The Acquisition of Spanish Vowels by Native English-Speaking Students in Spanish Immersion Programs

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Abstract

Native-like pronunciation is necessary for membership into some social groups and to be considered a legitimate speaker of a language. Language immersion education aims to develop bilingual individuals, able to participate in multiple global communities, and while the lexical, syntactic, and sociolinguistic development of immersion learners is well documented, their phonological skills are not. This study set out to address this gap by investigating immersion learners' pronunciation of Spanish vowels, a sound class known to lead to a foreign accent, comparing the vowel productions of native English-speaking learners in one-way (foreign language) immersion and two-way (bilingual) immersion programs to those of their native Spanish-speaking peers and their teachers.

A total of 85 immersion students participated in this study. A cross-sectional sample of students from each of the program/language groups was taken; students from each of four grade levels (first, third, fifth, and seventh) participated. Students completed an animal picture sorting task in pairs during which their speech was audio and video recorded. Up to twenty tokens of each of the five Spanish vowels, for a possible total of 100 tokens per subject, were isolated and examined via spectrographic analysis in order to measure first and second formant values. The tokens examined for each vowel were balanced for their occurrence in stressed and unstressed syllables. Students also completed a written questionnaire in order to gather data about extralinguistic factors (i.e., attitudes and motivation) that have been shown to influence pronunciation.

The findings indicate that the vowel productions of immersion learners differ from those of native Spanish-speaking peers. In general, the vowel space of the learner groups is larger than that of the native speaker peer group. Over time, the number of differences between one-way NES learners and native speakers increase while the number of differences between two-way NES learners and native speakers decrease. This finding suggests that there may be an effect of program model; however, differences in the ethnic background and exposure to Spanish outside of school between the two learner groups may also play a role and thus make it difficult to attribute differences solely to the effect of program model. Differences in attitude between the groups do not reach statistical significance and do not correlate with more native-like vowel pronunciations.

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Introduction

1.1 Background & Statement of Problem

An overwhelming majority of individuals who study a second language (L2)[1] never reach the same level of proficiency as native speakers, maintaining some mark of foreign accent. While for many individuals this holds true across the different language subsystems, such as syntax, lexicon, pragmatics, and phonology, it seems that native-like phonological skills may be the most difficult to develop (Scovel, 1969). In fact, terms such as the *Joseph Conrad Phenomenon* or the *Henry Kissinger Effect* have been created to describe this trend of having native-like abilities in all language areas with the exception of pronunciation. Unfortunately, individuals who maintain a mark of foreign accent in their L2 speech may pay a serious "social penalty" (Oyama, 1982, p. 35) as a result of "less language-wise members of our society…concentrate[ing] more on the way something is said than on the actual content of the message" (Leahy, 1980, p. 217).

In most native speaker – native speaker interactions, the communicative burden is equally shared by both interlocutors; they work together to make meaning and understand one another. When a speaker is confronted with a non-native accent, however, his/her first decision is whether or not to accept his/her share of the communicative burden. Lippi-Green (1997) comments that many speakers of the dominant language feel

[1] The term second language is used in this dissertation to refer to both second language and foreign language unless otherwise specified. A foreign language is a language not spoken by the people of the place of language study while a second language refers to a language that is not the first language of the individual but that is spoken by the people in the place where language study occurs. For example, in the

empowered to reject their role in such situations, placing the entire burden of communication on the other. In this way, accent is often the “first point of gatekeeping,” or a “litmus test for exclusion” (Lippi-Green, 1997, p. 64). Consequently, language, or accent, serves to separate individuals into groups; the tendency for individuals in the same social groups to share similar language patterns is well attested in both first language (L1) (e.g., Bucholtz, 1999; Mendoza-Denton, 1997; Pierrehumbert, Bent, Munson, Bradlow, & Bailey, 2004) and L2 literature (e.g., Beebe & Zuengler, 1983; Bolton & Kwok, 1999; Lefkowitz & Hedgcock, 2002, 2006; Lybeck, 2002; Major, 2004; Zuengler, 1998).

Pronunciation as a tool for group membership is not limited to social groups; it is also used to deny individuals access to employment or educational opportunities, and more generally the ability to participate in certain discourses. Kerr (1994, as cited in Lippi-Green, 1997) speaks to this:

> no matter how qualified a person is, a voice twisted by regional or ethnic influences can be a stumbling block socially and professionally. If others can’t understand you or your words are too richly flavored with down-home spice, you could find all your skill and intelligence thwarted by a telltale tongue. (p. 135)

The General Accounting Office of the United States Government (1986, as cited in Lippi-Green, 1997) reported that approximately 10% of the stratified random sample taken of employers admitted to discriminating against potential employees based upon foreign appearance or accent, and numerous court cases are documented in both the U.S. and Great Britain in which language-based discrimination occurs. In one particular case, a bilingual speaker of English and Hawai'ian Creole English was not given a promotion to read pre-scripted weather reports on the radio because he had a Hawai'ian accent (Kahakua, 1987, as cited in Lippi-Green, 1997). In another, an employment agency receptionist was directed to screen applicants based upon accent; those who did not speak "right" were told the job was closed whereas non-accented applicants were provided with the solicited information (Carroll, 1989, as cited in Lippi-Green, 1997). If the goal of a L2 learner is to have access to the same opportunities and discourses as native speakers, producing L2 sounds in a native-like way is of utmost importance.

Pennington and Richards (1986) describe the process of acquiring L2 pronunciation as "dynamic" given the variety of factors that influence it. The hypothesized sources of variation in pronunciation are many, ranging from issues of identity or self-representation (e.g., Brown & Yule, 1983; Lefkowitz & Hedgcock, 2006; Lybeck, 2002; Tarone, 1978) to the quality and type of input (e.g., Højen & Flege, 2006; Long, 1990). Perhaps the most frequently cited and studied explanation, however, is one of age.

The critical period hypothesis (CPH) posits a timeframe for optimal acquisition; after this critical period has passed, complete acquisition is impossible, and the ultimate attainment of individuals is compromised.[2] Lenneberg (1967) proposed the onset of puberty as the end point of the critical period as a result of decreased neural plasticity and completion of hemispheric lateralization that occurs around this time. Others have

[2] The term sensitive period is often used interchangeably with the term critical period. Sensitive period makes reference to the gradual and variable decline in language acquisition abilities whereas the term critical implies an abrupt or sudden end to such abilities. I will use the term critical in this dissertation, as this is the term most often used in the literature.

suggested that the critical period concludes much earlier, around 6 years of age (e.g., Tahta, Wood, & Lowenthal, 1981), while still others have argued for a later closure, such as 16 or 17 (e.g., Oyama, 1978). Whatever the cause and whatever the age, a substantial body of research suggests that the earlier exposure to a second language occurs, the more native-like pronunciation is in the long run (e.g., DeKeyser, 2000; Flege, MacKay, & Meador, 1999; Guion, 2003; Højen & Flege, 2006; Munro, Flege, & MacKay, 1996; Scovel, 1969). Most of this research has investigated L2 acquisition of pronunciation in a second language environment, not the foreign language context. Moreover, few studies have explored phonological acquisition by L2 learners exposed to the second language via classroom instruction or how early learners acquire the phonological system of a foreign language. Consequently, little is known about the phonetic norms of early immersion learners and how they develop over time.

Language immersion education is an L2 program model that integrates content and language learning; more specifically, content is learned through the medium of the L2. A variety of immersion program models exist and classification of particular programs occurs in relation to a variety of characteristics including student population, percentage of instructional time in the immersion language, and level of entry. Depending on student audience and concomitantly program purpose, programs are classified as one-way (foreign language), two-way (bilingual), or indigenous. One-way immersion programs predominantly educate majority-language learners (i.e., in the U.S., native English speakers) whereas two-way programs educate majority-language and minority-language students simultaneously. Ideally, each language group comprises 50% of the total student population in a two-way program, but this is not always the case; as long as neither population makes up more than 66% of the student population, the program can be considered a two-way model. Indigenous programs are primarily geared toward students with ethnic ties to the indigenous language. Programs can be further classified by the amount of instructional time in the immersion language. One-way programs are often classified as either full/total or partial. Full or total immersion programs provide all subject matter instruction in the immersion language while partial immersion programs provide only a portion of instruction in the immersion language. Two-way programs also vary in the amount of instructional time devoted to each language; the amount of time in each language is expressed as a ratio, percentage of instructional time in the minority language to percentage of time in the majority language. Two common designators are 90:10, in which 90% of content instruction is in the minority language and 10% in English, and 50:50, in which instructional time is split equally between the two languages. For both one-way and two-way programs, designators of instructional time in the minority language reflect practice in the early elementary grades; programs typically increase the amount of instruction in English as grade level increases. Finally, programs can also be classified according to when language immersion begins; if it begins in the early elementary grades, typically either kindergarten or first grade, the program is classified as an early immersion program. If language immersion does not begin until the later elementary grades, such as fourth or fifth, it is a delayed or mid immersion program, and if immersion does not begin until secondary school, it is considered to be a late immersion program.

One of the early hypotheses supporting early immersion programs was that early, intensive, extended exposure to a second language might result in native-like proficiency. Many early programs were also established on the theory that L2 acquisition parallels L1 acquisition if L2 exposure is meaningful and focused on communication (Krashen, 1981). While the L2 gains of early immersion learners are greater than those made by students in other elementary language programs, such as Foreign Language in the Elementary Schools (FLES) (e.g., Campbell, Snow, Rhodes, & Gray, 1984; Genesee 1987, 1991; Swain & Lapkin, 1982), a multitude of studies have shown that immersion learners do not achieve native-like proficiency in all areas of language, including syntax, vocabulary, and sociolinguistic competencies (e.g., Boyd, 1975; Cohen, 1975; Genesee, 1978a; Harley, 1979; Harley & Swain, 1984; Plann, 1979; Potowski, 2005; Potowski, 2007a, 2007b; Swain, 1985).

Research on the phonological competencies of early immersion learners has, however, received much less attention.[3] While informal observations of immersion learners' pronunciation abilities contradict one another (e.g., Campbell, 1984; Day & Shapson, 1996; Flores, 1973), the findings studies which have attended to phonological performance in a more systematic matter converge to suggest that the productions of early immersion learners do differ from the monolingual native speaker's phonetic norm (Genesee, 1978a, 1987; Harada, 1999; Snow & Campbell, 1985). Even more interesting perhaps is the finding by both Snow and Campbell (1985) and Harada (1999) that

[3] This appears to be a general trend in SLA research. Tarone (2005) comments, "research on pronunciation learning in a second language is less popular than research on interlanguage morphology, syntax, discourse, or pragmatics. It seems that publications in the area of interlanguage phonology often seem to slip under the radar screen of researchers focusing on other aspects of learner language" (p. 490).

pronunciation accuracy peaks around third grade; in other words, the pronunciation of older immersion learners, specifically fifth and sixth graders, is less native-like than that of younger immersion learners. Of these studies, only that of Harada (1999) employs acoustic analysis to describe how the immersion learners' productions differ from those of monolingual peers; his study was, however, carried out with Japanese immersion learners. And while Snow and Campbell's (1985) study addresses the phonological acquisition of Spanish immersion learners, it relies on phonetic transcriptions and nativeness ratings. No descriptions of learner productions are provided, only an error analysis. In this way, our understanding of how immersion learners acquire language is incomplete. Moreover, the few studies to consider phonological acquisition have only done so in one-way immersion programs where the teacher is the primary source of auditory input. No research to date has investigated the phonological skills of the majority-language immersion learner in a two-way immersion context, where native speaker peers potentially provide additional language models.[4]

As noted by Tarone (2005), the amount of attention being given to the acquisition of pronunciation skills in a second language has been increasing during recent years. This holds true in the Spanish L2 literature; within the last two decades the number of studies investigating L2 acquisition of the Spanish phonological system has grown rapidly. Nevertheless, the vast majority focuses on the acquisition of consonantal segments (e.g., Castino, 1991; Colantini & Steele, 2006; Díaz-Campos, 2004; Díaz-Campos & Morgan,

[4] The presence of native speakers of the immersion language in immersion programs does not guarantee that the two student groups will interact in meaningful ways in the immersion language. Studies have shown that the majority language maintains its dominance even in the two-way context (Carranza, 1995; Carrigo, 2000; Fortune, 2001; Potowski, 2002, 2007b).

