Similarities and differences in perception and production of diphthong sounds among native speakers of Spanish and English

Kelley Wilkinson
University of Northern Iowa

Similarities and Differences in Perception and Production of Diphthong Sounds Among Native Speakers of Spanish and English

Kelley Wilkinson
University of Northern Iowa
Honors Program/Presidential Scholar Program Graduation Thesis Requirement
March 8, 2004

- ## Abstract

This thesis studies the similarities and differences between native speakers of the Spanish and English languages in the pronunciation of diphthong sounds, both the speakers' perception of such sounds as well as the actual sound produced. Two methods were used in determining trends and dissimilarities. Participants were asked to identify how many distinct segments they perceived in each of four test words. The results were then calculated and compared to seek common trends between the languages. The second method of determining similarities and differences involved measuring voice samples from the participants with a spectrograph. The end results were that while there is no significant difference in the frequency or change of the actual sounds produced by the speakers, there is a difference in the way in which native Spanish and native English speakers perceive these sounds.

- ## Introduction

The English writing system is highly challenging. This is attributed to many factors, including poor correspondence between phonemes (or sound units) and graphemes (alphabetic characters). One letter can correspond to more than one sound, such as the letter "c." This letter can represent sounds similar to that of either the letters "k" or "s," such as in the words *recess* and *ironic*. Conversely, different letters can represent the same sound. The word *recess* above is an example of this. Both the graphemes "c" and "ss" both correspond to the same sound.[1] [2]

---

[1] Letters within "quotations" represent written letters, while letters enclosed in /slashes/ represent phonological sounds.

[2] The following phonetic symbols will be used to correspond to the sounds analyzed in this investigation:

/au/	loud
/oi/	boy
/ei/	fade
/ai/	fight

Certain graphemes can even correspond to sounds that are normally associated with a different grapheme altogether. Consider the word *tough*" The grapheme "gh" makes the sound that is typically produced when the grapheme "f" is present, such as in the word *fin*.

A study by Colin Phillips, et al, shows that there is a discrete point at which the brain distinguishes between two phonemes, such as "t" and "d." The researchers of this study propose that there is a boundary between two phonemes, whereat all sounds on one side of the boundary correspond to one phoneme and all sounds on the other side correspond to the other phoneme. This study examined brain waves of participants as they listened to a series of tones. The tones would all correspond to one phoneme, the letter /d/, for example. One mismatch tone categorized as the letter "t" would be inserted somewhere in the sequence. The results were that the auditory cortex region of the brain responded differently to the mismatch tone, thus distinguishing between the two tones.

The Phillips, et al study supports the theory of this thesis that even though two sounds may be similar, it is possible to distinguish between them. However, speakers of English are not generally able to perceive the two distinct sounds in diphthongs. This was visible in an introductory linguistics course at the University of Northern Iowa. The instructor, born and educated through the college level in Spain, was able to distinguish between and identify the two phonemes in a diphthong. The students, all native to either the United States or Germany, identified diphthongs as a single segment.

A diphthong, according to Raymond D. Kent in his book <u>The Speech Sciences</u>, is a vowel-like sound that is produced as a slow gliding movement from one vowel (the onglide) to a following vowel (the offglide). Nine diphthongs exist in the English language. The four diphthongs analyzed in this study are all closing diphthongs which means that the second vowel position is closer to the roof of the mouth than is the first. The tongue changes position from the first vowel sound to the second to form a combined diphthong.

Vowels, although they do not have as sharp boundaries as consonants, still form categories.[3] This suggests that individuals should be able to distinguish between two separate sounds (segments) in diphthong if they are, in fact, pronouncing two sounds or segments. A simple definition of the word "segment" as it is used in this paper is the smallest unit of speech that is discernible individually from other segments.

The knowledge that diphthongs are comprised of two distinct "vowel" segments, both orthographically (written) and phonetically (spoken) prompted two principle questions in this thesis:

1) If English speakers only perceive a diphthong as one segment, are they actually producing only one instead of the two that should comprise a diphthong?

---

[3] Phillips, Colin and Thomas Pellathy, et al. "Auditory Cortex Accesses Phonological Categories: An MEG Mismatch Study." *Journal of Cognitive Neuroscience*. 2000. Volume 12, Issue 6. Page 1038.

2) Do Spanish speakers pronounce and perceive the same diphthong sounds in the same manner as do English speakers?

- **Discussion**

Why the discrepancy?

Although this research has determined that native speakers of English and Spanish pronounce both the onglide and the offglide sounds in a diphthong, there still exists a disparity between this pronunciation and its perception. While native Spanish speakers are able to identify that there are two distinct sounds in a diphthong, English speakers fail to do so. There are several possible reasons that could explain why this is so.

Spanish Spelling Bees?

Spelling Bees are common events among elementary school children in the United States. However, this is not so for Spanish-speaking countries. This is because the Spanish language system is not as orthographically or phonologically complex as is the English language system. American English has at least twelve distinct vowel sounds that correspond to five vowels. The Spanish language has one vowel sound to correspond to each of the five written vowels.

A college professor who once worked as a court interpreter told the story of a Spanish-speaking man who was asked to spell his name for the court. He replied, "Mendoza: Men Do Za." He did not understand how anyone would have trouble writing his name because it was spelled exactly as it sounded. There is not a problem with corresponding words to their correct phonological symbols in Spanish, as there is in English, because Spanish is univocal from spelling to speaking. This means that a Spanish speaker can see a word and know exactly how to speak it. However, if a native Spanish speaker hears a word spoken, he or she will not necessarily know how to spell it. Consider the Spanish word "vaca," which translates into English as "cow." There are three other possible spellings of this word that would yield an identical pronunciation: "baca," "vaka," and "baka," because the letters "b" and "v" represent the same sound in the Spanish language, as do the letters "k" and "c."

English, on the other hand, is not entirely univocal. The two words "eight" and "receive" both contain the letters "ei" together, but they are pronounced differently. The "ei" in "eight" is phonetically represented as /ei/, but the same grapheme combination in "receive" is clearly pronounced with as a "long e" vowel. Conversely, an English speaker could hear the word "eight" spoken and not know whether it should be written as before or as "ate." These two words have very different orthographical structures, but their pronunciations are identical.

Data analyzation found later in this paper will show that Spanish speakers are able to distinguish between the two distinct sounds in a diphthong, but that some consider a consonant and a vowel to be one segment. For instance. An English speaker would consider the word "ray" to have two segments, /r/ and /ay/. A Spanish speaker would also consider the word "rey" (pronounced the same as the English "ray") to have two segments. However, the Spanish speaker would more likely identify the segments as /re/ and /y/. This is also seen in the preceding paragraph in the way the Spanish-speaking man spelled his name: /Men/ /do/ /za/. Because Spanish vowel sounds correspond to one and only one orthographical symbol (letter), they are often taught in conjunction with a vowel sound as "syllables."[4] This could explain why some of the Spanish-speaking participants combined a consonant and a vowel as one segment. However, it does not affect the fact that they were able to identify both parts of a diphthong, which was the aim and interest of this study.

Language games

Some force in the English phonological system makes native speakers of English perceive a diphthong as one segment (the smallest distinguishable unit of speech), while Spanish speakers perceive it as two. Evidence of this fact is found in speech games or "secret languages" among children in the two languages.

