VOWEL PRODUCTION ABILITIES OF HAITIAN AMERICAN CHILDREN

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Stacey V. Cunningham Wallen, M. A.

****

The Ohio State University

2008

Dissertation Committee:

Robert A. Fox, Advisor

Donald Winford

Jeanne Gokcen

Approved by

______________________________

Graduate Program in Speech and Hearing Science
ABSTRACT

The presence of Haitians in the United States and their dominant use of Kreyol present a unique challenge for professionals in the field of communication disorders in this country. The discipline of speech-language pathology has traditionally used phonetic transcription to describe differences in production between the mainstream and non-mainstream speaker. These descriptions would then aide in the diagnosis and treatment of communication disorders. Recently, acoustic analysis has been used to provide a more objective description of vowel production. However, the use of acoustic analysis to investigate differences between language groups has not been widely used.

This study provides an acoustic description of Kreyol and English vowels spoken by monolingual and bilingual Haitian American children. Speakers, ages 5-6 years, identified pictures using either Kreyol or English words that contained target vowels. Vowel durations, as well as the first two formants, were measured and compared across 3 groups (Haitian American Bilingual, Haitian American Monolingual and Non-Haitian) and across gender.

Durational results for Kreyol and English vowels indicated significant differences in the durations for individual vowels, as well as gender differences. However, no significant group differences were observed.
Spectral results for Kreyol vowels revealed that acoustically, the Kreyol vowel space matches non-acoustic descriptions. Differences were observed between bilingual and monolingual Haitian speakers’ production of the vowel, /o/ only. Differences in the production of other vowels were insignificant. During production of English vowels, monolingual (English) Haitian American speakers’ productions were no different than their non-Haitian counterparts. No significant group differences (between Haitian American Bilingual and Non-Haitian) speakers were observed. Gender differences were noted for both Kreyol and English vowels.

These results indicate that bilingual children as young as five years old can produce vowel sounds in their second language (English) like a monolingual native speaker of English. This has implications for the speech-language pathologist that works with young bilingual speakers.
DEDICATION

"For the Lord God will help me; therefore I will not be disgraced; therefore I have set my face like a flint, and I know that I will not be ashamed."

Isaiah 50:7

For the people (and experiences) in my life who constantly shape my character.
ACKNOWLEDGMENTS

I chose to take the scenic route on this journey. First, I’d like to thank my advisor, Dr. Robert Fox, for being my GPS and guiding me through this challenging process. He provided direction when all I had was a destination, and he did it without taking the wheel. I’m also grateful to the other members of my committee, Dr. Donald Winford and Dr. Jeanne Gokcen, who together were the collective “gentle” voice of my GPS. They provided patient encouragement and direction at the right time.

Throughout this trip, my family has traveled with me, not knowing exactly where we would end up or when we would get there. My husband has been my constant traveling companion during this adventure. He had no idea what he was in for when we set off. He asked “Are we there yet?” many times but was always there (through detours, breakdowns, and road rage). Anthony, I love you more than you know and appreciate your dedication to this! Temple, Ransom, and Hendrix, I thank you for coming along for the ride and making me stop and enjoy the scenery (especially when I wasn’t aware of the beauty around me). I thank my parents, John and Ruby Cunningham, and my sister, the future Dr. Jeryl Cunningham-Fleming, for being my “rest area”, allowing me to rest and refuel at the right time—you’re the best! I also thank my “Wallen” parents for their support.
Along with my family, my friends and colleagues encouraged me throughout this trek. Their feedback, kind words, jokes, and prayers helped make this trip (and my life) more bearable. I’d thank them all by name if I had the space.

This journey could not have been completed without the participation of the kindergarten classes at New Hope SDA School and Broward Junior Academy. Thank you to the administration, staff, parents and student participants. I am also indebted to Katia Clervaud for her interpreting services.
VITA

February 24, 1973……………………………………………….Born—Bronx, New York

1994……………………………………………………………………….Bachelor of Arts, 
English Oakwood College 

1996-1997………………………………………………Graduate Teaching/Research Associate, 
The Ohio State University 

1997………………………………………………………… Master of Arts, Speech and Hearing Science, 
The Ohio State University 

1998………………………………………………………… Graduate Teaching/Research Associate, 
The Ohio State University 

1998-2001……………………………………………… Speech Language Pathologist, 
The School Board of Broward County Florida 

2000-2002……………………………………………… Graduate Teaching/Research Associate, 
The Ohio State University 

2001-Present……………………………………………… Speech Language Pathologist, 
Axisbold Inc. Deerfield Beach, Florida 

FIELDS OF STUDY

Major Field:  Speech and Hearing Science
TABLE OF CONTENTS

Abstract........................................................................................................................................... ii
Dedication.......................................................................................................................................... iv
Acknowledgments........................................................................................................................... v
Vita.................................................................................................................................................... vii
List of Tables.................................................................................................................................... xiii
List of Figures.................................................................................................................................... xvii

Chapters:

1 Introduction................................................................................................................................. 1
2 Literature Review....................................................................................................................... 11
   2.1 Speech and Language Development.................................................................................. 11
      2.1.1 Vowel Development Theories.................................................................................. 12
      2.1.2 Stages of Phonological Development................................................................. 16
   2.2 Second Language Acquisition......................................................................................... 19
      2.2.1 Theories of Development for Second Language Learners.................................... 20
      2.2.2 Phonological Development in Bilingual Children............................................... 25
   2.3 Vowel Production and Development............................................................................. 29
      2.3.1 Source Filter Theory............................................................................................... 29
      2.3.2 Acoustic Characteristics of Vowels....................................................................... 31
      2.3.3 Children’s Vowel Development: Formant Frequencies....................................... 36
      2.3.4 Children’s Vowel Development: Vowel Inventory.............................................. 38
      2.3.5 Acoustic Cues and Linguistic Variation............................................................... 39
2.4 Haitian Kreyol.........................................................................................44
  2.4.1 Origins..............................................................................................45
  2.4.2 Standardization.................................................................................46
  2.4.3 Phonology..........................................................................................48

3 Methodology.............................................................................................53
  3.1 Subjects.................................................................................................54
  3.2 Stimuli....................................................................................................60
  3.3 Procedures.............................................................................................62
  3.4 Acoustic Analysis..................................................................................62
  3.5 Data Analysis........................................................................................64

4 Durational Results......................................................................................66
  4.1 Kreyol Vowel Durations.......................................................................66
    4.1.1 All Haitian American Speakers.....................................................66
    4.1.2 Haitian American Monolingual vs. Bilingual Speakers..............69
    4.1.3 Male vs. Female Speakers..............................................................72
  4.2 English Vowel Durations.....................................................................75
    4.2.1 All Haitian American Speakers.....................................................75
    4.2.2 Haitian American Monolingual vs. Bilingual Speakers..............77
    4.2.3 Haitian American Monolingual vs. Bilingual Speakers: Gender Differences..............................................................80
    4.2.4 All Haitian American and Non-Haitian Speakers......................84
    4.2.5 All Haitian American vs. Non-Haitian Speakers........................87
4.2.6 Haitian American vs. Non-Haitian Speakers: Gender Differences..88
4.2.7 All Haitian-American Bilingual and Non-Haitian Speakers………90
4.2.8 Haitian-American Bilingual vs. Non-Haitian Speakers…………..93
4.2.9 Haitian-American Bilingual vs. Non-Haitian Speakers: Gender
   Differences..........................................................................................94
4.3 Summary of Durational Results.....................................................96
5. Formant Frequency Results............................................................99
   5.1 Kreyol Vowel Space.................................................................99
      5.1.1 Kreyol Vowel Space: Group Differences.........................105
         5.1.1.1 First Formant Comparisons.................................108
         5.1.1.2 Second Formant Comparisons...............................108
      5.1.2 Kreyol Vowel Space: Gender Differences....................109
         5.1.2.1 First Formant Comparisons.................................112
         5.1.2.2 Second Formant Comparisons...............................112
   5.2 English Vowel Space: All Haitian-American Speakers.............113
      5.2.1 English Vowel Space: Haitian-American Bilingual and
         Monolingual Speakers.......................................................116
         5.2.1.1 First Formant Comparisons.................................120
         5.2.1.2 Second Formant Comparisons...............................120
      5.2.2 English Vowel Space: Gender Differences for Monolingual and
         Bilingual Speakers.........................................................121
         5.2.2.1 First Formant Comparisons.................................124
         5.2.2.2 Second Formant Comparisons...............................124
5.3 English Vowel Space: All Speakers

5.3.1 English Vowel Space: Haitian American vs. Non-Haitian Speakers

5.3.1.1 First Formant Comparisons

5.3.1.2 Second Formant Comparisons

5.3.2 English Vowel Space Gender Differences for Haitian American and Non-Haitian Speakers

5.3.2.1 First Formant Comparisons

5.3.2.2 Second Formant Comparisons

5.3.3 English Vowel Space: Haitian American Bilingual and Non-Haitian Speakers

5.3.3.1 First Formant Comparisons

5.3.3.2 Second Formant Comparisons

5.3.4 English Vowel Space: Haitian American Bilingual vs. Non-Haitian Speakers Gender Differences

5.3.4.1 First Formant Comparisons

5.3.4.2 Second Formant Comparisons

5.4 Summary of Spectral Results

6 Conclusion

References

Appendix A: Language Questionnaire

Appendix B: Picture Stimuli

Appendix C: Elicitation Script

Appendix D: Kreyol Vowel Durations for each Haitian Subject
Appendix E: Subject Vowel Spaces for Kreyol Words ..............................226
Appendix F: Subject Vowel Durations for English Words.............................236
Appendix G: Subject Vowel Spaces for English Words....................................255
Appendix H: Letters of Agreement.......................................................................274
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Ranking of Top Sixty Languages Spoken by English Language Learner (ELL)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Students in the United States</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Stark (1986) and Oller (1980) Stages of Prelinguistic Development</td>
<td>18</td>
</tr>
<tr>
<td>2.2</td>
<td>Dinnesen’s Order of Acquisition for Phonetic Categories</td>
<td>19</td>
</tr>
<tr>
<td>2.3</td>
<td>Types of Bilingualism according to Romaine (1999)</td>
<td>23</td>
</tr>
<tr>
<td>2.4</td>
<td>Fundamental and formant frequencies taken from Hillenbrand, et al. (1995)</td>
<td>34</td>
</tr>
<tr>
<td>2.5</td>
<td>Vowel Inventory of American English for Children ages 15-36 months</td>
<td>39</td>
</tr>
<tr>
<td>2.6</td>
<td>Haitian Kreyol Alphabet</td>
<td>48</td>
</tr>
<tr>
<td>2.7</td>
<td>Haitian Kreyol Vowels</td>
<td>50</td>
</tr>
<tr>
<td>3.1</td>
<td>Participant Description</td>
<td>55</td>
</tr>
<tr>
<td>3.2</td>
<td>Language Input for Each Haitian American Participant</td>
<td>58</td>
</tr>
<tr>
<td>3.3</td>
<td>Stimulus Items</td>
<td>61</td>
</tr>
<tr>
<td>4.1</td>
<td>Mean vowel durations (in ms) for all Haitian American subjects</td>
<td>68</td>
</tr>
<tr>
<td>4.2</td>
<td>Mean Kreyol Vowel Durations and Standard Deviations (in ms) for Haitian</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>American Monolingual and Bilingual Speakers</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Mean Kreyol Vowel Durations for Male and Female Speakers………………..73
4.4 Mean English Vowel Durations for All Haitian American Subjects……………76
4.5 Mean English Vowel Durations for Haitian American Monolingual and Haitian American Bilingual Speakers…………………………………………….78
4.6 Mean English Vowel Durations for Male and Female Haitian American Monolingual and Haitian American Bilingual Speakers……………………………81
4.7 Mean English Vowel Durations for Haitian American and Non-Haitian Speakers……………………………………………………………………….86
4.8 Mean English Vowel Durations for Haitian American Bilingual and Non-Haitian Speakers…………………………………………………………………………92
5.1 Mean F1 and F2 Measures (in Hz) for Kreyol Vowels Produced by All Haitian Subjects……………………………………………………………………….102
5.2 Normalized Mean F1 and F2 Values for Kreyol Vowels Produced by All Haitian Subjects……………………………………………………………………….103
5.3 F1 and F2 Values for Kreyol Vowels Produced by Haitian American Monolingual and Bilingual Speakers. ……………………………..106
5.4 ANOVA Summary Table for Kreyol Vowels Produced by Haitian American Monolingual and Bilingual Speakers…………………………………………….107
5.5 F1 and F2 Values for Kreyol Vowels as a Function of Gender ............ 110
5.6 F1 and F2 Values for Kreyol Vowels Produced by Male and Female Haitian American Monolingual and Bilingual Speakers ........................................ 111
5.7 English F1 and F2 Values (in Hz) for All Haitian American Subjects .......... 115
5.8 Mean English F1 and F2 Values (in Hz) for All Haitian American Subjects.... 118
5.9 ANOVA Summary Table for English Vowels Produced by Haitian American Monolingual and Bilingual Speakers ........................................ 119
5.10 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Speakers ................................................................. 122
5.11 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Speakers Broken Down by Group ........................................ 123
5.12 Mean English F1 and F2 Values (in Hz) for Haitian American and Non-Haitian Speakers ................................................................. 129
5.13 ANOVA Summary Table for English Vowels Produced by Haitian American and Non-Haitian Speakers ........................................ 130
5.14 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American and Non-Haitian Speakers ........................................ 133
5.15 Mean English F1 and F2 Values (in Hz) for Haitian American Bilingual and Non-Haitian Speakers. ..........................................................136

5.16 ANOVA Summary Table for English Vowels Produced by Haitian American Bilingual and Non-Haitian Speakers......................................................138

5.17 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Bilingual and Non-Haitian Speakers.................................141
LIST OF FIGURES

Figure........................................................................................................................Page
2.1 Glottal Noise Source Spectrum .................................................................32
2.2 Sound Source Spectrum, Filter Function, and Resulting Vowel Spectrum for [uh].................................................................33
2.3 American English Vowels........................................................................35
2.4 Vowel Spaces of Men, Women, and Children based on Peterson and Barney (1952).................................................................36
3.1 Haitian American Population in Central Broward County, FL..............57
4.1 Mean Kreyol Vowel Durations for All Haitian Speakers......................69
4.2 Mean Kreyol Vowel Durations for Haitian American Monolingual (HAM) and Haitian American Bilingual (HAB) Speakers......................72
4.3 Mean Kreyol Vowel Durations for Male and Female Haitian American Speakers........................................................................74
4.4 Mean English Vowel Durations for All Haitian Speakers .........................77
4.5 Mean English Vowel Durations for Haitian American Bilingual (HAB) and Haitian American Monolingual (HAM) Speakers .........................79
4.6 Mean English Vowel Durations for All Male and Female Haitian American Speakers ........................................................................82
4.7 Mean English Vowel Durations for Male and Female Haitian American Bilingual (HAB) Speakers

4.8 Mean English Vowel Durations for Male and Female Haitian American Monolingual (HAM) Speakers

4.9 Combined Mean English Vowel Durations for Haitian American (HA) and Non-Haitian (NH) Speakers

4.10 Mean English Vowel Durations for Haitian American (HA) and Non-Haitian Speakers

4.11 Mean English Vowel Durations (in ms) for Haitian American (Combined) Male and Female Speakers

4.12 Mean English Vowel Durations (in ms) for Non-Haitian Male and Female Speakers

4.13 Combined Mean English Vowel Durations (in ms) for Haitian American Bilingual (HAB) and Non-Haitian (NH) Speakers

4.14 Mean English Vowel Durations for Haitian American and Non-Haitian Speakers

4.15 Mean English Vowel Durations (in ms) for Haitian American Bilingual Male and Female Speakers
5.1 Kreyol Vowel Space for Haitian American Subjects..........................104
5.2 Normalized Kreyol Vowel Space for Haitian American Subjects............105
5.3 Kreyol Vowel Space (in Hz) for Monolingual and Bilingual Subjects........109
5.4 Kreyol Vowel Space (in Hz) for Male and Female Subjects....................113
5.5 English Vowel Space (in Hz) for All Haitian American Subjects.............116
5.6 English Vowel Space (in Hz) for Haitian American Monolingual and Bilingual Speakers..........................................................121
5.7 English Vowel Space for All Haitian American Male and Female Speakers.................................................................125
5.8 English Vowel Space for Monolingual Haitian American Male and Female Speakers.................................................................126
5.9 English Vowel Space for Bilingual Haitian American Male and Female Speakers.................................................................127
5.10 English Vowel Space (in Hz) for Haitian American and Non-Haitian Speakers.................................................................132
5.11 English Vowel Space (in Hz) for All Male and Female Speakers..........................135
5.12 English Vowel Space (in Hz) for Haitian American Bilingual and Non-Haitian Speakers

5.13 English Vowel Space (in Hz) for Haitian American Bilingual Male and Female Speakers
CHAPTER 1
INTRODUCTION

The United States is known for its diversity. With the arrival of the first settlers in the 17th century, the U. S. has been recognized as a haven for immigrants. From the “pre-industrial period” (the 1600s) to what Moch (1992) calls the “urbanization period” (1815-1914), the face of the American immigrant was mostly White. Immigrants came from Western and Eastern Europe and settled in various parts of the U. S., becoming “Americans” by adopting American values and assimilating somewhat easily into the American culture. Changes in U. S. immigration laws in the 1960s (including those that abolished “national origins” quotas established in the early 20th century and preferences to family reunification over occupational skills) ¹ altered the face of the American immigrant. The “face” of the immigrant changed from White European to African, ¹ The “Chinese Exclusion Act” of 1882 required Chinese laborers working in the United States to wait ten years before immigrating. “National Origins Act” of 1924 took full effect in 1929, and placed strict limitations on how many immigrants from a particular country were allowed in the United States. It was intended to limit the number of immigrants coming to the United States from Southern and Eastern Europe. In 1965 the amendments to the Immigration and Nationality Act repealed those quotas. It allowed access into the United States based on family reunification and occupational qualification.
Asian, and Latin American (Moch, 1992; Massey, 1986). In 2000, 1 out of 4 Americans were non-White (as compared to 1 out of 8 in 1900).  

In 2003, 11.7% of the United States’ population was foreign-born. Of that 11.7%, 53% were born in Latin America, and 25% in Asia, as compared to 13.7% born in Europe.  By 2050, approximately 50% of the U. S. population will be a racial/ethnic “minority,” with people of Hispanic and Asian descent becoming the fastest-growing minority groups in the United States. Despite the rapid growth of Hispanic and Asian minority groups, people of African descent continue to be a major group within the minority population in this country. As of 2005, African Americans comprised 12.1% of the U.S. population. Within this racial group are people of different ethnic backgrounds or ancestry.

According to the United States Census Bureau, ancestry is defined as follows: “a person’s ethnic origin, heritage, descent, or ‘roots,’ which may reflect their place of birth, place of birth of parents or ancestors, and ethnic identities that have evolved within the United States.” The terms “ethnicity” and “ancestry” are somewhat indistinct terms

---


3 http://factfinder.census.gov/jsp/saff/SAFFInfo.jsp?_pageId=tp7_origins_language

4 http://www.census.gov/ipc/www/usinterimproj/natprojtab01a.pdf

5 http://factfinder.census.gov/servlet/GRTTable?_bm=y&-geo_id=01000US&-_box_head_nbr=R0202&-ds_name=ACS_2005_EST_G00&-redoLog=false&-format=US-30&-mt_name=ACS_2005_EST_G00_R0202_US30

within the African American population, according to Census reports. Because of the “broadness” of the definition, some people that report their race as “African American” or “Black” tend to be more specific when reporting their ethnicity/ancestry, reporting an ancestry based on their (or their parents’) country of origin (such as Jamaican, Haitian, Nigerian, etc.). Others are more general in their reporting of their ethnicity, simply indicating African American as their ethnicity regardless of where their parents/grandparents were born. This produces uncontrolled variation in the census data.

African Americans of Haitian heritage are one of many minority groups in the United States. The 2000 United States Census report indicates that approximately 500,000 (.2%) of the United States’ population label themselves “Haitian.” However, other reports indicate that there are as many as 1-2 million people of Haitian descent living in the United States, concentrated in the metropolitan areas of New York, Massachusetts, Illinois, and Florida.

Approximately 95% of Haitians living in Haiti speak Haitian Kreyol as their primary language (Regan, 2005; St. Fort, 2000; http://www.cal.org/co/haiti/htoc.html). Some sources report that approximately 46% of Haitians in America speak Kreyol at home. However, there is limited empirical data available on Kreyol language use by

Haitians living in America. Most information on language use among Haitian Americans tends to focus on social factors that impact isolated groups of Haitian Americans. In census and other demographic surveys, language use is usually a secondary area that is ignored or deemphasized. For example, a study by Stepick, Stepick, and Kretsedemas (2001), describes language solely as a factor that contributes to the limited Haitian-American involvement in civic aspects of the South Florida community. The report identifies language as a significant barrier to civic participation, specifically with older Haitian Americans. However, it does not provide specifics on either language form or language use.

The presence of Haitians in the United States and the dominant use of Kreyol by that population present a unique challenge for professionals in the field of communication disorders in this country. According to census data on language use in the United States, French-based Creoles (including Haitian Kreyol) are ranked 14th in languages spoken in the home. The National Clearinghouse for English Language Acquisition and Language Instruction Educational Programs (NCELA) reports that Haitian Kreyol is one of the most common languages spoken by school-aged English language learners in the United States. Kreyol is ranked sixth in language backgrounds of English Language Learners.\textsuperscript{10} Table 1.1 provides the rankings for languages spoken at home by English language learners (ELL) in the United States.