2002; Face, 2006; Face & Menke, 2009; González-Bueno, 1995, 1997; Major, 1986; Reeder, 1998; Shively, 2008; Waltmunson, 2005; Zampini, 1994, 1998; Zampini, Clarke, & Green, 2000). Less is known about how native English speakers acquire, develop, and/or produce the five Spanish vowels. Based on a contrastive analysis, Stockwell and Bowen (1965) predicted that in the context of stressed syllables, producing English-like Spanish vowels would result in foreign accent, but not misunderstanding. Pronunciation of unstressed Spanish vowels, however, was likely to be more challenging as a result of "interlingual identification" (Weinreich, 1953), resulting in the transfer of the L1 process of vowel reduction. Despite evidence that Spanish vowels are perceived by English-speaking learners of Spanish in a way similar to that of native Spanish speakers (García de las Bayonas, 2004; Morrison, 2003), production studies consistently point to differences in the vowel articulations of these two groups.

Early studies by Hammerly (1982) and Elliot (1997) suggested that vowel reduction is a concern and that the productions of both beginning and intermediate adult learners differed from those of native speakers, but little description was provided as to how. More recent studies provide further details about how the vowels differ. Two studies have documented movement toward native speaker norms between intermediate and advanced adult learners (Cobb, 2009; Menke & Face, 2010); however, the Spanish vowel system of advanced learners has been found to manifest differences from that of native Spanish speakers. For example, Cordero, Munson, and Face (2006) found that advanced learners of Spanish did not differentiate their productions of the four non-low vowels, /i, e, o, u/ according to language; in other words, the vowels had the same acoustic properties in both languages. Cobb (2009) pointed to particular difficulty with /e/ on the part of English learners of Spanish as productions of the both intermediate and advanced learners of this vowel differ in both tonic and atonic positions from native Spanish speakers. Findings from Menke and Face (2010) differ slightly from those of Cobb in that no differences were found with respect to /e/; advanced learners in their study produced /a/, /o/, and /u/ with different acoustic properties than native speakers. The recent interest in L2 production of Spanish vowels is deepening our understanding of how native English speakers acquire them, yet the differing findings from empirical studies have yet to be reconciled and many questions remain to be answered.

Given that nonnative vowel production can lead to a foreign accent (e.g, Flege, 1997; Flege et al., 1999; Munro, 1993), there is a general lack of understanding of what the process of vowel acquisition looks like for native English speakers acquiring Spanish as a second language. Do L2 Spanish learners produce native-like Spanish vowels? What stages do they pass through? What are the characteristics of their Spanish vowel productions? These questions are as important for adult learners as they are for English-speaking children learning Spanish through an immersion program. Given the younger age of immersion learners, additional questions arise: To what extent are children in an immersion program able to attain the phonetic norms of native speakers? Does program model affect the process of acquisition? If so, how?

This study sets out to answer some of these questions by addressing the gaps in both immersion and second language acquisition (SLA) research. It will attempt to answer the question of how immersion learners' L2 phonological system develops over time as well as the question of differential program effects. It will do so by investigating the vowel productions of Spanish immersion learners, which will simultaneously add to our understanding of how Spanish vowels are acquired by native English speakers.

1.2 The Current Study

The fundamental question posed by this study is: How do native English-speaking learners in Spanish immersion programs produce the Spanish vowels? As a means of addressing this broad question, more specific sub-questions were identified:

1. Do the vowel productions of native English-speaking learners in Spanish immersion programs differ from those of native Spanish-speaking peers? If so, how?
2. Do the vowel productions of native English-speaking learners in a one-way foreign language immersion context differ from those of English-speaking learners in a two-way immersion context? If so, how?
3. Does this sound class develop over time? If so, how?
4. Do the vowel productions of immersion learners differ from those of immersion teachers? If so, how?
5. Is there a relationship between attitudes toward Spanish and English and the pronunciation of Spanish vowels by immersion learners? If so, what does it look like?

In order to answer these questions, the speech of a cross-sectional sample of both one-way and two-way immersion learners was collected via a picture identification task.

Learners identified animals as they classified them into groups in response to a question. Up to one hundred vowels produced by each immersion learner, divided across the five Spanish vowels in stressed and unstressed syllables, were analyzed acoustically and then compared to vowels of same-age Spanish-English bilinguals enrolled in a two-way immersion program. Comparisons at each grade level and across grade levels provide responses as to how program model impacts pronunciation acquisition and also how productions change over time. In addition, 10 immersion teachers participated in the study as a means for accounting for the input students receive. Each participant additionally completed an attitudinal questionnaire; findings from this measure are used to explain differences in production and development.

1.3 Significance of the current study

The findings from this study contribute to both the immersion research literature as well as that of the larger field of SLA. While the L2 outcomes of immersion learners are well documented with respect to syntax and vocabulary, there is a relative absence of studies that address phonological acquisition. Specifically, studies that address how learner productions develop over time are needed in order to better understand the L2 skills of immersion learners and the effect of program models on them.

Secondly, few SLA studies have addressed how the vowel productions of native English-speaking learners of Spanish develop over time; this study will continue to shed light on this question by looking at learners at multiple stages of L2 acquisition. Additionally, to date Spanish L2 phonological studies primarily consider acquisition by adult learners; this will be the first that investigates how English-speaking child learners acquire the sound system in a foreign language context. It will also be one of the first to provide acoustical data on the vowel productions of bilingual Spanish-English children.

1.4 Overview

The remaining portion of this dissertation is organized as follows: Chapters 2 and 3 provide the reader with an overview of terminology, theoretical concepts, and findings from empirical studies related to language immersion education and L2 acquisition of vowels. Within the chapter on immersion, defining features of different program models will be presented as well as findings related to L2 acquisition in this context, with special attention given to those studies that have investigated the phonological abilities of immersion learners. In Chapter 3, details about the Spanish and English vocalic systems will be provided as will findings related to L2 acquisition of vowels, with a special focus on L2 acquisition of Spanish vowels. Chapter 4 details the research design of this study. Information about the research sites, study participants, instruments and tasks, data collection and analysis is included; results of the study are presented in Chapter 5. How study findings relate to previous work and their implications for theory and instructional practices are discussed in Chapter 6, the concluding chapter of this dissertation.

Chapter 2
Literature Review: Immersion

2.1 Definitions

"Language immersion is thought to be the most successful of several program types that teach languages other than English at the elementary school level" (Potowski, 2007b, p. 1), yet the term "immersion" is often misused to reference other educational alternatives and language methodologies. Clarification of the many terms circling around language immersion education is thus necessary in order to sufficiently delimit the scope of this study (see Fortune and Tedick (2008) for a complete review of the use and misuse of the term immersion in the field of L2 education). Immersion education is a form of enriched education (Cloud, Genesee, & Hamayan, 2000) that aims for high levels of functional proficiency in a second language (L2) while simultaneously developing the first language (L1); in this sense, immersion falls under the umbrella term of dual language education.[5]

Immersion programs use an integrated approach to language and content instruction; in them, students receive a portion of their subject matter learning in a second language. Immersion language education differs from more traditional, skills- or grammar-based foreign language programs in that language learning is secondary to academic achievement; thus, language is not the goal of instruction, rather it is the means to other ends, specifically content learning and academic achievement. In order for this

[5] Dual language education is comprised of three program models according to Cloud et al. (2000): one-way foreign language immersion, two-way immersion, and developmental or maintenance bilingual. Fortune and Tedick (2008) add indigenous immersion to this list.

to occur, language instruction is integrated with content instruction in a “rich and meaningful communicative context” (Genesee, 1994, p. 10); content is the focus, the second or foreign language is the means to that end. The core set of goals shared by immersion programs reflects this purpose:

- functional proficiency in both written and spoken aspects of the immersion language,
- mastery of subject content material with students’ academic achievement commensurate with that of same age peers not participating in immersion programs,
- cross-cultural understanding, and
- maintenance of normal levels of first language development.

(Curtain & Pesola, 1994; Genesee, 1987)

Despite a common set of goals, programs differ in the amount of time devoted to instruction in the second language, level of entry, and the population dynamics of the students, but in order to be considered immersion, a core set of features must be present. Swain and Johnson (1997, pp. 6-8) identified eight defining elements of prototypical immersion programs:

1. L2 is the medium of instruction.
2. Immersion curriculum parallels the local curriculum.
3. Overt support exists for the L1.
4. The program aims for additive bilingualism.
5. Exposure to the L2 is largely confined to the classroom.

6. Students enter with similar (and limited) levels of L2 proficiency.
7. Teachers are bilingual.
8. The classroom culture is that of the local L1 community.

The authors note that these features should be considered to occur along a continuum with the prototypical program implementing each of the eight features to the fullest. The extent to which each feature is implemented affects the potential successes and pitfalls of a program.

The first two features are what distinguish language immersion programs from other foreign language programs; not only is the L2 used for instruction, but the content of instruction in an immersion classroom mirrors that of other "regular" or English-medium classrooms. Immersion students, teachers, and schools are held accountable for meeting the same learning objectives as other, non-immersion schools. Genesee (1987) and Fortune and Tedick (2008) elaborate further on the use of the L2 for content instruction, emphasizing the need to provide a minimum of 50% of content instruction in the immersion language (IL) at the preschool and elementary levels in order to be considered immersion.

The third and fourth characteristics serve to facilitate additive bilingualism as opposed to subtractive bilingualism, which is characteristic of transitional bilingual education programs and other weaker forms of bilingual education.[6] Programs that strive for additive bilingualism are considered to be enriching, or additive, since through them "children can add one or more foreign languages to their accumulating skills and profit

[6] Transitional bilingual education prepares minority language students for schooling in the majority language, transitioning them into mainstream language and content classes. Little, if any, attention is given to native language development in these programs.

immensely from the experience – cognitively, socially, educationally, and even economically" (Lambert, 1984, p. 19). In programs that strive for additive bilingualism, attention is given to developing the L1, not replacing it with a second or other language; this differs from programs in which subtractive bilingualism is the norm.[7] Immersion programs promote additive bilingualism by attending to the development of the L1. According to Fortune and Tedick (2008), however, there is "reliance" on support for the L1 from sources outside the school, especially in the case of language-majority learners in early, total, one-way immersion programs and 90:10 two-way immersion programs.[8]

For most students in immersion, their primary contact with the immersion language (IL) occurs in the classroom.[9] In many cases, the IL differs from the home language; consequently, most students enter the program with limited proficiency in it. Given the dual focus of L1 and L2 development, it is encouraged that teachers in immersion programs be bilingual in the immersion language as well as the home language of the learners; frequently this does not hold true in partial, one-way programs and 50:50 two-way programs. In order to be successful, however, teachers must be "fully proficient" in the language of instruction (Fortune & Tedick, 2008, p. 12). The final characteristic, related to the culture of the classroom, is an artifact of the larger socio-political context, resulting from the physical location of immersion classrooms within a majority-language and majority-culture school, district, and state. The culture of the

[7] In programs that allow subtractive bilingualism to occur, the L1 is neither attended to nor valued; rather, children are "forced to put aside or subtract out their ethnic languages for a more necessary, useful, and prestigious national language" (Lambert, 1984, p. 19).
[8] Amount of instructional time in the immersion languages is typically expressed as a ratio in two-way programs, i.e. 90:10, 80:20, 50:50. The first number in the ratio represents the percentage of time in the minority language, and the second number corresponds to the percentage of time in the majority language.
[9] Non-native English speakers in two-way immersion programs may be exposed to English outside the four walls of the school as well given the prevalence of English in the larger social context.

classroom is not similar to that of a classroom in the immersion culture but rather the same as non-immersion classrooms in the same community.