Spaniards have their own equivalent to the English code "Pig Latin." This game is played by adding the syllable *ti* (pronounced /tī/) in front of every syllable in a word. For instance, the word *aire*, which is Spanish for *air*, would be pronounced *ti-a ti-i ti-re*. This shows a distinction between the diphthong components *a* and *i* in the word *aire* as two separate segments of the word.

Next consider the English game of Pig Latin. Alvin Schwartz, in his book *The Cat's Elbow and other Secret Languages*, gives three rules for the language. The first states, "Move the first letter in a word to the end of the word. Then add *ay*. Following this rule, we know that only the initial sounds of a word are altered using Pig Latin, so words that start with diphthongs would be affected by manipulating the order of the letters in the word. If English speakers truly identify diphthongs as one sound, would they not move both vowel letters to the end of the word since they are one segment? However, another rule Schwartz gives is, "If the word starts with a vowel, don't move the vowel. Instead, add *way* to the end of the word." Since the position of the initial vowel/diphthong sound does not change in Pig Latin, it is impossible to identify an exact parallel between segmentation of diphthong sounds between the two aforementioned language games.

A history of American phonics/phonetics

[4] Landol, Inc. Consonantes Y Vocales. Ashland, OH: Tribune Education: 2000. Page 5

Phonics instruction is deeply rooted in the American school system. It was first employed in the 1600's version of the *New England Primer*, which reflected a strong emphasis on phonics, including instruction on the alphabet and simple syllables. That has changed considerably compared with current views and applications of phonics instruction in American schools. Students do not learn to identify syllables but rather individual letters. Linguists and literacy educators generally agree that regardless of the method of instruction, learning phonics in English is difficult for children because the English writing system is not purely phonetic. Gail E. Tompkins, in a textbook for prospective educators, projects that only half English words are spelled phonetically. Although the English alphabet includes twenty-six letters (called graphemes), there are forty-four phonemes, and many of them do not represent unique phonemes.[5] Another difficulty is that the same sound can be represented by two different graphemes, such as "k" and "c", or "c" and "s". In summary, although phonics instruction is generally viewed as necessary for children to learn to read and speak correctly, it is an exceedingly complicated process.

In the past century, there has been some backlash against phonics instruction in the American schools. In the early Twentieth Century, the Progressive Movement was all the rage. It emphasized the school's role in helping the child adapt to society's needs rather than focus on academic curricula. Phonics instruction in schools decreased in favor of the whole-language method, which encouraged children to explore reading and did not give explicit instruction on the sounds identified with individual graphemes. Children educated under the whole-language method had virtually no background in phonics instruction and the mechanics of reading. As a result, reading achievement scores in the United States plummeted. After years of researching methods for teaching phonics and reading, Harvard professor Jeanne S. Chall determined that phonics instruction is vital for competence literacy and reading skills. A statement by the National Institute on Education states, "Classroom research shows that, on average, children who are taught phonics get off to a better start in learning to read than children who are not taught phonics" (Hirsch, 103).

Phonics Education Today

It is currently accepted that phonics instruction is important for literacy, both in speaking and reading. Public schools in America identify specific objectives related to phonics instruction. The government of Iowa mandates that phonics be taught in the state's public schools. In 2000, the Code of Iowa was amended by adding the sentence, "Language arts and communication skills shall be taught using a systematic, phonics-based approach" for kindergarten through grade three. However, even though states and schools in the United States recognize the importance of phonics instruction, students graduating from the country's public schools still cannot distinguish the two separate segments in diphthong sounds.

---

[5] Tompkins, Gail E. Literacy for the Twenty-First Century. Upper Saddle River, NJ: Merrill Prentice Hall. 2003. Page 164.

Phonics instruction in the early elementary grades does not acknowledge that diphthong sounds are different than other vowels, for teachers or for students. Rather than explain what diphthongs are, textbooks describe some of them as *long vowels*. The following statement from the textbook *Literacy for the 21st Century: A Balanced Approach* by Gail E. Tompkins, explains vowel sounds to teachers: "Vowel sounds are more complicated than consonant sounds, and there are many vowel combinations representing long vowels and other vowel sounds."[6] Tompkins also states that most vowel combinations are diphthongs. The text states, "When the two vowels represent a glide from one sound to another, the combination is a diphthong." The text recognizes the existence of diphthongs, but its method for teaching vowels is to group diphthongs and long vowels in the same category.

Segmentation in Elkonin Boxes

Elkonin boxes are tools for segmentation that can be used to help children in the early stages of literacy to identify sounds. Elkonin boxes were developed by psychologist D.B. Elkonin.[7] The teacher shows the student an object, such as a light. He or she then draws a box with the "correct" number of compartments for the number of sounds in the name of the object. Then, the teacher or student moves a marker into each box as the sound is pronounced. Finally, the student writes the letters (graphemes) that correspond to each sound (phoneme) in each box. A finished Elkonin box would look like this:

Table 1: Elkonin box

l	igh	t

Here, the three graphemes /i/, /g/, and /h/ are all said to produce only one sound, when in fact they produce a diphthong. This is a clear example of combining the distinct sounds in a diphthong into one segment.

Segmentation in Dictionaries

Dictionaries also support the fact that the diphthong sound in words such as *race* and *light* is subtle and difficult to perceive in the English language. The results from the spectrograph analysis confirm that there is very little change in the speakers' pronunciation of words containing this sound.

Both Webster's New World College Dictionary and The Random House Dictionary fail to identify the vowel sound in the words *race* (/r/A/s) and *light* (l/I/t) as a diphthong. The

---

[6] Tompkins, Gail E. Literacy for the Twenty-First Century. Upper Saddle River, NJ: Merrill Prentice Hall. 2003. Page 174.

[7] Tompkins, Gail E. Literacy for the Twenty-First Century. Upper Saddle River, NJ: Merrill Prentice Hall. 2003. Page 169.

transcription for the words *doubt* and *boy* do show two vowel graphemes (a vowel and a diphthong); however, the each dictionary's key shows the same two graphemes used to describe the pronunciation of the word as one segment. Although each of the graphemes /i/, /o/, and /u/ are shown in the key as separate phonetic units, their combinations (diphthongs) /au/ and /oi/ are also shown as units. This shows that dictionaries, like Elkonin boxes, do not consistently identify diphthong sounds as two segments.

Long Vowels

Education in what are considered "long vowels" follows the trend of Elkonin boxes and dictionaries in failing to identify diphthongs as two segments. Diphthongs are identified in many language arts, grammar, and phonics textbooks as *long vowels*. The textbook *Literacy for the 21st Century* by Gail E. Tompkins states, "The phoneme in *soap* that is represented by the grapheme "oa" is called "long o" and is written /ō/."[8] The grapheme "oa" above is actually a diphthong, and since there are two distinct sounds, it should technically be identified as two separate graphemes.

Phonics textbooks and workbooks for children learning to read also identify diphthongs as long vowels. The text *Reading Skills for Life, Level A* by Jack Cassidy, Ph.D., gives a list of words to be placed under one of four categories: short a, long a, short i, and long i. There are also several diphthongs in the list, such as *place, glide, time,* and *game*. The correct answer for this activity is to place these diphthong words as words with long vowels.