\textsuperscript{10} http://www.ncela.gwu.edu
<table>
<thead>
<tr>
<th>Rank</th>
<th>Language</th>
<th>LEP Students (estimate)</th>
<th>% of LEPs (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spanish</td>
<td>3,986,451</td>
<td>15.95%</td>
</tr>
<tr>
<td>2</td>
<td>Vietnamese</td>
<td>88,006</td>
<td>0.36%</td>
</tr>
<tr>
<td>3</td>
<td>Hmong</td>
<td>72,035</td>
<td>0.30%</td>
</tr>
<tr>
<td>4</td>
<td>Chinese, Cantonese</td>
<td>46,480</td>
<td>0.21%</td>
</tr>
<tr>
<td>5</td>
<td>Korean</td>
<td>43,950</td>
<td>0.20%</td>
</tr>
<tr>
<td>6</td>
<td>Russian</td>
<td>37,127</td>
<td>0.17%</td>
</tr>
<tr>
<td>7</td>
<td>Tagalog</td>
<td>34,113</td>
<td>0.16%</td>
</tr>
<tr>
<td>8</td>
<td>Ivraje</td>
<td>27,029</td>
<td>0.12%</td>
</tr>
<tr>
<td>9</td>
<td>Khmer</td>
<td>26,815</td>
<td>0.12%</td>
</tr>
<tr>
<td>10</td>
<td>Chinese, Mandarin</td>
<td>22,397</td>
<td>0.10%</td>
</tr>
<tr>
<td>11</td>
<td>Portuguese</td>
<td>20,817</td>
<td>0.10%</td>
</tr>
<tr>
<td>12</td>
<td>Urdu</td>
<td>15,949</td>
<td>0.12%</td>
</tr>
<tr>
<td>13</td>
<td>Serbo-Croatian</td>
<td>17,183</td>
<td>0.07%</td>
</tr>
<tr>
<td>14</td>
<td>Lao</td>
<td>15,386</td>
<td>0.10%</td>
</tr>
<tr>
<td>15</td>
<td>Japanese</td>
<td>15,423</td>
<td>0.22%</td>
</tr>
<tr>
<td>16</td>
<td>Chuukese</td>
<td>15,184</td>
<td>0.34%</td>
</tr>
<tr>
<td>17</td>
<td>Chinese, unspecified</td>
<td>14,617</td>
<td>0.32%</td>
</tr>
<tr>
<td>18</td>
<td>Chamorro</td>
<td>14,554</td>
<td>0.31%</td>
</tr>
<tr>
<td>19</td>
<td>Marshallese</td>
<td>13,828</td>
<td>0.03%</td>
</tr>
<tr>
<td>20</td>
<td>Penjabi</td>
<td>13,396</td>
<td>0.30%</td>
</tr>
<tr>
<td>21</td>
<td>Amharic</td>
<td>13,362</td>
<td>0.28%</td>
</tr>
<tr>
<td>22</td>
<td>Polish</td>
<td>11,847</td>
<td>0.26%</td>
</tr>
<tr>
<td>23</td>
<td>French</td>
<td>11,325</td>
<td>0.24%</td>
</tr>
<tr>
<td>24</td>
<td>Hindi</td>
<td>10,877</td>
<td>0.23%</td>
</tr>
<tr>
<td>25</td>
<td>Native American, unspecified</td>
<td>10,174</td>
<td>0.23%</td>
</tr>
<tr>
<td>26</td>
<td>Ukrainian</td>
<td>6,748</td>
<td>0.21%</td>
</tr>
<tr>
<td>27</td>
<td>Pohnpeian</td>
<td>6,746</td>
<td>0.31%</td>
</tr>
<tr>
<td>28</td>
<td>Farsi</td>
<td>5,843</td>
<td>0.21%</td>
</tr>
<tr>
<td>29</td>
<td>Somali</td>
<td>5,800</td>
<td>0.20%</td>
</tr>
<tr>
<td>30</td>
<td>Cherokee</td>
<td>5,809</td>
<td>0.20%</td>
</tr>
<tr>
<td>31</td>
<td>Gujarati</td>
<td>5,845</td>
<td>0.17%</td>
</tr>
<tr>
<td>32</td>
<td>Albanian</td>
<td>7,874</td>
<td>0.17%</td>
</tr>
<tr>
<td>33</td>
<td>German</td>
<td>7,706</td>
<td>0.16%</td>
</tr>
<tr>
<td>34</td>
<td>Yiddish</td>
<td>7,073</td>
<td>0.16%</td>
</tr>
<tr>
<td>35</td>
<td>Bengali</td>
<td>6,897</td>
<td>0.15%</td>
</tr>
<tr>
<td>36</td>
<td>Hmong</td>
<td>5,898</td>
<td>0.13%</td>
</tr>
<tr>
<td>37</td>
<td>Ilocano</td>
<td>5,770</td>
<td>0.12%</td>
</tr>
<tr>
<td>38</td>
<td>African Language, unspecified</td>
<td>4,874</td>
<td>0.10%</td>
</tr>
<tr>
<td>39</td>
<td>Korean</td>
<td>4,846</td>
<td>0.10%</td>
</tr>
<tr>
<td>40</td>
<td>Samoan</td>
<td>4,353</td>
<td>0.09%</td>
</tr>
<tr>
<td>41</td>
<td>Thai</td>
<td>3,989</td>
<td>0.09%</td>
</tr>
<tr>
<td>42</td>
<td>Palauan</td>
<td>3,947</td>
<td>0.07%</td>
</tr>
<tr>
<td>43</td>
<td>Lakota</td>
<td>3,500</td>
<td>0.07%</td>
</tr>
<tr>
<td>44</td>
<td>European Language, unspecified</td>
<td>3,250</td>
<td>0.07%</td>
</tr>
<tr>
<td>45</td>
<td>Azeri</td>
<td>3,115</td>
<td>0.07%</td>
</tr>
<tr>
<td>46</td>
<td>Maltese</td>
<td>3,090</td>
<td>0.06%</td>
</tr>
<tr>
<td>47</td>
<td>Anhui</td>
<td>2,825</td>
<td>0.05%</td>
</tr>
<tr>
<td>48</td>
<td>Tungarian</td>
<td>2,741</td>
<td>0.05%</td>
</tr>
<tr>
<td>49</td>
<td>Apache</td>
<td>7,857</td>
<td>0.06%</td>
</tr>
<tr>
<td>50</td>
<td>Turkish</td>
<td>2,868</td>
<td>0.06%</td>
</tr>
<tr>
<td></td>
<td>Chinese, Min Nan</td>
<td>2,456</td>
<td>0.05%</td>
</tr>
<tr>
<td>51</td>
<td>Yoruba</td>
<td>2,356</td>
<td>0.05%</td>
</tr>
<tr>
<td>52</td>
<td>Kuropean</td>
<td>2,344</td>
<td>0.05%</td>
</tr>
<tr>
<td>53</td>
<td>Inupiaq</td>
<td>2,318</td>
<td>0.05%</td>
</tr>
<tr>
<td>54</td>
<td>Indonesian</td>
<td>2,229</td>
<td>0.04%</td>
</tr>
<tr>
<td>55</td>
<td>Choctaw</td>
<td>2,133</td>
<td>0.04%</td>
</tr>
<tr>
<td>56</td>
<td>Kurdish</td>
<td>2,131</td>
<td>0.04%</td>
</tr>
</tbody>
</table>

Table 1.1 Ranking of Top Sixty Languages Spoken by English Language Learner (ELL) Students in the United States.
Children of Haitian descent living in the United States fall into the population that Portes and Rumbout (2001) call "children of the second generation." They are first generation Americans either born in the United States to immigrant parents or brought to this country before turning 18. These children have connections to both the American and Haitian culture and can, much of the time, communicate in either English or Haitian Kreyol. Like most other children of the second generation (Portes & Rumbaut, 2001), most Haitian American children become fluent English speakers. This fluency in English can have an effect on how speech-language pathologists (and other academic professionals) in the United States view speech and language data in this population. A clinician may misidentify children of Haitian descent as speakers of other languages or linguistic varieties (i.e., French, a French-derived Creole, or African American English) or simply assume that because they are of Haitian descent, they are a fluent Haitian Kreyol speaker. When viewing this issue through the lens of articulation disorders, misidentification or lack of knowledge of the phonological features of Haitian Kreyol (or any linguistic variety) could lead to an incorrect diagnosis of an articulation disorder for a particular child. It is the duty of the speech-language pathologist to know the phonological features of the mainstream language, as well as the features of the linguistic varieties within the population she serves.

Linguistic variation has historically provided subjective descriptions of speech behaviors. Specifically, phonetic transcription has been used to describe differences in production between the mainstream and non-mainstream speaker. The discipline of
speech-language pathology has used these descriptions to aide in the diagnosis and treatment of communication disorders. Through these descriptions of linguistic differences, the field of speech-language pathology has taught that minority languages/dialects fall into the category of language difference (and not disorder) (ASHA position statement, 1983; Cole & Taylor, 1990). Based on that principle, speech-language pathologists are taught that the use of standardized assessments (normed on monolingual speakers of mainstream English) is not appropriate for speakers of a minority language/dialect. However, there are few assessments available that are made for speakers of linguistic varieties of English or bilingual speakers. There is also limited information on developmental features for different languages readily available. This presents a problem for the therapist, making it difficult for her to determine whether a linguistic variation is a difference or a disorder.

The issue of determining “difference vs. disorder” becomes compounded by the subjectivity of the data that exists. Much of the relevant sociophonetic research examines production differences via careful listening and phonetic transcription. Very few researchers investigate phonetic differences between minority languages/dialects using acoustic analysis.

Acoustic characteristics in the speech signal provide the listener with important information about the speaker, including information about the speaker’s gender, age, place and/or length of residence, as well as the language or dialect he speaks. There are many factors that influence an individual’s speech patterns. Research (Best, 1995; Flege,
et al., 1995; Goldstein, 2001) indicates that a person’s native language (L1) can influence the production of words/sounds in a second language (L2). For example, if a particular sound in L2 does not exist in L1, the speaker will most likely substitute the sound that is closest to the sound in L1. Goldstein (1991) uses the example of Spanish speakers’ substitution of /i/ for /u/ during the production of English. Flege, et al., (1995) found that native Italian speakers didn’t produce English consonants like a native English speaker (even after speaking English for years). This could lead one to think that English productions of children living in a home where Haitian Kreyol is spoken would be influenced by Haitian Kreyol.

However, it has also been determined that other sociolinguistic factors, including age of acquisition, gender, geographical region, and socioeconomic status, can affect speech production and perception (DeBose, 1992; Labov, 1972; Hinton and Pollock, 2000; Edwards, 1996; Wolfram and Schilling-Estes, 1998; Cunningham, 1997; Vaughn-Cooke, 1987; Clopper, 2000; Flege, 1999; MacKay, and Meador, 1999).

Although Haitian Kreyol is the primary language spoken in Haiti, its status in that country has been marginalized. Haitian monolingual Kreyol speakers make up the majority of the population, and Kreyol is spoken by almost all of Haiti’s population, yet, having fluency in French is what allows upward social mobility (Nwenmely, 1995, St. Fort, 2000).

Currently there is no published data on speech or language development in children of Haitian descent. This includes data on Haitians living in Haiti or abroad
speaking Kreyol, French, or English. With the increasing number of English language learners that speak Kreyol or come from Kreyol-speaking households, it becomes more important that speech-language specialists know and understand how the features of Haitian Kreyol develop. By obtaining objective data on how the speech patterns of speakers in this population differ from the mainstream, we can increase the knowledge base of speech and language development in a population that has received little attention. Having this data will allow the speech-language pathologist to more accurately identify the presence of a speech or language disorder.

In the interest of obtaining information on speech and language development in minority populations, the goal of this research is to provide an acoustic description of Haitian Kreyol and American English vowels spoken by Haitian American children living in the United States. Specifically, this study will examine influences of L1 and L2 on the vowel spaces (defined in terms of the frequencies of the vowels’ first two formants) of kindergarten-age children of Haitian descent residing in South Florida. An acoustic analysis of both American English and Haitian Kreyol vowels will be conducted to determine if any gender or language group differences exist during production of these vowels. The following questions will be addressed:

1. What are the acoustic characteristics of Haitian Kreyol vowels spoken by 4 and 5 year olds of Haitian descent? To address this question, the first two formants of all Haitian Kreyol vowels will be obtained from each speaker of Haitian descent. Because there is no information on speech sound development in children who
speak Haitian Kreyol, a child-based acoustic description will provide more appropriate data than the adult-based descriptions currently available.

2. What is the acoustic vowel space of American English vowels spoken by 4-and 5-year olds of Haitian descent? Most Haitian American kids are either bilingual (Kreyol/English) or are monolingual English speakers. There is no data on how these children produce the English sounds that they use in the school environment. To address this question, the first two formants of all English vowels will be obtained from each speaker of Haitian descent.

3. How does this English acoustic space produced by Haitian speakers compare to that of native speakers of American English that live in the same region and are of similar ages? Do Haitian American speakers produce these English sounds like a native speaker of English? Currently, one of two assumptions are made: either it is assumed that the bilingual child of Haitian descent produces English forms that are influenced by Kreyol, or the child uses the forms described for native English speakers. The acoustic measurements obtained in question two will be compared to non-Haitian age-matched peers within the same region to determine if differences exist.
CHAPTER 2
LITERATURE REVIEW

Because the overall aim of this study is to provide an acoustic description of vowels spoken by Haitian American children, it is necessary to understand the principles of particular areas related to speech development overall, as well as speech differences. This chapter provides a review of the research related to speech and language development overall, vowel development, and background on Haitian Kreyol.

2.1. Speech and Language Development

Learning language is a complex process that occurs in a relatively short period of time. In spite of its complexity, children learn language with relative ease. Though many people equate “first words” as the initiation of language learning, the process of learning language begins before the child ever speaks a word. The child’s ability to perceive distinctive differences in sounds in his native language is a pillar in the foundation of how he develops spoken language. Learning the distinctive sounds of a language (phonology) is the foundation upon which the other aspects of spoken language rely. There have been many theories that attempt to explain the way in which one learns his native language. They fall under three broad categories: Behaviorist theory, Nativist theory, and Interactionist theory.
2.1.1. Vowel Development Theories

The Behaviorist Theory (Skinner) explains language development as other learned human behavior. According to this theory, the child learns language by way of linguistic experience that is reinforced by the adult. Specifically, the child is taught to produce sounds solely by modeling of new sounds, imitation of those sounds, and shaping of any imperfect productions of those sounds (Fey, 1986; Vihman, 1993; Cattell, 2000). Although this concept is used in modifying a speech/language behavior and can provide a possible explanation of language learning, behaviorist theory alone cannot account for spontaneous productions that have not been specifically introduced by the adult. Because of this, the Behaviorist Theory has been rejected as a model for learning L1.

Nativist Theory (Chomsky) can answer the question of how a child learns new sounds that are not directly introduced and reinforced. It states that children do not “learn” a particular language solely from adult input; they are “pre-wired” with the rules for all languages via a language acquisition device (LAD) (Vihman, 1993; Reddy, 1999; Cattell, 2000). The LAD is an innate system that allows the child to learn the rules of a language relatively quickly. Phonological development follows a pre-set hierarchy that unfolds as the child develops and produces various phonological contrasts. As a result, the language process simply manifests itself without much outside influence. The Natural Phonology model (Stampe) is one that fits this view of development. According
to this model, the child is born with the phonological processes that exist for all languages. As the child attempts to achieve the adult model, he suppresses those processes that do not occur in the language to which he is exposed. The Generative Phonology model also supports the concept of an innate language system. It accounts for changes in the system by attributing them to outside influences (i.e., the adult model). Adult input acts as the trigger that activates alterations to the child’s phonological system. Overall, the Nativist Theory supports the idea that the language learner’s readiness to perceive the sounds of language is predisposed. However, what prevents children from immediately producing adult forms are constraints placed on them by decreased articulatory skill (Barrett, 1999; Reddy, 1999; Vihman, 1993; Lund and Duchan, 1993). This theory fails to view the social “requirements” of language learning as an important contributing factor as the innate ability. It is unable to account for grammatical productions that are meaningless, or features that carry relative meaning but that do not follow the innate rules of the system.

The most recent explanations of language development take a more interactive approach. Interactionist Theory states that language development requires both cognitive and behavioral systems. It accepts the idea that the child is cognitively predisposed (has the “wiring”) to learn language. However, it also acknowledges that environmental input plays an active role in language development, providing motivation for communication, as well as a model for development (Vihman, 1993; Cattell, 2000).
Optimality Theory is technically a model that utilizes the Interactionist approach. It combines the concepts found in both behavioral and structural models. As with the Generative Phonology model, Optimality Theory examines the child’s phonological system as an “input-output” device. However, this device, or grammar, is not simply triggered into action with passive exposure (input) to a specific language; the grammar requires active exposure (interaction) in order to alter output (Barlow and Gierut, 1999).

According to this theory, within the grammar there is a “generator” and an “evaluator.” The generator determines possible outputs based on various perceivable inputs. The evaluator determines which of these possible outputs will be acceptable (based on language-specific constraints or “rules” placed on the system) and ranks them in order from optimal/best to least likely.

Constraints (what features are “allowable” and “not allowable” in a particular language), which are present in all languages/grammars, differ as a function of one’s native language. Within a given grammar are faithfulness and markedness constraints. Faithfulness constraints require that the input and output match (for example, “cat” must be produced as /kæt/, and not /tæt/, or it would violate the faithfulness constraint in English). Markedness constraints require that the output be in as simple a form as possible—unmarked. Because unmarked features are present in all grammars, the existence of any deviation from that simplest form is considered a violation of “markedness.” For example, the existence of consonant clusters is a violation because
consonant clusters do not exist in all languages. Even if it does occur in a particular language, the consonant cluster is not the simplest form in any grammar.

Constraints are innate. The language learner ranks constraints according to the rules of his native language. The higher the constraint ranking, the more important it is to the language. Ranking changes as a result of language input. Initially, markedness constraints out-rank faithfulness constraints. This can be seen in a child’s production of the simplest word forms whether or not they match the input (i.e., /du/ for /dʒus/). As knowledge of the grammar rules increases (via input), the possibility that faithfulness constraints will out-rank markedness constraints becomes more likely (Barlow, 2001; Barlow and Gierut, 1999; Boersma and Levelt, 2003).

The output that least violates the constraints of a given language (gained through input) is considered “optimal.” As the child develops and learns more about the language to which he is exposed, the constraints are re-ranked and optimal output is updated (Stemberger, 1992; Barlow and Gierut, 1999; Barlow, 2001).

The theories that explain language development have changed as our understanding of the language-learning process has grown. Early beliefs that language learning relied purely on input (nurture) or innate ability (nature), have evolved into the view of language learning as an intricate process that relies on both (nature and nurture). Interactionist Theories, such as Optimality Theory, stress the important relationship between innate ability and outside influence. These theories, which explain the language
development process overall, can be applied to different areas of language, including phonology.

One’s phonological abilities represent the organizational set up (rules) for speech sound/phoneme production in the brain, whereas articulation abilities points to how one produces a particular speech sound/phoneme. The field of communication disorders has, historically, taken its knowledge of language theory and combined it with practical observations/descriptions of behavior to determine the existence of abnormal development. When phonological development is discussed in this practical context, the productive output (articulation of speech sounds) becomes the starting point that leads to the determination of an articulation or phonological disorder, as well as the starting point for treating the disorder.

2.1.2. Stages of Phonological Development

The early process of learning to produce speech sounds can be broken down into six prelinguistic stages (see Table 2.1), a “first words” stage, and a phoneme development stage. Speech behaviors during these stages can overlap.

During the first prelinguistic stage (Stage 1), the child produces vegetative noises and reflexive sounds, such as sneezes, burps, and crying. When the child enters the second stage (Stage 2), she begins producing cooing sounds, which consist of back vowels and velar approximations. These sounds develop into syllable sequences. As the
child gains better control of her articulators, the syllable sequences expand (Stage 3) and longer, more varied syllable sequences are produced (including sequences containing front and back vowels, as well as sequences with varied pitch). In Stage 4, the child begins babbling (combining a single vowel-consonant/consonant-vowel sequence). This babbling doesn’t always have a communicative function; it can serve as practice/self-stimulation. During Stage 5, the child’s babbling begins to resemble adult language somewhat. Productions contain new and varied sounds across the syllable sequence, varied intonation, and communicative intent. Once the child is in Stage 6, she produces vocal segments that, paired with gestures, can be linked consistently to a specific context. Though the child’s productions might have communicative intent, they often do not sound very close to the adult model. Situational context is required to “make sense” of the child’s productions (Ingram, 1999; Lund and Duchan, 1993; Vihman, 1993).

When the child enters the “first words” stage, the words contain simple syllable structure, which is made up of a small number of vowels (V) and consonants (C). These syllables usually take the form of VC, CV, CVC and reduplicated CV or VC. It is during this stage that the child begins to work to organize and perfect her articulatory movements. As this stage develops, there are considerable phonological differences from the adult model (e.g., “foot” /fʊt/ might be produced as “poo” /pu/). Variability within the child’s productions can also be observed (Ingram, 1999).
During the phoneme development stage, the child continues to perfect her phonological system by understanding the syllable sequences of her native language. Simplification and substitution of sounds is a normal occurrence as the child develops/learns phonetic distinctions and her phonetic inventory increases. Dinnesen (1999) describes the method in which children acquire the phonetic distinctions that help form a phoneme inventory. Table 2.2 provides a summary of that complex process.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Approximate Age</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Birth-2 months</td>
<td>Phonation (including sneezing, crying, burping)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>2-3 months</td>
<td>Cooing</td>
</tr>
<tr>
<td>Stage 3</td>
<td>4-6 months</td>
<td>Vocal Play</td>
</tr>
<tr>
<td>Stage 4</td>
<td>6-12 months</td>
<td>Reduplicated Babbling</td>
</tr>
<tr>
<td>Stage 5</td>
<td>9-18 months</td>
<td>Variegated Babbling</td>
</tr>
<tr>
<td>Stage 6</td>
<td>10+ months</td>
<td>Vocables</td>
</tr>
</tbody>
</table>

Table 2.1 Stark (1986) and Oller (1980) Stages of prelinguistic development adapted from Lund and Duchan (1993) and Vihman (1993)
<table>
<thead>
<tr>
<th>Level</th>
<th>Phoneme Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Vowels, glides, nasals, obstruent stops (no voice or manner distinctions)</td>
</tr>
<tr>
<td>B</td>
<td>Vowels, glides, nasals, obstruent stops (voice distinctions become apparent)</td>
</tr>
<tr>
<td>C</td>
<td>Vowels, glides, nasals, obstruent stops, fricatives/affricates (manner distinctions become apparent)</td>
</tr>
<tr>
<td>D</td>
<td>Vowels, glides, nasals, obstruent stops, fricatives/affricates, liquids</td>
</tr>
<tr>
<td>E</td>
<td>Vowels, glides, nasals, obstruent stops, fricatives/affricates, liquids (lateral and strident distinctions become apparent)</td>
</tr>
</tbody>
</table>

Table 2.2 Dinnesen’s Order of Acquisition for Phonetic Categories

2.2. Second Language Acquisition

Children from linguistically diverse backgrounds are a growing population in the United States. Results of the 2000 Census indicate that 10.4% of the United States population is from another country (http://www.census.gov). Children make up a sizeable portion of this population. The National Clearinghouse on English Language Acquisition and Language Instruction Educational Programs (NCELA) reports that for the 2003-2004 school year, minority children made up about 10.3% of the public school population in the United States (http://www.ncela.gwu.edu).
Immigrant children, as well as children born in the United States to immigrant parents—labeled "children of the second generation"—are considered the fastest-growing group among the population of children under 18 years of age (Portes & Rumbou, 2001). As of 2000, one in six children is a child of the second generation (http://www.census.gov). Because language is a means of cultural identity as well as basic communication, children of the second generation do not fully associate with language or culture of their native or second language, but instead tend to operate between the culture they were born into and the American culture. The possibility of children of the second generation exhibiting communicative competence in two languages (i.e., being bilingual) or communicating in different dialects is very common in today’s world.

2.2.1. Theories of Development for Second Language Learners:

Most conventions describe language acquisition for second language learners in terms of two main types: simultaneous and sequential. These types are based on the condition by which the second language (L2) is introduced or learned.

Simultaneous (also known as horizontal) bilingualism occurs when a child learns two languages at the same time. This learning usually takes place in infancy (before age 3 years) within a naturalistic setting (Kessler, 1984). There are two methods of
presentation within this type of bilingualism. Either the caregiver(s) speaks both languages to the child during daily interactions, or each caregiver interacts with the child exclusively in one language (e.g., mother in English, father in Spanish). In each presentation code-switching (changing the language pattern to match the listener’s) is an important technique used by the child in order to effectively communicate. In the case where each caregiver speaks a different language, it is the child's job to effectively code-switch in order to understand and communicate with each speaker. For example, the child must understand that he speaks English with mommy and Spanish with daddy. When the caregiver(s) speaks both languages simultaneously, the child must still code-switch, however, the rules of language choice are not as strict. The lax rules of language use in this case usually leads to the dominance of one language and the subordination of the other.