Fortune and Tedick (2008) add one additional feature to this list created by Swain and Johnson (1997); they advise that immersion programs also maintain a clear and consistent separation of languages, sustaining the language of instruction over a period of time. Language separation may be achieved in a number of different ways; some common ways to divide languages are by content area (e.g., social studies and math in the immersion language; science and language arts in English), by time of day, and/or by teacher. Such a clear, extended separation of languages has been found to be effective for L2 instruction (e.g., Legaretta, 1981; Milk, 1982; Wong Fillmore, 1982) and is recommended by other researchers as best practice (e.g., Calderón & Minaya-Rowe, 2003; Freeman, Freeman, & Mercuri, 2005; Genesee, 1987; Lindholm-Leary, 2001).

Despite sharing a core set of features, immersion programs are hardly homogeneous; the differences between programs are many. Features that vary across programs are related to the level at which immersion begins, the amount of instructional time in the IL, the continuity of the program, available resources and supports for both students and teachers, how success is measured, and the attitudes of the larger community toward the IL and culture (Swain & Johnson, 1997, pp. 8-12). Many of these features serve to distinguish different program models. For example, programs that begin in the early elementary grades, typically kindergarten or first grade are considered to be early immersion programs; those that begin in the upper elementary grades (grade 4 or 5), mid- or delayed immersion, and those that postpone content instruction in the IL until secondary school, late immersion. The extent of the immersion is reflected in the amount of instructional time in the immersion language; students in full or total immersion programs receive 100% of their subject matter instruction in the immersion language whereas students in partial immersion programs receive only a portion of content instruction, minimally 50%, in the immersion language. Designation of a program as total- or partial-immersion usually depends upon the percentage of instructional time in each language during the initial year(s) as the amount of L1 generally increases as students progress through the program. The continuation of early programs into the secondary school can vary by district, and the percentage of time dedicated to the immersion language almost always decreases. A minimal requirement for secondary programs is two year-long content courses taught in the IL (Fortune & Tedick, 2008).

The support and resources available to both students and instructional personnel also vary from program to program; some of the possible supports and/or resources include special education services in the immersion language, immersion language texts and reading books, professional development opportunities, and language classes for parents. The success of many programs varies proportionally with the commitment to the program by teachers, parents, administrators at both the school- and district-level, and the broader community, which is often, but not always, related to the attitude toward both the immersion language and culture as well as the status of the language and program within the community. In some instances, the IL is spoken as an L1 by others in the community or is seen as necessary for future social, political, or economic gains; in other cases, the language has no ties to the community outside of the school itself. The interaction of these three features – commitment, attitude, and status – often manifests itself in what counts as success. Success in some programs may be a change in cultural competencies or attitudes, whereas in others it may be greater proficiency than traditional foreign language instruction affords, and still in others, success is native-like proficiency in the IL.

The changing demographics of many communities in addition to increased immigration and L1 maintenance have resulted in increased cultural and linguistic diversity within the immersion classroom (Fortune & Tedick, 2008). When immersion programs first began in the 1960s and 1970s, there was little need to talk about third or fourth languages, but contemporary programs are faced with a wide variety of students with varying language backgrounds and experiences.

As can be seen, the potential for variation across immersion programs and individual programs is vast. Nonetheless, all the variation occurs within only a few program models; in the U.S., there are three main branches of immersion: one-way (foreign language), two-way (bilingual), and indigenous (language and culture revitalization) (Fortune & Tedick, 2008).[10] One-way foreign language immersion programs are designed for majority-language students and instruct learners through a world language; for example, in the U.S., English-speaking students receive content instruction in a language other than English, such as Chinese, French, German, Japanese,

[10] Other typologies have been proposed for describing bilingual education programs (e.g., Baker, 2001; Christian & Genesee, 2001; Ferguson, Houghton, & Wells, 1977; Fishman & Lovas, 1970; Genesee, 1987; Mackey, 1972). The classification scheme presented in this dissertation is in line with that of Christian and Gensee (2001). These authors consider three “intersecting dimensions” in their classification of bilingual education programs across the world: 1) program goals, 2) sociolinguistic status of the languages used for instruction, and 3) profile of students (p. 1).

or Spanish. All students in a one-way program are moving in the same direction, toward greater proficiency in the IL.

Two-way bilingual programs differ in that they educate two distinct learner populations simultaneously, a majority-language group and a minority-language group. Equal numbers of the two learner groups is ideal, but a minimum of one-third is required for successful implementation of a two-way program. Both groups of students receive a portion of their daily content instruction in a language that is not their first or home language. Students are moving in two directions; majority-language students are moving toward proficiency in the minority language, and minority-language students are moving toward proficiency in the majority language. Spanish-English two-way programs are the most common in the U.S. context (Center for Applied Linguistics, 2007).

The purpose of the third program model, indigenous language immersion, differs greatly from that of the previous two in that its primary goal is to preserve and/or revitalize an endangered language while fostering a sense of cultural identity and ethnic pride. Most students enrolled in indigenous language immersion programs have strong ethnic ties to the language of instruction (Slaughter, 1997; Wilson & Kamanā, 2001). Indigenous programs may have a student population similar to that of either the one-way or two-way context, but given their unique program goals, they are considered to be a unique branch of language immersion education (Fortune & Tedick, 2008).

Table 2.1 summarizes the various terms used to describe immersion programs. Programs tend to carry three designations; one that references the student population, one that speaks to the amount of instructional time spent in the language of immersion, and one that references when instruction in the immersion language begins.

Table 2.1: Summary of Immersion Program Classifications

Category		Designation	Description
Student population		One-way (foreign language)	Language-majority learners
		Two-way (bilingual)	Language-majority and language-minority learners Ideally 50% from each language group, maximum of 67% for either group
		Indigenous	Learners with ethnic ties to the indigenous language
Percentage of instructional time in immersion language (during initial years of immersion)	One-way	Total / Full	100% of content instruction occurs in immersion language
		Partial	Only a portion of content instruction in immersion language *Minimum of 50% of instructional time in immersion language in preK - 6
	Two-way	90:10	90% of content instruction occurs in the minority language 10% of content instruction occurs in the majority language
		50:50	50% of content instruction occurs in the minority language 50% of content instruction occurs in the majority language
Level of entry, i.e. when content instruction in the IL begins		Early	Begins in early elementary years, typically kindergarten or first grade
		Delayed or Mid	Begins in upper elementary years, fourth or fifth grade
		Late	Begins in secondary school, typically 7^{th} or 8^{th} grade Builds upon skills established through FLES instruction in the elementary grades

In this dissertation, only the one-way and two-way program models will be considered. In the following review of the literature, a general overview of the theoretical basis for immersion will be provided, followed by a brief history of immersion education in the North American context. Finally, the language outcomes of immersion student populations will be reviewed, with an emphasis on findings related to phonological acquisition by immersion learners.

2.2 Theoretical Base of Immersion

Immersion programs were originally grounded on the premise that an L2 is learned in much the same way as the L1 (Krashen, 1981). It was thought that since students were exposed to large amounts of meaningful, comprehensible input they would naturally acquire the immersion language as a byproduct of content instruction. Therefore, the design of immersion programs was intended to draw upon the "natural language learning" abilities of students (Genesee, 1987) and create a language-rich learning environment. The following practices were implemented in order to create an environment that encourages language acquisition:

- providing opportunities and contexts for learners to engage in meaningful communication,
- little (or no) explicit teaching of L2 grammar,
- viewing errors as a normal and necessary part of the learning process, and
- allowing students to progress at their own individual rate and style.

  (Genesee, 1987; Snow, 1987)

Moreover, the quality of input was modified to mirror that which is present during first language acquisition, "motherese." Some characteristics of this speech are a slower rate, simplified vocabulary and grammar, and repetition. Consequently, ideal input in an immersion classroom is appropriate to the learners' ability level, plentiful, motivating, significant, and challenging (Lindholm-Leary, 2001).

Early immersion is also founded upon the notion that early, extended exposure leads to greater proficiency. When the first one-way immersion program was established in St. Lambert, Canada in 1965, a decision to start in the primary grades was based on dominant neuropsychological, psycholinguistic, and social psychological theories at the time, all of which suggested that language learning was most effective if it began prior to puberty (Genesee, 1987). The case for late immersion, on the other hand, can be made based on findings that the greater cognitive abilities of adults give them an advantage during the initial stages of L2 learning (e.g., Krashen, Long, & Scarcella, 1979).[11]

The rationale behind two-way immersion programs differs from that of one-way programs. Two-way programs were designed to enhance the cognitive, academic, and linguistic development of language-minority learners by affording them opportunities to develop their L1 while simultaneously promoting the learning of an L2 by language-majority learners. By combining two different language groups, opportunities for the negotiation of meaning are present, providing both groups with L2 input and an occasion in which to produce L2 output. Being able to communicate with native speaker peers and learn through both an L1 and L2 holds potential advantages for both groups. For both groups of learners, native language development is a priority; this is especially beneficial for minority-language learners since studies have shown that initial literacy in the L1 can lead to greater academic and L2 achievement (e.g., Thomas & Collier, 1997, 2002).

[11] Late immersion programs exist in Canada, but none have been reported in the United States context. Late immersion in Canada builds upon the proficiency base gained through core French in the elementary grades.

Additionally, it was believed that such an environment would provide language-minority students with linguistic and sociocultural benefits and language-majority learners with peer language models.

This thinking led to an explosion of both one-way and two-way immersion programs across North America beginning in the second half of the twentieth century. Many programs achieved great success, but they also faced serious challenges as a result of the theoretical assumptions on which they were based. Both the successes and challenges of immersion will be considered after a brief summary of the rise of immersion in the U.S.

2.3 History of Immersion

Foreign language immersion in North America began in 1965 in St. Lambert, Canada by a group of parents who wanted to enhance the future opportunities of their children as well as improve relations between English- and French-speaking Canadians. This first immersion program was an early, total, one-way program. Six years later, in 1971, the first one-way immersion program was created in the U.S. in Culver City, California. Much like the St. Lambert program, this program was an early, total immersion model designed to provide students with the benefits associated with bilingualism. The language of this program was Spanish, a language already present in the community. After the establishment of the Culver City program, immersion schools were started in other regions of the U.S. These first immersion programs were the result of community initiatives, a characteristic which remains true of many programs to this day.

Since the introduction of immersion to the U.S., the number of programs has continued to increased rapidly. The Center for Applied Linguistics (CAL) reported that as of 2006 263 one-way immersion programs existed in the United States (Center for Applied Linguistics, 2006).[12] A total of 18 different languages were represented in these programs, including Arabic, Cantonese, French, German, Japanese, Mandarin, Norwegian, Russian, and Spanish. All one-way immersion programs in the U.S. are early immersion programs (Met & Lorenz, 1997), and just over half, 56%, are partial immersion programs (Center for Applied Linguistics, 2006).

