiana and North Carolina speakers. This supports the prediction that there is the potential for a large amount of dialect variability that exists within the dialect regions specified on the American Dialect Map. Differences in trajectory length may exhibit the potential for inferences to be made about conditions of the production of each vowel (e.g., duration and changes in the configuration of the vocal tract). Shorter trajectory lengths may indicate shorter vowel durations as well as decreased amounts of change for F1 and F2 values over time. Considering vocal tract configuration and vowel duration both have the potential to impact trajectory length measures, separating which variable is responsible for a change in trajectory length may be difficult.

The results of this study revealed differences for Southern Louisiana dialect for the parameters of vowel duration, F1 and F2 values, and trajectory length when other dialects were considered. Not only were differences observed, general comparisons revealed that specific patterns of differences for vowel duration and F1 and F2 values based on vowel type. Additionally, variability was noted within the population when analyzing F2 slope values suggesting the potential for moderate amounts of variability within certain dialects in addition to across dialects.
DISCUSSION

The overall purpose of this study was to examine several acoustic variables that have been well-established in vowel acoustics and/or dialect research to describe the acoustic characteristics of vowels for speakers of Southern Louisiana dialect. This study sought to include a variety of parameters that have been used in prior research so as to provide a large amount of data and descriptive analysis regarding Southern Louisiana dialect (Fox and Jacewicz, 2009; Hillenbrand et al., 1995; Jacewicz, Fox, & Salmons, 2007; Jacewicz, Fox, & Salmons, 2011).

Characteristics Consistent With Prior Research

The results of this study indicate that vowels spoken in Southern Louisiana have characteristics that are consistent with the patterns of American English vowels including (Assman, Neary, & Hogan, 1982): longer vowel durations for low vowels when compared to high vowels (Hixon, Hoit, & Weismer, 2008) and the F1 and F2 pattern that correlates with tongue movement (Steven, 2000). Increased duration for low vowels when compared to high vowels can be attributed to the need for greater jaw excursion for the production of low vowels. This mechanical change affects the temporal aspects of vowel production leading to increased vowel duration (Hixon, Hoit, & Weismer, 2008). Findings regarding F1 and F2 can be attributed to tongue placement required for the production of specific vowels. F1 values decrease as tongue height increases and F2 values increase as tongue advancement increases (Steven, 2000).

Effect of Dialect

While some characteristics of vowels spoken by speakers of Southern Louisiana dialect were consistent with that of mainstream American English dialect, comparison of vowels spoken
by speakers of Southern Louisiana dialect to other dialects revealed the presence of a dialectical
difference for certain parameters.

Longer vowel durations were found for diphthong or diphthongized vowels when
compared to monophthongs for Southern Louisiana dialect. When comparing this finding to the
data reported by Hillenbrand and colleagues (1995) it was noted that mean vowel durations for
Southern Louisiana speakers were longer for all vowels spoken by Upper Mid-Western speakers
except for /e/. This was noteworthy considering that speakers of Southern dialect are often
perceptually identified to speak more slowly than northern speakers (G. Weismer, personal
communication, March 27, 2013). It is possible that this perceptual difference may potentially
be related to the difference in monopthong and diphthong duration which may affect the
rhythmical pattern of speech, contributing to the perception of slower speech rates for Southern
speakers.

When compared to Hillenbrand and colleagues (1995), F1 and F2 values were different
for Southern Louisiana dialect. Patterns of differences were found for F2 values of mid vowels,
F1 and F2 values for high vowels, and F1 and F2 values for the central vowel /ʌ/ although no
statistical analysis was performed. However, patterns of differences found between these
dialects, especially in regards to F1 and F2 values, indicate that articulatory placement for vowel
production may be dependent on the dialect of the speaker. The most notable difference was seen
for vowel /æ/, a vowel which is known for a large degree of formant movement (Jacewicz &
Fox, 2013). Differences in formant frequency values may be impacted by the method of
measurement chosen. F1 and F2 values measured from the temporal midpoint of the vowel
assume articulatory equivalency of vowel production; therefore, the differences seen between
these dialect may be reflective of differing movement patterns. Differences that can be attributed
solely to dialectical differences may be easier to determine by using measurements that do not assume articulatory equivalency.

Measures of trajectory length were also found to differ between dialects. Comparison of this data reported by Fox & Jacewicz (2009) revealed different values for Northern dialect as well as for speakers from North Carolina. Differences found between these dialects may be related to differences in both the configuration of the vocal tract and vowel duration. These differences suggest not only are there differences between the main dialect regions (e.g., North and South), but there are also differences within these regions (e.g., the Southern region).

Implications

The results of this study may lead to further investigation regarding the impact of dialect differences. For example, dramatic differences between vowel duration for monophthongs and diphthongs have the potential to impact speech intelligibility considering that these differences may alter the rhythmic patterns of speech production. Considering differences were found between dialects for measures of trajectory length, further research in this area may allow for inferences to be made about dialectical differences in vowel production based on changes in trajectory length. These differences aid in supporting the idea that there is variability within the dialect regions specified within the American Dialect Map.

Considering dearth of data including speakers of Southern Louisiana dialect, these findings support further research in this area. This data provides foundational information regarding acoustic parameters of Southern Louisiana dialect considering this is an area that has not been previously researched using acoustical analysis. This study also used measures that have not been widely used in dialect studies such as F2 slope and trajectory length. Based on the measures employed by this study, sufficient evidence was found that dialect differences do exist
between Upper Mid-Western and Wisconsin dialects despite the lack of statistical analysis. Since it is well-known that vowels heavily affect the perceptual judgment of speech, differences found for Southern Louisiana dialect have the potential to affect listeners’ perceptual identification of vowels which may impact speech intelligibility. The results of this study have the potential to provide the grounds for the next phase of research to directly compare dialects to determine the presence or absence of differences.