Sequential (also known as vertical) bilingualism occurs when a child acquires L2 after acquiring L1. It usually takes place after a child turns 3 years old or enters preschool. At this point in the language-learning process, the child is age-proficient in L1. Therefore, when L2 is introduced, L2 is heavily influenced by L1. As L2 proficiency increases, the influence of L1 decreases. Proficiency in L2 (just as in L1) is largely based on communicative need (Kessler, 1984).

Romaine (1999) provides a description of six situations in which a child becomes bilingual. This description is based on the parents’ native language, native language of
the community, and strategy used when speaking to the child (see Table 2.3). Although
Romaine provides a detailed description of bilingual typology, her description does not
account for the child’s response to the parents’ input.
<table>
<thead>
<tr>
<th>Types of Bilingualism “Scenarios”</th>
<th>Speaking Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type 1: One Person, One Language</strong></td>
<td>Each parent speaks their native language to child.</td>
</tr>
<tr>
<td>- Parents have different native languages (but each is competent in the spouse’s language).</td>
<td></td>
</tr>
<tr>
<td>- The language of one parent is the dominant community language.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 2: Non-Dominant Home Language</strong></td>
<td>Both parents speak the non-dominant language to child. The dominant language is introduced outside the home.</td>
</tr>
<tr>
<td>- Parents have different native languages.</td>
<td></td>
</tr>
<tr>
<td>- The language of one parent is the dominant community language.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 3: Non-Dominant Home Language without Community Support</strong></td>
<td>Parents speak their native language to the child. The dominant language is introduced outside the home.</td>
</tr>
<tr>
<td>- Parents have the same native language.</td>
<td></td>
</tr>
<tr>
<td>- Language of parents is not dominant in the community.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 4: Double Non-Dominant Home without Community Support</strong></td>
<td>Each parent speaks their native language to the child.</td>
</tr>
<tr>
<td>- Parents have different native languages.</td>
<td></td>
</tr>
<tr>
<td>- The dominant language is different from either parent’s language.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 5: Non-Native</strong></td>
<td>One (or both) parent(s) always speaks to the child in a non-native language.</td>
</tr>
<tr>
<td>- Parents have same native language.</td>
<td></td>
</tr>
<tr>
<td>- The dominant language is the same as the parents.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 6: Mixed Language</strong></td>
<td>Parents code-switch between languages.</td>
</tr>
<tr>
<td>- Parents are bilingual.</td>
<td></td>
</tr>
<tr>
<td>- Community is bilingual.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3 Types of Situations in Which a Child becomes Bilingual according to Romaine (1999).
There are 3 hypotheses that explain the process by which bilingual speakers respond to that input and acquire language: The fusion hypothesis, the differentiation with autonomous development hypothesis, and the differentiation with interdependent development hypothesis (Kessler, 1984; McLaughlin, B., Blanchard, A., and Osanai, Y., 1995).

In the fusion theory, bilingual language learners have a dual system that is made up of linguistic elements of both languages. Over time, these two systems fuse into one system that may combine lexical, syntactic, or morphological features of both languages.

The differentiation with autonomous development hypothesis describes a dual system in which the two languages are independent of each other. The child uses both languages distinctly, code-switching between the two languages depending on the speaker/situation.

The differentiation with interdependent development describes an “inter-language system” where the two separate language systems develop and have elements distinct to each language, but also have common elements (picture a Venn diagram). This “inter-language system” constantly changes and reorganizes itself as the child learns new linguistic rules.

Receptive bilingualism has also been described as a type of bilingualism. It occurs when a child is exposed to L2, but has little opportunity to use it in everyday
contexts. Children who are receptively bilingual can understand and follow directions in L2 but don’t express themselves using it; they express themselves using L1. For example, a child from a Kreyol-speaking household might hear English on television, but is not required to use English to communicate to those around her (McLaughlin, Blanchard, and Osanai, 1995).

2.2.2. Phonological Development in Bilingual Children:

Regardless of the type of bilingualism, a child learning two languages must learn the phonological rules and produce the sounds of both languages in order to communicate effectively. The process of distinguishing features of a language begins within the first six months of life. Research points to the concept of infants as universal language learners—having the capacity to learn any language to which they are exposed (Cattell, 2000; Jusczyk and Bertoncini, 1988; Kuhl, 1987; Werker and Lalonde, 1988).

Although research on bilingual children was in existence early in the twentieth century (Leopold, 1949), “in depth research” that investigates phonological development in bilingual children is limited (Goldstein, 2001; Kester, Davis, and Pena, 2008; Yavas and Goldstein, 1997). Yet, this limited information points to relevant models on speech sound acquisition in this population. One such model is the Competition Model. It suggests that a person acquiring two languages learns/produces speech sounds with the
most perceptually salient (easily understandable or heard) cues first (Gorman & Stubbe-Kester, 2005). For some children who are learning two languages simultaneously that process appears to follow a “one-system” pattern, with phonological features of both languages emerging simultaneously in a developmental pattern (i.e., the similar sounds of both languages appearing in the phonemic repertoire before those different, less perceptually salient sounds). For other children this process of phonological development takes a two-system approach, with the child developing the perceptually salient features of L1 and L2 in a more sequential manner (learning the features of one language at a time).

The Competition Model can also be applied to dialect differences. Although the underlying language is the same, each regional or social dialect has subtle differences. A speaker of a particular dialect interprets information from the new dialect using his native dialect as reference.

When vowel development is viewed through the lens of the Competition Model, we find that the vowels most salient perceptually will be produced first. This is applicable for different languages or different dialects. The Perceptual Assimilation Model (Best, 1995) provides an explanation of how/why this occurs. This model relates perceptual saliency to perceived vocal tract constrictions. A listener perceives the constrictions of the vocal tract that relate to their native language, judging similarities
between the sound structures of L2 and L1. The listener then associates the non-native sound to the native sound that most closely resembles it.

For example, a child learning Spanish and English simultaneously would most likely produce the vowels /i, u, a/ first. These “point vowels” represent extreme articulatory gestures that exist in both languages. As that bilingual child’s speech develops, he develops a phonological system influenced by two different languages. This influence could result in interactions in his production of both languages. Goldstein (2001) discusses the interactions that could occur phonologically when a child learns Spanish and English. English phonological rules could influence the production of Spanish vowels, with monophthongs being realized as diphthongs. A more commonly discussed interaction is the influence of Spanish phonology on the production of English vowels. Because Spanish vowels consist of monophthongs /i/, /e/, /u/, /o/, and /a/, the child learning both English and Spanish would most likely substitute the vowel in L1 that perceptually approximates the new vowel encountered in L2 (Goldstein, 2001). For example, a Spanish speaker producing American English might substitute /i/ for /i/. This interference also occurs in the productions of different dialects of the same language (e.g. the production of /a/ for /æ/ in the case of a Jamaican English speaker producing American English or the production of /u/ for /ɛ/ in the case of a speaker of Southern
American English). This phenomenon manifests itself into what is commonly termed “an accent” (Kessler, 1984; Piper, 1993; Romaine, 1999).

Flege (1995) defined “accent” via the Speech Learning Model. The Speech Learning Model (SLM) also explains the changes that occur in L1 and L2 phonological systems when the two languages interact. It asserts that as L1 and L2 interact, performance in both languages is affected. Different factors, including age of acquisition, length of exposure, and access to/use of L2 determine how L1 and L2 will interact. Flege, et al (1999), examined age of arrival (AOA) and use of L1 as factors in native-like perception and production in bilingual (Italian/English) speakers. They determined that the earlier bilingual subjects began speaking L2 (English), the more likely it was that their L2 productions were like that of a native English speaker. Subjects learning English at a later age were more heavily influenced by their L1 (Italian) and had a tendency of producing English phonemes more consistent with phonemes in Italian. Continued use of L1 was not found to be significant in native-like production or perception in this particular study. However, other studies found that increased use of L1 lead to more “accented” productions of L2 (Flege, 1999; Bohn and Flege).

Overall, the Speech Learning Model and the Competition Model explain the cause and effect relationship that exists in learning to produce the sounds of a second language (or dialect). SLM focuses on the factors that affect the production of the “second language” phonemes, whereas the Competition Model focuses on the phonetic changes
that manifest as a result of those factors. These changes can be explained descriptively or measured acoustically from the speech signal.

2.3. Vowel Production and Development

Vowels tend to carry information about the acoustic signal and provide information about the speaker. The process by which vowels are formed is described by the source-filter theory of speech production.

2.3.1 Source-Filter Theory:

The source-filter theory of vowel production describes speech as the result of a sound source (vocal folds) shaped by a filter (vocal tract). The process of producing speech begins with airflow. The lungs provide the airflow that power the vibratory cycle. Subglottal air pressure from the lungs pushes against the lower portions of the vocal folds, blowing them apart. As the lower portions of the vocal folds separate, the myoelastic properties of the vocal folds pull apart the upper sections of the vocal folds attached to the lower sections. This results in an open glottis. Once the glottis opens and air flows through the glottal opening, the negative pressure decreases rapidly, causing the lower sections of the vocal folds to fall back toward the original (closed) position. As the
vocal folds come close together, the Bernoulli Effect works to correct difference in the pressure above and below the glottis, causing the lower sections of the vocal folds to close in order to maintain equal pressure in the vocal tract. Once closed, the negative pressure below the vocal folds builds up again and the cycle continues. These cycles occur quickly—producing “vibration” of the vocal folds (Kent and Read, 2002; Ladefoged, 1996, Morrison and Rammage, 1994; Pickett, 1999).

Vibration of the vocal folds provides a glottal noise source. The manner in which the vocal folds vibrate, as well as the size of the vocal folds, help determine the quality and fundamental frequency of the glottal noise. Though differences exist, the noise emitted from the vocal folds sounds like a weak “buzz” (Pickett, 1999). It is the function of the vocal tract to shape and amplify that buzz (in a frequency-selective manner) into a vowel sound.

The vocal tract shapes the noise “buzz” created by the vocal folds into a particular vowel sound through the phenomenon of “resonance” (and the selective reinforcement and dampening of acoustic energy at different frequencies). There is a specific resonance pattern (acoustic filter) associated with each vocal tract shape. In essence, the vocal tract is an acoustic tube that starts at the glottis and ends at the lips. The tongue, soft palate, jaws, and lips provide constrictions within the tube that determine the shape and/or length of the tube. The different shapes/lengths that are created correspond to different acoustic filters producing different vowel sounds.
2.3.2. Acoustic Characteristics of Vowels

Since it is difficult to see what the articulators are doing to shape the vocal tract and produce a particular vowel, phoneticians examine the acoustic consequences of these articulatory patterns using spectrographic analysis. The glottal source spectrum provides the frequency spacing (fundamental frequency) of the glottal source. Fundamental frequency of a given vowel indicates the rate of vocal fold movement needed to produce that vowel, measured in cycles per second. This measurement is influenced by the size and shape of the vocal folds. One’s fundamental frequency can be high (in the case of a child whose vocal fold mass is small) or low (in the case of an adult male whose vocal fold mass is large). The glottal source spectrum also presents the intensity (amplitude pattern) of the spectral components over frequency. As the frequency of the spectrum increase, the amplitude decreases. This decrease occurs at a rate of approximately 12 dB per octave, resulting in a downward slope. However, when a vowel sound is projected from the mouth, the amplitude for the higher frequencies are actually higher than for the lower frequencies—an increase of about 6 dB per octave (Pickett, 1999). When these radiation characteristics (from the vowel sound projecting from the mouth) are factored into the equation, the effective source spectrum has a downward slope of about 6 dB per octave (see Figure 2.1).
Filtering of the vocal tract shapes the glottal source. This “shaping” of the glottal source produces formant peaks (resonances) that represent a particular vowel sound. For example, in order to produce the neutral vowel /uh/, the vocal tract has little constriction. The resulting filter response is flat, with the exception of formant resonances that occur due to amplification at 500, 1500, and 2500 Hz. When this filter response is applied to the glottal source spectrum, it produces a vowel spectrum that is a downward-sloping scalloped spectrum (see Figure 2.2) (Pickett, 1999; Ladefoged, 1996).
Because of their influence on the glottal spectrum, formants act as acoustic cues to the identification/categorization of vowels, providing information on the position/shape of the articulators in the oral cavity. The first formant (F1) and the second formant (F2) provide information regarding vowel quality. F1 corresponds with tongue height (Ladefoged, 1996). As the tongue rises, F1 decreases; as the tongue lowers, F1 increases. F2 corresponds with tongue advancement. As the tongue moves forward, F2 increases; as the tongue moves backward, F2 decreases (Mosser, 1999). The lips also influence formant frequency. Lip rounding increases the length of the vocal tract, effectively lowering all formant frequencies. A sample of formant frequency measures for American English vowels can be found in Table 2.4. These measures were taken...
from Hillenbrand, et al., (1995). Figure 2.3 provides an acoustic phonetic representation of the 10 major vowels in American English as noted in the Peterson and Barney study.

<table>
<thead>
<tr>
<th></th>
<th>/ɑ/</th>
<th>/ɔ/</th>
<th>/ʌ/</th>
<th>/ʊ/</th>
<th>/e/</th>
<th>/ɛ/</th>
<th>/æ/</th>
<th>/eɪ/</th>
<th>/aɪ/</th>
<th>/ɒ/</th>
<th>/ɑɪ/</th>
</tr>
</thead>
</table>
| **Dur**
| M   | 243 | 192 | 267 | 189 | 278 | 267 | 283 | 265 | 192 | 237 | 188 | 263 |
| W   | 306 | 237 | 320 | 254 | 332 | 323 | 353 | 326 | 249 | 303 | 226 | 321 |
| C   | 297 | 248 | 314 | 235 | 322 | 311 | 319 | 310 | 247 | 278 | 234 | 307 |
| **F0**
| M   | 138 | 135 | 129 | 127 | 123 | 123 | 121 | 129 | 133 | 143 | 133 | 130 |
| W   | 227 | 224 | 219 | 214 | 215 | 215 | 210 | 217 | 230 | 235 | 218 | 217 |
| C   | 246 | 241 | 237 | 230 | 228 | 229 | 225 | 236 | 243 | 249 | 236 | 237 |
| **F1**
| M   | 342 | 427 | 476 | 580 | 588 | 768 | 652 | 497 | 469 | 378 | 623 | 474 |
| W   | 437 | 483 | 536 | 731 | 669 | 936 | 781 | 555 | 519 | 459 | 753 | 523 |
| C   | 452 | 511 | 564 | 749 | 717 | 1002| 803 | 597 | 568 | 494 | 749 | 586 |
| **F2**
| M   | 2322| 2034| 2089| 1799| 1952| 1333| 997 | 910 | 1122| 997 | 1200| 1379|
| W   | 2761| 2365| 2530| 2058| 2349| 1551| 1136| 1035| 1225| 1105| 1426| 1588|
| C   | 3081| 2552| 2656| 2267| 2501| 1688| 1210| 1137| 1140| 1345| 1546| 1719|
| **F3**
| M   | 3000| 2684| 2691| 2505| 2601| 2522| 2538| 2459| 2434| 2343| 2550| 1710|
| W   | 3372| 3053| 3047| 2979| 2972| 2815| 2824| 2828| 2827| 2735| 2933| 1929|
| C   | 3702| 3403| 3323| 3310| 3289| 2950| 2982| 2987| 3072| 2988| 3145| 2143|
| **F4**
| M   | 3657| 3618| 3649| 3677| 3624| 3687| 3486| 3384| 3400| 3357| 3557| 3334|
| W   | 4352| 4334| 4319| 4294| 4290| 4299| 3923| 3927| 4052| 4115| 4092| 3914|
| C   | 4572| 4575| 4422| 4671| 4409| 4307| 3919| 4167| 4328| 4276| 4320| 3788|

Table 2.4 Fundamental and formant frequencies taken from Hillenbrand, et al. (1995)
The source-filter theory is applicable to all speakers. However, differences in vocal tract size result in different vowel spaces for men, women, and children (See Figure 2.4). Men have more compressed vowel spaces as a result of increased vocal tract length. This results in lower overall formant frequencies. Women, on the other hand, have more expanded vowel spaces than men. Their shorter vocal tract results in higher overall formant frequencies. Variable formant frequencies are also the result of articulatory adjustments, which is compensation for harmonic interference that occurs due to higher
F0 values. This explanation can also explain the large vowel spaces of children (as compared to adults).

![Figure 2.4 Vowel Spaces of Men, Women, and Children based on Peterson and Barney (1952).](image)

2.3.3. Children’s Vowel Development: Formant Frequencies

Children’s articulation patterns are constantly changing to match the adult model. That, along with physical growth and laryngeal changes (both overall growth and positioning), has an impact on formant frequency measures. The infant’s short vocal
tract and limited articulatory abilities impact formant frequencies as well as F0. Infant vocalizations (including crying) have extremely high formant frequencies, approximately 1000 Hz for F1 and 3000 Hz for F2 (Kent and Murray, 1982; Rvachew, et al., 1996). These values are generally viewed with caution because of harmonic interference. These extremely high values have also been shown to decrease as the infant grows, with average F1 and F2 values for 1 year olds being 1078 Hz and 2558 Hz, respectively (Gilbert, et al., 1997). However, because of high variability in vocal productions, it is difficult to relate the infant’s/toddler’s formant structure to a particular adult vowel model (Andreeva, et al., 2001). For this population, F0 contours and durational cues are more important (Hsu, et al., 2000).

As the toddler grows, formant frequencies decrease again. The child’s articulation skills are improving and begin to sound more like the adult model. By the time a child is 3 years old, mean F1 and F2 values are 645 Hz and 1938 Hz, respectively (Gilbert, et al., 1997). Even with the increased connection to the adult model, formant frequency measures of children continue to be highly variable, partly due to decreased articulatory skill. Variability in formant frequencies continues until around puberty (Lee, et al., 1999). However, even when formant frequency values become less variable, other factors, such as speaking rate, influence attainment of the adult model (Perry, et al., 2000).
2.3.4. Children’s Vowel Development: Vowel Inventory

Difficulty in obtaining formant frequency measures (due to high F0) is a major contributing factor in the limited number of studies dedicated to vowel production in young children. Studies that have investigated vowel development in this population (Selby et al., 2000) have identified a vowel inventory based on a limited number of children. It is generally accepted that vowel production is mastered (i.e., replicates the adult model) by age 3 (McLeod, 2002; Bernthal and Bankson, 1993). However, subtle differences (noted through spectral and durational measures) continue to exist until adolescence (Lee, et al., 1999; Perry, et al., 2000). Table 2.5 provides a vowel inventory of American English for children from ages 15-36 months.
<table>
<thead>
<tr>
<th>Age</th>
<th>Vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 months</td>
<td>/i, u, a, λ/</td>
</tr>
<tr>
<td>18 months</td>
<td>/i, u, o, a, æ, λ/</td>
</tr>
<tr>
<td>21 months</td>
<td>/i, i, u, e, o, ɔ, a, λ/</td>
</tr>
<tr>
<td>24 months</td>
<td>/i, i, u, e, e, o, ɔ, a, æ/</td>
</tr>
<tr>
<td>36 months</td>
<td>/i, i, u, e, e, λ, æ, o, ɔ, a, æ/</td>
</tr>
</tbody>
</table>

Table 2.5 Vowel Inventory of American English for Children ages 15-36 months.

2.3.5. Acoustic Cues and Linguistic Variation

It has been noted by researchers that people are able to identify a speaker’s language/dialect, race, or gender using small portions of the speech signal. (Irwin, 1977; Lass, et al., 1978; Lass, et al., 1982; Ash and Myhill, 1986; Graff, et al., 1986; Baugh, 1996; Purnell, et al., 1999; Clopper, 2000; Perry, 2001). These acoustic cues can be durational or spectral.

Although vowel duration can serve as a phonological marker in certain languages (such as Japanese, Swedish, and Thai), the length of a vowel does not, by itself, serve as a
phonological marker in English. Duration is, instead, linked to segmental characteristics of a particular vowel (Rosner and Pickering, 1994).

English vowels are described by their location in the vowel space, which is guided by the position of the articulators during production. For example, high and low vowels are categorized by the position of the tongue in the oral cavity. Vowels produced with tongue placement higher in oral cavity are said to be “high”, whereas vowels produced with tongue placement low in the oral cavity are said to be “low”. This distinction is considered mechanical, and is, therefore, a quality that is universal to all languages. There is also a “tense/lax” distinction used to describe vowels. This distinction is considered a learned, “language-specific” vowel quality. Tense vowels are produced with more peripheral tongue position, but lax vowels are produced with a more centralized tongue position. (Pickett, 1999; Rosner and Pickering, 1994; Klatt, 1976).

Differences in how specific vowels are produced result in different durational features. Because of the extreme tongue positioning required to produce tense vowels, they are longer than lax vowels (which exhibit more neutral tongue positioning). Low vowels, because of the time it takes to open the jaw, are longer than high vowels (which do not have extreme jaw positioning).

Other factors that impact the duration of a given vowel include syllabic stress, pitch accent, and prevocalic/postvocalic consonants (Pickett, 1999; Klatt, 1976). Vowels that are located within a stressed syllable are longer than those in an unstressed syllable. It
has also been determined that vowels preceding voiced consonants are longer than those preceding voiceless consonants. Postvocalic nasal consonants also tend to lengthen the preceding vowel.

Because some vowel qualities are learned, vowel duration differences can be observed between gender, age, and language/dialect groups (Hillenbrand, et al., 1995; Jacewicz, et al., 2007; Ko, 2007; Krause, 1982; Keller, 1993; Perry, 2001; Clopper, et al., 2005). Krause (1982) investigated children’s ability to alter vowel duration as a cue to postvocalic stop consonant voicing. She provided a developmental comparison, looking at three year-olds, six year-olds, and adults. Results indicated that children as young as three years old can signal the presence of a voiced stop consonant by lengthening the preceding vowel. This lengthening, however, is less exaggerated for older than for younger children. The idea that children can alter vowel duration based on context is also supported by Ko (2007), who noted that children can alter vowel duration of tense/lax vowels and vowels preceding voiced/voiceless consonants even before the age of two. As children get older, their “lengthening” becomes less exaggerated. These results were supported by Lee, et al (1999), who noted developmental changes in vowel duration for children ages 5-18. They found that 5 and 6 year old children exhibited significantly longer vowel durations than older counterparts. There were also noted vowel reductions for older children as they reached adulthood.
Research has also documented vowel duration differences between male and female speakers. Ericsdotter and Ericsson (2001) found that female speakers of Swedish produced greater durational contrasts than their male counterparts. They produced longer vowels than their male counterparts when that vowel was located in a stressed syllable. These findings support those by Hillenbrand, et al (1995) and Clopper, et al (2005). Both studies noted that female speakers produced longer vowels than their male counterparts.

Dialect differences also impact vowel duration. Keller (1993), when looking at final stop consonant production in African American Vernacular English (AAVE) speakers, noted that they used vowel duration to signal the presence of a final devoiced consonant. Clopper, et al., (2005) noted that Southern American English speakers exhibited longer vowel durations than speakers of other regional dialects, specifically for lax vowels, (/u/, /ɛ/, /ʌ/, /ʌ/).