The first two-way program was established by the Cuban community in Dade County, FL in 1963. Coral Way Elementary was created in order to meet the needs of the children of Cuban immigrants, who were Spanish-speaking and who would potentially be returning to Cuban schools. Within the next 10 years, 14 additional two-way bilingual schools were started in Dade County to meet the growing needs of the community, and by 1975, two-way immersion schools had also been established in Washington, D.C., Chicago, and San Diego (Potowski, 2007b). Similar to the trend with one-way programs, the number of two-way immersion programs increased dramatically. In 1987, there were 30 two-way schools in existence (Lindholm, 1987), and by 1995, 182 schools had started

[12] The CAL database is based upon the self-reporting of programs. The possibility exists that some of the programs do not meet the definition of immersion and that other programs have not registered with this database.

two-way immersion programs (Christian & Whitcher, 1995).[13] In 2010, CAL reports 366 two-way immersion programs in the U.S., spread across 29 different states (Center for Applied Linguistics, 2010).[14] Ninety-two percent of the programs are Spanish-English programs, but Cantonese-English, French-English, Japanese-English, Mandarin-English, and Navajo-English programs also exist (Center for Applied Linguistics, 2007). According to Christian (1996), most two-way programs adhere to either a 50:50 or 90:10 model, with the majority of the 90:10 programs located in the western U.S. and the 50:50 programs are primarily in the East, South, and Midwest.

The astonishing growth in both one-way and two-way programs is no doubt due in part to the reported effectiveness of immersion for both content and L2 learning. While the academic achievement of immersion students is well attested (e.g., Genesee, 1987; Jones, 2005; Lambert & Tucker, 1972; Lindholm-Leary, 2001; Potowski, 2007b; Thomas & Collier, 1997), findings of the effectiveness of these programs for L2 acquisition are not as conclusive. Research findings of the L2 abilities of immersion learners will be summarized in the next section, with a focus on the findings related to phonological skills.

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[13] Christian et al. (1997) note, however, that this number includes all schools who reported housing a two-way program and that "some features would not be widely accepted as characteristics of two-way immersion" (p. 4). Based upon this cautionary note, it is probable that this reported number is higher than the actual count in 1995.

[14] This reported number is likely to be accurate as CAL reviewed the characteristics of the self-reported programs and removed programs that did not meet criteria for a two-way immersion program. Many of those originally reported as pertaining to this class of language education model were actually developmental bilingual, one-way immersion, or ESL programs. Nonetheless, because these numbers are based upon self-report, it is possible that some schools have not registered their program in the CAL database.

2.4 Language Acquisition by native English speakers in Immersion Programs

2.4.1 L2 Syntactical and Lexical Acquisition

Most of the research conducted in language immersion programs has investigated the academic achievement and English language development of immersion learners as this is what most concerns the principal stakeholders, such as parents and administrators. Much of what is known about second language development in the one-way foreign language immersion context comes from the research on French immersion in Canada as fewer programs in the U.S. assess second language proficiency (Met & Lorenz, 1997). Within the past decade, however, more U.S. programs are beginning to assess learners' IL skills; some of the measures that have been used to assess students' second language proficiency in a variety of elementary dual language contexts are[15]:

- Student Oral Language Observation Matrix (SOLOM) (e.g., Fortune & Arabbo, 2006; Lindholm-Leary, 2001),
- Foreign Language Oral Skills Evaluation Matrix (FLOSEM) (e.g., Lindholm-Leary, 2001),
- Student Oral Proficiency Assessment (SOPA) (e.g., Fortune & Arabbo, 2006; Howard, Christian, & Genesee, 2003),
- Language Assessment Scales – Oral (LAS-O) (e.g., Potowski, 2007b),
- Aprenda II (e.g., Fortune & Arabbo, 2006)

[15] Two recent publications address language assessment and evaluation in dual language programs. See Sugarman et al. (2007) and Lindholm-Leary and Hargett (2007) for more information.

- Center for Applied Linguistics' Oral Proficiency Exam (COPE) (e.g., Fortune, 2001; Fortune & Arabbo, 2006), and
- Bilingual Syntax Measure (Burt, Dulay, & Hernández-Chavez, 1976) (e.g., Boyd, 1975).

Students enrolled in immersion programs have been found to attain higher levels of L2 proficiency than peers in less time-intensive elementary foreign language programs (Campbell, et al., 1984; Genesee, 1987, 1991; Swain & Lapkin, 1982). In a similar vein, the language skills of learners enrolled in partial and 50:50 programs have tended to not be as developed as those of total or 90:10 immersion students (e.g., Lindholm-Leary, 2001, 2005; Swain & Lapkin, 1982; Turnbull, Lapkin, Hart, & Swain, 1998). While more time in the second language may account for greater gains in these early immersion programs, the time factor cannot always be used to explain differences in IL proficiency. For example, Genesee (1981b) found that despite considerably less exposure to French on the part of two-year late immersion students, they did not show any significant differences in L2 ability (as measured by tests of listening and reading comprehension, oral production, dictation, and writing) from early immersion students. Also, more English-medium instruction in English-only and transitional bilingual programs does not guarantee as high of levels of proficiency in English for Spanish-speaking students as participation in two-way immersion programs, in which students receive less instruction in English (e.g., Lindholm-Leary, 2001). Overall, research points to high levels of communicative ability developed by immersion students in both written and oral formats, but it also reveals immersion learners' general tendency to produce linguistic errors (e.g., Genesee, 1987; Potowski, 2005, 2007a; Swain & Lapkin, 1982). In fact, the linguistic errors of immersion learners have been found to fossilize, creating an interlanguage unique to the immersion context that Lyster (1987) names "immersion speak."

It is the productive skills of immersion learners that most lag behind those of native peers in the majority of cases. For example, research carried out in French immersion programs in Canada has found that the receptive skills of most French immersion learners are as good as those of Francophone peers (e.g., Genesee, 1987; Lambert & Tucker, 1972; Pawley, 1985). Studies in U.S. Spanish immersion programs present mixed results; several have observed better reading comprehension skills in a native Spanish control group than in English-speaking immersion learners (e.g., Campbell, 1984; Cazabon, Nicoladis, & Lambert, 1998; Potowski, 2007a) while others have documented the opposite, better reading skills by the native English-speaking learners of Spanish (Fortune & Arabbo, 2006). Fortune and Arrabo (2006) suggest that the inconsistency of their findings with previous research may be the result of specific design and implementation features of the program their subjects attended which were not in line with tenets of best practice for language-minority students.[16] Despite this discrepancy, the receptive skills tend to be better developed than productive skills (e.g., Genesee, 1978a).

Although the output of most immersion students is more grammatical than ungrammatical, it retains foreign, or non-native, aspects (Campbell, 1984), specifically in the areas of grammar and lexicon (e.g., Christian, Montone, Lindholm, & Carranza,

[16] For example, this particular program adhered to a one-way instructional model despite approximately 1/3 of the student population speaking Spanish as a home language.

1997; Harley, 1979; Swain, 1985). For instance, the French output of one-way immersion learners in Canada reveals a reduced verb system (Harley & Swain, 1984); in Grade 4, French immersion students did not make use of the imperfect in either the progressive or habitual context, nor did they utilize the conditional. By Grade 10, they had begun to use the conditional and the imperfect in the progressive context, yet they still did not employ these forms in all of the obligatory contexts. Moreover, use of the imperfect in the habitual context still was not used. In much the same way, the output of one-way Spanish immersion learners in the U.S. lacks number and gender agreement, accurate expression of tense, use of the subjunctive, and native-like use of definite articles and object pronouns (e.g., Boyd, 1975; Cohen, 1975; Plann, 1979).

Similar patterns are present in the two-way context; Christian et al. (1997) noted a limited vocabulary and incorrect grammar patterns in the Spanish speech and writing of English-speaking students. In Grade 8, English-speaking immersion learners have been found to correctly produce the present subjunctive, imperfect subjunctive, and conditional at significantly lower levels than native speaker peers (Potowski, 2007b), and they have also shown incomplete, albeit advanced, acquisition of the Spanish tense/aspect system (Potowski, 2005). Moreover, English-speaking learners in the two-way immersion context have not developed their sociolinguistic competence to the same levels as native speakers; specifically they do not successfully differentiate their language based on the formality of the situation (Potowski, 2007a). Differences such as these in grammatical and lexical accuracy reveal themselves in general oral proficiency assessments. English-speaking learners at two different two-way immersion schools averaged lower scores on Spanish oral language assessments than Spanish-speaking peers (Christian et al., 1997)

2.4.2 Phonological Acquisition in Immersion Programs

In addition to non-native vocabulary and grammar, it appears that non-native pronunciation is a problem as well. Most reports of immersion learners' oral language abilities are informal, comprising general comments, such as "[they] do not sound like native speakers" (Campbell, 1984, p. 131) or "the immersion students were not comparable to a group of native French-speaking students in their pronunciation/intonation" (Day & Shapson, 1996, p. 11). One of the first studies to include pronunciation as one component of a battery of assessments to measure speaking skills was Genesee (1978a). Subjects were rated by two native speaker judges on a 5-point scale on 5 different speaking subskills – comprehension, pronunciation, grammar, vocabulary, and communicativeness – based on an oral interview. He found the pronunciation abilities of Grade 4, 5, and 6 students to be rated at about 4.0 on the 5-point scale and to differ significantly from ratings of native Francophone peers; however, pronunciation skills were not discussed further.

Similar pronunciation ratings were reported for both English-speaking learners and Spanish heritage language students in a one-way Spanish immersion program as part of a program-level immersion language proficiency assessment (Fortune & Arabbo, 2006).[17] The MN-SOLOM was employed as one measure of oral proficiency and

[17] The particular program in which the assessment was conducted considered itself to be a one-way program even though its student demographics were more like those of a two-way program; 65% had English as the language of the home and 34% had Spanish as the primary home language.

listening comprehension at grades 2, 5, and 8. In this evaluation tool, teachers rate students on a five-point scale in each of five categories - global comprehension (academic and social language), fluency, vocabulary, pronunciation, and grammar - based on both formal and informal classroom interactions over a 2- to 3-week period. Teacher ratings of the 62 Spanish home language students ranged from 4.0 to 5.0 (early advanced to advanced/native speaker level); the rating of pronunciation of these learners increased from 4.0 in Grade 2 (N=31) to 5.0 in Grade 5 (N=20). Between Grades 5 and 8 (N=11), however, pronunciation ratings dropped from 5.0 to 4.0. English learners of Spanish[18] demonstrated a different pattern with respect to pronunciation; their pronunciation ratings show a gradual increase across grade levels. The pronunciation of English-speaking Grade 2 students was assigned a rating of 3.5 (N=84); the rating of Grade 5 learners increased to 4.0 (N=45), and that of Grade 8 learners increased to 4.1 (N=32). Upon comparing the two groups, it seems that by eighth grade, the pronunciation of English-speaking learners is comparable to that of Spanish-speaking peers; in other words, the initial stronger performance of Spanish-speaking students disappears over time.

Snow and Campbell (1985) more directly investigated immersion learners' pronunciation by exploring the acquisition of phonological rules by Spanish immersion students in the Culver City one-way, total immersion program. Earlier linguistic analyses carried out in this program referenced students' pronunciation skill in an informal fashion as commented above. Unlike the comments shared earlier, the evaluation of children's pronunciation abilities in this program was positive as can been seen in two comments

[18] Included with the English home language students are students whose home language was one other than Spanish. Two second grade student participants, one fifth grade participant, and one eighth grade participant spoke another language at home.

made by Flores (1973, as cited in Snow & Campbell, 1985): “Most of the children are now able to articulate the Spanish sounds with native like accuracy” (p. 13) and “the phonological development has also reached a point where most of the children sound native-like” (p. 64). Snow and Campbell (1985), thus, set out to formally evaluate the pronunciation abilities of Spanish immersion students.

Forty-eight students participated in their study – 16 kindergartners, 17 third graders, and 15 sixth graders. Students participated in three different tasks: a picture identification task, an imitation task, and a reading task.[19] All three tasks tested the same 73 words, which enabled the researchers to look at consonant production in a variety of linguistic contexts. The production of the learners was then rated by two native Spanish-speaking judges on a 3-point scale that ranged from native-like to English-like.