Another phonics textbook, *Riverside Phonics* by Arthur W. Weilman, also identifies diphthongs as long vowels. One exercise asks students to identify the vowel sounds in words in the context of a sentence. The correct vowel sounds for the words *veil* and *weights* are both identified as /ā/, when these sounds are actually diphthongs. The vowel sound in *yield* is identified as /ē/, as is the sound in *receive*. These two words clearly have very different vowel sounds, yet they are both identified as belonging to the long vowel category.

The term *long vowel* is not just a simple way of explaining diphthongs to children learning to read. There are, in fact, long vowels. The words *be* (pronounced bē) and *go* (pronounced /gō/) are examples of long vowels. These sounds are distinctly different from diphthongs because there is only one vowel sound in these words. However, both the "pure" long vowels in words such as *be* and the vowel/glide combination in diphthongs such as *soul* are identified as long vowels.

The "Silent E" Phenomenon

---

[8] Tompkins, Gail E. Literacy for the Twenty-First Century. Upper Saddle River, NJ: Merrill Prentice Hall. 2003. Page 7.

Another explanation for children's lack of knowledge of diphthong sounds may be attributed to the orthographical structure of English words with diphthongs. There are two ways in which a diphthong may occur in a word. A word can have two vowels next to each other in a word, such as in *nail*. There are two consecutive "vowel" sounds (the vowel /a/ and the glide /i/) in this word, and there are two consecutive vowel graphemes in the word.

English words with diphthongs may also indicate one vowel within the confines of the word and a *silent e* at the end of the word, such as in the word *pine*. Even though there is a glide from the /a/ vowel sound to the /ī/ glide sound, the diphthong is symbolized only by the grapheme /i/. Children are taught that the "e" at the end of the word is silent. Cassidy's phonics textbook explains the silent "e" phenomenon in the following manner: "If there are two vowels in a word and one is a final "e," the first vowel usually stands for a long sound. The final "e" is silent."[9]

In reality, the grapheme "e" at the end of words is not always silent. If the last letter of the word *pine* was not "e", the word would be *pin*. These two spellings have different pronunciations and different meanings. When the grapheme "e" occurs at the end of a word, it may change the vowel sound from a short vowel to a diphthong. It may also change the vowel into a true long vowel, such as in the word *rote*. Nonetheless, children are taught to group the diphthong sounds into the same category as long vowels, when they are actually two distinct categories of sounds.

Speaking Spell Checker

Analysis of diphthong sounds was done using the Franklin Speller, an English spell checking machine with an automated voice feature. The Franklin Speller has the ability to pronounce the word as a whole, as well as phonetically. The twenty English words used in the investigation were analyzed using both of these functions, and the results support the tendency to group the two diphthong sounds into one segment.

In each of the words analyzed, a shift from between the vowel and the glide in the diphthong is present when the machine pronounces the whole word. In the second formant, the change is between 110 Hertz in the word *able* and 1862 Hertz in the word *boy*, with an average change of 731.45 Hertz (or 32.23% the initial frequency) from the start of the pronunciation of the diphthong to the end. There is also a change in the third formant of all but one of the words. Even though the voice is automated and the analyzed data is not that of a live human being, as are the voice samples in the rest of this investigation, this tool (which is used to teach phonics to children) does, in fact, pronounce two distinct sounds in the diphthong.

Regardless, the phonetic pronunciation function of the Franklin Speller teaches the children that the diphthong is one segment. This function works by using the "phonics"

---

9 Cassidy, Jack Ph.D. et al. Reading Skills for Life: Level A. Circle Pines, MN: American Guidance Services, Inc. 2002. Page 22.

button on the machine's keypad. The first time the button is pushed, the machine speaks the word; the subsequent pushes of the button prompt the machine to pronounce each sound separately. In each word, the diphthong sounds are identified as one segment, or sound. This contradicts not only the spectrograph analyzation of human speech, but also the analyzation of the automated voice feature of the machine itself.

Even though the phonetic function of this spell checker identifies the diphthong sounds as one segment, the spectrograph detected two distinct sounds in each of the words. The average change from the beginning of the diphthong pronunciation to the end is comparable to the analyzation of the word spoken as a whole, with an range of change in frequency of 110 Hertz to 1862 Hertz, or 1.1% to 144.3% the initial frequency, for the twenty words. However, the phonetic pronunciation of the word yields more examples of diphthong sounds that exhibit no change from the beginning to the end of pronunciation in six words: *cow, ray, race, light, ice,* and *boy*. The word *boy* shows no change in the second formant when the diphthong is pronounced as an individual segment, and the remaining words show no change in the third formant. The whole word pronunciation produced a change in the diphthong sound in each of these words, but the pronunciation changes when using the phonetic function of the spell checker.[10]

Connection and Application

The "Silent E" words from this investigation are classified as either *long a* vowels (*fade, race, able*, and *ape*) or *long i* vowels (*fine, light, ice*, and *bye*). This type of vowel, along with *long u* vowels such as *mule*, should not be classified as *long vowels* because they are actually diphthongs. The *long e* and *long o* vowels, such as in the words *bee* and *foe*, are true long vowels because there is no diphthong present. Grouping diphthongs, which have two vowel qualities, and true long vowels, which have only one, leads to the tendency to incorrectly identify diphthong sounds as one segment.

The spectrograph analysis of both the spell checker and the research subjects confirms the fact that the vowel sounds in the words used in the investigation do, in fact, have two distinct vowel sounds. It also confirms the fact that the subjects, all born in the United States and educated under the United States educational system, can only identify the existence of one vowel in the diphthong sounds. This exhibits the tendency to group two sound segments into one.

Words with *long o* and *long e* vowel sounds should continue to be classified as such; however, identifying a new label and group of classification for diphthongs that actually have two vowel components, would help speakers of English to identify them as two distinct segments.

[10] See Appendix A: Franklin Speller Data Analysis.

Process and Methods

Eighteen male participants between the ages of eighteen and thirty-five were involved in this study. Nine were native speakers of Spanish and nine were native speakers of English. Males were the exclusive participants of this study because their voices are lower and are thus more easily measured using a spectrograph.

The participants were asked to speak a series of twenty words in their native language into a tape recorder for future analysis with a spectrograph machine.[11] The words each contained one of four diphthongs and varied in placement and type of consonants (voiced or voiceless) before and after the diphthong. Not all possible combinations of voiced and voiceless consonants placed before and/or after diphthongs were used because there are some combinations that are not possible in the Spanish language. The following words were used in the investigation.

Table 2: English and Spanish test words[12]

Voiced before Voiceless after		Voiceless before Voiced after		Nothing before Voiceless after		Voiced before Nothing after		Nothing before Voiced after	
English	Spanish	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Joyce	boys	coin	coil	oink	hoys	boy	voy	(v)oid	oig(o)
doubt	laus	found	caul	out	aut(o)	cow	(baca)lao	(cl)own	aul
race	seis	fade	veil	ape	eis	ray	rey	able	eil
light	vais	fine	bail(e)[13]	ice	aiz	bye	bai(lar)	eyes	ail

Once the voice samples were collected and recorded, they were analyzed using a spectrograph. This machine measures the frequency and duration of speech sounds and separates them into formants. The first and second formants are most useful in identifying vowels (Castle, 13). Thus, these formants were the two analyzed for this investigation.