Formant frequencies are another type of acoustic measure that can serve as a cue to language, dialect, or racial identification. Walton and Orlikoff (1994) found differences in formant frequency values (with African American subjects producing lower formant frequencies than Caucasian subjects), but these differences were not significant. Findings of Andrianopoulos, et al., (2001) support Walton and Orlikoff (1994) and offer normative data on other culturally/linguistically different groups. Although subjects were matched for physical features (such as age, height, weight) and proficient use of Standard American English, significant differences between the racial/cultural groups were found
in formant frequencies of certain vowels. Among the differences noted, native Hindi Indian men were found to have lower first formant frequencies for /a/ and /i/ than African American, Caucasian, and Mandarin Chinese men; Caucasian men had higher second formant frequencies for /a/ than other male groups. Female differences were noted for the third formant frequency, with African American and Caucasian subjects exhibiting lower third formant frequency values for /a/.

Purnell and Kopplin (2002), when investigating fundamental and formant frequencies as cues to dialect identification, found that listeners’ identification of “racially affiliated” dialects (i.e. African American Vernacular English, Standard American English, and Chicano American English) is significantly dependent on formant frequencies. Listeners were able to identify the dialect of a given token when the formant frequencies were swapped between dialects (e.g. the formant frequencies of the AAVE dialect would be acoustically paired with the fundamental frequency of the SAE dialect). This supports findings by Purnell, et al., (1999), who found differences in the second formant frequency values of a trialectal speaker of the same three dialects.

These studies point to the importance of duration and formant frequencies in the identification of perceived differences in the speech signal. Although duration and formant frequencies have been investigated in speakers of prominent dialects/languages,
these cues in less common languages/dialects, such as Haitian Kreyol, have not been investigated.

2.4. Haitian Kreyol

Haitian Kreyol is a member of the “Atlantic French-based Creoles.” By definition, a creole is a “dialect or language which is the result of contact between the language of a colonizing people and the languages of a colonized people” (Roberts, 1998; p. 13). A creole is an autonomous language, with rules that differ from the languages from which it was derived (Laver, 1994; Holm, 1988, Muhlhausler, 1986). Creoles can begin as a pidgin, a language form that combines reduced/simplified forms of dominant and non-dominant languages in order to facilitate communication required for specific tasks (such as trade). Once the pidgin has acquired native speakers (via. descendents’ use of a pidgin as a first/native language), its forms are expanded and it evolves into a creole. However, not all language varieties fall into this “classic” definition of a creole. Haitian Kreyol, as well as other Caribbean Creoles, are said to be language varieties of the European languages spoken by the colonizers. These linguistic varieties are considered second language varieties that exhibit features of native African languages (Mufwene, 2002; Chaudenson, 2003).

Haitian Kreyol derives approximately 90% of its lexicon from 16th-18th century French, but its morphology, semantics and syntax is more closely related to West African languages (Savain, 1999; St. Fort, 2000). Though approximately 90% of Kreyol's
vocabulary is derived from French, few Haitians (approximately 5-10%) actually speak French (http://www.culturalorientation.net/haiti/hlang.html). Kreyol is the primary language spoken by about 90-95% of Haitians, and with approximately 8 million speakers in Haiti and approximately one million speakers worldwide, Kreyol is considered the most widely spoken creole in the world (St. Fort, 2000).

2.4.1. Origins

As with most creoles, the origins of Haitian Kreyol have been debated among scholars (Cadely, 2006). The impact of African languages versus colonial languages on the development of Kreyol is the major factor that impacts theories on Kreyol's origins. According to Winford (2006), the French had a presence in Haiti (known then as St. Dominique) as early as the 1600s. In 1665, there were small numbers of French colonists and their slaves. This low colonist to slave ratio allowed for closer interactions, resulting in the direct learning of French dialects spoken by the colonists.

Between 1681 and 1791, the population of the colony was made up of mostly French colonists, and their slaves (the minority). After that time, with the growth of sugar plantations and the importing of African slaves to work the plantations, the population of the colony shifted from majority White French colonist to majority Black African slave. This change in demographics altered the interaction pattern and, as a
result, the language. Lefebvre (2001) indicates that this is truly when Haitian Kreyol developed. She indicated that between 1680-1740 contact between Haitians of African descent was extensive, whereas contact between Haitians of African descent and French colonists was limited. In 1728, the slave population in Haiti was approximately 50,000 (Muysken, P. and Veenstra, 1995). From 1741-1791, the slave population was approximately 500,000 with the majority coming from West Africa (St. Fort, 2000). The large number of Africans in Haiti likely retained certain aspects of their native language. This likely influenced the learning of the French variety spoken in the colony. Sylvain (1936) identified African and French features in Kreyol, with the African influence coming mainly in the form of syntactic similarities to Niger-Congo languages (Holm, 1988).

Although different views exist on the precise nature of the emergence of Kreyol, there is a general consensus that Kreyol is the result of language contact between regional French spoken by the colonists and African languages spoken by slaves brought to the area (Corne, 1999; DeGraff, 2002; http://www.culturalorientation.net).

2.4.2. Standardization

Even with the predominant use of Kreyol as the primary language in Haiti, Kreyol did not become an official language until 1987 (St. Fort, 2000). Historically, Kreyol was
considered an informal language, used in everyday interactions. French was the language used in formal situations, including education, legal proceedings, etc. (Etienne, 2005)

Kreyol has gone through many changes in attempts to standardize it. Early attempts at recording Kreyol in written form began in 1786. Most of the early attempts at writing Kreyol yielded texts that closely resembled French (St. Fort, 2000). In 1943, linguist Charles Laubach, and minister H. O. O’Connell, used the International Phonetic Alphabet (IPA) form to represent spoken Kreyol words (Metellus, 1998; Savain, 1999). From 1975-1979, educators and linguists developed a new spelling system for Kreyol that would be used for language instruction. The new rules were based on the following phonetic principles:

1. One sign for each sound
2. The same sign for the same sound
3. No silent letters
4. Each letter has its own function

These principles helped form the Haitian Kreyol alphabet. Table 2.6 provides the 30 symbols that make up the Haitian Kreyol’s alphabet.
Consonants | Vowels | Semi-vowels
---|---|---
[b, ch, d, f, g, h, j, k, l, m, p, r, s, t, v, z] | [a, an, e, é, en, i, o, ó, on, ou] | [ui, w, y]

Table 2.6 Haitian Kreyol Alphabet

With the development of a Kreyol orthography (in 1980), the status of Kreyol began to change. Kreyol became an official language of Haiti in 1987 and more people began to use Kreyol during public interactions (including education and official meetings). However, the use of Kreyol for official business and as the standard written medium has not been prevalent. Even though many documents are written in Kreyol, many Kreyol speakers do not read Kreyol. Children in Haiti are still taught their lessons in French, although reading and writing are supposed to be taught in Kreyol for two hours a day (Regan, 2005). Though Kreyol has been accepted as a spoken language, the acceptance of written/standard Kreyol is still a work in progress.

2.4.3. Phonology

Though Kreyol is one of the most often studied of the creoles, the vast majority of the research has been in the area of morphology, syntax, and semantics (St. Fort, 2000). This is the result of the controversy surrounding Kreyol's "French versus African"
origins. Few studies written in English (Tinelli, 1981) have done an in-depth analysis of Kreyol phonology.

As with all languages, dialectal differences occur in Kreyol. There are between three to five dialects in Haitian Kreyol, which vary by region (Corne, 1999; St. Fort, 2000; Muysken & Veenstra, 1995). Kreyol spoken in rural areas tends to sound less French than Kreyol spoken in urban areas (Muysken & Veenstra, 1995). The prestige/standard dialect is found in the central part of the country (where the capital, Port-au-Prince, is located). Kreyol spoken in this part of Haiti tends to have more of a French influence. Kreyol spoken in the northern part of the country (which includes the city of Cap-Haitien) differs from Kreyol spoken in both central and southern (including Cays) regions in terms of nasality (Muysken and Veenstra, 1995; St. Fort. 2000). Most Haitians are bidialectal, speaking both the standard dialect along with their native dialect (St. Fort, 2000; Muysken & Veenstra, 1995). According to Corne (1999), dialectal differences in Haitian Kreyol have not been fully described or analyzed.

Haitian Kreyol has ten vowels in its phonological system, including three nasal vowels and seven non-nasal vowels (Savain, 1999; St. Fort, 2000; Muysken and Veenstra, 1995; Tinelli, 1981). Some (Corne, 1999) that have identified Kreyol more closely with French have identified two additional nasal vowels /i/ and /ũ/). However most have come to a consensus on at least 3 of the nasal vowels. (See Table 2.7 for Haitian Kreyol vowels).
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Example (in Kreyol)</th>
<th>Example (in English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/i/</td>
<td>[diri] (rice)</td>
<td>[beet]</td>
</tr>
<tr>
<td>/ɛ/</td>
<td>[bèbè] (mute)</td>
<td>[bet]</td>
</tr>
<tr>
<td>/e/</td>
<td>[bebe] (baby)</td>
<td>[make]</td>
</tr>
<tr>
<td>/a/</td>
<td>[papa] (father)</td>
<td>[hot]</td>
</tr>
<tr>
<td>/u/</td>
<td>[moumou] (house dress)</td>
<td>[shoe]</td>
</tr>
<tr>
<td>/o/</td>
<td>[bobo] (small cut)</td>
<td>[go]</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>[bozo] (elegant)</td>
<td>[awful]</td>
</tr>
<tr>
<td>/ɑ/</td>
<td>[manman] (mother)</td>
<td>No English equivalent</td>
</tr>
<tr>
<td>/ɔː/</td>
<td>[bonbon] (sweet cake)</td>
<td>No English equivalent</td>
</tr>
<tr>
<td>/ɛː/</td>
<td>[benyen] (bathing)</td>
<td>No English equivalent</td>
</tr>
</tbody>
</table>

Table 2.7 Haitian Kreyol Vowels (Savain, 1999; Muysken & Veenstra, 1995, Corne, 1999).
Though research has examined speech production in various bilingual speakers (Goldstein, et al., 2005; Goldstein & Washington, 2001; Ray, 2002), to date there has been little research examining Kreyol/English bilingual speakers. One of the few studies noted was a speech perception study by Felder (2003). This study investigated SLM as it pertained to bilingual/bidialectal speakers. Felder predicted that L1 as well as the dialect of L2 would influence perception of fricatives /θ/, /ð/. Subjects were adult native speakers of either Haitian Kreyol or African American Vernacular English. They were asked to discriminate between the minimal pairs that correspond to common substitutions in both Kreyol and AAVE (e.g., f/θ, d/ð, v/ð for AAVE and t/θ, t/ð for Haitian Kreyol).

Results indicated that although AAVE subjects exhibited better discrimination abilities than Kreyol subjects, overall, all subjects had difficulty with non-native contrasts (e.g., Kreyol speakers had difficulty perceiving substitution contrasts of AAVE, and AAVE speakers had difficulty perceiving substitution contrasts of Kreyol). These findings support those views of Flege (1995) and point toward a view of dialect speakers as having a more “native-like” perception than a bilingual speaker.

Because studies have indicated that perception influences production (Keller, 1993; Cunningham, 1997; Flege, 1995), it can be said that “native-like” perception yields “native-like” production. Does this concept change when the speaker is influenced by two languages simultaneously? Goldstein (2001) notes that the phonological system of a child that speaks Spanish can influence that child’s production of English. However, to
date, there are no known studies that look at this possibility for Haitian American children that are fluent in or influenced by English and Haitian Kreyol. Knowing this information becomes very important for the speech-language pathologist who has a Haitian American child on her caseload. Not all speech-language pathologists have access to interpreters, bilingual support personnel, or family members that can determine what is typical in terms of development. This problem can become compounded if we consider that the child is not only influenced by one language, but two.

If we consider the fact that an older speaker learning a second language is less likely to sound like a native speaker of L2, what happens when a younger speaker learns a second language? In order to address this question, the goal of this study is to provide information on the speech patterns of Haitian American children born in the United States (to Haitian parents) that are influenced not only by Kreyol, but by English. Speakers’ vowel spaces will be compared as they produce words containing American English and Haitian Kreyol vowels.
CHAPTER 3

METHODOLOGY

This study was designed to provide developmental data on Haitian American children. Specifically, the goal of this research is to describe the English and Kreyol vowel spaces of kindergarteners of Haitian descent. Because Haitian American children are influenced by both Haitian and American languages/cultures, this study will not only describe the Kreyol vowel space, but will describe their English vowel space as well.

Due to its large Haitian population and its close proximity to Haiti, Florida is one of the ideal locations to conduct this research. According to estimates from Haitians for Economic Development (HAFED), South Florida is home to the second largest Haitian population in the United States, with approximately 385,000 people. Of this number, approximately 260,000 were born in the United States (http://www.haiti-usa.org/modern/HAFED.pdf). United States Census 2000 records indicate that, in Broward County (which includes the city of Fort Lauderdale), approximately 4% of its residents (nearly 63,000 people) are of Haitian descent (www.co.broward.fl.us/planningservices/bbtn6.pdf). According to data compiled by Visions Decisions Demography for Churches, about 34% of the Haitian population in this area (as of 2000) was between the ages of 25-44. Children under the age of 18 represent approximately 35% of the Haitian population. Approximately 72% of the Haitian population in the area was born outside of the United States and about 95% of Haitians
ages 5 and older in the area speak Kreyol in the home (leaving only 5% that speak only English at home) (http://www.visions-decisions.com/ETHPRO.pdf).

3.1. Subjects

Ten Haitian American children (6 male, 4 female) and eight non-Haitian American children (4 male, 4 female) participated in this study. The label of Haitian American was used for subjects born in the United States to Haitian parents. Non-Haitian children (the control group) consisted of Black American children born to parents that were not of Haitian descent. These children were either of American or Caribbean descent. Of the Haitian American children, five were monolingual English speakers and five were bilingual (English/Kreyol) speakers (see Table 3.1 for participant description).
Participants were recruited from kindergarten classes at 2 private church schools in Fort Lauderdale (Broward County), Florida. The schools were located on the border of Lauderhill and Plantation, Florida, which is an area with a large concentration of Haitian Americans (see Figure 3.1 for map of Haitian American population in central Broward County). The children were between the ages of 5-6 years old.

All subjects used English during school interactions. A short questionnaire (See Appendix A) was administered to parents (in either oral or written form) in the parents’ preferred language to obtain information on the subjects’ language use at home. An English/Kreyol interpreter provided services to parents if or when needed. Four out of five parents of the bilingual subjects, three parents of the monolingual subjects, and seven parents of the non-Haitian subjects filled out the questionnaire. Of the monolingual
subjects, two parents responded that their child is either spoken to or hears Kreyol during the day. Three of the five bilingual subjects were reported to have learned Kreyol first (though born in the United States). Of the remaining bilingual subjects, one learned Kreyol and English at the same time, and the other did not respond to the questionnaire. Table 3.2 provides a breakdown of language use by subject.
Figure 3.1 Haitian American population in central Broward County, FL
Table 3.2 Language Input for Each Haitian American Participant

<table>
<thead>
<tr>
<th>Subject</th>
<th>Language Status</th>
<th>Language Spoken in the Home</th>
<th>Language Learned First</th>
<th>Exposed to Kreyol Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bilingual</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>4</td>
<td>Bilingual</td>
<td>Kreyol</td>
<td>Kreyol</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Monolingual</td>
<td>English</td>
<td>English</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Bilingual</td>
<td>Kreyol/English</td>
<td>Kreyol</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Monolingual</td>
<td>English</td>
<td>English</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Monolingual</td>
<td>English/Kreyol</td>
<td>Kreyol</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Monolingual</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>17</td>
<td>Monolingual</td>
<td>English</td>
<td>English</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Bilingual</td>
<td>Kreyol/English</td>
<td>Kreyol/English</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>Bilingual</td>
<td>Kreyol</td>
<td>Kreyol</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Each subject was required to pass a pure tone hearing screening at 20 dB HL at 500, 1000, 2000, and 4000 Hz. An oral motor screening was administered to ensure normal oral-motor function. Because of noted differences between mainstream American English and minority language/dialect users on standardized assessments (Cole
and Taylor, 1990; Washington and Craig, 1992), formal language and articulation tests were not given. Language status (whether the subject was monolingual or bilingual) was obtained from teacher and parent reports. An informal assessment by a certified speech-language pathologist as well as teacher and parent reports were used to determine if a possible speech/language disorder was present.

Follow-up information and referrals were given to parents of five children (one of non-Haitian descent and four of Haitian descent) that exhibited abnormal speech/language/hearing behaviors. Two of the five children did not pass the hearing screening. One speaker had an ear infection at the time of the screening, and the other exhibited symptoms of a sinus infection or allergies. Because teacher reports indicated that the two speakers were good students, the informal language screening was administered in spite of hearing results. Both speakers passed the language and articulation screening.

One of the five children (a monolingual English speaker) exhibited developmental errors of consonant sound, /t/ (based on English developmental norms). However, this speaker did not exhibit any vowel errors. The remaining two subjects exhibited difficulty with skills in the informal language screening. Although these subjects exhibited abnormal language behaviors, they did not exhibit any articulation errors. Based on the fact that none of the “referred” subjects exhibited vowel errors, it was the recommendation of the speech-language pathologist that these subjects remain a
part of the sample in order to obtain a realistic representative sample of vowel production abilities.

### 3.2. Stimuli

Two sets of picture stimuli were presented to elicit word productions in both English and Kreyol. The English stimulus set contained 18 pictures, whereas the Kreyol stimulus set contained 20 pictures. Both sets of picture stimuli were flashcards of everyday household/play items gathered from Baby Bumblebee (http://www.babybumblebee.com) (See Appendix B). Elicited words contained the following vowels: /ɪ, i, ɛ, ae, u, o, ɑ, ɔ, ści, ā, ɔ/. Oral vowels, in general, exist in the vowel inventory of both English and Kreyol. Although nasal vowels occur in English, they are allophones of oral vowels and do not represent separate and distinct phonemes. However, in order to maintain balance in the stimuli, English words that have features of nasal assimilation were included in the stimulus set. Stimuli were presented in 3 syllabic formats. In English, stimulus items were in Consonant Vowel Consonant (CVC) or CCVC format only since English lax vowels cannot occur in open syllables. However, in Kreyol, the labels for the target vowels can occur in CV, CVC, or CVCV formats. Table 3.3 provides labels for the stimulus items in both English and Kreyol.
<table>
<thead>
<tr>
<th>English</th>
<th>IPA</th>
<th>Kreyol</th>
<th>IPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boot</td>
<td>but</td>
<td>Bouch (Mouth)</td>
<td>buʃ</td>
</tr>
<tr>
<td>Spoon</td>
<td>spūn</td>
<td>Boul (Ball)</td>
<td>bul</td>
</tr>
<tr>
<td>Baby</td>
<td>bebi</td>
<td>Zye (Eye)</td>
<td>zje</td>
</tr>
<tr>
<td>Train</td>
<td>tʁeŋ</td>
<td>Pye (Foot)</td>
<td>pje</td>
</tr>
<tr>
<td>Boat</td>
<td>bot</td>
<td>Chapo (Hat)</td>
<td>ʃapo</td>
</tr>
<tr>
<td>Comb</td>
<td>kɔm</td>
<td>Dlo (Water)</td>
<td>dlo</td>
</tr>
<tr>
<td>Tree</td>
<td>tri</td>
<td>Liv (Book)</td>
<td>liv</td>
</tr>
<tr>
<td>Key</td>
<td>ki</td>
<td>Bis (Bus)</td>
<td>bis</td>
</tr>
<tr>
<td>Pig</td>
<td>pɪɡ</td>
<td>Flé (Flower)</td>
<td>flɛ</td>
</tr>
<tr>
<td>Fish</td>
<td>fɪʃ</td>
<td>Chez (Chair)</td>
<td>ʃɛ</td>
</tr>
<tr>
<td>Dress</td>
<td>dɾes</td>
<td>Mato(Hammer)</td>
<td>mato</td>
</tr>
<tr>
<td>Leg</td>
<td>leg</td>
<td>Tab (Table)</td>
<td>tab</td>
</tr>
<tr>
<td>Hand</td>
<td>hænd</td>
<td>Ból (Bowl)</td>
<td>bol</td>
</tr>
<tr>
<td>Cat</td>
<td>kæt</td>
<td>Póm (Apple)</td>
<td>pɔm</td>
</tr>
<tr>
<td>Clock</td>
<td>klʌk</td>
<td>Chen (Dog)</td>
<td>ʃɛ</td>
</tr>
<tr>
<td>Car</td>
<td>kær</td>
<td>Nen (Nose)</td>
<td>nɛ</td>
</tr>
<tr>
<td>Cup</td>
<td>kʌp</td>
<td>Elefan (Elephant)</td>
<td>ɛlɛfɑ</td>
</tr>
<tr>
<td>Duck</td>
<td>dʌk</td>
<td>Zoranj (Orange)</td>
<td>zɔɾɑʒ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lion (Lion)</td>
<td>liɔ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avyon (Plane)</td>
<td>ɑvjo</td>
</tr>
</tbody>
</table>

*Stimuli in bold indicate Kreyol nasal vowels and nasalized English vowels

Table 3.3 Stimulus Items (www.babybumblebee.com; www.kreyol.com; Savain, 1999)
3.3. Procedures

Subjects were tested in a quiet room. Stimuli were presented in picture form using flash cards. Each subject participated in a practice session in order to become familiar with the stimulus pictures. Each child was asked to provide a label for each given stimulus item in English and/or Kreyol (See Appendix C for elicitation script). When a child was unable to provide a label, a model was provided and the child was asked to repeat the label.

Subjects wore a head-mounted Platronics DSP-400 headset with a noise canceling microphone. Subjects’ productions were recorded directly onto a computer hard drive as a Quick Time audio file (.mov file) using a sampling rate of 44.1 kHz with 16-bit quantization. Tokens were then exported as a .wav file using the same sampling/quantization rate and saved on disk.

3.4. Acoustic Analysis

Subjects’ productions were segmented using the waveform analysis program, Adobe Audition1.5. Before segmentation, samples underwent a noise reduction process to reduce ambient noise in the signal. A portion of each sample (which contained ambient noise only) was taken out to create a noise profile. This profile was then applied
to the subject’s entire signal. This “noise reduction” process was implemented for each subject. Once each sample went through the process, it was saved to a disk and down-sampled to 11.025 kHz for spectrographic analysis.

Target vowels for each word were then analyzed using TF32 (Milenkovic, 2001). TF32 is an acoustic analysis software program that allows for extraction and analysis of speech and other audio-frequency waveforms. Vowel onsets and offsets were located manually (using the waveform and spectrogram as a reference). Determination of vowel onset location was made as follows:

1. For vowels preceded by stop consonants: Vowel onsets were marked just after the release of the consonant (and at the beginning of voicing for a particular vowel). Vowel offsets were marked at the beginning of the closure for the final consonant following the target vowel.

2. For vowels preceded by the liquid /l/: The vowel onset was marked following elimination of the spectral zero (produced by alveolar contact) and increased energy in the F2-F3 frequency range.

3. For vowels preceded by the liquid /r/: Vowel onsets were marked at the point where F3 was raised and separated from F2 (i.e., the point at which the sound was no longer rhotacized).
4. For vowels followed by the liquid /r/: Vowel offsets were marked at the point where F3 was lowered to a frequency close to F2 (i.e., onset of rhotacticization).

5. For vowels followed by nasals /n, m/, with the exception of Kreyol nasal vowels: Vowel offsets were marked at the drop in amplitude energy at the third formant.