Overall, Grade 3 subjects scored significantly higher than either the kindergarten or Grade 6 participants. Kindergarten subjects had a mean rating of 2.435, Grade 3 subjects, 2.625, and Grade 6 subjects, 2.520. Subjects were rated more native-like on the imitation task than the picture identification task, and negative transfer from the L1 was found for both stops and liquids. Specifically, there was aspiration of word-initial, voiceless stops, only partial spirantization of voiced obstruents, and retroflex or tap productions of medial /r/. Snow and Campbell (1985) concluded that “while many non-native forms exist in the Spanish sound system of these students, …they are making significant progress in acquiring native-like pronunciation” (p. 28). The authors do not,

[19] Only findings related to the first two tasks, picture identification and imitation, are reported in this chapter.

however, employ an acoustic analysis, nor do they attempt to explain the regression in pronunciation abilities from third to sixth grade.

In a more recent study, Harada (1999) did not find a decrease in the ratings of native English-speaking Japanese immersion learners between Grade 3 and Grade 5, but acoustic analysis did not coincide with the ratings, revealing less native-like features in the speech of the older group. Harada studied 19 English-speaking children enrolled in a one-way Japanese immersion program – 7 first graders, 6 third graders, and 6 fifth graders. Subjects participated in two 20-minute data collection sessions, during which they participated in an elicitation task. The data collection sessions were 2½ months apart. Harada specifically looked at the Voice Onset Time (VOT)[20] and closure duration[21] for each of the groups of learners, comparing them to monolingual Japanese peers and their bilingual immersion teachers.

Japanese voiceless stops have shorter VOT values than voiceless stops in English. The immersion students did produce stops with shorter VOT values in Japanese than in English, but they were still longer than the VOT values of monolingual Japanese children. Moreover, Grade 5 students produced Japanese voiceless stops with significantly longer VOT values than both Grade 1 and Grade 3 students. Closure duration is needed to distinguish single and geminate consonants in Japanese. Immersion learners are less clear in their distinction of singletons and geminates than monolingual

[20] VOT is the amount of time between the release of a consonant closure and the onset of voicing (the vibrating of vocal folds).
[21] Closure duration refers to the period of time between oral closure and its release.

peers, evidenced by smaller closure duration ratios.[22] Foreign accent ratings also reveal differences between native speakers and immersion learners; monolingual Japanese speakers received an average score of 9.85 while the scores of individual immersion students ranged from 3.35 to 9.65. On average, Grade 5 students received higher ratings, 7.69, than either Grade 1 or Grade 3 subjects, 5.72 and 5.74. Grade 5 students, however, showed more variation as evidenced by a larger standard deviation; differences between grade levels were not found to be statistically significant.

Harada (1999) summarizes his findings, stating that the immersion learners do separate the L1 and L2 phonological systems, but that their L2 productions do not resemble those of monolinguals and that they present greater variability in their productions than monolinguals. He concludes "that most immersion children may develop good pronunciation in the long run – possibly being perceived as a native-like pronunciation – though they do not acoustically reach the native speaker's norm" (p. 99).

Taken together, these reported findings suggest that immersion learners do not achieve native-like pronunciation; each of the studies points to English-speaking immersion learners producing accented immersion language sounds, whether measured on a native-like rating scale or through acoustic analysis. This finding holds across three different languages – French, Japanese, and Spanish. The difference in the findings of Fortune and Arabbo (2006) may be attributable to methodological differences. In Fortune and Arrabo (2006) comparisons were made to a bilingual group, not a monolingual group

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[22] A longer closer duration tends to be associated with geminates. The closure duration ratio compares the closure duration for a geminate to that of a singleton. A larger ratio means that the distinction between the two is greater, i.e. there is more of a difference in the production of each. A smaller ratio results in a less clear distinction.

as in Harada (1999) and Genesee (1978); this particular comparison group resided in the upper Midwest, an English-dominant context, which may have impacted their Spanish-language proficiency, language dominance, and pronunciation in line with findings from previous work (e.g., Flege & Hillebrand, 1984; Fortune, 2001; Guion, 2003; Potowski, 2007a; Silva-Corvalán, 1994). Also the tool used to measure pronunciation in Fortune and Arrabo (2006), a coarse teacher rating, differed from those of Harada (1999) and Snow and Campbell (1985). Overall, however, the findings from the phonological studies conducted to date resemble the findings from other areas of L2 acquisition in immersion classrooms; although immersion learners develop fluency and are able to easily communicate, they do not do so in native-like ways. Their output is marked in a variety of ways, such as uncommon lexical selections, aberrant grammar forms, and non-native pronunciations.

Researchers have attributed such discrepancies to a variety of factors, including the type of input being received from teachers (Boyd, 1975; Valdés, 1997), a lack of L2 output (Swain, 1985), and a lack of attention to language (Lyster, 1987). As a result attention has shifted in recent years from assessing the L2 skills of immersion learners to classroom discourse practices (e.g., Broner, 2000; Fleming, 2006; Fortune, 2001; Potowski, 2002, 2004) and the need for greater instructional focus on developing all students' skills in the IL (e.g., Cloud et al., 2000; Fortune & Arabbo, 2006; Fortune, Tedick, & Walker, 2008; Genesee, 1987, 1991, 1994; Lyster, 2007; Snow, Met, & Genesee, 1989; Swain, 1996). Many have come to accept that extended, intensive language input is not enough for complete language acquisition in an immersion program. In order to promote academic success and greater linguistic proficiency, Fortune and Tedick (2008) recommend implementing the following key curricular and instructional elements:

- Curriculum is content-driven and language-attentive.
- Language, culture and content are integrated.
- Classroom tasks are designed to challenge students both cognitively and linguistically.
- Instructional strategies reflect linguistically and developmentally-appropriate scaffolding and elicit frequent use of the immersion language.
- Classroom interactional dynamics encourage peer-peer communication.
- Cooperative learning techniques seek to build more equitable and socially respectful student relationships.

(p. 12-13)

Implementing the above practices encourages language development in conjunction with content learning; in this way the goals of immersion education can be achieved. Although increasingly more attention is given to developing the IL skills of students, pronunciation tends to be ignored in most immersion classrooms with the possible exception of indigenous immersion programs (T. Fortune, personal communication, January 25, 2008). The relative unimportance of pronunciation is similarly reflected in its absence from some oral language assessments, such as the COPE and SOPA. Dispensing with pronunciation instruction is not unique to the immersion context; Tarone (1978), Pennington and Richards (1986), and Elliot (1995b, 1997) each comment that a majority of L2 classrooms tend to forego any explicit development of pronunciation.[23] Pronunciation may, however, impact the social relationships a L2 learner is able to establish and the discourses he/she is able to enter into (e.g., Lippi-Green, 1997; Lybeck, 2002; Mendoza-Denton, 1997; Miller, 2004); for this reason, development of the L2 phonological system is valuable and understanding how learners acquire it, important.

[23] These observations are based upon foreign language classrooms in the United States. Whether pronunciation instruction varies according to context, foreign language versus second language, is unclear. It may be that pronunciation is attended to more regularly and more systematically in second language contexts than in foreign language contexts.

Chapter 3
Literature Review: Vowels

3.1 The Acoustic Analysis of Vowels

Vowels are produced when the vocal tract is in a "relatively open configuration"; this differs from the production of consonants, which are characterized by some sort of constriction or closure along some point of the vocal tract above the glottis (Stevens, 1998, p. 258). Quilis (1999) described the articulatory contrast between the production of consonants and vowels in the following way:

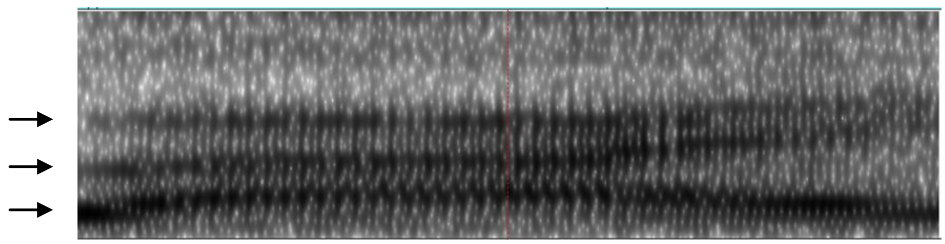
> *Para la emisión de las vocales actúan los músculos depresores, que tienden a inferir un movimiento de abertura de los órganos articulatorios, mientras que para la emisión de las consonantes, actúan los músculos elevadores que infieren un movimiento de cierre en los órganos articulatorios*. (p. 143)

The sound of a vowel depends upon the pitch (F0) at which it is spoken and the overtone pitches. The pitch of a sound is determined by the rate of vibration of the vocal folds, and the overtone pitches are established by the shape of the resonating cavities in the vocal tract. Vowels can be produced at any pitch as the overtone pitches are what give each particular vowel its distinctive quality. The shape of the resonating cavity is determined by the position of the tongue in the mouth (height, backness), the lips (degree of roundness) and the soft palate (nasalization), as well as the width of the pharynx. While the position of the tongue, lips, and soft palate are all used to describe Spanish sounds, typically only tongue position and lip rounding are used to describe the vowels.

Furthermore, only characteristics related to tongue position - height (high, mid, low) and backness (front, central, back) – are distinctive in Spanish; lip rounding is not.

Acoustic descriptions of vowels, rather than focusing on the position of the articulators, consider the frequencies at which sound waves resonate. The resonances produced by the vocal cavity are called formants; the frequency at which formants, or resonances, occur are vowel- (and language-) specific and are what provide each vowel with its distinctive quality. Formants appear as dark bands of energy in spectrograms (See Figure 3.1). In spectrograms, the vertical scale indicates the frequency of the formants, the horizontal scale indicates the time at which a sound occurs, and the lightness or darkness of the formant indicates the amplitude with which the sound is produced. Three formant measurements are generally used across languages to describe vowels, but in Spanish, typically only the first and second are used. While a variety of factors exert an influence on formant values, the primary correlate of the first formant (F1) is tongue height, and the primary correlate of the second formant (F2) is tongue backness. Lip rounding also affects formant values, resulting in lower F2 frequencies (Ladefoged, 2005). Because lip rounding is not distinctive in Spanish (front vowels are unrounded and back vowels are rounded), it is not considered further in this discussion. The relationship between F1 values and height is an inverse one: the higher the F1 value, the lower the vowel; conversely, the lower the F1 value, the higher the vowel. Higher F2 values are related to more fronted vowels, and lower F2 values to more back vowels. Ladefoged (2006) cautions, however, that such descriptions “are often not in accord with the actual articulatory facts" since high-low and front-back refer more to acoustic dimensions than actual tongue positions (p. 189).

Figure 3.1: Sample Spectrogram Image (A3-3a8-1)

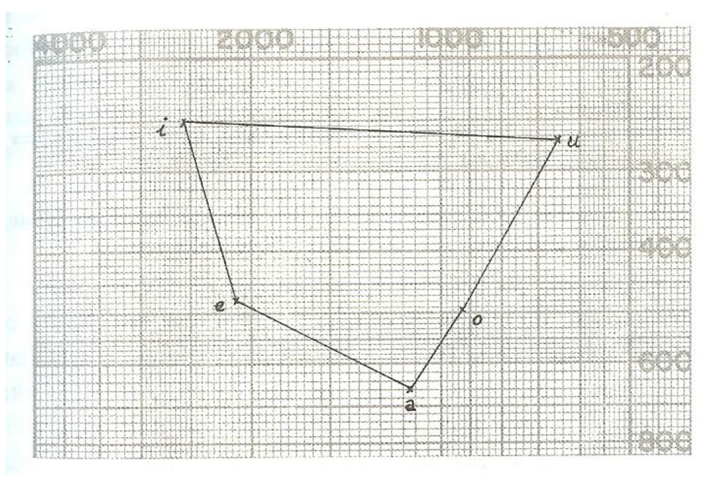


Spectrograms "*refleja[n] el sonido en su evolución frecuencial a lo largo del tiempo,"* allowing for formants to be measured (Martínez Celdrán, 1998, p. 31). Formant charts, such as the one seen for Spanish in Figure 3.2, are commonly used to depict the location of vowels in the acoustic space. In formant charts, F1 is plotted on the y-axis, and F2 on the x-axis. Because formant frequencies are inversely related, the axes are placed so that (0,0) is in the upper right hand corner in order to align the visual depiction with our conception of the vowel space. A logarithmic scale is typically employed to mark the values on the axes of formant charts so that equal distances on the scale represent perceptually equal intervals of pitch. In other words, since the difference between 200 Hz and 300 Hz is perceived by a listener as greater than the difference between 600 Hz and 700 Hz, the distance between 200 Hz and 300 Hz on the formant chart is greater.