Participants were also asked to identify the segments in written words in their native language. This was done in order to determine if the perception of spoken phonemes (one or two in a diphthong) corresponds with the actual pronunciation of the sound when analyzed with the spectrograph. The words were chosen to include different orthographical structures. English participants were asked to segment the words *coin, fade, boy,* and *Abe*, which were words analyzed by the spectrograph. Spanish-speaking participants were asked to speak the words *voy, auto, oigo,* and *rey*, also words containing diphthongs and analyzed by the spectrograph.

[11] See Appendix B: Spectrograph Images.

[12] In the absence of an actual Spanish word in the category, a word has been substituted that is either made-up but grammatically possible or a part of an existing word.

[13] Portions of words in parenthesis indicate to omit that portion when pronouncing the words. They are given as a reference to the desired sound.

- **Results**

Segment Identification

Results of the segment identification portion of this investigation show that the English-speaking participants do not perceive a diphthong in the words tested. Below is a table showing the number of syllables each perceived:

Table 3: English segment perception

Word	A	B	C	D	E	F	G	H	I
coin	3	3	3	3	3	3	3	3	4
fade	4	3	3	3	3	3	2	2	3
boy	2	2	2	2	2	2	2	2	3
Abe	3	1	2	2	2	2	2	2	2

If the participants had perceived the diphthong as two segments, their answers would reflect the table below:

Table 4: English segment perception if diphthong is perceived as two segments

Word	Segments	Segmented
coin	4	c-o-i-n
fade	4	f-e-i-d
boy	3	b-o-i
Abe	3	e-i-b

The participants did, in fact, exhibit some degree of variety in their answers. The first to consider is Participant I. He perceived the diphthong in the words *coin* and *boy*. This participant admitted to having experience with singing, which had provided him with some linguistic knowledge. He explained that if he was singing the word *coin* and was asked to hold the note, he would hold the "o" and go to the "i" just before pronouncing the 'n.' However, Participant I did not perceive two segments in the words *fade* and *Abe*. As is discussed later in this paper, the /ei/ diphthong combination has very little (if any) change from one vowel to the next. It is very close to being a "long vowel" (also described later in this paper). Thus, perceiving the diphthong in words with this sound is much more difficult, especially for individuals without formal linguistic education, than is perceiving other diphthongs as two segments.

Participant A also showed a substantial amount of variation in his perception of the diphthong sounds. When compared to the other speakers (omitting Participant I) he perceived an additional segment to the words *Abe* and *fade*. However, Participant A placed the additional segment at the end of the word that he associated with the grapheme

/e/. This could be an effect of the "Silent E Phenomenon," which was discussed previously.

The native Spanish-speaking participants did not exhibit a drastic difference in the number of segments in the words compared to the English speakers; however, they identified the sounds in each word differently than did the English speakers. Their segmentation acknowledges that diphthongs have two distinct sounds.

Table 5: Spanish segment perception

Word	J	K	L	M	N	O	P	Q	R
voy	2	2	2	3	2	3	3	3	3
auto	3	3	3	3	3	4	4	4	4
oigo	3	3	3	3	4	3	4	4	4
rey	2	2	2	3	3	3	3	3	3

Each of the Spanish speakers identified each diphthong as two distinct units of speech. This shows a drastic shift from the English speakers, only one of whom identified two total diphthongs as separate units. However, even though the Spanish speakers were able to distinguish between the two vowel sounds in a diphthong, the overall number of segments they perceived in the words is not always different from the number perceived by the English speakers. This is explained by the fact that some of the Spanish speakers identified the consonants in the test words as combined with either a vowel or an on-glide of the diphthong as one segment.

Thus, the conclusion from this study on segment identification confirms the fact that native English speakers rarely identify the two sounds in a diphthong as distinct segments. It also concludes that although there is a trend among native Spanish speakers to group a consonant with a vowel to form one segment, they are able to distinguish between the two segments in a diphthong.

Table 6: Spanish segment perception if diphthong is perceived as two segments

Word	Segments	Segmented	Segments	Segmented	Segments	Segmented
voy	3	v-o-i	3	v-o-i	2	vo-i
auto	4	a-u-t-o	3	a-u-to	3	a-u-to
oigo	4	o-i-g-o	3	o-i-go	3	o-i-go
rey	3	r-e-i	3	r-e-i	2	re-i

Spectrograph Analysis

The spectrograph analysis of the English speakers indicated that there was a shift from the first vowel sound in a diphthong to the second in both the first and second formant of all of the vowels. The second formants showed significantly more change than the first formants for each of the four diphthong sounds. The data, including an average change for each of the for vowel sounds, are described below in Table 7.

Table 7: Spectrograph analysis of English speakers:

Formant One			Formant Two	
Word	Average change		Word	Average change
coin	91.4		coin	1018.2
oink	122.2		oink	1199.1
Joyce	54.1		Joyce	743.2
boy	54.8		boy	944.0
void	59.0		void	1037.8
Average for /oi/	**76.3**		**Average for /oi/**	**988.4**
loud	341.2		loud	217.6
out	320.9		out	503.8
doubt	250.8		doubt	542.7
cow	147.0		cow	705.4
clown	173.9		clown	558.9
Average for /au/	**246.8**		**Average for /au/**	**462.2**
fade	74.7		fade	366.1
ape	79.6		ape	210.6
race	58.2		race	767.7
ray	82.3		ray	884.4
Abe	42.4		Abe	73.2
Average for /ei/	**67.4**		**Average for /ei/**	**460.4**
fine	88.6		fine	751.0
ice	292.1		ice	555.1
light	303.2		light	914.3
bye	104.2		bye	630.9
eyes	329.3		eyes	447.9
Average for /ai/	**223.5**		**Average for /ai/**	**659.8**

The spectrograph analysis for the native Spanish speakers showed trends similar to those for the native English speakers. There was a definite shift between vowel sounds in each of the four diphthongs. Again, the change was greater in the second formant than in the first formant for each of the vowel sounds. See Table 8 below for a more complete explanation of the data for native Spanish speakers.[14]

[14] See Appendix C: Spectrograph Analysis.