The onsets and offsets were used to calculate the overall vowel duration. Formant frequency values were then extracted manually with 98% pre-emphasis using LPC with a 450 Hz bandwidth and a Hamming window. F1 and F2 frequencies were measured at three temporal points within the duration of the vowel:

1. 20 ms from vowel onset
2. at vowel midpoint
3. 20 ms from vowel offset

3.5 Data Analysis

Data for Haitian American subjects consisted of both Kreyol and English words (38 words total). All Haitian subjects produced both Kreyol and English vowels, with the exception of subject 8 (who produced English words, but refused to say or repeat any
words in Kreyol). Haitian subjects produced the ten Kreyol vowels two times each (for a total of 180 tokens).

Both Haitian and non-Haitian subjects produced the nine English vowels two times each, for a total of 324 English tokens (180 for Haitian American subjects; 144 for Non-Haitian subjects).
CHAPTER 4
VOWEL DURATION

This study was designed to examine the vowels of Haitian American children during their productions of Kreyol and English words. Because vowel duration differences are an important cue in the development of children’s vowel production (as well as a cue for linguistic differences), it is an important component in providing an accurate description of the vowel. The current chapter will discuss and describe the durational characteristics of both the Kreyol and English vowels produced in this study.

4.1 Kreyol Vowel Durations

Mean vowel durations in milliseconds for all vowels across all Haitian American subjects are shown in Table 4.1. These durations were analyzed using a repeated-measures ANOVA with one within-subject factor (vowel) and two between subject factors (group and gender). Eta squared ($\eta^2$) values, a measure of effect size (the strength of the relationship between variables), are also reported.

4.1.1. All Haitian-American Speakers

ANOVA results indicated a significant main effect for vowel type [$F(9,45)=5.881$, $p<.001$, $\eta^2=.540$]. Post hoc analyses using Bonferonni adjusted paired t-tests were performed to determine which vowels were significantly different. Results
indicated significant vowel duration differences (at the adjusted p<.05 level or better) for the following vowel pairs: /i/>/õ/; /e/< /õ/; /e/>/u/; /e/>/e/; /e/>/a/; /e/>/o/; /e/>/ɔ/; /ʊ/ > /ɑ/. Overall, Haitian-American speakers’ production of /e/ was significantly longer in duration than /i, u, e, a, ɔ/. Overall production of /i/ was significantly longer than /õ/. Nasal vowel /ʊ/ was longer than its non-nasal cognate, /ɑ/.

Longer /e/ durations were not expected due to its “lax” quality. However, phonetic context (i.e. the position of /e/ in the word/syllable) appears to play a part in longer durations. Both target words provided opportunities for vowel lengthening. The word-final position of /e/ in /fle/ promotes longer vowel duration because it is part of a stressed syllable. In /fɛz/, because /e/ is part of a stressed syllable that is before a voiced word-final consonant, it is more likely to be produced with greater duration (Rosner and Pickering, 1994). These findings support rules set forth in Klatt (1987), which describe features to consider when creating synthetic vowels.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration in ms (Std. Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ō</td>
<td>211 (75.0)</td>
</tr>
<tr>
<td>ē</td>
<td>251 (86.1)</td>
</tr>
<tr>
<td>ā</td>
<td>267 (90.0)</td>
</tr>
<tr>
<td>i</td>
<td>256 (94.7)</td>
</tr>
<tr>
<td>u</td>
<td>210 (69.2)</td>
</tr>
<tr>
<td>e</td>
<td>214 (64.4)</td>
</tr>
<tr>
<td>a</td>
<td>198 (65.0)</td>
</tr>
<tr>
<td>o</td>
<td>215 (77.4)</td>
</tr>
<tr>
<td>e</td>
<td>303 (94.1)</td>
</tr>
<tr>
<td>o</td>
<td>243 (92.3)</td>
</tr>
</tbody>
</table>

Table 4.1 Mean vowel durations (in ms) for all Haitian American subjects
4.1.2. Haitian-American Monolingual vs. Bilingual Speakers

Mean vowel durations (in ms) for each subject as a function of group can be found in Table 4.2. Though Haitian American monolingual English (HAM) speakers had slightly longer vowel durations than their Haitian American bilingual (HAB) counterparts (See Figure 4.2), ANOVA results indicated that these differences were not significant \( [F(1,5) = .293 \ p = .611, \ \eta^2 = .055] \). A contributing factor to this insignificant difference could have been the “one-on-one” model provided by the interpreter. Because of their
inexperience with Kreyol, HAM speakers were unable to spontaneously provide Kreyol labels for stimulus pictures. Therefore, these speakers, when presented with the Kreyol stimulus items, were asked to imitate Kreyol labels provided by the interpreter. There were little to no spontaneous productions of the target words. If a “one-on-one” model had not been provided, the durational differences between the groups might have been more significant. There were also no significant group interactions observed.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>HAM Durations</th>
<th>HAB Durations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ō</td>
<td>219 (101.4)</td>
<td>205 (50.4)</td>
</tr>
<tr>
<td>ē</td>
<td>264 (116.1)</td>
<td>240 (56.7)</td>
</tr>
<tr>
<td>ā</td>
<td>266 (75.0)</td>
<td>267 (104.5)</td>
</tr>
<tr>
<td>i</td>
<td>251 (111.4)</td>
<td>260 (85.0)</td>
</tr>
<tr>
<td>u</td>
<td>228 (91.)</td>
<td>196 (45.9)</td>
</tr>
<tr>
<td>e</td>
<td>208 (73.0)</td>
<td>219 (60.3)</td>
</tr>
<tr>
<td>a</td>
<td>203 (78.1)</td>
<td>193 (56.5)</td>
</tr>
<tr>
<td>o</td>
<td>237 (97.1)</td>
<td>196 (56.3)</td>
</tr>
<tr>
<td>ē</td>
<td>330 (119.0)</td>
<td>282 (67.5)</td>
</tr>
<tr>
<td>ō</td>
<td>265.8 (128)</td>
<td>224 (50.3)</td>
</tr>
</tbody>
</table>

Table 4.2 Mean Kreyol Vowel Durations and Standard Deviations (in ms) for Haitian American Monolingual and Bilingual Speakers. Standard deviations are in parentheses.
4.1.3. Male vs. Female Speakers

Mean Kreyol vowel durations (in ms) for male and female speakers can be found in Table 4.3. In general, female speakers’ total vowel durations were longer than their male counterparts (see Figure 4.3), although this difference was not significant.
There were also no significant gender interactions observed.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Female Durations</th>
<th>Male Durations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ò</td>
<td>232 (83.1)</td>
<td>185 (58.1)</td>
</tr>
<tr>
<td>ê</td>
<td>287 (94.0)</td>
<td>205 (48.0)</td>
</tr>
<tr>
<td>ā</td>
<td>284 (98.5)</td>
<td>245 (79.0)</td>
</tr>
<tr>
<td>i</td>
<td>278 (100.9)</td>
<td>230 (85.0)</td>
</tr>
<tr>
<td>u</td>
<td>222 (81.2)</td>
<td>195 (51.6)</td>
</tr>
<tr>
<td>e</td>
<td>228 (57.2)</td>
<td>197 (72.4)</td>
</tr>
<tr>
<td>o</td>
<td>199 (73.1)</td>
<td>196 (58.2)</td>
</tr>
<tr>
<td>o</td>
<td>236 (93.6)</td>
<td>188 (42.8)</td>
</tr>
<tr>
<td>ε</td>
<td>346 (93.1)</td>
<td>250 (66.6)</td>
</tr>
<tr>
<td>ɔ</td>
<td>273 (108.5)</td>
<td>205 (51.3)</td>
</tr>
</tbody>
</table>

Table 4.3 Mean Kreyol Vowel Durations (in ms) for Male and Female Speakers. Standard deviations are in parentheses.
Figure 4.3 Mean Kreyol Vowel Durations for Male and Female Haitian American Speakers
4.2 English Vowel Durations

4.2.1. All Haitian-American Speakers

Mean English vowel durations for Haitian American speakers are reported in Table 4.4. At first glance, it was observed that /ʌ/ had the shortest duration; and /i/ the longest duration (see Figure 4.4). ANOVA results indicated a significant effect of vowel type on duration [F(8,48)=11.579, p<.001], η² = .659. Post hoc analyses using Bonferonni adjusted paired t-tests indicated significant vowel duration differences (at the adjusted p<.05 level or better) for the following vowel pairs: /i/>/e/; /i/>/e/; /i/>/ʌ/; /i/>/ɜ/; /i/>/æ/; /æ/>/ʌ/; /æ/>/e/; /æ/>/æ/; /æ/>/ʌ/; /æ/>/ʌ/; /ʌ/>/e/; /ʌ/>/o/; /ʌ/>/u/.

Specifically, /i/ was significantly longer than /e/, /e/, /ʌ/, /ʌ/ and /æ/. The centralized lax vowel, /ʌ/, was significantly shorter than /i/, /i/, /e/, /e/, /æ/, /o/, /u/. (See Figure 4.4). Significantly longer /i/ durations could be attributed to vowel context. Target words for /i/ were in CV context, providing an opportunity for final vowel lengthening (Rosner and Pickering, 1994). Shorter /ʌ/ duration can also be attributed to vowel context. Target words contained voiceless consonants, which influenced the length of the preceding vowel, making them shorter (Klatt, 1987).
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration in ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>251 (65.1)</td>
</tr>
<tr>
<td>e</td>
<td>227 (57.6)</td>
</tr>
<tr>
<td>e</td>
<td>233 (66.1)</td>
</tr>
<tr>
<td>i</td>
<td>281 (66.5)</td>
</tr>
<tr>
<td>ï</td>
<td>209 (50.0)</td>
</tr>
<tr>
<td>o</td>
<td>248 (65.6)</td>
</tr>
<tr>
<td>u</td>
<td>227 (76.7)</td>
</tr>
<tr>
<td>œ</td>
<td>191 (48.5)</td>
</tr>
<tr>
<td>ɔ</td>
<td>161 (33.7)</td>
</tr>
</tbody>
</table>

Table 4.4 Mean English Vowel Durations (in ms) for All Haitian American Subjects. Standard deviations are in parentheses.)
4.2.2. Haitian-American Bilingual vs. Monolingual Speakers

Mean English vowel durations (in ms) for Haitian American Bilingual (HAB) and Monolingual (HAM) speakers are located in Table 4.5. ANOVA results revealed no significant differences between the two groups \[F(1,6)=.044, \ p=.842, \ \eta^2=.007\]. HAB and HAM speakers produced English vowels with relatively similar durations. (See Figure 4.5).
Table 4.5 Mean English Vowel Durations (in ms) for Haitian American Monolingual and Haitian American Bilingual Speakers. Standard deviations are in parentheses.
Figure 4.5 Mean English Vowel Durations for Haitian American Bilingual (HAB) and Haitian American Monolingual (HAM) Subjects
4.2.3. Haitian-American Bilingual vs. Monolingual Speakers: Gender Differences

Mean English vowel durations (in ms) for male and female Haitian American speakers are found in Table 4.6. ANOVA results indicated a significant main effect for gender \[ F(1,6)=8.984, \ p<.05 \], \( \eta^2 = .600 \). Female subjects’ vowel durations were longer than their male counterparts (See Figure 4.6). These results are similar to those found in Hillenbrand, et al (1995) and Lee, et al (1999). When these results were broken down by group, a significant interaction was observed between group and gender \[ F(1,6)=6.060, \ p<.05 \], \( \eta^2 = .502 \). HAB male and female durations were not significantly different (See Fig 4.7). However, HAM female durations were significantly longer than their male counterparts (See Figure 4.8). These results were likely the consequence of subject variability. Subject 10 (female HAM speaker), specifically, produced longer vowels than any other subjects overall. That subject, generally, exhibited a slower rate of speech across all contexts (See Appendix D).
<table>
<thead>
<tr>
<th>Vowel</th>
<th>HAM Durations</th>
<th>HAB Durations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>æ</td>
<td>204 (50.3)</td>
<td>306 (86.2)</td>
</tr>
<tr>
<td>e</td>
<td>193 (43.3)</td>
<td>280 (51.1)</td>
</tr>
<tr>
<td>e</td>
<td>196 (39.7)</td>
<td>288 (98.9)</td>
</tr>
<tr>
<td>i</td>
<td>236 (50.2)</td>
<td>337 (93.4)</td>
</tr>
<tr>
<td>ï</td>
<td>192 (46.8)</td>
<td>251 (44.9)</td>
</tr>
<tr>
<td>o</td>
<td>203 (28.3)</td>
<td>283 (88.8)</td>
</tr>
<tr>
<td>u</td>
<td>219 (75.5)</td>
<td>264 (86.0)</td>
</tr>
<tr>
<td>ɔ</td>
<td>149 (28.7)</td>
<td>218 (64.4)</td>
</tr>
<tr>
<td>ʌ</td>
<td>136 (32.5)</td>
<td>193 (14.7)</td>
</tr>
</tbody>
</table>

Table 4.6 Mean English Vowel Durations (in ms) for Male and Female Haitian American Monolingual and Haitian American Bilingual Speakers. Standard deviations are in parentheses.
Figure 4.6 Mean English Vowel Durations (in ms) for All Male and Female Haitian American Speakers
Figure 4.7 Mean English Vowel Durations (in ms) for Male and Female Haitian American Bilingual (HAB) Speakers.
4.2.4 All Haitian-American and Non-Haitian Speakers

Vowel durations of Haitian American speakers were compared to Non-Haitian speakers from the same geographical region. Mean English vowel durations (in ms) for Haitian (HA) and Non-Haitian (NH) speakers are located in Table 4.7. ANOVA results revealed a significant effect of vowel type on vowel duration \( [F(8,112)=22.301, p<.001,\)

Specifically, /i/ was produced with the longest duration overall, significantly longer than /e, ɛ, ɪ, ɑ, ʌ/. The vowel /æ/ was significantly longer than /ɪ, ɑ, ʌ/. The vowel /ʌ/ was the shortest vowel overall, followed by /ɑ/ (See Figure 4.9).

The vowel /i/ was produced in CV context, which resulted in final vowel lengthening. The short duration for /ʌ/ can be attributed to its neutral position in the vowel space (which allows for a shorter transition time between it and the adjacent consonants), as well as by the influence of the adjacent voiceless consonant.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Haitian American Durations</th>
<th>Non-Haitian Durations</th>
<th>All Subjects’ Durations</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>251 (65.1)</td>
<td>235 (57.5)</td>
<td>244 (61.5)</td>
</tr>
<tr>
<td>e</td>
<td>227 (57.6)</td>
<td>225 (49.7)</td>
<td>226 (53.5)</td>
</tr>
<tr>
<td>ε</td>
<td>234 (66.1)</td>
<td>214 (69.6)</td>
<td>225 (67.4)</td>
</tr>
<tr>
<td>i</td>
<td>281 (66.5)</td>
<td>255 (76.0)</td>
<td>270 (71.0)</td>
</tr>
<tr>
<td>ɪ</td>
<td>209 (50.0)</td>
<td>193 (46.4)</td>
<td>202 (48.4)</td>
</tr>
<tr>
<td>o</td>
<td>248 (65.6)</td>
<td>268 (77.1)</td>
<td>257 (70.6)</td>
</tr>
<tr>
<td>u</td>
<td>227 (76.7)</td>
<td>241 (79.2)</td>
<td>233 (77.0)</td>
</tr>
<tr>
<td>a</td>
<td>191 (48.5)</td>
<td>171 (57.7)</td>
<td>182 (52.9)</td>
</tr>
<tr>
<td>Λ</td>
<td>161 (33.7)</td>
<td>150 (55.5)</td>
<td>156 (44.4)</td>
</tr>
</tbody>
</table>

Table 4.7 Mean English Vowel Durations (in ms) for Haitian American and Non-Haitian Speakers.

Standard deviations are in parentheses.
4.2.5. Haitian-American vs. Non-Haitian Speakers

Table 4.7 provides the mean vowel durations for English vowels produced by HA and NH speakers. ANOVA revealed no significant differences in vowel length between Haitian American and Non-Haitian speakers. \[F(1,14) = .265, p = .614, \eta^2 = .019\] (See Figure 4.10).
4.2.6. Haitian-American vs. Non-Haitian Speakers: Gender Differences

Gender differences also were not significant \([F(1,14)=4.266, \ p=.058, \ \eta^2 =.234]\).

No interactions were observed. There were no differences between how male and female Haitian American or non-Haitian speakers produced vowels (See Figures 4.11 and 4.12).
Figure 4.11 Mean English Vowel Durations (in ms) for Haitian American (Combined) Male and Female Speakers.
Figure 4.12 Mean English Vowel Durations (in ms) for Non-Haitian Male and Female Speakers.

4.2.7. All Haitian-American Bilingual and Non-Haitian Speakers

In order to determine if the similarities between Haitian and Non-Haitian speakers was influenced by native language, Haitian American Monolingual (English) speakers were filtered out in order to examine durational differences that could occur between
native Non-Haitian (NH) and Haitian-American bilingual English/Kreyol (HAB))
speakers.

Mean English vowel durations for both HAB and NH speakers (combined) can be
found in Table 4.8. ANOVA results indicated a significant main effect for vowel type on
vowel duration [F(8,72)=13.045, p<.001], $\eta^2 = .592$. Post hoc tests revealed significant
differences in vowel duration for the following vowel pairs: /i/ > /u/; /i/>/a/; /æ/>/u/;
/æ/>/a/; /e/>/a/; /e/>/æ/; /o/>/i/; /o/>/e/; /i/>/a/; /u/>/a/; /ʌ/</i/; /ʌ/</u/; /ʌ/</e/;
/ʌ/</æ/; /ʌ/</o/; /ʌ/</u/ (See Figure 4.13).

Overall, /i/ had the longest duration of all the vowels, followed by /o/. The vowel
/ʌ/ had the shortest duration. Again, vowel length differences are most likely to the result
of consonantal influences.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Haitian American Bilingual</th>
<th>Non-Haitian</th>
<th>HAB and NH Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>258 (46.6)</td>
<td>235 (57.5)</td>
<td>244 (53.8)</td>
</tr>
<tr>
<td>e</td>
<td>225 (55.8)</td>
<td>225 (49.7)</td>
<td>225 (51.0)</td>
</tr>
<tr>
<td>ε</td>
<td>235 (53.3)</td>
<td>214 (69.6)</td>
<td>222 (63.5)</td>
</tr>
<tr>
<td>i</td>
<td>286 (47.4)</td>
<td>255 (76.0)</td>
<td>267 (67.1)</td>
</tr>
<tr>
<td>ñ</td>
<td>202 (48.4)</td>
<td>193 (46.4)</td>
<td>196 (46.4)</td>
</tr>
<tr>
<td>o</td>
<td>260 (62.9)</td>
<td>268 (77.1)</td>
<td>265 (70.7)</td>
</tr>
<tr>
<td>u</td>
<td>217 (77.7)</td>
<td>241 (79.2)</td>
<td>232 (78.0)</td>
</tr>
<tr>
<td>a</td>
<td>205 (36.0)</td>
<td>171 (57.7)</td>
<td>184 (52.4)</td>
</tr>
<tr>
<td>Λ</td>
<td>164 (31.2)</td>
<td>150 (55.5)</td>
<td>155 (47.4)</td>
</tr>
</tbody>
</table>

Table 4.8 Mean English Vowel Durations (in ms) for Haitian American Bilingual and Non-Haitian Speakers. Standard deviations are in parentheses.
4.2.8. Haitian-American Bilingual vs. Non-Haitian Speakers

ANOVA revealed no significant differences in vowel length between Haitian American Bilingual and Non-Haitian speakers. [F(1,9)=.267, p=.618, \( \eta^2 = .029 \)] (See Figure 4.14).
4.2.9. Haitian-American Bilingual vs. Non-Haitian Speakers: Gender Differences

Gender differences were also not significant \([F(1,9)=.660, p=.438, \eta^2=068]\). No interactions were observed. There were no gender differences among male and female Haitian American bilingual or non-Haitian speakers (See Figures 4.15 and 4.12).
Figure 4.15 Mean English Vowel Durations (in ms) for Haitian American Bilingual Male and Female Speakers.
4.3. Summary of Durational Results

Durational results examined in this study can be summarized using the questions posed in the beginning of this paper:

1. **What are the durational characteristics of Haitian Kreyol vowels spoken by American 4 and 5 year olds of Haitian descent?**

   Overall, the Haitian American speakers in this study produced vowels of varying lengths. The vowel /e/ was produced with the longest duration, followed by the nasal vowel /ā/ and the high front vowel, /i/. The low back vowel /a/ had the shortest duration overall. Some of the differences in vowel durations could be attributed to phonetic context.

2. **How do the durational characteristics of Haitian Kreyol vowels differ among male and female speakers?**

   There were no durational differences observed between male and female speakers of Haitian descent.

3. **What are the durational characteristics of American English vowels spoken by 4- and 5-year olds of Haitian descent?**

   As with Kreyol vowels, Haitian speakers produced English vowels with varying lengths. During production of English vowels, Haitian speakers produced the high front vowel /i/ with the longest duration. The vowel /ʌ/ had the shortest duration. These
findings support the concept that lax vowels exhibit shorter durations and more tense vowels exhibit longer durations. The differences could also be attributed to phonetic context.

There were no significant differences in how monolingual and bilingual Haitian American speakers produced English vowels. Bilingual speakers produced English vowels with native-like durational qualities. This appears to be the result of early/simultaneous English language learning.

4. How do these durational characteristics compare to that of native speakers of American English of similar ages?

When Haitian American productions were compared to their non-Haitian counterparts, there were no group differences observed. When monolingual Haitian American speakers were factored out, and bilingual Haitian and non-Haitian speakers were examined, group differences were again not significant. This could be attributed to simultaneous learning of English and Kreyol (by bilingual speakers). Speakers’ increased exposure and experience with English via school interactions allowed for native-like vowel duration (Flege, et al., 1999; Piske, et al., 2001).

5. How do the durational characteristics of English vowels differ among male and female speakers?

There were no significant gender differences observed for Haitian American speakers during production of Kreyol vowels.
Overall, for this group of speakers, the durational characteristics of Kreyol and English vowels did not appear to be influenced by gender or language status. These group results support findings of Flege (1999) and Flege, et al (2003) which indicated the importance of Age of Acquisition (AOA) and language use on native-like production. Although the gender results in this study were not statistically different, there were differences observed. Female HAM and NH speakers produced vowels with longer durations than their male counterparts. This result supports recent findings of Fox and Jacewicz (2008), who found, when replicating the House and Fairbanks (1953) study, that female speakers produced vowels with longer duration than male speakers. As the Italian/English “early” bilingual speakers in the previously mentioned studies, the Haitian American speakers in this study produced both English and Kreyol vowels with native-like duration.

The speakers in this study appeared to be able to distinguish durational features of both English and Kreyol and use them appropriately based on context. This appears to follow the theory of differentiation with autonomous development. These speakers, were born in the United States, and were influenced by both Haitian Kreyol and English early in development (according to parental language questionnaire), learning English as a first language or acquiring English as a second language early in life (before the age of 5). Those speakers that did not speak Kreyol received some input in Kreyol by family members or family friends. Therefore there was some familiarity with Kreyol before this study.
CHAPTER 5

RESULTS: VOWEL FORMANTS

The previous chapter provided a description of the durational characteristics of Kreyol and English vowels produced by Haitian-American 4 and 5 year old children. The current chapter describes the spectral characteristics—specifically, the formant measures—of the Kreyol and English vowels produced in this study. A two-way ANOVA (with group and gender as the between-subject factors) was performed to determine if significant differences existed between Haitian American monolingual (English) and bilingual (Kreyol/English) speakers during the production of Kreyol and English vowels. Gender differences, along with non-Haitian speaker comparisons, will also be discussed.