Non-native vowel production can lead to a foreign accent or unintelligibility (e.g, Flege, 1997; Flege et al., 1999; Munro, 1993). This holds true for English speakers learning Spanish as an L2 as evidenced by the inclusion of the five vowel sounds (/a, e, i, o, u/) in a list of almost 20 sounds that most contribute to a foreign accent[24] in Spanish as judged by several Spanish instructors, professors, and graduate students (Elliot, 1997). In this section a brief, general description of both the Spanish and English vocalic systems will be offered, followed by a discussion of how the two systems are related. Given that this dissertation investigates the acquisition of vowels by child second language learners, it is important to consider both developmental factors related to language acquisition as well as what is known about the acquisition of vowels in a second language. In the last section, which discusses L2 vowel acquisition, studies that have specifically explored the acquisition of Spanish vowels by native English-speakers will be addressed.

Figure 3.2: Spanish Formant Chart

(Quilis, 1999, p. 163)



[24] Foreign-accented speech is defined by Munro (1993) as "speech which differs audibly from native speaker norms" (p. 40). The differences can occur across a variety of segmental and/or suprasegmental dimensions (Flege, 1995).

3.2 The Vocalic Systems of Spanish and English

3.2.1 The Vocalic System of Spanish

Linguists agree that there are five vocalic phonemes in Spanish: /i, e, a, o, u/ (e.g., Martínez Celdrán, 1998; Navarro Tomás, 1957; Quilis, 1999). They account for just under half of spoken speech in Spanish; frequency analyses have found that vowels comprise approximately 48% of all sounds in spoken Spanish (Guirao & Jurado, 1990; Moren Sandoval, Toledano, de la Torre, Garrote & Guirao, 2008; Quilis & Esgueva, 1980) and 46% of written Spanish (Moreno Sandoval et al., 2008). The Spanish vowels are also considered to be highly regular, showing little variation across dialect regions or social groupings (Morrison & Escudero, 2007; Stockwell & Bowen, 1965).[25] In a comparison of the Peruvian and Castilian dialects, Morrison and Escudero (2007) found that despite lower fundamental frequencies and shorter durations on the part of Peninsular speakers, only F2 values for /o/ show an effect of dialect. The authors concluded that such findings upheld the assumption that dialectal differences in formant values are minimal in Spanish.

The five Spanish vowels are traditionally distinguished in terms of height and backness, which allows for the following groupings:

<u>Height</u>	<u>Backness</u>
high: [i], [u]	front: [i], [e]
mid: [e], [o]	central: [a]
low: [a]	back: [o], [u]

[25] The lack of variation in vowel production across dialects of Spanish is noticeable in a relative lack of cross-dialectal and sociolinguistic studies on vowel variation. Nearly all Spanish sociolinguistic studies investigate the variation in consonant production (see Blas Arroyo, 2005, pp. 25-55 and Silva-Corvalán, 2001, pp. 85-126 for a review). Recently, empirical work has begun to question this as dialectal differences in how vowels are realized have been identified (e.g., Garrido, 2007; Guion, 2003; Oliver, 2007; O'Rourke, 2010; Willis, 2005, 2008)

Acoustic studies have supported these divisions. In Table 3.1 the formant frequencies reported in the literature for the five Spanish vowels are compiled. Most reported values are based upon the Castilian dialect, with the exception of Mendez (1982) who reports on the Puerto Rican dialect and Skelton (1969) who includes informants from both Spain and Spanish America.

Table 3.1: Reported F1 and F2 Values for Spanish Vowels

Source	Speaker group	N	i		e		a		o		u	
			F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Martínez Celdrán (1995)	Castilian	NR	313	2200	457	1926	699	1471	495	1070	349	877
Quilis & Esgueva* (1983)	Castilian males	16	265	2318	455	1995	657	1215	475	888	295	669
Quilis & Esgueva* (1983)	Castilian females	6	241	2835	492	2252	665	1168	511	981	243	629
Delattre (1965)	Castilian	NR	275	2300	450	1900	725	1300	450	900	275	800
Skelton (1969)	Spain & Spanish America	20	495	2470	685	214	965	1590	685	1150	505	990
Mendez (1982)	Puerto Rico males	3	350	2478	NR	NR	756	1178	NR	NR	336	751
Bradlow (1995)	Castilian males	4	286	2147	458	1814	638	1353	460	1019	322	992

NR=not reported
*Values are rounded to the nearest whole number

Typically, values reported in the literature represent the mean, or the center, of a range of values; actual formant values cover a range of values, which is known as the dispersion field. When the range of values is considered, some overlap occurs. For example, Skelton (1969) reported a range of F1 values for /e/ and /a/, 500 to 850 Hz and 700 to 1150 respectively. The F1 values of the two vowels overlap in the frequency range of 700-850 Hz. The amount of overlap is generally small however; Skelton (1969) reported for example that the number of tokens which fell in overlapping zones comprised less than 10% of the sample. In order for confusion to result, both formants in a single token must overlap.[26] As a means of displaying the range of values specific to each vowel, some vowel charts include an ellipse around the mean value, which shows the range within which 95% of the vowel productions of a particular population occur. Reported values such as those presented in Table 3.1 have led to graphic representations of the Spanish acoustic vowel space such as was seen previously in Figure 3.2.

3.2.1.1 Spanish Vowels of the American Southwest

The Spanish that the NES immersion learners in this study are exposed to is not the monolingual variety most often reported in the literature; the Spanish of the Southwest United States forms the basis of their input. The Spanish of this region is recognized as its own variety, with unique lexical, syntactic, pragmatic, and phonetic features. Sánchez (1983) points out that the phonetic variants present in the speech of Spanish speakers in the US Southwest are also present in the Spanish of Peninsular and Latin American speakers. Early accounts of the Spanish vowels of this region are based upon perceptual analyses; although there is mention of phonological processes (i.e. apheresis, apocope, syncope, reduction of diphthongs) which affect vowels (Clegg 1969; Phillips 1967, 1976; Sánchez 1982, 1983), descriptions of the vowel qualities are limited by the method of analysis.

[26] Linguistic and semantic context also serve to disambiguate potential confounds.

Clegg (1969) analyzed the speech of speakers, aged 35-55 years old, from rural and urban areas of Texas. His analysis revealed 7-8 allophones of each of the five vocalic phonemes of Spanish, amongst the variants identified were elided, open, closed, and relaxed allophones in addition to semi-vowels. Phillips (1976) identified fewer variants in the speech of Spanish speakers in Los Angeles; his analysis revealed only 3-4 allophones of each phoneme. In both cases, the allophones resulted from contact with specific consonants and prosodic stress. Phillips noted the presence of relaxed variants in unstressed syllables; his analysis suggested that these variants are most common for /a/ and /o/. He also reported production of [ə] by these speakers for /a/; production of this centralized variant was, however, highly infrequent, produced in only 4 instances (less than 1% of the sample).

In a descriptive study of the Spanish of the U.S. Southwest, Sánchez (1982) highlighted some of the phonetic processes that affect the vowel productions. Phonetic processes which affect vowel production were more prevalent in rural varieties as overall few phonetic variants were observed in urban varieties, suggesting a more conservative nature. Some of the processes observed in rural dialects were apheresis (loss of initial syllable), apocope (loss of final sound), syncope (loss of middle sound), changes in verb stems, and diphthong reduction (/pues/ > [pos]). Sánchez highlighted, however, that all of the variants are phonetic in nature, as opposed to phonological; the underlying form is the same.

The only mention of vowels in a recent review of the varieties of Spanish in the United States is with respect to the Mexican-American variety. Lipski (2008) documented the presence of a lax variant of /e/, [ɛ], in the speech of Mexican-American communities, most notably in word-final, closed syllables. He also observed that unstressed vowel reduction is not common to Mexican-American dialects of the U.S. Southwest as most speakers are from northern Mexico where reduction is uncommon. He noted that in other areas of the U.S., in which speakers from central and southern Mexico are more numerous, unstressed vowel reduction does occur.

Willis (2005) conducted an acoustic analysis of the vowel productions of four Spanish-English female speakers in the U.S. Southwest. He found that the formant frequencies of these speakers differed significantly from those reported for a monolingual speaker from the Mexican dialect in Quilis and Esgueva (1983). All vowels were produced with higher F2 frequencies, most notably the non-front vowels, /a/, /o/, and /u/. In addition, the high vowels, /i/ and /u/, were produced with higher F1 values (lower tongue height) than what had been reported previously. Although contact with English and dialectal differences are potential explanations for the different acoustic features, Willis (2005) suggested that other explanations, such as vowel chain movement or speech style differences, may be possible as well. Willis also addressed the issue of lexical stress by comparing subjects' stressed and unstressed productions of /a/. Although one speaker did produce tonic and atonic tokens of /a/ with statistically significant differences in formant values, there was no evidence of reduction of unstressed /a/ to the mid-centralized vowel [ə] as occurs in English.

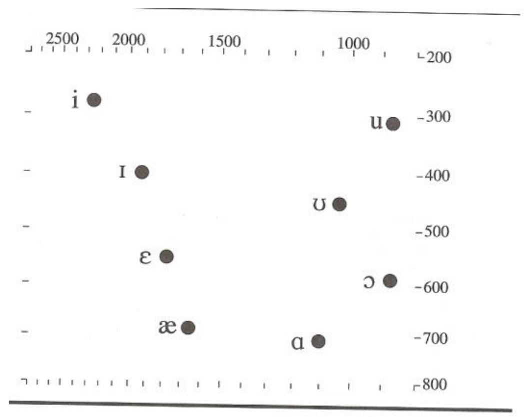
3.2.2 The Vocalic System of English

The English vocalic system is much richer and more complex than the Spanish vowel system (Delattre, 1981); Ladefoged (2006) commented that approximately 25 different tongue and lip gestures are needed to produce the English vowels. Descriptions of the English system vary in their counts of vowels, typically ranging from 9-14 (e.g., Bradlow, 1995; Delattre, 1965; Ladefoged, 2006), depending upon how lengthening, reduction, and diphthongization are incorporated. Ladefoged (2006) identified nine monophthongs, /i, ɪ, ɛ, æ, ɑ, ɔ, ʊ, u, ʌ/, and six diphthongs, /eɪ, oʊ, aɪ, aʊ, ɔɪ, ju /. Unlike the stability of the Spanish vocalic system, English vowels vary widely between speakers and dialects; in fact, regional accents are often marked by the differences in vowels (Ladefoged, 2006; Stockwell & Bowen, 1965).

Like the Spanish vowels, English vowels are most typically characterized and depicted in terms of height and backness; unlike Spanish vowels, however, descriptions typically also include tense/lax or closed/open distinctions. Figure 3.3 illustrates the distribution of English phonemes throughout the acoustic vowel space based upon these distinctions. In Table 3.2, a compilation of the formant frequency values, upon which such representations as Figure 3.3 are based, is presented.