Table 8: Spectrograph analysis of Spanish speakers:

Formant One			Formant Two	
Word	Average change		Word	Average change
coil	119.1		coil	983.2
hoys	163.2		hoys	826.2
boys	124.1		boys	826.2
voy	114. 8		voy	877.0
oig	161. 9		oig	813.9
Average for /oi/	**136.6**		**Average for /oi/**	**865.4**
caul	235. 1		caul	362.6
aut	348. 8		aut	301.9
laus	152. 6		laus	450.3
lao	191.0		lao	560
aul	278. 6		aul	285.9
Average for /au/	**241.2**		**Average for /au/**	**335.0**
veil	101. 4		veil	671.3
eis	138. 6		eis	345.2
seis	150.7		seis	379.9
rey	125. 3		rey	626.6
eil	125. 4		eil	433.7
Average for /ei/	**128.3**		**Average for /ei/**	**491.3**
bail	211. 1		bail	788.8
aiz	382. 2		aiz	473.9
vais	208.0		vais	774.6
bai	180.7		bai	541.8
ail	333. 4		ail	589.9
Average for /ai/	**288.7**		**Average for /ai/**	**643.8**

The data for the native English and native Spanish speakers are comparable. The general trend that is true for both groups is that analyzed voice samples show a definite change from one sound to another in a diphthong. More specifically, the values of these changes among the Spanish-speaking and English-speaking participants are roughly similar when comparing the same formant and the same diphthong sound. See Table 9 below for a side-by-side comparison of the data.[15]

Table 9: Comparing sounds in Spanish and English

Sound	English Formant 1	Spanish Formant 1		English Formant 2	Spanish Formant 2
/oi/	76.3	136.6		988.4	865.4
/au/	246.8	241.2		462.2	335.0
/ei/	67.4	128.3		460.4	491.3
/ai/	223.5	288.7		659.8	643.8

The Spanish speakers produced a greater shift in four categories (Formant 1: /oi/, /ei/, /ai/; Formant 2: /ei/) as did the English speakers (Formant 1: /au/; Formant 2: /oi/, /au/, /ai/). There is no conclusive evidence that either Spanish or English speakers produce

[15] See Appendix C: Spectrograph Analysis.

greater variation of frequency when pronouncing the same diphthong sounds in words in their native languages.

Interpreting the Data

The data from the spectrograph analysis shows that Spanish and English speakers pronounce the same diphthong sounds at relatively the same frequencies, as is evident in *Table 8* and *Table 9* above. There is phonetically no difference between English and Spanish diphthongs.

It is important to acknowledge that English diphthongs, unlike Spanish diphthongs,[16] are not exactly a combination of two vowels but are rather separate sounds that occur between two vowels. For instance, the diphthong /ei/, such as occurs in the word *race*, does not start and finish at the same point at which the vowels "ϵ" (such as in the word *bet*) and "i" (such as in the word *beat*) are pronounced.[17] The frequency of the onglide in the diphthong /ei/ is slightly higher than the frequency of the individually occurring vowel "ϵ," and the frequency of the offglide is slightly lower than the frequency of the vowel /i/.

The fact that diphthongs occur at frequencies between the separate vowels proves that they are not phonetically commutable. Peter Ladefoged, in his book *A Course in Phonetics*, explains this well:

> "Each of these (diphthong) sounds involves a change in quality within one vowel. As a matter of convenience, they can be described as movements from one vowel to another. The first part of the diphthong is usually more prominent than the last. In fact, the last part is often so brief and transitory that it is difficult to determine its exact quality. Furthermore, contrary to the traditional transcriptions, the diphthongs often do not begin and end with any of the sounds that occur in simple vowels."[18]

The qualities in diphthongs do not occur anywhere else in spoken English except in other diphthongs, making them very unique sounds. The same is not true in Spanish. Each of the qualities in diphthongs are commutable and do exist independently outside the diphthong.[19]

However, even if English diphthongs have distinct qualities from other vowels in the spoken language, the two principle questions of this thesis remain proven. The voice samples of English speakers, although they only perceive that they pronounce one sound

---

[16] See Appendix E: Spanish Vowel Identification.

[17] Ladefoged, Peter. A Course in Phonetics. New York, NY: Harcourt Brace Jovanovich, Inc. 1975. Page 75.

[18] Ladefoged, Peter. A Course in Phonetics. New York, NY: Harcourt Brace Jovanovich, Inc. 1975. Page 76.

[19] See Appendix D: Ladefoged's Relative Auditory Qualities.

in a diphthong, do contain two distinct vowel qualities. Native Spanish speakers produce the same diphthong qualities as do native English speakers, although they recognize that they are pronouncing two distinct sounds.

▪ Conclusion

From the research in this thesis, two points are evident. First, diphthongs include two distinct qualities regardless of language. Native speakers of both the Spanish and English languages produce two distinct and separate sounds when pronouncing words with diphthongs, as is seen in Tables 7, 8, and 9.

Second, although both Spanish and English speakers produce two segments in diphthong sounds, they interpret them differently. Spanish speakers in the study considered the diphthong two distinct elements, while English speakers failed to do so. There are several possible explanations for this trend in English speakers, including methods of teaching phonics and the complexity of the English written language.

In conclusion, the main similarity between Spanish and English speakers lies in diphthong pronunciation, in which speakers of both language produce similar shifts from the onglide to the offglide of a diphthong. The difference is that Spanish speakers are conscious of doing so, while English speakers perceive a diphthong as one segment of speech.

▪ Acknowledgements

Dr. Juan Carlos Castillo of the Modern Languages Department at the University of Northern Iowa, both for the guidance in this thesis as well as for the introduction to a fascinating area of language study.

Dr. Carlin Hageman of the Communicative Disorders Department at the University of Northern Iowa for allowing me countless hours of time with the spectrograph, as well as his instruction in using the machine.

Dr. Robert Seager of the Biology Department at the University of Northern Iowa, my Presidential Scholar class mentor who has been for me so much more than that title requires of him.

Jessica Moon, Director of the University of Iowa Honors Program, for her guidance and friendship throughout my time at the University.

Works consulted

Arnold, DJ. "Inflection." 1995. [online] http://www.essex.uk/Mtbook/html/node45.html. Accessed 08 December 2002.

Blevins, Wiley. Phonics From A to Z: A Practical Guide. New York, NY: Scholastic Professional Books.1998.

Cassidy, Jack Ph.D. et al. Reading Skills for Life: Level A. Circle Pines, MN: American Guidance Services, Inc. 2002.

Castle, William E. The Effect of Selective Narrow-Band Filtering on the Perception of Certain English Vowels. London: Mouton and Company. 1964.

Cohen, Antoine. The Phonetics of English. The Hague: Martins Nijoff, 1965.

Colson, Greta. Voice Production and Speech. London: London Museum Press Limited, 1964.

Fromkin, Victoria, et al. An Introduction to Language. Boston: Thomson Heinle. 2003.

Guy, Jacques B.M. "Vowel Identification: An Old (But Good) Algorithm." *Cryptologia*. Volume XV, Number 3. July 1991. Pages 258-262.

Harris, James W. Spanish Phonology. Cambridge, Massachusetts: The M.I.T. Press. 1969.

Jacobsen, Martin. "Linguist List." [online] http://www.linguistlist.org/issues. Accessed 06 November 2003.

Kent, Raymond D. and Charles Read. The Acoustic Analysis of Speech. San Diego: Singular Publishing Group, Inc. 1992.

Kent, Raymond D. The Speech Sciences. San Diego: Singular Publishing Group, Inc. 1997.

Kuhn, Effie Georgine, PhD. "The Pronunciation of Vowel Sounds." *Teachers College, Columbia University, Contributions to Education*. Number 757. Columbia, NY: Teachers College Bureau of Publications. 1938.

Ladefoged, Peter. A Course in Phonetics. New York, NY: Harcourt Brace Jovanovich, Inc. 1975.

Landol, Inc. Consonantes Y Vocales. Ashland, OH: Tribune Education: 2000.

"Learning Pig Latin." [online] http://www.idioma-software.com/pig/pig_latin.html. Accessed 06 November 2003. Idioma Software, Inc. 1999.
Lieberman, Phillip and Sheila E. Blumstein. Speech Physiology, Speech Perception, and Acoustic Phonetics. Cambridge, MA: Cambridge University Press. 1988.