5.1 Kreyol Vowel Space

Mean F1 and F2 measures in Hz for all vowels across all Haitian-American subjects are located in Table 5.1. In an attempt to see if the vowel space was influenced by individual speaker differences, normalized F1 and F2 values were computed using the Lobanov technique to control for vocal tract differences (See Table 5.2). The Lobanov
technique is an extrinsic vowel normalization procedure designed primarily to eliminate or reduce inter-speaker differences results from variations in vocal tract length. This normalization process, based on each individual speaker’s vowel system, uses the speaker’s formant mean and standard deviation to create scaled formant values that are not influenced by physical differences of the vocal tract. For a given vowel produced by a given speaker:

\[
\text{Normalized } F1 = F1 \text{ (for that vowel)} - F1 \text{ mean (for all vowels)} \\
\qquad \quad \text{F1 standard deviation (for all vowels)}
\]

\[
\text{Normalized } F2 = F2 \text{ (for that vowel)} - F2 \text{ mean (for all vowels)} \\
\qquad \quad \text{F2 standard deviation (for all vowels)}
\]

The units of the resulting normalized F1 and F2 values represent standard deviations from the mean F1 or F2 frequencies, respectively.

The acoustic phonetic representation of the ten Kreyol vowels can be found in Figure 5.1; the normalized version is located in Figure 5.2. There were no real
differences observed between the non-normalized and normalized vowel spaces for these speakers. This supports the findings of Lee, et al., (1999), who found that vocal tract differences for prepubescent child speakers were minimal. Research also indicates that dialect variations can be minimized when normalization process is applied (Jacewitz, et al., 2007) Based on this information, only non-normalized results (in Hz) will be discussed from this point forward.

The basic Kreyol vowel space is triangular with three “point” vowels, /i, u, a/. The nasal vowels /a, ō/ are located within the vowel space, as are the mid front vowels, /e, ɛ/. The back vowels /ɔ, o/ are located in the back of the vowel space, somewhat outside of the vowel triangle. The nasal vowel /ɐ/ is located in the front of the oral cavity, somewhat outside of the vowel triangle.
<table>
<thead>
<tr>
<th>Vowel Type</th>
<th>F1</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ō</td>
<td>547</td>
<td>1519</td>
</tr>
<tr>
<td></td>
<td>(186.0)</td>
<td>(271.0)</td>
</tr>
<tr>
<td>ē</td>
<td>783</td>
<td>2513</td>
</tr>
<tr>
<td></td>
<td>(121.6)</td>
<td>(234.1)</td>
</tr>
<tr>
<td>ā</td>
<td>955</td>
<td>1860</td>
</tr>
<tr>
<td></td>
<td>(172.3)</td>
<td>(201.8)</td>
</tr>
<tr>
<td>i</td>
<td>406</td>
<td>2928</td>
</tr>
<tr>
<td></td>
<td>(66.3)</td>
<td>(270.1)</td>
</tr>
<tr>
<td>u</td>
<td>481</td>
<td>1191</td>
</tr>
<tr>
<td></td>
<td>(49.6)</td>
<td>(113.9)</td>
</tr>
<tr>
<td>e</td>
<td>662</td>
<td>2508</td>
</tr>
<tr>
<td></td>
<td>(32.3)</td>
<td>(157.3)</td>
</tr>
<tr>
<td>a</td>
<td>1091</td>
<td>1760</td>
</tr>
<tr>
<td></td>
<td>(154.1)</td>
<td>(125.8)</td>
</tr>
<tr>
<td>o</td>
<td>623</td>
<td>1241</td>
</tr>
<tr>
<td></td>
<td>(84.9)</td>
<td>(113.0)</td>
</tr>
<tr>
<td>ē</td>
<td>731</td>
<td>2403</td>
</tr>
<tr>
<td></td>
<td>(65.9)</td>
<td>(83.9)</td>
</tr>
<tr>
<td>ō</td>
<td>692</td>
<td>1263</td>
</tr>
<tr>
<td></td>
<td>(141.1)</td>
<td>(206.3)</td>
</tr>
</tbody>
</table>

Table 5.1 Mean F1 and F2 Measures (in Hz) for Kreyol Vowels Produced by All Haitian Subjects
<table>
<thead>
<tr>
<th>Vowel Type</th>
<th>F1 Normalized</th>
<th>F2 Normalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>ō</td>
<td>-0.61</td>
<td>-0.62</td>
</tr>
<tr>
<td>ê</td>
<td>0.35</td>
<td>0.92</td>
</tr>
<tr>
<td>ā</td>
<td>1.05</td>
<td>-0.09</td>
</tr>
<tr>
<td>i</td>
<td>-1.19</td>
<td>1.56</td>
</tr>
<tr>
<td>u</td>
<td>-0.88</td>
<td>-1.12</td>
</tr>
<tr>
<td>e</td>
<td>-0.14</td>
<td>0.91</td>
</tr>
<tr>
<td>a</td>
<td>1.61</td>
<td>-0.25</td>
</tr>
<tr>
<td>o</td>
<td>-0.31</td>
<td>-1.05</td>
</tr>
<tr>
<td>e</td>
<td>0.14</td>
<td>0.75</td>
</tr>
<tr>
<td>ō</td>
<td>-0.02</td>
<td>-1.01</td>
</tr>
</tbody>
</table>

Table 5.2 Normalized Mean F1 and F2 Values for Kreyol Vowels Produced by All Haitian Subjects
Figure 5.1 Kreyol Vowel Space for Haitian American Subjects
5.1.1. Kreyol Vowel Space: Group Differences

Mean F1 and F2 measures (in Hz) for each Kreyol vowel as a function of group are listed in Table 5.3. A summary chart of significant between-subject factors from the two-way ANOVA is provided in Table 5.4.
Table 5.3 F1 and F2 Values for Kreyol Vowels Produced by Haitian American Monolingual and Bilingual Speakers. Standard deviations are in parentheses.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>F1 Between Interactions</th>
<th>F1 Between Interactions</th>
<th>F2 Between Interactions</th>
<th>F2 Between Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ð</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ê</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ã</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>i</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>u</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>e</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ð</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>o</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ð</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>η</td>
<td>Significant Gender</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ð</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 5.4 ANOVA Summary Table for Kreyol Vowels Produced by Haitian American Monolingual and Bilingual Speakers. F1 and F2 main effects and interactions are provided. NS= Not Significant
5.1.1.1 First Formant Comparisons:

Results indicated no significant main effects of group on F1 values. HAM and HAB speakers produced all Kreyol vowels with similar F1 values, revealing that both HAM and HAB speakers exhibited similar tongue height during the production of Kreyol vowels (see Figure 5.3).

5.1.1.2 Second Formant Comparisons:

ANOVA results also revealed no significant group differences for F2. This provides evidence that HAM and HAB speakers exhibit similar tongue positions (e.g., “forwardness/backwardness”) during the production of all Kreyol vowels (see Figure 5.3).
5.1.2. Kreyol Vowel Space: Gender Differences

Mean F1 and F2 measures (in Hz) for each Kreyol vowel as a function of gender are shown in Table 5.5. Table 5.6 provides these measures as a function of group and gender. Refer to Table 5.4 to view the summary chart of significant between-subject factors.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>ò</td>
<td>586</td>
<td>1571</td>
</tr>
<tr>
<td></td>
<td>(182.2)</td>
<td>(251.7)</td>
</tr>
<tr>
<td>ē</td>
<td>773</td>
<td>2438</td>
</tr>
<tr>
<td></td>
<td>(134.8)</td>
<td>(174.0)</td>
</tr>
<tr>
<td>ū</td>
<td>942</td>
<td>1841</td>
</tr>
<tr>
<td></td>
<td>(102.6)</td>
<td>(180.9)</td>
</tr>
<tr>
<td>i</td>
<td>419</td>
<td>3077</td>
</tr>
<tr>
<td></td>
<td>(65.9)</td>
<td>(278.6)</td>
</tr>
<tr>
<td>u</td>
<td>479</td>
<td>1227</td>
</tr>
<tr>
<td></td>
<td>(61.3)</td>
<td>(117.2)</td>
</tr>
<tr>
<td>e</td>
<td>673</td>
<td>2448</td>
</tr>
<tr>
<td></td>
<td>(25.5)</td>
<td>(148.5)</td>
</tr>
<tr>
<td>α</td>
<td>1142</td>
<td>1794</td>
</tr>
<tr>
<td></td>
<td>(178.8)</td>
<td>(155.8)</td>
</tr>
<tr>
<td>o</td>
<td>631</td>
<td>1253</td>
</tr>
<tr>
<td></td>
<td>(71.2)</td>
<td>(152.3)</td>
</tr>
<tr>
<td>ē</td>
<td>773</td>
<td>2379</td>
</tr>
<tr>
<td></td>
<td>(47.0)</td>
<td>(93.2)</td>
</tr>
<tr>
<td>o</td>
<td>732</td>
<td>1323</td>
</tr>
<tr>
<td></td>
<td>(90.4)</td>
<td>(135.2)</td>
</tr>
</tbody>
</table>

Table 5.5 F1 and F2 Values for Kreyol Vowels as a Function of Gender
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Female</th>
<th></th>
<th>Vowel</th>
<th>Male</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HAM</td>
<td>HAB</td>
<td>HAM</td>
<td>HAB</td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>744</td>
<td>1600</td>
<td>481</td>
<td>1551</td>
<td>665</td>
<td>1389</td>
</tr>
<tr>
<td>(47.7)</td>
<td>(246.8)</td>
<td>(153.9)</td>
<td>(308.0)</td>
<td>(275.4)</td>
<td>(475.5)</td>
</tr>
<tr>
<td>720</td>
<td>2559.75</td>
<td>808</td>
<td>2357</td>
<td>881</td>
<td>2518</td>
</tr>
<tr>
<td>(18.7)</td>
<td>(93.7)</td>
<td>(177.4)</td>
<td>(177.6)</td>
<td>(115.3)</td>
<td>(72.5)</td>
</tr>
<tr>
<td>1002</td>
<td>1936.25</td>
<td>902</td>
<td>1777</td>
<td>807</td>
<td>1738</td>
</tr>
<tr>
<td>(1.8)</td>
<td>(55.5)</td>
<td>(122.5)</td>
<td>(220.5)</td>
<td>(230.2)</td>
<td>(269.4)</td>
</tr>
<tr>
<td>443</td>
<td>3225.75</td>
<td>403</td>
<td>2978</td>
<td>432</td>
<td>2744</td>
</tr>
<tr>
<td>(120.6)</td>
<td>(326.3)</td>
<td>(22.1)</td>
<td>(255.1)</td>
<td>(37.5)</td>
<td>(134.7)</td>
</tr>
<tr>
<td>500</td>
<td>1189.25</td>
<td>465</td>
<td>1252</td>
<td>518</td>
<td>1082</td>
</tr>
<tr>
<td>(83.1)</td>
<td>(160.2)</td>
<td>(57.9)</td>
<td>(110.7)</td>
<td>(8.8)</td>
<td>(71.4)</td>
</tr>
<tr>
<td>697</td>
<td>2511.5</td>
<td>657</td>
<td>2406</td>
<td>650</td>
<td>2492</td>
</tr>
<tr>
<td>(16.6)</td>
<td>(28.3)</td>
<td>(13.1)</td>
<td>(192.4)</td>
<td>(11.0)</td>
<td>(127.6)</td>
</tr>
<tr>
<td>1167</td>
<td>1905</td>
<td>1126</td>
<td>1719</td>
<td>1009</td>
<td>1742</td>
</tr>
<tr>
<td>(226.3)</td>
<td>(4.9)</td>
<td>(193.2)</td>
<td>(166.9)</td>
<td>(55.5)</td>
<td>(117.7)</td>
</tr>
<tr>
<td>695</td>
<td>1390</td>
<td>588</td>
<td>1162</td>
<td>622</td>
<td>1253</td>
</tr>
<tr>
<td>(10.6)</td>
<td>(90.2)</td>
<td>(57.0)</td>
<td>(106.2)</td>
<td>(37.8)</td>
<td>(54.4)</td>
</tr>
<tr>
<td>800</td>
<td>2352</td>
<td>755</td>
<td>2397</td>
<td>696</td>
<td>2422</td>
</tr>
<tr>
<td>(12.4)</td>
<td>(132.2)</td>
<td>(56.0)</td>
<td>(85.9)</td>
<td>(15.9)</td>
<td>(97.2)</td>
</tr>
<tr>
<td>733</td>
<td>1363</td>
<td>732</td>
<td>1297</td>
<td>669</td>
<td>1161</td>
</tr>
<tr>
<td>(22.3)</td>
<td>(53.4)</td>
<td>(126.8)</td>
<td>(180.5)</td>
<td>(115.3)</td>
<td>(89.8)</td>
</tr>
</tbody>
</table>

Table 5.6 F1 and F2 Values for Kreyol Vowels Produced by Male and Female Haitian American Monolingual and Bilingual Speakers.
5.1.2.1. First Formant Comparisons:

ANOVA results revealed significant main effects of gender on F1 values for /ɛ/ [F(1, 5)= 9.4, p<.05, \(\eta^2=.652\)]. For this vowel, male speakers’ F1 was significantly lower than their female counterparts (679 Hz and 773 Hz, respectively) (see Figure 5.4). Although F1 differences were also observed during production of vowels /õ, ò, ø/, these results were not statistically significant. There were no significant group by gender interactions noted.

5.1.2.2. Second Formant Comparisons:

Although observable F2 differences were observed between male and female speakers during the production of /i/ (2742 Hz and 3077 Hz, respectively), these differences were not significant. Group by gender interactions also were not significant.
5.2 English Vowel Space: All Haitian-American Speakers

F1 and F2 values for English vowels produced by Haitian American subjects (in Hz) are located in Table 5.7. Corresponding vowel spaces (in Hz) for Haitian American subjects can be found in Figure 5.5. The overall shape of the vowel space is consistent with previous studies that describe the English vowel space (Peterson and Barney, 1952; Hillenbrand, et al., 1995; Lee, et al., 1999; Hagiwara, 1997; Vorperian and Kent, 2007).
The English vowel space produced by the Haitian American is quadrilateral-shaped with four “point” vowels (/i, æ, u, ə/), three mid-front vowels (/ɪ, e, ɛ/), one middle vowel /ʌ/, and one mid-back vowel /o/. 
<table>
<thead>
<tr>
<th>Vowel</th>
<th>F1</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>1036</td>
<td>2295</td>
</tr>
<tr>
<td></td>
<td>(99.2)</td>
<td>(148.7)</td>
</tr>
<tr>
<td>e</td>
<td>543</td>
<td>2832</td>
</tr>
<tr>
<td></td>
<td>(83.4)</td>
<td>(170.4)</td>
</tr>
<tr>
<td>e</td>
<td>790</td>
<td>2330</td>
</tr>
<tr>
<td></td>
<td>(69.6)</td>
<td>(132.4)</td>
</tr>
<tr>
<td>i</td>
<td>406</td>
<td>3297</td>
</tr>
<tr>
<td></td>
<td>(42.8)</td>
<td>(188.4)</td>
</tr>
<tr>
<td>I</td>
<td>592</td>
<td>2677</td>
</tr>
<tr>
<td></td>
<td>(59.6)</td>
<td>(163.0)</td>
</tr>
<tr>
<td>o</td>
<td>670</td>
<td>1237</td>
</tr>
<tr>
<td></td>
<td>(76.0)</td>
<td>(194.8)</td>
</tr>
<tr>
<td>u</td>
<td>441</td>
<td>1117</td>
</tr>
<tr>
<td></td>
<td>(64.3)</td>
<td>(245.5)</td>
</tr>
<tr>
<td>a</td>
<td>1037</td>
<td>1529</td>
</tr>
<tr>
<td></td>
<td>(83.3)</td>
<td>(112.5)</td>
</tr>
<tr>
<td>Λ</td>
<td>855</td>
<td>1694</td>
</tr>
<tr>
<td></td>
<td>(50.9)</td>
<td>(236.6)</td>
</tr>
</tbody>
</table>

Table 5.7 English F1 and F2 Values (in Hz) for All Haitian American Subjects
5.2.1. English Vowel Space: Haitian-American Bilingual and Monolingual Speakers

In order to determine if differences exist between the two Haitian American groups, formant values of HAB and HAM speakers were analyzed. Mean English vowel formant frequencies for HAB and HAM speakers are located in Table 5.8. When the Haitian American speakers were separated into bilingual and monolingual (English) speakers,
there were observable differences in the shape of the vowel space (see Figure 5.6). Bilingual speakers’ space was slightly larger than the monolingual speakers’. A two-way ANOVA was performed on the formant frequencies, with group and gender as the between-subjects factors. A summary chart of significant between-subject factors is provided in Table 5.9.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>HAM</th>
<th>HAB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>ð</td>
<td>1018</td>
<td>2320</td>
</tr>
<tr>
<td></td>
<td>(117.0)</td>
<td>(125.0)</td>
</tr>
<tr>
<td>e</td>
<td>497</td>
<td>2807</td>
</tr>
<tr>
<td></td>
<td>(83.8)</td>
<td>(158.1)</td>
</tr>
<tr>
<td>e</td>
<td>780</td>
<td>2317</td>
</tr>
<tr>
<td></td>
<td>(81.0)</td>
<td>(173.9)</td>
</tr>
<tr>
<td>i</td>
<td>422</td>
<td>3217</td>
</tr>
<tr>
<td></td>
<td>(43.1)</td>
<td>(227.0)</td>
</tr>
<tr>
<td>i</td>
<td>590</td>
<td>2679</td>
</tr>
<tr>
<td></td>
<td>(86.1)</td>
<td>(207.7)</td>
</tr>
<tr>
<td>o</td>
<td>726</td>
<td>1352</td>
</tr>
<tr>
<td></td>
<td>(45.6)</td>
<td>(201.1)</td>
</tr>
<tr>
<td>u</td>
<td>451</td>
<td>1190</td>
</tr>
<tr>
<td></td>
<td>(77.0)</td>
<td>(286.5)</td>
</tr>
<tr>
<td>a</td>
<td>1023</td>
<td>1519</td>
</tr>
<tr>
<td></td>
<td>(92.2)</td>
<td>(110.0)</td>
</tr>
<tr>
<td>A</td>
<td>833</td>
<td>1571</td>
</tr>
<tr>
<td></td>
<td>(62.2)</td>
<td>(155.8)</td>
</tr>
</tbody>
</table>

Table 5.8 Mean English F1 and F2 Values (in Hz) for All Haitian American Subjects
<table>
<thead>
<tr>
<th>Vowel</th>
<th>F1 Between</th>
<th>F1 Between Interactions</th>
<th>F2 Between</th>
<th>F2 Between Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ae</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>e</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ε</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>i</td>
<td>Significant: Gender</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>I</td>
<td>Significant: Gender</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>o</td>
<td>Significant: Group</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>u</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>a</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>Significant: Gender x Group</td>
</tr>
<tr>
<td>Λ</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 5.9 ANOVA Summary Table for English Vowels Produced by Haitian American Monolingual and Bilingual Speakers. F1 and F2 main effects and interactions are provided. NS= Not Significant
5.2.1.1. First Formant Comparisons

Results indicated significant main effects of group on F1 values for /o/ [F(1, 6)= 9.9, p<.05, $\eta^2=.623$. HAM speakers produced /o/ lower in the vowel space (closer toward /ʌ/, whereas HAB speakers produced /o/ higher in the space (closer toward /u/) (see Figure 5.6). HAM and HAB speakers produced all other English vowels with similar F1 values, exhibiting similar tongue height during the production of English vowels.

5.2.1.2. Second Formant Comparisons

ANOVA results revealed no significant group differences for F2. Again, HAM and HAB speakers exhibited similar tongue positions (e.g., “forwardness/backwardness”) during the production of all English vowels (see Figure 5.6).
5.2.2. English Vowel Space: Gender Differences for Monolingual and Bilingual Speakers

Mean F1 and F2 measures (in Hz) for English vowels produced by male and female Haitian American speakers are located in Table 5.10. Mean F1 and F2 measures (in Hz) for English vowels broken down by gender and group can be found in Table 5.11.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>æ</td>
<td>1049 (84.0)</td>
<td>2275 (168.7)</td>
</tr>
<tr>
<td>e</td>
<td>574 (80.1)</td>
<td>2803 (156.9)</td>
</tr>
<tr>
<td>ε</td>
<td>828 (59.4)</td>
<td>2380 (86.8)</td>
</tr>
<tr>
<td>i</td>
<td>428 (52.3)</td>
<td>3234 (228.3)</td>
</tr>
<tr>
<td>I</td>
<td>628 (45.2)</td>
<td>2642 (178.9)</td>
</tr>
<tr>
<td>o</td>
<td>665 (84.1)</td>
<td>1233 (207.6)</td>
</tr>
<tr>
<td>u</td>
<td>467 (70.4)</td>
<td>1188 (216.6)</td>
</tr>
<tr>
<td>α</td>
<td>1080 (95.5)</td>
<td>1518 (108.3)</td>
</tr>
<tr>
<td>Λ</td>
<td>879 (47.5)</td>
<td>1713 (147.4)</td>
</tr>
</tbody>
</table>

Table 5.10 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Speakers.
<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Vowel</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAM</td>
<td>HAB</td>
<td>HAM</td>
<td>HAB</td>
</tr>
<tr>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>1046</td>
<td>2407</td>
<td>1051</td>
<td>2187</td>
</tr>
<tr>
<td>(99.3)</td>
<td>(22.6)</td>
<td>(95.6)</td>
<td>(166.8)</td>
</tr>
<tr>
<td>540</td>
<td>2890</td>
<td>596</td>
<td>2745</td>
</tr>
<tr>
<td>(131.5)</td>
<td>(146.4)</td>
<td>(48.0)</td>
<td>(161.0)</td>
</tr>
<tr>
<td>849</td>
<td>2396</td>
<td>813</td>
<td>2369</td>
</tr>
<tr>
<td>(2.8)</td>
<td>(38.2)</td>
<td>(79.3)</td>
<td>(117.8)</td>
</tr>
<tr>
<td>467</td>
<td>3061</td>
<td>402</td>
<td>3350</td>
</tr>
<tr>
<td>(8.8)</td>
<td>(293.4)</td>
<td>(53.3)</td>
<td>(104.1)</td>
</tr>
<tr>
<td>670</td>
<td>2664</td>
<td>599</td>
<td>2628</td>
</tr>
<tr>
<td>(20.9)</td>
<td>(332.3)</td>
<td>(29.0)</td>
<td>(89.6)</td>
</tr>
<tr>
<td>745</td>
<td>1446</td>
<td>612</td>
<td>1091</td>
</tr>
<tr>
<td>(41.7)</td>
<td>(88.4)</td>
<td>(50.8)</td>
<td>(81.3)</td>
</tr>
<tr>
<td>495</td>
<td>1411</td>
<td>448</td>
<td>1039</td>
</tr>
<tr>
<td>(112.4)</td>
<td>(62.6)</td>
<td>(47.6)</td>
<td>(95.0)</td>
</tr>
<tr>
<td>1072</td>
<td>1600</td>
<td>1086</td>
<td>1464</td>
</tr>
<tr>
<td>(141.1)</td>
<td>(106.8)</td>
<td>(90.4)</td>
<td>(82.1)</td>
</tr>
<tr>
<td>877</td>
<td>1689</td>
<td>881</td>
<td>1730</td>
</tr>
<tr>
<td>(77.8)</td>
<td>(163.7)</td>
<td>(38.5)</td>
<td>(170.4)</td>
</tr>
</tbody>
</table>

Table 5.11 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Speakers Broken Down by Group.
5.2.2.1. First Formant Comparisons

When looking at F1 values alone, it appeared that there were large differences for /e, e, i, u, A/ (see Table 5.10). However, ANOVA results indicated significant F1 differences for /i/, \[F(1, 6) = 5.8, p=.05, \eta^2=.491\] and /i/, \[F(1, 6) = 7.5, p<.05, \eta^2=.554\] only (refer to Table 5.9). This is most likely due to high variability during the production of these vowels.