Figure 3.3: English Formant Chart

(Ladefoged, 2006, p. 189)



3.2.3 The relationship between the English and Spanish vocalic systems

The most obvious difference between the vocalic system of Spanish and English is the number of phonemes present in each language. English speakers employ a greater number of distinctive units, somewhere between 9 and 14, than do Spanish speakers who employ only 5. The location of the phonemes in the acoustic vowel space also varies according to language. Delattre (1965) superimposed the formant charts of Spanish and English to show the location of each language's vowels in relation to the other's as shown in Figure 3.4.

From this chart, the Spanish vowel space appears to be slightly narrower on the horizontal plane and slightly higher on the vertical plane. Specifically, Spanish /i/, /a/, and /u/ show lower F1 values (i.e., higher tongue position in the mouth) when compared to the respective English counterparts, and Spanish /e/ is slightly more back while Spanish /o/ is slightly more fronted.

Table 3.2: Reported F1 and F2 Frequencies (in Hz) of American English Vowels

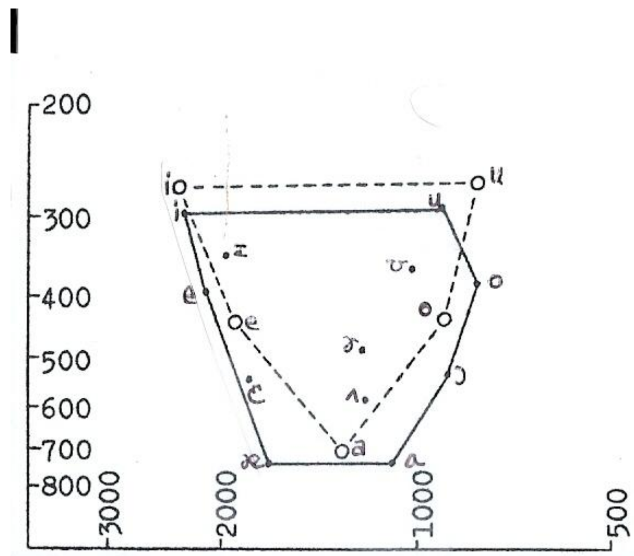
	i		ɪ		e		ɛ		æ		ʌ		ɑ		ɔ	
	F1	**F2**	**F1**	**F2**	**F1**	**F2**	**F1**	**F2**	**F1**	**F2**	**F1**	**F2**	**F1**	**F2**	**F1**	**F2**
Bradlow (1995) CVC context	268	2393	463	1995	430	2200	780	1244	620	1033	640	1354	780	1244	620	1033
Bradlow (1995) CVCV context	264	2268	429	1831	424	2020	783	1182	614	945	655	1216	783	1182	614	945
Delattre (1965)	300	2250	350	1950	400	2100	750	1100	550	900	600	1200	750	1100	550	900
Mendez (1982)**	306	2410	NR	NR	NR	NR	765	1100	NR	NR	NR	NR	765	1100	NR	NR
Ladefoged* (2006)	280	2250	400	1920	NR	NR	710	1100	590	880	NR	NR	710	1100	590	880

	o		ʊ		u	
	F1	**F2**	**F1**	**F2**	**F1**	**F2**
Bradlow (1995) CVC context	482	1160	481	1331	326	1238
Bradlow (1995) CVCV context	473	1094	411	1361	316	1183
Delattre (1965)	400	800	375	1000	300	900
Mendez (1982)**	NR	NR	NR	NR	364	968
Ladefoged* (2006)	NR	NR	450	1030	310	870

NR=not reported
* Ladefoged (2006) does not consider English /e/ and /o/ as monophthongs; rather they note that they are produced as diphthongs, /eɪ/ and /oʊ/.
**Mendez (1982) used the symbol /a/ and not /ɑ / for the low central/back vowel. His study only investigated three phonemes: /ɪ, ɑ, u/.

Figure 3.4: English and Spanish Formant Chart

(Delattre, 1965, p.51)[27]



The findings of Mendez (1982) are similar to the differences seen in Delattre's chart. Mendez compared the /i, a, u/ productions of three monolingual English-speaking males and three monolingual Spanish-speaking males. His findings pointed to relatively similar formant frequencies for /i/ and /a/ in both languages, but lower F1 and F2 frequencies for Spanish /u/ (i.e., a higher, more back production) when compared to English /u/. He attributed this difference in F2 values to greater lip rounding in Spanish than in English.

Bradlow (1995) too found differences in the formant frequencies of /u/ between the two languages, but she found differences for /i, e, o/ as well. She hypothesized that a language-specific base-of-articulation effect results in English vowels having slightly

[27] Delattre's original charts did not include the phonemic labels. They have been added by the author in this reproduction.

higher F2 values; in other words, English vowels are articulated with a more fronted tongue position. Additionally, her data showed lower F1 frequencies for English /i/ and /e/ but a higher F1 frequency for /o/. The findings for /e/ and /o/ were in line with the graphic representation made by Delattre (1965), but the /i/ position differed. Bradlow did not consider the low vowels (Spanish /a/, English /æ/ and /ɑ/) since they are not the same across the two languages.

More general comparisons of the two languages suggest that Spanish /i/ occupies portions of the space delimited by English /i/ and /ɪ/, and similarly Spanish /e/[28] encompasses parts of the space occupied by English /ɪ/ and /ɛ/ (e.g., Flege et al., 1997; Morrison, 2003; Stockwell & Bowen, 1965). Comparisons also point out that the Spanish vowels generally show less formant movement than their English counterparts (e.g., Flege et al., 1997), highlighting that /e/ and /o/ in Spanish are monophthongs while in English, they are produced as diphthongs (e.g., Bradlow, 1995; Delattre, 1965; Stockwell & Bowen, 1965). Finally, comparisons of the low vowels are sparse, but Spanish /a/ is generally regarded as falling between English /æ/ and /ɑ/ (e.g., Bradlow, 1995; Delattre, 1965; Stockwell & Bowen, 1965).

Some researchers make reference to two similar theories which deal with the relative positioning of vowels with respect to the number of vowels in the system, Theory of Adaptive Dispersion (Liljencrants and Lindblom, 1972; Lindblom, 1983, 1986;

[28] Flege et al. (1997), who referenced Dalbor (1980), and Stockwell and Bowen (1965) make reference to two different realizations of the /e/ phoneme in Spanish, [e] and [ɛ]. In the third edition of his Spanish pronunciation textbook, however, Dalbor (1997) states that /e/ has only one allophone, [e], a mid front oral vowel (p. 142). Linguists have not reached a consensus about the number or characteristics of vocalic allophones in Spanish; for example, Navarro Tomas (1957) proposed open and closed allophones for each phoneme whereas Quilis (1999) suggested that there were oral and nasal allophones. While a complete discussion of the vocalic allophones falls outside the scope of this dissertation, it is important to note that there is a great deal of variation in how they are treated in the literature.

Lindblom & Engstrand, 1989) and Dispersion-Focalization Theory (Schwartz, Boë, Vallée, & Abry, 1997). Both theories are built upon the premise that vowels of a particular language are spread throughout the vowel space in order to ease discrimination of vowel sounds without increasing demand on articulatory effort. Flege (1989) put forth that the larger English vowel inventory, as compared to that of Spanish, results in the need for speakers of English to produce more extreme, or distinct, values for point phonemes. The findings of Bradlow (1995) only partially confirm this postulate. First, although her findings did point to a more expanded vowel space for English, this was only true for vowels in open syllables (as tested in CVCV nonse words) and not in closed syllables (investigated through CVC words). Moreover, more extreme F2 values were only found for front vowels, not back vowels. Similarly, findings from Cordero et al. (2006) point to more extreme F1 values for mid vowels and more extreme F2 values for front vowels, but not high or back vowels; in this way, they only partially support these two theories.

One final division sometimes drawn between the two vowel systems is one of length; English vowels are sometimes considered to be distinguished from one another by differences in duration (e.g., Flege et al., 1997; Stockwell & Bowen, 1965) whereas vowel length is not phonemic in Spanish. Related to the feature of duration is vowel reduction. Vowel reduction can take many forms: centralization, devoicing, elision, shortening, etc. Davidson (2006) distinguishes between phonetic reduction and phonological reduction. Phonetic reduction results when the target vowel is not “reached” for reasons of coarticulation or centralization; this process is not categorical as it is dependent upon the rate of speech, speech style, prosodic stress, and context. Phonological reduction, on the other hand, refers to the loss of phonemic contrast, or neutralization, that is not context-dependent, but rather categorical, resulting in [ə]. English possesses a phonological rule, in which pre-tonic vowels are centralized (Burzio, 1994); Spanish reduction, however, is phonetic in nature resulting in devoicing and elision in certain dialects (Boyd-Bowman, 1952; Canellada de Zamora and Zamora Vicente, 1960; Delforge, 2008; Gordon, 1980; Hundley, 1983; Lipski, 1990; Lope Blanch, 1963, Matluck, 1952).

English unstressed vowel reduction often takes the form of centralization. Delattre (1981) defines centralization in a subjective manner: "an obscuration of color with respect to the target color of the vowel" (p. 64); more objective definitions define vowel centralization as the loss of acoustic distinctiveness that results when a vowel "moves" near to the middle of the vowel space, where differences in vowel quality are minimized.[29] Such is the definition given by Harmegnies and Poch-Olivé (1992): "timbre degradation resulting in schwa-like qualities" (p. 431).

Although Burzio (1994) highlights only centralization of vowels in pretonic syllables in English, it is commonly held that unstressed vowels, regardless of position, are centralized. The prevalence of vowel centralization in English is evident in frequency analyses. One analysis found [ə] to be the most common phone in adult, conversational speech in English, occurring with a relative frequency of 7.3% (Mines, Hanson, & Shoup,

[29] The causes of vowel reduction are many, but often the cause is tied to issues of rhythm, muscular tenseness, stress, vowel duration, physical intensity, and contextual assimilation (Delattre, 1981).

1978).[30] In much the same way, Delattre (1965) reported that [ə] was pronounced in 22.99% of vocalic productions, more than any other vocalic sound.

In a comparative study of reduction in four languages (English, French, German, and Spanish), Delattre (1981) found English to have more reduction than any other language, 17.78%. Spanish represented the other extreme, showing the least amount of reduction, 3.65%. Delattre (1981) theorized that the low levels of reduction in Spanish may be a result of unstressed syllables being of nearly equal length as stressed syllables in medial position. Quilis (1971), on the other hand, attributes a secondary role to duration in stress perception. Although the two studies report different findings on how syllable length varies in accordance with syllable stress in Spanish, they are in agreement that syllable length (or duration) is not the principal correlate of accent.

Classic descriptions of Spanish vowels have also suggested the system to be free of reduction at the perceptual level (Barrutia & Schwegler, 1993; Navarro Tomás, 1977; Lacerda & Canellada, 1945; Quilis & Esgueva, 1983); in other words, the five vowels have the same articulatory and acoustic characteristics in tonic and atonic syllables. The data upon which these conclusions have been drawn were laboratory speech samples, often isolated segments, isolated words, or words within a carrier phrase. Assuming that laboratory speech samples are representative of all speech is problematic as studies of vowels in other languages have shown speech rate and style to effect vowel production (e.g., Lindblom, 1963; Nooteboom, 1972; Den Os, 1985).

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[30] Interesting to note is that 54% of the productions of [ə] occurred in six of the ten most common lexical items: *the, uh, a, to, of, was*.