Ornstein, Robert and Richard F. Thompson. The Amazing Brain. Boston, MA: Houghton, Mifflin Company. 1984.

Phillips, Colin and Thomas Pellathy, et al. "Auditory Cortex Accesses Phonological Categories: An MEG Mismatch Study." *Journal of Cognitive Neuroscience*. 2000. Volume 12, Issue 6. pages 1038-1055.

Quilis, Antonio. Fonética Acústica de la Lengua Española. Madrid: Editorial Gredos. 1988.

Random House Dictionary of the English Language: Second Edition, Unabridged. New York, NY: Random House, Inc. 1987.

Ravitch, Diane. Left Back: A Century of Battles Over School Reform. New York: Simon and Schuster. 2000.

Roth, Hazel M, Ph.D. "Vowel Tonality," *University of Iowa Humanistic Studies Journal*. Volume 4, Issue 2. Iowa City, IA: University of Iowa. 1931.

Schwartz, Alvin. The Cat's Elbow and Other Secret Languages. New York: Farrar Straus Giroux. 1982.

Sykes, Charles J. Dumbing Down our Kids. New York: St. Martin's Griffin. 1995.

Tompkins, Gail E. Language Arts: Content and Teaching Strategies. Upper Saddle River, NJ: Merrill Prentice Hall. 2002.

Tompkins, Gail E. Literacy for the Twenty-First Century. Upper Saddle River, NJ: Merrill Prentice Hall. 2003.

Tompkins, Gail E. Literacy for the Twenty-First Century: A Balanced Approach. Upper Saddle River, NJ: Merrill Prentice Hall. 2001.

Webster's New World College Dictionary. John Wiley & Sons. 1999.

Weilman, Arthur W. and Aileen Thomas, et al. Riverside Phonics: Teacher's Edition. Chicago, IL: The Riverside Publishing Company. 1988.

Appendix A: Franklin Speller Data Analysis[20]

Whole Word Pronunciation: Formant 2

Word	Pronunciation start (Hz)	Pronunciation finish (Hz)	Change (Hz)	Change/Start (Percentage)	Change/Finish (Percentage)	Change StartFinish (Difference)
coin	1013	2000	987	97.43%	49.35%	48.08%
loud	1013	493	520	51.33%	105.48%	54.14%
fade	2219	2465	246	11.09%	9.98%	1.11%
fine	1599	2177	578	36.15%	26.55%	9.60%
Joyce	1370	2000	630	45.99%	31.50%	14.49%
doubt	1890	1150	740	39.15%	64.35%	25.19%
race	1808	2575	767	42.42%	29.79%	12.64%
light	1863	2054	191	10.25%	9.30%	0.95%
void	1013	2465	1452	143.34%	58.90%	84.43%
clown	1616	1287	329	20.36%	25.56%	5.20%
able	1452	1342	110	7.58%	8.20%	0.62%
eyes	1561	2356	795	50.93%	33.74%	17.19%
oink	1041	2794	1753	168.40%	62.74%	105.65%
out	1698	1096	602	35.45%	54.93%	19.47%
ape	2684	2410	274	10.21%	11.37%	1.16%
ice	1534	2054	520	33.90%	25.32%	8.58%
boy	877	2739	1862	212.31%	67.98%	144.33%
cow	1671	931	740	44.28%	79.48%	35.20%
ray	1863	2684	821	44.07%	30.59%	13.48%
bye	1698	2410	712	41.93%	29.54%	12.39%
Average			399.95	2.78%	5.80%	30.70%

[20] Data analysis using "Franklin Language Master Speaking Dictionary, Thesaurus, and Grammar Guide" from MerriamWebster(rounded to 1/10th percent)

Whole Word Pronunciation: Formant 3

Word	Pronunciation start (Hz)	Pronunciation finish (Hz)	Change (Hz)	Change/Start (Percentage)	Change/Finish (Percentage)	Change StartFinish (Difference)
coin	2602	2410	192	7.38%	7.97%	0.59%
loud	1780	1233	547	30.73%	44.36%	13.63%
fade	2219	2465	246	11.09%	9.98%	1.11%
fine	3059	3445	386	12.62%	11.20%	1.41%
Joyce	2646	2646	0	0.00%	0.00%	0.00%
doubt	2986	2821	165	5.53%	5.85%	0.32%
race	2640	3095	455	17.23%	14.70%	2.53%
light	3040	2958	82	2.70%	2.77%	0.07%
void	2958	2986	28	0.95%	0.94%	0.01%
clown	2410	2246	164	6.80%	7.30%	0.50%
able	2493	2520	27	1.08%	1.07%	0.01%
eyes	2986	2794	192	6.43%	6.87%	0.44%
oink	2903	2794	109	3.75%	3.90%	0.15%
out	2931	2849	82	2.80%	2.88%	0.08%
ape	3260	2849	411	12.61%	14.43%	1.82%
ice	3013	2849	164	5.44%	5.76%	0.31%
boy	2958	2739	219	7.40%	8.00%	0.59%
cow	2876	3232	356	12.38%	11.01%	1.36%
ray	2712	3150	438	16.15%	13.90%	2.25%
bye	3123	2958	165	5.28%	5.58%	0.29%
Average			27.8	1.27%	2.64%	1.37%

Phonetic Pronunciation: Formant 2

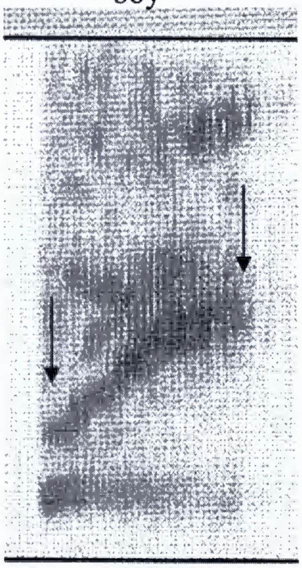
Word	Pronunciation start (Hz)	Pronunciation finish (Hz)	Change (Hz)	Change/Start (Percentage)	Change/Finish (Percentage)	Change StartFinish (Difference)
coin	603	2931	2328	386.07%	79.43%	306.64%
loud	1268	1020	248	19.56%	24.31%	4.76%
fade	1957	2067	110	5.62%	5.32%	0.30%
fine	1233	1863	630	51.09%	33.82%	17.28%
Joyce	1020	1957	937	91.86%	47.88%	43.98%
doubt	1378	772	606	43.98%	78.50%	34.52%
race	1957	1929	28	1.43%	1.45%	0.02%
light	1213	2012	799	65.87%	39.71%	26.16%
void	882	1957	1075	121.88%	54.93%	66.95%
clown	1323	910	413	31.22%	45.38%	14.17%
able	1929	1985	56	2.90%	2.82%	0.08%
eyes	1213	2040	827	68.18%	40.54%	27.64%
oink	965	1957	992	102.80%	50.69%	52.11%
out	1323	882	441	33.33%	50.00%	16.67%
ape	2839	2839	0	0.00%	0.00%	0.00%
ice	1213	1985	772	63.64%	38.89%	24.75%
boy	937	1957	1020	108.86%	52.12%	56.74%
cow	1323	882	441	33.33%	50.00%	16.67%
ray	1929	1985	56	2.90%	2.82%	0.08%
bye	1213	2012	799	65.87%	39.71%	26.16%
Average			411.2	48.74%	11.95%	36.78%