For vowels /i/ and /i/, female speakers’ F1 was higher than male speakers’. These findings support those of Perry, et al., (2001) and Andrianopoulos, et al., (2001), who found that female speakers (children and adults, respectively) exhibited higher F1 than their male counterparts (see Figure 5.7).

5.2.2.2. Second Formant Comparisons

ANOVA results indicated no significant main effects of gender on F2 values for any English vowels. There was, however, a significant gender by group interaction effect for the English vowel /a/, \[F (1, 6) = 7.8, p<.05, \eta^2=.564\]. HAM female speakers exhibited higher F2 values than HAM male speakers (1686 Hz and 1494 Hz, respectively); however, HAB females’ F2 was lower than HAB males’ (1513 Hz and 1612 Hz, respectively) (see Figures 5.8 and 5.9).
Figure 5.7 English Vowel Space (in Hz) for All Haitian American Male and Female Speakers
Figure 5.8 English Vowel Space (in Hz) for Monolingual Haitian American Male and Female Speakers
5.3 English Vowel Space: All Speakers

5.3.1 English Vowel Space: Haitian American vs. Non-Haitian Speakers

In order to determine if Haitian American’s speakers produced English vowels
differently than a Non-Haitian speaker, their productions were compared with Non-Haitian (NH) peers from the same region. Formant values (in Hz) for English vowels as a function of group can be found in Table 5.12. A summary chart of significant between-subject factors is provided in Table 5.13.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Haitian</th>
<th>Non-Haitian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>ñ</td>
<td>1036</td>
<td>2295</td>
</tr>
<tr>
<td></td>
<td>(92.2)</td>
<td>(148.7)</td>
</tr>
<tr>
<td>ẽ</td>
<td>543</td>
<td>2832</td>
</tr>
<tr>
<td></td>
<td>(83.4)</td>
<td>(170.4)</td>
</tr>
<tr>
<td>ē</td>
<td>790</td>
<td>2330</td>
</tr>
<tr>
<td></td>
<td>(69.6)</td>
<td>(132.4)</td>
</tr>
<tr>
<td>i</td>
<td>406</td>
<td>3297</td>
</tr>
<tr>
<td></td>
<td>(42.8)</td>
<td>(188.4)</td>
</tr>
<tr>
<td>ɪ</td>
<td>592</td>
<td>2677</td>
</tr>
<tr>
<td></td>
<td>(59.6)</td>
<td>(163.0)</td>
</tr>
<tr>
<td>o</td>
<td>670</td>
<td>1237</td>
</tr>
<tr>
<td></td>
<td>(76.0)</td>
<td>(194.8)</td>
</tr>
<tr>
<td>u</td>
<td>441</td>
<td>1117</td>
</tr>
<tr>
<td></td>
<td>(64.3)</td>
<td>(245.5)</td>
</tr>
<tr>
<td>a</td>
<td>1037</td>
<td>1529</td>
</tr>
<tr>
<td></td>
<td>(83.3)</td>
<td>(112.5)</td>
</tr>
<tr>
<td>Λ</td>
<td>855</td>
<td>1695</td>
</tr>
<tr>
<td></td>
<td>(50.9)</td>
<td>(236.6)</td>
</tr>
</tbody>
</table>

Table 5.12 Mean English F1 and F2 Values (in Hz) for Haitian American and Non-Haitian Speakers.
Table 5.13 ANOVA Summary Table for English Vowels Produced by Haitian American and Non-Haitian Speakers. F1 and F2 main effects and interactions are provided. NS= Not Significant

<table>
<thead>
<tr>
<th>Vowel</th>
<th>F1 Between</th>
<th>F1 Between Interactions</th>
<th>F2 Between</th>
<th>F2 Between Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ae</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>e</td>
<td>Significant:</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ε</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>i</td>
<td>Significant:</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ï</td>
<td>Significant:</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>u</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>α</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>ñ</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 5.13 ANOVA Summary Table for English Vowels Produced by Haitian American and Non-Haitian Speakers. F1 and F2 main effects and interactions are provided. NS= Not Significant
5.3.1.1. First Formant

At first glance, Non-Haitian speakers’ productions of /æ/ and /ʌ/ were observed to be lower than their Haitian American counterparts. However, ANOVA results indicated that differences in F1 were not significant (refer to Table 5.13). Again, this could be attributed to high variability during production. Overall, both Haitian American and Non-Haitian speakers produced English vowels with similar tongue height (see Figure 5.10).

5.3.1.2. Second Formant

ANOVA results also indicated no significant differences in F2 values between Haitian American and non-Haitian speakers (see Figure 5.10).
5.3.2. English Vowel Space: Gender Differences for Haitian and Non-Haitian Speakers

Mean F1 and F2 measures (in Hz) for English vowels for Haitian and non-Haitian speakers are listed in Table 5.14.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>æ</td>
<td>1042 (154.1)</td>
<td>2308 (167.9)</td>
</tr>
<tr>
<td>e</td>
<td>568 (61.8)</td>
<td>2797 (199.9)</td>
</tr>
<tr>
<td>ε</td>
<td>804 (76.7)</td>
<td>2425 (87.0)</td>
</tr>
<tr>
<td>i</td>
<td>439 (49.7)</td>
<td>3270 (194.1)</td>
</tr>
<tr>
<td>ï</td>
<td>605 (48.7)</td>
<td>2667 (172.1)</td>
</tr>
<tr>
<td>o</td>
<td>646 (75.3)</td>
<td>1178 (178.5)</td>
</tr>
<tr>
<td>u</td>
<td>486 (91.4)</td>
<td>1256 (220.0)</td>
</tr>
<tr>
<td>æ</td>
<td>1070 (75.5)</td>
<td>1507 (146.2)</td>
</tr>
<tr>
<td>æ</td>
<td>873 (71.0)</td>
<td>1703 (128.8)</td>
</tr>
</tbody>
</table>

Table 5.14 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American and Non-Haitian Speakers.
5.3.2.1. First Formant Comparisons

As with previously discussed gender results, F1 values were highly variable during production (as indicated by high standard deviations). ANOVA results indicated significant F1 differences for /i/ [F(1, 14)= 5.7, p<.05, $\eta^2=.289$], /i/ [F(1, 14)= 4.9, p<.05, $\eta^2=.261$], and /e/ [F(1, 14)= 4.9, p<.05, $\eta^2=.259$], (refer to Table 5.13). For those vowels, female speakers’ F1 was higher than male speakers’ (See Figure 5.11). Gender by group interactions were not observed.

5.3.2.2. Second Formant Comparisons

ANOVA results indicated no significant main or interaction effects of gender on F2 values for any English vowels.
5.3.3. English Vowel Space: Haitian American Bilingual vs. Non-Haitian Speakers

Because of their status as monolingual English speakers, HAM speakers were factored out and Haitian American bilingual speakers’ productions were compared to their non-Haitian (NH) peers from the same region. Formant values (in Hz) for English vowels as a function of group can be found in Table 5.15.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Haitian American Bilingual</th>
<th>Non-Haitian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>æ</td>
<td>1055</td>
<td>2269</td>
</tr>
<tr>
<td></td>
<td>(67.9)</td>
<td>(180.2)</td>
</tr>
<tr>
<td>e</td>
<td>588</td>
<td>2857</td>
</tr>
<tr>
<td></td>
<td>(58.9)</td>
<td>(196.8)</td>
</tr>
<tr>
<td>ẹ</td>
<td>800</td>
<td>2343</td>
</tr>
<tr>
<td></td>
<td>(63.9)</td>
<td>(93.8)</td>
</tr>
<tr>
<td>i</td>
<td>391</td>
<td>3378</td>
</tr>
<tr>
<td></td>
<td>(40.9)</td>
<td>(110.4)</td>
</tr>
<tr>
<td>ɪ</td>
<td>594</td>
<td>2675</td>
</tr>
<tr>
<td></td>
<td>(23.9)</td>
<td>(129.0)</td>
</tr>
<tr>
<td>o</td>
<td>614</td>
<td>1122</td>
</tr>
<tr>
<td></td>
<td>(55.0)</td>
<td>(108.1)</td>
</tr>
<tr>
<td>u</td>
<td>431</td>
<td>1043</td>
</tr>
<tr>
<td></td>
<td>(55.9)</td>
<td>(200.1)</td>
</tr>
<tr>
<td>ọ</td>
<td>1052</td>
<td>1539</td>
</tr>
<tr>
<td></td>
<td>(81.3)</td>
<td>(127.0)</td>
</tr>
<tr>
<td>ʌ</td>
<td>877</td>
<td>1818</td>
</tr>
<tr>
<td></td>
<td>(27.8)</td>
<td>(252.2)</td>
</tr>
</tbody>
</table>

Table 5.15 Mean English F1 and F2 Values (in Hz) for Haitian American Bilingual and Non-Haitian Speakers.
5.3.3.1. First Formant Comparisons

ANOVA results did not indicate significant F1 differences between groups (refer to Table 5.16). Overall, both Haitian American bilingual and Non-Haitian speakers produced English vowels with similar tongue height (see Figure 5.12).

5.3.3.2. Second Formant Comparisons

Although F2 differences were observed for /u/, ANOVA results indicated that these differences were insignificant (most likely due to large standard deviations). Significant F2 differences were not observed between Haitian American bilingual and non-Haitian speakers for any English vowels (see Figure 5.12).
<table>
<thead>
<tr>
<th>Vowel</th>
<th>F1 Between</th>
<th>F1 Between</th>
<th>F2 Between</th>
<th>F2 Between</th>
<th>Interactions</th>
<th>Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ae</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ε</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Λ</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.16 ANOVA Summary Table for English Vowels Produced by Haitian American Bilingual and Non-Haitian Speakers. F1 and F2 main effects and interactions are provided. NS= Not Significant
Figure 5.12 English Vowel Space (in Hz) for Haitian American Bilingual and Non-Haitian Speakers

5.3.4. English Vowel Space: Haitian American Bilingual vs. Non-Haitian Speakers

Gender Differences

Mean F1 and F2 measures (in Hz) for each English vowel as a function of gender are located in Table 5.17.
5.3.4.1. First Formant Comparisons

ANOVA results indicated no significant F1 differences for English vowels. There were no significant interactions noted (See Figure 5.13).

5.3.4.2. Second Formant Comparisons

ANOVA results also indicated no significant main effects on gender. Group by gender interactions were not significant (See Figure 5.13).
<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Vowel</th>
<th>Male</th>
<th></th>
<th>Vowel</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HAB</td>
<td>Non-Haitian</td>
<td>HAB</td>
<td>Non-Haitian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
<td>F1</td>
</tr>
<tr>
<td>1051</td>
<td>2187</td>
<td>1034</td>
<td>2349</td>
<td>ø</td>
<td>1060</td>
<td>2392</td>
</tr>
<tr>
<td>(157.6)</td>
<td>(356.9)</td>
<td>(227.9)</td>
<td>(189.6)</td>
<td>(188.9)</td>
<td>(137.1)</td>
<td>(119.1)</td>
</tr>
<tr>
<td>596</td>
<td>2745</td>
<td>561</td>
<td>2790</td>
<td>e</td>
<td>576</td>
<td>3025</td>
</tr>
<tr>
<td>(107.8)</td>
<td>(238.7)</td>
<td>(65.1)</td>
<td>(351.52)</td>
<td>(262.2)</td>
<td>(146.7)</td>
<td>(78.4)</td>
</tr>
<tr>
<td>813</td>
<td>2369</td>
<td>775</td>
<td>2481</td>
<td>ø</td>
<td>781</td>
<td>2305</td>
</tr>
<tr>
<td>(89.8)</td>
<td>(190.4)</td>
<td>(134.2)</td>
<td>(154.2)</td>
<td>(73.4)</td>
<td>(73.6)</td>
<td>(49.8)</td>
</tr>
<tr>
<td>402</td>
<td>3350</td>
<td>452</td>
<td>3315</td>
<td>i</td>
<td>375</td>
<td>3419</td>
</tr>
<tr>
<td>(64.3)</td>
<td>(287.1)</td>
<td>(57.4)</td>
<td>(250.3)</td>
<td>(30.9)</td>
<td>(291.0)</td>
<td>(34.4)</td>
</tr>
<tr>
<td>599</td>
<td>2628</td>
<td>578</td>
<td>2697</td>
<td>i</td>
<td>586</td>
<td>2746</td>
</tr>
<tr>
<td>(54.2)</td>
<td>(180.4)</td>
<td>(43.1)</td>
<td>(272.5)</td>
<td>(88.7)</td>
<td>(283.05)</td>
<td>(48.6)</td>
</tr>
<tr>
<td>612</td>
<td>1091</td>
<td>623</td>
<td>1109</td>
<td>ø</td>
<td>617</td>
<td>1168</td>
</tr>
<tr>
<td>(111.4)</td>
<td>(148.4)</td>
<td>(74.0)</td>
<td>(148.7)</td>
<td>(184.7)</td>
<td>(209.0)</td>
<td>(173.3)</td>
</tr>
<tr>
<td>448</td>
<td>1039</td>
<td>509</td>
<td>1342</td>
<td>u</td>
<td>405</td>
<td>1049</td>
</tr>
<tr>
<td>(84.5)</td>
<td>(184.0)</td>
<td>(129.7)</td>
<td>(286.8)</td>
<td>(89.9)</td>
<td>(332.2)</td>
<td>(78.7)</td>
</tr>
<tr>
<td>1086</td>
<td>1513</td>
<td>1058</td>
<td>1535</td>
<td>æ</td>
<td>863</td>
<td>1612</td>
</tr>
<tr>
<td>(102.7)</td>
<td>(112.6)</td>
<td>(59.0)</td>
<td>(160.0)</td>
<td>(62.0)</td>
<td>(137.6)</td>
<td>(126.7)</td>
</tr>
<tr>
<td>870</td>
<td>1775</td>
<td>870</td>
<td>1701</td>
<td>æ</td>
<td>1001</td>
<td>1513</td>
</tr>
<tr>
<td>(69.9)</td>
<td>(773.1)</td>
<td>(94.4)</td>
<td>(93.5)</td>
<td>(46.7)</td>
<td>(115.3)</td>
<td>(93.6)</td>
</tr>
</tbody>
</table>

Table 5.17 F1 and F2 Values for English Vowels Produced by Male and Female Haitian American Bilingual and Non-Haitian Speakers.
Figure 5.13 English Vowel Space (in Hz) for Haitian American Bilingual Male and Female Speakers
5.4. Summary of Spectral Results

Spectral results examined in this study were summarized using the questions posed in the beginning of this paper:

1. **What are the spectral characteristics of Haitian Kreyol vowels spoken by American 4 and 5 year olds of Haitian descent?**

The Haitian American kindergarteners in this study appear to produce Kreyol vowels that follow the non-acoustic descriptions found in texts (Muysken, P. and Veenstra, 1994; Corne, 1999; Savain, 1999; Tinelli, 1981). The vowel space is triangular-shaped, consisting of the point vowels /i, a, u/. Front vowels /e, e/ and nasal vowels /õ, ā/ are located within the vowel triangle (close to their non-nasal cognates). Back vowels /o, ɔ/ and the nasal vowel /ɛ/ are located outside the vowel triangle.

2. **How do the spectral characteristics of Haitian Kreyol vowels differ between male and female speakers?**

There were no major differences between male and female production of Kreyol vowels, with the exception of /e/. Male speakers produced /e/ with a lower F1 than the female speakers in this study. This finding is most likely due to the French-influenced production of the target Kreyol word “fle” (inconsistently produced as the French word “fleur”) by male speakers.
3. **What are the spectral characteristics of American English vowels spoken by American 4 and 5 year olds of Haitian descent?**

Overall, Haitian American speakers in this study produced English vowels with F1 and F2 values similar to those of non-Haitian speakers. Their vowel space contains four “point” vowels (/i, ə, u, a/), three mid front vowels (/ɪ, e, ɛ/), one middle vowel (/ʌ/), and one mid back vowel (/o/).

4. **How do these spectral characteristics compare to that of (monolingual) native speakers of American English of similar ages?**

When formant values of Haitian speakers (both monolingual English speakers and bilingual Kreyol/English speakers) were compared, F1 differences were noted for /ʌ/. Monolingual English speakers produced an /o/ that moves toward the neutral vowel, /ʌ/, whereas HAB speakers’/o/ moved toward the point vowel, /u/.

When productions of Haitian American and non-Haitian speakers were compared, there were no significant differences noted between productions of Haitian American and non-Haitian speakers. When the monolingual (English) Haitian American speakers were factored out and spectral characteristics of bilingual Haitian American speakers were compared with non-Haitian speakers, again, there were no significant differences. Bilingual speakers in this study produced English vowels like a native English speaker from the same region. These findings appear to be different from
those studies that looked at adult bilingual speakers (Chen, et al, 2001; Flege, 1999), which documents noted differences in vowel spaces for adult English language learners. However, the results of this study support the idea that people who learn a second language at an early age produce the sounds of that second language with less of an “accent”, or more like native speakers (Flege, 1999).

5. How do the spectral characteristics of English vowels differ between male and female speakers?

Gender appeared to influence Haitian American speakers’ production of certain English vowels. Results indicated that there were only significant differences in how male and female Haitian American speakers produced the English vowels, /i/, and /u/. Female speakers exhibited a higher F1, resulting in a lower position in the vowel space for both /i/ and /u/.

Gender differences were also observed between groups for the vowel /a/. Monolingual male speakers produced /a/ further back in the vowel space than their female counterparts. However, bilingual female speakers’ /a/ was further back in the vowel space than their male counterparts.

When gender differences between Haitian American and non-Haitian speakers were examined, there were significant differences in the production of /i/, /u/, and /e/. Overall, female speakers in this study (both Haitian American and non-Haitian)
produced /i/, /ɪ/, and /e/ with F1 values that were higher than their male counterparts. When comparisons were made between Haitian American bilingual and non-Haitian speakers, gender differences were not observed.

These results indicate that the bilingual speakers in this study produced Kreyol vowels that appear to match the non-acoustic descriptions of adult Kreyol productions. Differences that occurred between male and female Kreyol speakers existed for the vowel /ɛ/ only. The male speakers in this study appeared to produce that vowel higher in the vowel space than their female counterparts.

Bilingual speakers also produced English vowels that were similar to those produced by native (non-Haitian) speakers in their region. These findings point toward a more “differentiated” method of development for bilingual speakers. The speakers in this study appear to have two distinct vowel spaces. They are able to produce Kreyol vowels like a native (Kreyol) speaker, and produce English vowels as a native English speaker without any confusion.
CHAPTER 6
CONCLUSION

The national origin of many American has changed from European to non-European (including origins from Africa, Asia, Latin America, and the Caribbean). Because of this, the speech-language pathologist working in the United States is likely to have clients on her caseload who are bilingual or come from households that speak languages other than English. These languages don’t always have established written norms. In order to appropriately assess and/or treat these clients, the speech-language pathologist should have information on what constitutes normal speech and language development in the primary language(s) of that client and his family.

In the past, when describing speech and language patterns, communication specialists relied on descriptive analyses that used careful listening and transcription to describe differences in the articulation patterns among different groups. Although the use of acoustic analysis has been used to describe speech patterns, it has not been widely used to describe articulation differences between groups.

This study was designed to provide developmental information on Haitian Kreyol, a language spoken by large percentage of Haitians living in the United States. Another goal of this research was to examine how Haitian (bilingual) speakers of Kreyol and English produce the sounds in the two languages. Specifically, this research provided an
acoustic description of Kreyol and English vowels produced by monolingual (English) and bilingual (Kreyol/English) children of Haitian descent.

Results of this study revealed that the acoustic description of the Kreyol vowel space produced by this group of Haitian American speakers (e.g., residents of South Florida) is consistent with non-acoustic adult descriptions. There were no significant differences in how monolingual and bilingual speakers produced Kreyol vowels. These results support the SLM, which indicates that early and prolonged exposure to a second language allows the bilingual speaker to produce sounds as a native speaker. With South Florida being one of the three states that report the largest Haitian American population, these results are to be expected. Haitians in South Florida appear to hold on to their identity as “Haitians”; going to churches where Kreyol is spoken, listening to Haitian radio broadcasts, and requesting information in Kreyol.

In the case of Kreyol, monolingual (English) Haitian American speakers were the second language learners. The fact that there were no differences between the monolingual and bilingual speakers speaks to the importance of input to producing sounds as a native speaker. Three out of four monolingual speakers were exposed to some amount of Kreyol in the home (refer to Table 3.2). Speakers were also exposed to Kreyol during the testing process via the interpreter.

Similarities in phonemic repertoire also could have contributed to similarities between groups. Best’s Perceptual Assimilation Model asserts that a bilingual speaker
looks for the features in L2 that match his L1 and uses those features as the “base” for learning the sounds of L2. Because of the similarities between the Kreyol and English phoneme repertoire, it might not be as difficult for the bilingual learner to distinguish between the sounds of the two languages. This idea could also be applied to the vowels that were not similar, specifically nasal vowels. Because nasal assimilation exists in English, nasalized vowels are not a completely “foreign” concept. This, combined with the “one-to-one” model provided during testing, could explain these results.

Another issue to consider is the fact that there were no monolingual Kreyol speakers in this study. The Kreyol speakers in this study also spoke English fluently. Although the acoustic results indicate that the Kreyol vowel space of these speakers appears to match non-acoustic descriptions, it is not clear if these productions are true representations of Kreyol (not influenced by English). Having data on how monolingual Kreyol speakers produce Kreyol vowels would provide baseline measurements that would allow for a better “monolingual/bilingual” comparison. It would be advantageous to find out if these results would be the same for monolingual Kreyol speakers.

Although group differences were not significant, there were significant differences in how female and male speakers produced the vowel /e/ only. This appeared to be the result of male speakers’ production of /ɛ/ that moved toward the point vowel /i/. 
When Haitian American speakers produced English vowels, acoustic analyses revealed that the English vowel space produced by was no different than the vowel space of non-Haitian native English speakers. This is to be expected for the Haitian American monolingual English speakers (because language use questionnaires indicated that either the child spoke only English at home). But this was also the case when Haitian American bilingual speakers’ productions were compared to non-Haitian native English speakers from the same geographical area. This suggests that bilingual speakers as young as 5 years old can produce the vowel sounds of their second language as a native speaker. These overall results support the SLM, which indicates the influence of AOA on native-like production (Flege, 1999). Haitian American bilingual speakers in this study (who spoke both English and Kreyol fluently) produced English and Kreyol vowels with native-like formant frequencies.