Limitations

This study was conducted using a small sample size of participants who were all the same gender and racial background. Because of this, there is a reduction in the ability for this study to generalize to diverse populations. However, considering the limited data regarding Southern Louisiana dialect, this study provides a foundation for the characteristics of this dialect from which further analysis can be conducted. General comparisons were made between the data of Southern Louisiana speakers and previously reported data; however, these studies did not employ the same methodology so only general inferences can be made from these comparisons. Statistical analyses could not be performed since there was no access to the raw data used in the comparison studies; therefore, statistical significance or effect size of the differences seen between groups could not be determined. Additionally, the data reported by Hillenbrand and colleagues (1995) was collected in 1995. It is possible that dialect shifts may have happened during this 18-year time difference between data collections, so comparisons made from this data may not completely reflect the dialect of the Upper Mid-Western area at this time.

Future Directions

While this study provides the foundation for identifying distinguishing characteristics of Southern Louisiana dialect, direct comparison between Southern Louisiana dialect and Northern
dialect will be helpful in identifying the specific differences in acoustic characteristics of vowels between dialects. Once a comparison is made, it will be important to widen the participant selection to include individuals of different genders and ethnical backgrounds so as to understand the potential impact these variables have on the effect of dialect. It will also be important to research other areas of Southern Louisiana as this study only examines on specific area within the region of Southern Louisiana. This information will be beneficial to understanding the effect of dialect on vowel production representative of the population of Southern Louisiana. Additionally, variability within each regional dialect should continue to be a research interest so that the possibility of high variability existing within regional dialects can be examined.
REFERENCES


APPENDIX A

Please rate yourself and/or your family according to the following rating scales. These scales are hierarchical so rate yourself according to the highest you can do (e.g., if you can count to ten and order a meal give yourself a 4). This is a survey regarding French/Cajun French only. If you or your family members speak languages other than French/Cajun French, choose the English only options.

Scale 1: Bilingualism/Heritage
1. I have no Cajun background and cannot speak Cajun French.
2. I have a Cajun background but do not speak Cajun French.
3. I am a passive speaker of Cajun French (can complete tasks 1-5 on scale 2).
4. I am a semi-speaker of Cajun French (can complete tasks 1-7 on scale 2).
5. I am a fluent speaker of Cajun French.

Scale 2: French Speaking Ability
1. I have no French speaking ability.
2. I can count to ten
3. I can name the days of the week
4. I can give the date (month and year)
5. I can order a meal in a restaurant
6. I can give biographical information (date of birth, family information)
7. I can speak to people in social situations using appropriate expressions (church, meetings, parties)
8. I can describe my hobbies in detail using appropriate vocabulary.
9. I can describe my present employment, my studies, and my main social activities in detail with native speakers.
10. I can describe what I hope to achieve in the next five years using future tense verbs with native speakers.
11. I can give my opinion on a controversial subject (abortion, religion, pollution, nuclear safety) with native speakers.

Scale 3: Family History
1. The elders in your family (grandparents) speak: (a) only Cajun French, (b) Cajun French and English, (c) only English.
2. The middle-aged people in your family (parents) speak: (a) only Cajun French, (b) Cajun French and English, (c) only English.
3. The young people in your family (peers) speak: (a) only Cajun French, (b) Cajun French and English, (c) only English.

(Dubois & Melancon, 1997)
APPENDIX B

1. heed
2. hid
3. head
4. hayed
5. had
6. hod
7. hawed
8. hoed
9. hood
10. who’d
11. hud
12. heard
13. hoyed
14. hide
15. hewed
16. how’d
APPENDIX C

ACTION ON PROTOCOL APPROVAL REQUEST

TO: Yunjung Kim
   Communication Sciences

FROM: Robert C. Mathews
   Chair, Institutional Review Board

DATE: August 2, 2012
RE: IRB# 3.305

TITLE: Acoustic Characteristics of Vowel Production in Speakers of Southern Louisiana Dialect and Southern Wisconsin Dialect


Review type: Full ___ Expedited X ___ Review date: 8/3/2012

Risk Factor: Minimal ___ Uncertain _____ Greater Than Minimal______

Approved ___ X ___ Disapproved ________

Approval Date: 8/3/2012 Approval Expiration Date: 8/2/2013

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: N/A

Protocol Matches Scope of Work in Grant proposal: (if applicable)________

By: Robert C. Mathews, Chairman

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –

Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*

2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.

3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.

4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.

5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.

6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.


*All Investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS. DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www lsu.edu/irb
VITA

Ali Beslin was born and raised in Broussard, a small town just outside of Lafayette, Louisiana. After graduating from LSU with a Bachelor of Arts in Communication Sciences and Disorders, she continued at LSU to pursue her Master of Arts degree in Communication Disorders. This was a seamless transition in which she continued to investigate her undergraduate research interests working under Dr. Yunjung Kim. She was able to work on a grant from the National Institute of Health-National Institute on Deafness and Other Communication Disorders (R03 DC012405-01A1) entitled The Same Dysarthria in Different Languages. This project was one of Ali’s interests since she was an underclassman. Along with completing this project, Ali was also involved in professional organizations such as Louisiana Speech Language and Hearing Association, National Student Speech Language and Hearing Association, Acoustical Society of America, and American Speech-Language-Hearing Association. These organizations contributed to her knowledge of the field of Communication Disorders and provided many opportunities for acquiring knowledge outside of the classroom. Ali plans to graduate with a Master of Arts in Communication Disorders from Louisiana State University in May 2013. Upon graduation, she plans to begin her career as a speech-language pathologist in a clinical setting in Lafayette, Louisiana.