Phonetic Pronunciation: Formant 3

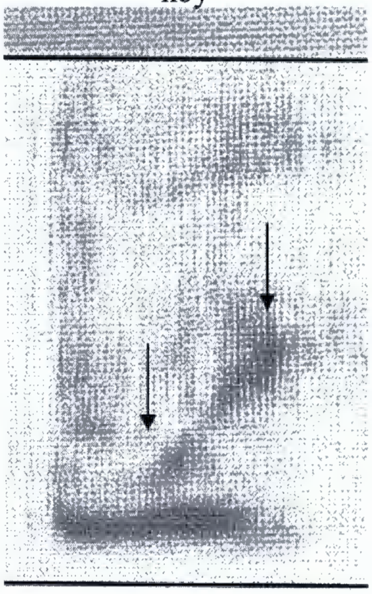
Word	Pronunciation start (Hz)	Pronunciation finish (Hz)	Change (Hz)	Change/Start (Percentage)	Change/Finish (Percentage)	Change StartFinish (Difference)
coin	3725	4109	384	10.31%	9.35%	0.96%
loud	2591	2839	248	9.57%	8.74%	0.84%
fade	2784	2602	182	6.54%	6.99%	0.46%
fine	2794	2602	192	6.87%	7.38%	0.51%
Joyce	2618	2370	248	9.47%	10.46%	0.99%
doubt	2591	2867	276	10.65%	9.63%	1.03%
race	2839	2839	0	0.00%	0.00%	0.00%
light	2756	2756	0	0.00%	0.00%	0.00%
void	2674	2370	304	11.37%	12.83%	1.46%
clown	2674	2894	220	8.23%	7.60%	0.63%
able	2784	2811	27	0.97%	0.96%	0.01%
eyes	2756	2674	82	2.98%	3.07%	0.09%
oink	2646	2398	248	9.37%	10.34%	0.97%
out	2756	2871	115	4.17%	4.01%	0.17%
ape	2811	2729	82	2.92%	3.00%	0.09%
ice	2729	2729	0	0.00%	0.00%	0.00%
boy	2646	2453	193	7.29%	7.87%	0.57%
cow	2784	2784	0	0.00%	0.00%	0.00%
ray	2839	2839	0	0.00%	0.00%	0.00%
bye	2784	2674	110	3.95%	4.11%	0.16%
Average			18.55	0.84%	1.29%	0.45%

Appendix B: Spectrograph Images

"boy"

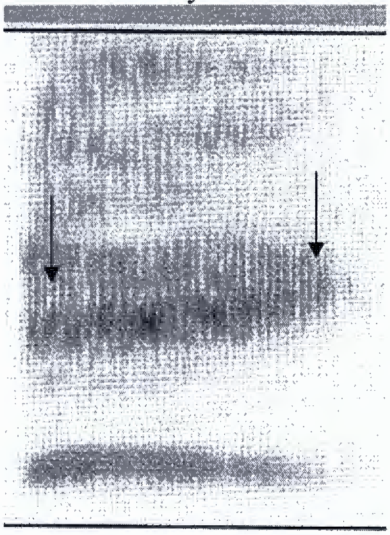


"hoy"



This is an example of an English word and a Spanish word both containing the same diphthong sound /oi/. Notice the similar shift in the second (most visible) formant indicated by the arrows. This indicates a shift from the initial vowel sound /o/ to the ending sound /i/.

"ray"



This is an example of the English word *ray*, which contains the diphthong /ei/. Notice that there is very little change from the beginning frequency to the ending frequency in this English diphthong. This demonstrates how different diphthongs have different values of change in frequency.

Appendix C: Spectrograph Analysis

English Formant 1: Change from onglide to offglide

Word										Mean
coin	0	28	55	82	82	109	110	166	191	91. 4
oink	0	0	82	82	138	164	193	193	248	122. 2
Joyce	0	18	28	28	55	82	83	83	110	54. 1
boy	27	27	28	54	55	55	55	82	110	54. 8
void	0	0	35	55	55	55	82	111	138	59
										76.3
loud	137	220	274	329	355	356	386	439	575	341.2
out	110	166	220	303	358	389	411	438	493	320.9
doubt	106	138	138	221	246	301	331	358	418	250. 8
cow	0	0	28	55	164	165	274	291	346	147
clown	0	0	27	110	165	165	276	356	466	173. 9
										246.8
fade	0	27	42	55	56	82	82	137	191	74. 7
ape	0	0	27	32	82	109	110	164	192	79. 6
race	0	0	28	55	55	56	109	110	111	58. 2
ray	28	55	55	82	82	82	83	109	165	82. 3
Abe	0	0	27	27	28	54	54	55	137	42. 4
										67. 4
fine	0	54	55	55	55	83	138	138	219	88. 6
ice	55	165	214	301	303	356	358	411	466	292. 1
light	83	246	248	248	274	276	386	472	496	303. 2
bye	0	27	55	83	83	115	191	191	193	104. 2
Eyes	110	192	219	274	303	356	383	383	744	329. 3
										223.5

English Formant 2: Change from onglide to offglide

Word									Mean
coin	595	661	759	821	822	1041	1068	1533	1864	1018.2
oink	438	548	1020	1185	1323	1357	1488	1516	1917	1199. 1
Joyce	209	441	496	689	712	739	1041	1047	1315	743.2
boy	328	767	772	1004	1013	1013	1103	1233	1263	944
void	717	882	965	992	1019	1041	1041	1332	1351	1037.8
										988.5
loud	0	164	274	279	301	303	328	384	411	271.6
out	328	383	386	496	496	524	603	634	684	503. 8
doubt	261	413	441	441	523	603	607	630	965	542. 7
cow	384	589	603	712	713	744	795	877	932	705. 4
clown	276	466	496	524	603	606	630	712	717	558. 9
										516.5
fade	137	220	301	329	356	384	441	524	603	366. 1
ape	137	138	138	165	165	219	246	276	411	2106
race	438	552	579	634	634	958	1020	1020	1074	767. 7
ray	438	524	593	603	744	795	1213	1516	1534	884. 4
Abe	0	54	54	56	82	83	83	83	164	73. 2
										460.4
fine	607	627	634	745	799	800	800	865	882	751
ice	137	441	548	575	575	606	630	717	767	555. 1
light	661	662	745	799	904	1020	1096	1102	1240	914. 3
bye	358	384	441	606	655	616	717	744	1157	630. 9
Eyes	191	359	383	383	496	521	547	548	603	447. 9
										Mean