The fact that bilingual speakers were able to do this can support the fusion, differentiation with autonomous development or interdependent development theories. Although it would seem that the bilingual speakers in this study developed their vowel skills based on the differentiation with interdependent development theory (because it allows for the development of both similar and different features between both English and Kreyol), determining which theory fits would be difficult (especially with simultaneous bilingual learners). Bilingual speakers in this study appeared to be able to produce English and Kreyol vowels independent of each other, code-switching successfully between the two when required. However, even if we consider the
similarities between the two languages vowel systems, it is unclear if the similar phonemic repertoires acted as the “common element” between the two languages at this time or if the dual languages merged into a single language system. Because these bilingual speakers were learning the language rules of Kreyol and English at the same time, any of these theories could explain how the bilingual learner organizes the languages he speaks.

Preliminary observations indicate that many of the bilingual speakers are spoken to in Kreyol (only) at home, whereas the monolingual speakers are spoken to in both English and Kreyol in the home. The language input scenarios discussed by Romaine (1999) that appear to fit the scenarios of these speakers are Type 3 (Non-dominant home language without community support) and Type 6 (Mixed languages). The parents of these bilingual speakers either speak Kreyol only, or Kreyol and English in the home. Finding out how the different input scenarios might impact the bilingual speaker’s vowels space (in the native and second language) would be a definite question of interest.

Results of this study indicate that young bilingual children produce English vowels without a Kreyol “accent.” However, the impact of the home language was not addressed as a factor in this study. “Home language” is currently used to help classify a child’s bilingual status. But, specific questions regarding language input (i.e. “how often is the child spoken to in the native/home language,” or “does the child speak in the non-dominant language spoken in the home?”) are not always asked. It is not known if there is a relationship between the language spoken in the home, when it was learned, how
often it is spoken (by parents), or how often responses are in the home language (by the child). Using the information gathered from the language questionnaire, future research would analyze the information/questions from the language use questionnaire (refer to Appendix A) in order to determine if there is a correlation between type and amount of language input on bilingual features exhibited.

These results have significant implications for the speech-language pathologist that works with bilingual speakers, specifically young school-age children. Because young school-aged children make up a large percentage of the children referred for articulation and language services, having knowledge about how bilingual speakers (Kreyol/English speakers in this case) produce phonemes is important in determining which child will need articulation services. Although speech-language pathologists are trained to take the child’s native language (dialect) into consideration when assessing speech and language skills, the lack of objective developmental data too often causes the speech-language specialist to treat children that are bilingual (or bidialectal) as monolingual speakers of their native or second language. Therapists either treat the bilingual child using the data available in their native language (not considering the fact that they know/speak English), or they treat the child as a native English speaker of the mainstream dialect (not taking into consideration the child’s use of their native language). This can lead to these children being under-diagnosed or over-diagnosed.
The fact that the young bilingual speakers in this study appear to be able to
differentiate between Kreyol and English vowels (their native and second language)
despite the fact that they are spoken to in Kreyol often and continue to speak Kreyol in
the home, speaks to whether or not our methods of assessment are sound for this
particular age group. It might be possible to test the articulation skills of a bilingual
speaker of this particular age in the second language only.

Consideration must be given to the fact that these results might be valid for
vowels only. However, it leads one to wonder if these same results would exist during
the production of consonant sounds. Because speech-language pathologists rarely test for
vowel errors during the average articulation assessment (Pollock, 1991; Pollock and
Berni, 2001), examining consonant production differences between bilingual and
monolingual speakers would be a good follow-up to this research. If the results are
similar for vowels and consonants, testing articulation skills in L1 might not be
necessary.

Because these results only examined Haitian American speakers from one region
in the United States, there is a need for further research that will increase the sample size,
looking at the vowel characteristics of 4-5 year old Haitian Americans from different
regions. Looking at productions of speakers in other regions would help determine if
bilingual speakers in those regions are producing vowels in the same way their non-
Haitian counterparts or if there is “Haitian” language connection between the Haitian American speakers (regardless of the region in which they reside).

These results can only apply to bilingual children between the ages of four and five. How would the results change if older children were participants? Lee, et al. (1999) results indicated that there were age differences noted for monolingual English child speakers during their productions of English vowels. Conducting a cross-sectional study that investigates differences in vowel characteristics of Haitian American speakers of different ages and different ages of arrival (AOA) in the United States would help determine the critical age for bilingual speakers producing vowels as a native speaker. Although research (Flege, et al., 1999; Flege, et al., 1997) conducted bilingual studies on adults and looked at various features that contributed to native-like production, these studies did not look at differences that might exist for bilingual child speakers as they age (up to age 18). Further research in this area for bilingual child speakers is needed.

Following the research approach of Peterson and Barney (1953) and Hillenbrand, et al., (1995), the results discussed in this study specifically examined midpoint formant values. With more recent descriptions of vowels looking at how the spectral features of the vowel change over the length of the vowel (Fox and McGory, 2007; Jacewicz, et al., 2006; Fox, et al., 2006), future research would look at dynamic spectral change to see if similarities in formant frequencies across groups continue to be evident.
Because of the similarities between the vowel spaces of bilingual speakers in this study (for both Kreyol and English vowels), comparing vowel space areas for these two groups might not yield significant differences (though this kind of comparison would probably be helpful when comparing Haitian Kreyol speakers from different regions) (Jacewicz, et al., 2007). However, tracking formant movement (for the vowel) over time would provide more detailed information about tongue positioning than midpoint values only (Jacewicz, et al., 2006; Fox and McGory, 2007). Tracking the direction of the formant movement and comparing the movement for both languages can help determine if the bilingual speaker’s vowel is moving in the same direction as a native speaker or exhibiting a movement pattern unique to a bilingual speaker. It would also be interesting to see if monolingual (English) Haitians exhibit a pattern that is similar to bilingual speakers. Findings from these comparisons might be able to more accurately determine if the bilingual speaker is utilizing the fusion, or differentiation hypotheses.

Another possibility is to examine F1 and F2 vector length, which determines how much diphthonization takes place during the production of vowels. The longer the vector length, the more a particular vowel is produced as a diphthong (Fox, et al., 2006). Comparing vector lengths of bilingual and monolingual speakers (when producing English vowels) will determine if bilingual speakers are producing monothongs as a native speaker, or creating a “diphthonized” version of the English vowels. It could also
be used to compare monolingual and bilingual speakers of Kreyol (specifically for the vowel /e/).
REFERENCES


www.babybumblebee.com

www.co.broward.fl.us/planningservices/bbtn6.pdf

http://www.cal.org/co/haiti/htoc.html

http://www.census.gov


www.haskins.yale.edu/featured/heads/MMSP/acoustic.html

www.kreyol.com

http://www.n cela.gwu.edu


http://www.unix.ott.umass.edu/~efhays/haitian/html

http://www.visions-decisions.com/ETHPRO.pdf


Siegel, G., Cooper, M., Morgan, J., and Brenneise-Sarshad, R. (1990) Imitation of

http://bbsonline.cup.cam.ac.uk/Preprints/Soltis-11072002/Referees/

SPSS for Windows, Rel. 16.0.1. 2007. Chicago: SPSS Inc.

Immigrants and Haitian Americans in Miami-Dade County. Prepared for Haitian
American Foundation, Inc., Human Services Coalition of Miami-Dade County,
Kellogg Foundation. Miami: Florida International University, Immigration &
Ethnicity Institute.

without Phonological Processes. In Ferguson, C., Menn, L., and Stoel-Gammon,
C. *Phonological Development: Models, Research, and Implications*. MD: York
Press.


Vihman, M. (1993). Early Phonological Development. In Bernthal and Bankson,
Articulation and Phonological Disorders. NJ: Prentice Hall.

Walton, J., and Orlifkoff, R. (1994). Speaker race identification from acoustic cues in the


perceptual reorganization during the first year of life. *Infant Behavior and
Development*, 7, 47-63.

Capabilities and Developmental Change. *Developmental Psychology*, 24, 672-683


APPENDIX A:

LANGUAGE QUESTIONNAIRE
Language Use Questionnaire

Child’s Name:                      Date of Birth:

Gender:                           Country of Birth:

Language(s) spoken in the home:

1. What language did your child learn first?

2. Where did your child learn English?

3. How long has your child lived in the United States?
   a. Since birth
   b. 2-3 years
   c. 1-2 years
   d. Less than 1 year

4. How often do you speak to your child in Kreyol?
   a. Always
   b. Often
   c. Sometimes
   d. Never

5. How often does your child hear Kreyol during the day?
   a. Always
   b. Often
   c. Sometimes
   d. Never
6. How often do you speak to your child in English?
   a. Always
   b. Often
   c. Sometimes
   d. Never

7. How often does your child speak to you in Kreyol?
   a. Always
   b. Often
   c. Sometimes
   d. Never

8. How often does your child speak to you in English?
   a. Always
   b. Often
   c. Sometimes
   d. Never

9. Has your child ever diagnosed with hearing problems?

10. Are you concerned about how your child speaks English or Kreyol?
APPENDIX B

PICTURE STIMULI
APPENDIX C:

ELICITATION SCRIPT
**Elicitation Script**

I’m going to show you some pictures. Your job is to tell me what each picture is. Each time I show a picture I’m going to ask “What is this?” I want you to answer “It’s a ______” and say the name of the picture. So if I show you a picture of a bird (hold up the picture of the bird) and say “What is this?” I want you to say “It’s a bird.”

Let’s try some for practice.

(Hold up example #1—a picture of a shirt) **What is this?**

(Wait for response. If child answers “It’s a shirt” then reply “You’re right it’s a shirt, good job” and continue to stimulus items).

(If child answers “shirt”, praise child for correct answer model the desired response “You’re right, it’s a shirt. Can you say ‘It’s a shirt.’?” Wait for child to repeat the desired response then move to example #2—a picture of a cookie—and repeat process).

(If child appears unable to label the picture, provide a verbal cue (i.e. “It’s a sh__.”) and wait for child to produce label. If the child is unable to name the picture after verbal cue, provide the label and ask child to repeat).
APPENDIX D:

KREYOL VOWEL DURATIONS FOR EACH HAITIAN SUBJECT
### Kreyol Vowel Durations: Speaker 3

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ŋ</td>
<td>175</td>
</tr>
<tr>
<td>ë</td>
<td>180</td>
</tr>
<tr>
<td>ā</td>
<td>185</td>
</tr>
<tr>
<td>i</td>
<td>190</td>
</tr>
<tr>
<td>u</td>
<td>195</td>
</tr>
<tr>
<td>e</td>
<td>200</td>
</tr>
<tr>
<td>a</td>
<td>205</td>
</tr>
<tr>
<td>o</td>
<td>210</td>
</tr>
<tr>
<td>e</td>
<td>215</td>
</tr>
<tr>
<td>ñ</td>
<td>220</td>
</tr>
</tbody>
</table>

**Diagram: Kreyol Vowel Durations**

The diagram above illustrates the duration (in milliseconds) of different vowel sounds for Speaker 3 in Kreyol. Each vowel is represented by a bar, with the height indicating the duration. The vowels are ordered from top to bottom as follows: ŋ, ë, ā, i, u, e, a, o, e, ñ.
Kreyol Vowel Durations: Speaker 4

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ź</td>
<td>250</td>
</tr>
<tr>
<td>ĺ</td>
<td>300</td>
</tr>
<tr>
<td>ĳ</td>
<td>350</td>
</tr>
<tr>
<td>ū</td>
<td>225</td>
</tr>
<tr>
<td>ė</td>
<td>225</td>
</tr>
<tr>
<td>ē</td>
<td>275</td>
</tr>
<tr>
<td>ø</td>
<td>275</td>
</tr>
<tr>
<td>ō</td>
<td>275</td>
</tr>
<tr>
<td>ẻ</td>
<td>225</td>
</tr>
<tr>
<td>ɛ</td>
<td>275</td>
</tr>
<tr>
<td>ɔ</td>
<td>275</td>
</tr>
</tbody>
</table>

Diagram showing vowel durations in milliseconds for Speaker 4.
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ð</td>
<td>110</td>
</tr>
<tr>
<td>ê</td>
<td>180</td>
</tr>
<tr>
<td>â</td>
<td>190</td>
</tr>
<tr>
<td>i</td>
<td>140</td>
</tr>
<tr>
<td>u</td>
<td>120</td>
</tr>
<tr>
<td>e</td>
<td>150</td>
</tr>
<tr>
<td>a</td>
<td>200</td>
</tr>
<tr>
<td>o</td>
<td>130</td>
</tr>
<tr>
<td>e</td>
<td>190</td>
</tr>
<tr>
<td>œ</td>
<td>160</td>
</tr>
</tbody>
</table>

Kreyol Vowel Durations: Speaker 5
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ð</td>
<td>250</td>
</tr>
<tr>
<td>è</td>
<td>250</td>
</tr>
<tr>
<td>à</td>
<td>250</td>
</tr>
<tr>
<td>i</td>
<td>250</td>
</tr>
<tr>
<td>u</td>
<td>250</td>
</tr>
<tr>
<td>e</td>
<td>300</td>
</tr>
<tr>
<td>a</td>
<td>200</td>
</tr>
<tr>
<td>o</td>
<td>225</td>
</tr>
<tr>
<td>e</td>
<td>225</td>
</tr>
<tr>
<td>o</td>
<td>225</td>
</tr>
</tbody>
</table>

Kreyol Vowel Durations: Speaker 6
Kreyol Vowel Durations: Speaker 7

Vowel Duration (ms)

0
50
100
150
200
250
300
350

舌
鼻
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
唇
lip

舌

舌

舌

舌

舌

舌

舌

舌

舌


Kreyol Vowel Durations: Speaker 17

Vowel
Duration (ms)
0
100
200
300
400

Kreyol Vowel Durations: Speaker 17

Duration (ms)
0
100
200
300
400

Vowel
Kreyol Vowel Durations: Speaker 19

![Bar Chart](chart.png)
APPENDIX E:
SUBJECT VOWEL SPACES FOR KREYOL WORDS
Speaker 4

F2
1000 2000 3000 4000

F1
200 400 600 800 1000 1200 1400

F1
F2
Speaker 6

F2
1000 2000 3000 4000
F1
200 400 600 800 1000 1200 1400

\( \epsilon \) 
\( \tilde{\epsilon} \) 
\( \tilde{\alpha} \) 
\( \alpha \) 
\( \tilde{\alpha} \) 
\( \epsilon \) 
\( \tilde{\epsilon} \) 
\( i \) 
\( u \) 
\( o \)
APPENDIX F:

SUBJECT VOWEL DURATIONS FOR ENGLISH WORDS
English Vowel Durations: Speaker 4

Vowel | Duration (ms) |
------|--------------|
æ     | 220          |
ɛ     | 180          |
i     | 280          |
i     | 220          |
o     | 220          |
u     | 220          |
a     | 180          |
ʌ     | 180          |

Duration (ms)
English Vowel Durations: Speaker 5

Vowel
Duration (ms)

\[ \begin{align*}
\text{æ} & \quad \text{100} \\
\text{e} & \quad \text{150} \\
\text{ɛ} & \quad \text{200} \\
\text{i} & \quad \text{250} \\
\text{ɪ} & \quad \text{200} \\
\text{o} & \quad \text{150} \\
\text{u} & \quad \text{125} \\
\text{ɑ} & \quad \text{100} \\
\text{ʌ} & \quad \text{80}
\end{align*} \]
English Vowel Durations: Speaker 7

Vowel

Duration (ms)

0
100
200
300
\( \ddot{a} \) 
\( \epsilon \) 
\( \dddot{e} \) 
\( \dddot{i} \) 
\( \dddot{u} \) 
\( \dddot{o} \) 
\( \dddot{a} \) 
\( \dddot{\Lambda} \)
English Vowel Durations: Speaker 8

Vowel
Duration (ms)
0
100
200
300
æ e ɛ i ɪ o ʊ ʌ æ
English Vowel Durations: Speaker 9

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>250</td>
</tr>
<tr>
<td>e</td>
<td>230</td>
</tr>
<tr>
<td>ə</td>
<td>220</td>
</tr>
<tr>
<td>i</td>
<td>370</td>
</tr>
<tr>
<td>ɪ</td>
<td>240</td>
</tr>
<tr>
<td>ı</td>
<td>210</td>
</tr>
<tr>
<td>o</td>
<td>330</td>
</tr>
<tr>
<td>u</td>
<td>260</td>
</tr>
<tr>
<td>a</td>
<td>200</td>
</tr>
<tr>
<td>ʌ</td>
<td>180</td>
</tr>
</tbody>
</table>
English Vowel Durations: Speaker 12

![Bar chart showing vowel durations in milliseconds for Speaker 12. The chart includes vowels such as /æ, e, ɛ, i, ɪ, o, u, ɑ, θ/ and their corresponding durations from 0 to 300 milliseconds.]
English Vowel Durations: Speaker 14

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
</tr>
<tr>
<td>ə</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td></td>
</tr>
<tr>
<td>ɪ</td>
<td></td>
</tr>
<tr>
<td>ɒ</td>
<td></td>
</tr>
<tr>
<td>u</td>
<td></td>
</tr>
<tr>
<td>ɑ</td>
<td></td>
</tr>
<tr>
<td>ʌ</td>
<td></td>
</tr>
</tbody>
</table>
English Vowel Durations: Speaker 17

Vowel

Duration (ms)

0
100
200
300

æ è ɛ i ɪ o u ø a ʌ
English Vowel Durations: Speaker 18

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ</td>
<td>200</td>
</tr>
<tr>
<td>e</td>
<td>230</td>
</tr>
<tr>
<td>ə</td>
<td>200</td>
</tr>
<tr>
<td>å</td>
<td>250</td>
</tr>
<tr>
<td>i</td>
<td>320</td>
</tr>
<tr>
<td>ɪ</td>
<td>200</td>
</tr>
<tr>
<td>o</td>
<td>180</td>
</tr>
<tr>
<td>u</td>
<td>160</td>
</tr>
<tr>
<td>a</td>
<td>190</td>
</tr>
<tr>
<td>ʌ</td>
<td>140</td>
</tr>
</tbody>
</table>

![Bar chart showing vowel durations for Speaker 18]
English Vowel Durations: Speaker 20

![Bar chart showing vowel durations in milliseconds for various English vowels. The chart includes vowels such as /æ/ (as in never), /e/ (as in see), /ɛ/ (as in bitter), /i/ (as in time), /ɪ/ (as in time), /o/ (as in open), /u/ (as in use), /ɑ/ (as in car), and /ʌ/ (as in cat). The x-axis represents the vowels, and the y-axis represents duration in milliseconds. Each vowel is represented by a bar indicating its average duration in milliseconds. The chart provides a visual comparison of vowel durations for Speaker 20.](image-url)
English Vowel Durations: Speaker 24

![Graph showing vowel durations](image)
APPENDIX G:

SUBJECT VOWEL SPACES FOR ENGLISH WORDS
English Vowel Space-Speaker 2

![Diagram of English vowel space for Speaker 2 with points for vowels i, I, e, æ, a, o, u labeled with corresponding F1 and F2 frequencies.]
English Vowel Space-Speaker 4

F1
200 400 600 800 1000 1200 1400

F2
1000 2000 3000 4000

Vowels: i, u, e, i, æ, a, œ, o
English Vowel Space-Speaker 5

![English Vowel Space-Speaker 5 Diagram](image-url)
English Vowel Space-Speaker 8

F1

F2

i

u

e

I

\varepsilon

\varepsilon

\theta

\alpha

\Lambda

\alpha
English Vowel Space-Speaker 9

The diagram illustrates the English vowel space for Speaker 9, with F1 and F2 axis values ranging from 200 to 2000 Hz. The vowels i, e, æ, ə, a, o, and u are plotted on the graph, showing their positions in the vowel space.
English Vowel Space - Speaker 11
English Vowel Space-Speaker 16

![Graph showing the vowel space for Speaker 16, with labels for the vowels i, e, ɛ, æ, u, and o. The graph uses F1 and F2 axes to plot the vowel positions.](image-url)
English Vowel Space-Speaker 17

F1

F2
APPENDIX H

LETTERS OF AGREEMENT
Letter of Agreement

This letter serves as documentation that George Aristide is familiar with Stacey Wallen’s research project titled *Vowel Production in Haitian American Children* and approves the involvement of students from *Broward Junior Academy* in the project as subjects. George Aristide understands that *Broward Junior Academy* is connected to the research project solely as a data collection site. *Broward Junior Academy* nor its teachers, staff or administrators, will be directly involved in subject recruitment, testing, or data collection and will thus not be engaged in the research.

I understand that signing this letter of agreement allows for the recruitment and participation of students enrolled at *Broward Junior Academy* by Stacey Wallen. I have received a copy of the research proposal and am satisfied that the safety and welfare of the students of *Broward Junior Academy* are adequately protected as described in the research protocol. I also understand that:

- this research will be carried out in accordance to sound ethical principles outlined by both this institution and The Ohio State University under an approved research protocol.

  ______

- consent forms (complete with a brief description of the study) will be provided to parents of potential subjects in both English and Kreyol.

  ______

- though the researcher and her assistants are the only people actively engaged in the research, they may require me or members of my staff to act as a liaison between the researcher and Kreyol-speaking parents.

  ______
• participation in this research is strictly voluntary. _______
• participants will be given a hearing screening and an informal language screening. Results and appropriate referrals will be provided to the parents of those participants that have exhibited difficulty. _______
• participants will not be tested during lunch, snack, or naptime. _______
• a quiet room, (with at least one standard electrical outlet), a table, and three chairs will be needed for testing. _______
• testing will begin between March 20, 2006 and April 24, 2006 and continue for approximately two weeks after the start date. _______

Any questions that arise can be directed to Stacey Wallen, MA, CCC-SLP @ (954) 415-4069 or Robert A. Fox, PhD @ (614) 292-8207

Signature ________________________________ Date___________

Witness Signature__________________________ Date_________
Letter of Agreement

This letter serves as documentation that Gayle Dawkins is familiar with Stacey Wallen’s research project titled *Vowel Production in Haitian American Children* and approves the involvement of students from *New Hope SDA Academy* in the project as subjects. Gayle Dawkins understands that *New Hope SDA Academy* is connected to the research project solely as a data collection site. *New Hope SDA Academy* nor its teachers, staff or administrators, will be directly involved in subject recruitment, testing, or data collection and will thus not be engaged in the research.

I understand that signing this letter of agreement allows for the recruitment and participation of students enrolled at *New Hope SDA Academy* by Stacey Wallen. I have received a copy of the research proposal and am satisfied that the safety and welfare of the students of *New Hope SDA Academy* are adequately protected as described in the research protocol. I also understand that:

- this research will be carried out in accordance to sound ethical principles outlined by both this institution and The Ohio State University under an approved research protocol.

- consent forms (complete with a brief description of the study) will be provided to parents of potential subjects in both English and Kreyol.

- though the researcher and her assistants are the only people actively engaged in the research, they may require me or members of my staff to act as a liaison between the researcher and Kreyol-speaking parents.
participation in this research is strictly voluntary.

participants will be given a hearing screening and an informal language screening. Results and appropriate referrals will be provided to the parents of those participants that have exhibited difficulty.

participants will not be tested during lunch, snack, or naptime.

a quiet room, (with at least one standard electrical outlet), a table, and three chairs will be needed for testing.

testing will begin between March 20, 2006 and April 24, 2006 and continue for approximately two weeks after the start date.

Any questions that arise can be directed to Stacey Wallen, MA, CCC-SLP @ (954) 415-4069 or Robert A. Fox, PhD @ (614) 292-8207

Signature ________________________________ Date___________

Witness Signature__________________________ Date___________