Spanish Formant 1: Change from onglide to offglide

Word									Mean
coil	140	55	82	137	219	165	82	137	55	119. 1
hoys	54	192	274	110	182	301	27	192	137	163. 2
boys	239	110	0	138	164	137	55	137	137	124. 1
voy	82	105	219	0	138	110	138	137	104	114. 8
oig	329	82	221	247	110	220	28	165	55	161. 9
									136.6
caul	195	304	137	302	247	246	356	137	192	235.1
aut	506	276	413	438	329	383	328	165	301	348.8
laus	83	28	384	220	0	164	192	165	137	152. 6
lau	164	82	249	153	246	249	110	137	329	191
aul	339	164	356	192	55	438	439	193	331	278. 6
									241.2
veil	83	198	27	54	166	165	55	83	82	101. 4
eis	55	55	110	11	248	275	164	274	55	138. 6
seis	28	219	302	137	83	66	165	274	82	150. 7
rey	220	192	0	192	113	83	0	82	246	125. 3
eil	111	165	137	138	109	220	28	221	0	125.4
									128.3
bail	137	165	110	386	248	303	55	220	276	211.
aiz	192	466	221	331	524	331	634	383	358	382.2
vais	82	110	193	304	358	166	247	302	110	208
bai	165	221	28	248	110	330	276	248	0	180.7
ail	137	411	385	634	27	497	386	193	331	333. 4
									288.7

Spanish Formant 2: Change from onglide to offglide

Word										Mean
coil	849	1124	603	1123	1096	1370	1233	684	767	983. 2
hoys	466	1114	579	521	1013	1315	456	438	1534	826. 2
boys	493	1206	552	1240	1178	1397	518	411	441	826. 2
voy	895	1616	1123	521	630	1096	524	248	1240	877
oig	1178	822	662	685	799	1232	109	496	1342	813. 9
										865.3
caul	182	248	712	384	695	137	548	165	192	362. 6
aut	84	441	386	465	27	411	329	301	273	301. 9
laus	303	717	521	661	164	576	176	383	552	450. 3
lau	466	606	602	795	689	356	950	384	192	560
aul	192	130	356	331	82	657	301	414	110	285. 9
										335
veil	866	937	661	466	552	524	993	578	465	671. 3
eis	82	384	662	523	220	330	276	274	356	345. 2
seis	110	27	738	439	346	745	110	247	657	379. 9
rey	716	630	904	1041	937	1185	9	25	192	626. 6
eil	965	1096	384	301	331	248	0	247	331	4337
										491.3
bail	603	807	661	729	386	1102	1516	441	854	788. 8
aiz	411	192	634	992	413	331	220	52	1020	473.9
vais	904	1150	110	1014	413	1103	607	1013	657	774. 6
bai	661	910	441	661	386	1157	220	330	110	541. 8
ail	331	931	634	937	439	1048	331	138	520	589. 9
										633. 8

Appendix D: Ladefoged's Relative Auditory Qualities[21]

Notice that the diphthongs are indicated to begin and end at locations between the positions of the separate vowels.

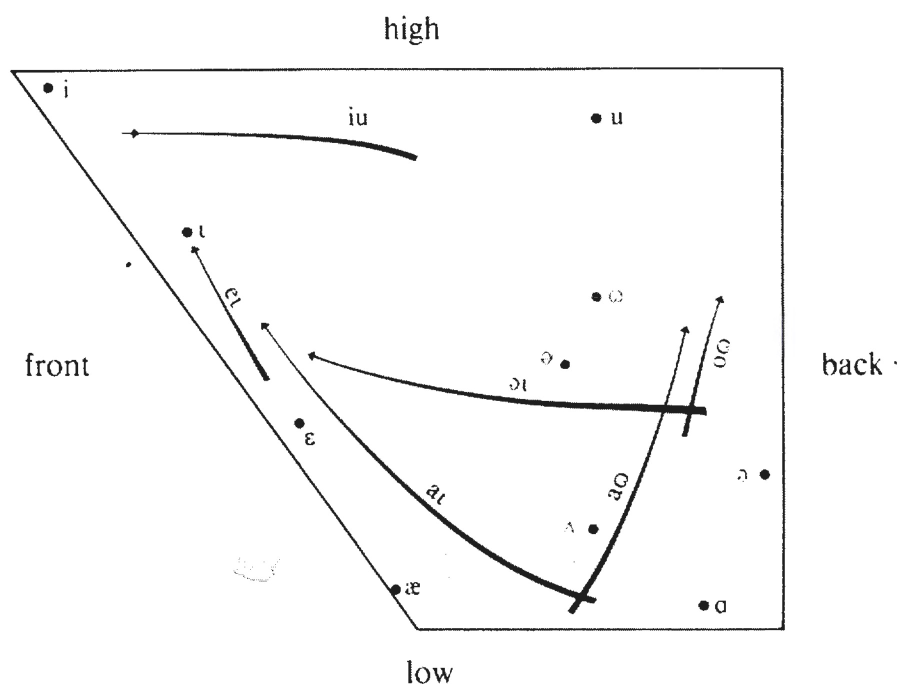


Figure 4.2 *The relative auditory qualities of some of the vowels of American English.*

---

[21] Ladefoged, Peter. A Course in Phonetics. New York, NY: Harcourt Brace Jovanovich, Inc. 1975. Page 75.

Appendix E: Spanish Vowel Identification[22]

(Note that Spanish diphthongs are not indicated as having separate beginning and ending points.)

The x-axis represents frequency (in Hertz) of the second formant.

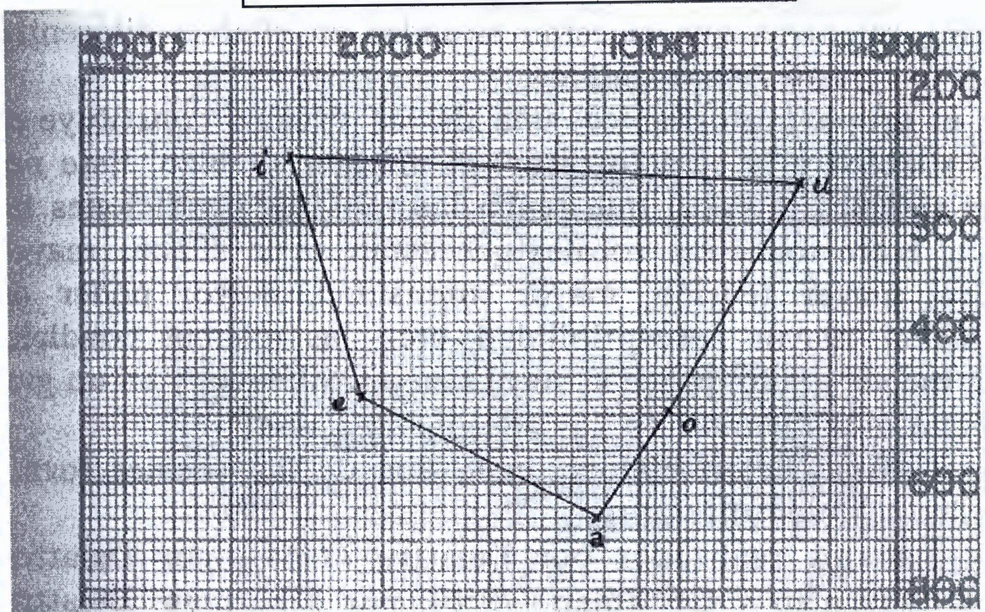


FIG. 6.20. *Un triángulo vocálico acústico de la lengua española*

The y-axis represents frequency (in Hertz) of the first formant.

[22] Quilis, Antonio. Fonética Acústica de la Lengua Española. Madrid: Editorial Gredos, 1988. Page 175.