The only study to investigate the effect of speech type on vowel production in Spanish is Harmegnies and Poch-Olivé (1992). This study, which compared the spontaneous and laboratory speech of one Castilian male speaker, found centralization to be highly significant in spontaneous, i.e. conversational, speech for all vowels with the exception of /a/, for which it was only weakly significant. Moreover, centralization was greater for front vowels than back vowels. Formant frequencies in the spontaneous speech sample were also found to be more variable than those in the laboratory sample; such variation led to overlapping vowel distributions in the spontaneous speech sample. This suggests that centralization may be a feature of spontaneous or conversational speech in Spanish, challenging the notion that Spanish is free of reduction.

Findings reported in Martínez Celdran (1983) similarly oppose the assertion that the Spanish vowel system is free of reduction. He reported that atonic vowels were more relaxed than tonic vowels, and similarly that they were more centralized, clearly located on the interior of the tonic vowel space. The average values reported by Martínez Celdrán are displayed in Table 3.3. No statistical analyses are carried out, and it could be argued that the differences are not significant given that the maximum difference between stressed and unstressed productions is 60 Hz for F1 and 74 Hz for F2. Although findings from both Martínez Celdrán (1983) and Harmegnies and Poch-Olivé (1992) point toward acoustic differences in the production of tonic and atonic vowels in Spanish, the perceptual salience of these differences has not been confirmed.

Table 3.3: F1 and F2 Values of Tonic and Atonic Productions of the Spanish Vowels as Reported by Martínez Celdrán (1983, p. 293-294)

	/i/		/e/		/a/		/o/		/u/	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
stressed	344	2202	471	1921	710	1230	506	1037	361	954
unstressed	347	2193	451	1847	650	1300	496	1007	385	1008
average	345.5	2197.5	461	1884	680	1265	499.5	1022	373	981

Other empirical accounts have detailed Spanish vowel reduction in the form of elision and devoicing in Mexican and Andean dialects. Reduction of unaccented vowels in Mexican Spanish is detailed by Matluck (1952), Canellada de Zamora and Zamora Vicente (1960), and Lope Blanch (1963). These reports document the elision, devoicing, and/or production of "relaxed" variants by speakers of various social groups in "popular," spontaneous speech. Amongst these reports, there is no consensus as to the relative effect of linguistic factors on unstressed vowel reduction in this dialect of Spanish. Matluck (1952) cited postonic, word-final vowels as the most susceptible to reduction, but all three studies referenced an effect of surrounding consonants, most notably /s/ (Canellada de Zamora and Zamora Vicente, 1960) and voiceless consonants (Lope Blanch, 1963). With respect to the frequency of reduction of individual vowel phonemes, Canellada de Zamora and Zamora Vicente (1960) and Lope Blanch (1963) both found /e/ to be the most susceptible to reduction and /a/, the most resistant.

Findings from Andean varieties of Spanish are similar. Gordon (1980) reported the weakening or disappearance of unstressed vowels in over half of his Bolivian subjects, and Lipski (1990) noted the prevalence of unstressed vowel reduction in the speech of speakers from all social groups, highlighting that reduction can take the form of deletion, devoicing, shortening, and centralization. Both linguists found /e/ and contact with /s/ to favor reduction. Hundley (1983) similarly found a following /s/ to favor weakening of the preceding vowel, most notably when the preceding and following consonants have the manner and place of articulation in common. Unlike Lipski (1990), however, his results indicated that unstressed vowel reduction is influenced by social class.

Some of these impressionistic findings are supported by the acoustic analyses reported in Delforge (2008) while others are challenged. Delforge found that unstressed vowel reduction may not be as prevalent as previously reported for when she removed high frequency words such as *pues*, *entonces*, *digamos*, etc. from analysis, only approximately 10% of all atonic vowels showed any form of reduction. Of these 16,581 reduced tokens, 56% were completely devoiced, 25% were weakly voiced, 10% were devoiced or shortened, and 9% were elided. Delforge (2008) thus argues that unstressed vowel reduction in the Andean dialect should be referred to as unstressed vowel devoicing. There was no evidence of centralization in the productions of the 16 subjects in her study. Like previous work, her findings pointed to higher rates of reduction of /e/ (20%) and an effect of /s/ as 69% of the devoiced tokens in her analysis were contiguous with /s/. She noted however that devoicing also occurs when vocalic segments are adjacent to other voiceless consonants, with both preceding and following consonants contributing to the process. Vowel devoicing was not strongly correlated with fast speech as it was observed in slow speech also. And while unstressed vowel devoicing was found in all speakers of all social groups, Delforge (2008) found it to be more common in males and speakers over the age of 50.

Taken together these findings suggest that the Spanish vowel system may not be as free from reduction as has generally been accepted. While centralization of atonic vowels may not occur in laboratory speech, evidence from more spontaneous speech data has shown that reduction, in a variety of forms, does occur in multiple dialects of Spanish.

Thus, variation in the number of vowel phonemes, formant frequency, formant movement, duration, and the process of reduction characterize the differences between the English and Spanish vowel systems. Despite what might appear to the naïve ear to be very similar sounds (Stockwell & Bowen, 1965), the differences are many.

3.3 Bilingual Acquisition of Vowels

Studies have shown bilingual first language acquisition takes a different path than monolingual acquisition (e.g. Johnson & Lancaster, 1998; Kehoe, 2002; Kehoe, Trujillo, & Lleó, 2001; Paradis, 2000). Work on L1 acquisition of the Spanish vowels suggest that children are able to produce the five basic vowels by 18-months of age, prior to the appearance of some consonants (Maez, 1985; Schnitzer & Krasinski, 1994; see Appendix A for a summary of language milestones in Spanish-speaking children). Vowels also show more consistency than consonants; both normally developing and language-disabled preschoolers produce few errors in vowels (Goldstein & Cintrón, 2001; Goldstein & Pollock, 2000). It is generally agreed that the vowels in Spanish are easily acquired; Goldstein and Iglesias (1996) suggest that Spanish-speaking children are able to acquire the Spanish sounds at an early age partially because of the predominant consonant-vowel (CV) syllable structure of Spanish which "aids phonological development by using a relatively simple parameter in which to slot segments" (p. 87). Another explanation is provided by Stoel-Gammon and Herrington (1990); they suggested that the presence of only cardinal vowels in Spanish makes the vocalic system less marked and in turn easier to acquire.[31] Although Spanish vowels do appear to be acquired easily, to date no acoustic studies have been carried out that provide specific details about how vowel productions change over time or the frequencies at which vowel formants are produced.

Work on the acquisition of Spanish vowels by simultaneous bilinguals similarly points to relative ease of acquisition. Early work on bilingual phonological acquisition proposed the existence of a period of unitary patterning (Leopold, 1939, 1947/1970; Volterra & Taeschner, 1978); during such a time, children have only one phonological system, which is not differentiated according to language. More recent work has refuted this notion, demonstrating that simultaneous bilingual children maintain two distinct phonological systems from an early age (e.g., Deuchar & Clark, 1995; Ingram, 1981/82; Johnson & Lancaster, 1998; Paradis, 1996; Schnitzer & Krasinski, 1994, 1996).

Despite the presence of two distinct phonological systems, interaction and influence from one language on the other is still possible. Paradis and Genesee (1996) identified three possible types of interaction – acceleration, delay, or transfer; they argued that the type of interaction depends upon the specific linguistic features within a language. In line with this, Kehoe (2002) found German-Spanish bilingual children to

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[31] Stoel-Gammon and Herrington (1990) use the term cardinal vowels to refer to the Spanish vowels; however, the Spanish vowels do not adhere to the definition. Cardinal vowels are a set of reference points used in descriptions of the vowels of the world's languages; they reference the sounds produced when the tongue is in extreme positions, either high-low or front-back.

have more accurate Spanish vowel productions than German vowel productions. With respect to Spanish articulations, their vowels were nearly identical to those of monolinguals. In German, their development of the length contrast lagged behind that of monolingual peers. Schnitzer and Krasinski (1994) similarly found less variability and greater accuracy in the Spanish vowel productions, as opposed to English, of their Spanish-English bilingual son. Spanish vowels stabilized by about the age of 22 months; English vowels took nearly a year longer to converge upon adult productions, not stabilizing until about 32 months.[32] Kehoe (2002) attributed the high rates of accuracy for Spanish vowels to their less-marked nature, especially as compared to German and English.

Unlike simultaneous bilinguals who develop both language systems at the same time, sequential bilinguals typically learn their first language in a monolingual environment and receive regular exposure to a second language later. One model of second language phonological acquisition, the Speech Learning Model (Flege, 1995), suggests that sequential bilinguals, like simultaneous bilinguals, "strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space" and that the phonetic categories of these individuals evolve over time to reflect properties of both the L1 and L2 (p. 239). In the following section the L2 vowels of sequential bilinguals will be explored, but it is important to note that effects of the L2 on the L1 have also been documented (Gildersleeve-Neumann, Peña, Davis, & Kester, 2009; Guion, 2003; O'Rourke, 2010).

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[32] Stabilization for this individual followed the following progression: /a/, /i/, /u/, /e/, /o/.

In one such study, Gildersleeve-Neumann et al. (2009) examined the phonological development of six Spanish-English sequential bilinguals (age 3;2 – 3;10 at study onset). Within eight months of exposure to English, the researchers were able to document a change in the children's phonological system, particularly in their vowels. During these eight months, the accuracy with which Spanish vowels were produced dropped from 93% to 87%. Phonetic transcription revealed three patterns which accounted for the vowel errors: vowel raising (e.g. /dos/ > [dus], 'two'), small/front back errors (e.g. /pero/>[pʌro], 'but'), and vowel lowering (e.g. /dedo/ > [dæðo], 'finger'). The researchers also documented the production of both [ə] and [ʌ] in the speech of these sequential bilinguals.

3.4 L2 Acquisition of Vowels

Empirical research in the field of second language acquisition did not begin until the late 1960s (Lafford & Salaberry, 2003); since then, many empirical studies have been carried out that investigate the acquisition of Spanish as a second language. The number of published, empirical research studies that investigate Spanish L2 phonological acquisition, however, are relatively few (see Elliot (2003) and Zampini (2010) for reviews), especially in comparison to other areas of Spanish L2 acquisition. Although most of the studies conducted in the area of Spanish L2 phonology have reported findings on the acquisition of individual segments (e.g., Castino, 1991; Cobb, 2009; Cordero et al., 2006; Díaz-Campos, 2004; Díaz-Campos & Morgan, 2002; Elliot, 1997; Face, 2006; Face & Menke, 2009; García de las Bayonas, 2004; González-Bueno, 1995, 1997; Hurtado & Estrada, 2010; Lord, 2005; Major, 1986; Menke & Face, 2010; Morrison, 2003; Nathan, 1987; Reeder, 1998; Shively, 2008; Waltmunson, 2005; Zampini, 1994, 1998; Zampini et al., 2000) or combinations of segments (e.g., Colantoni & Steele, 2006) as opposed to prosodic elements (Henriksen, Geeslin, & Willis, 2010) or overall global accent,[33] they have done so indirectly. Face (2006) observed that the primary focus of many L2 Spanish phonology studies has been the effect of context of instruction on pronunciation (e.g., Castino, 1991; Díaz-Campos, 2004; Elliot, 1997; González-Bueno, 1997; Lord, 2005) or the non-linguistic factors that influence pronunciation (e.g., Díaz-Campos & Lazar, 2003; Díaz-Campos, 2004; Elliot, 1995a, 1995b; Hurtado & Estrada, 2010; Reeder, 1998; Shively, 2008; Simões, 1996). More recently, the influence of linguistic context on the acquisition of specific segments has been attested in the literature (Colantoni & Steele, 2008; Díaz-Campos & Lazar, 2003; Face & Menke, 2009; Shively, 2008; Hurtado & Estrada, 2010; Vokic, 2008; Waltmunson, 2005). Within these empirical studies, only eight have touched upon the acquisition of Spanish vowels by native English-speaking learners (Cobb, 2009; Cordero et al., 2006; Elliot, 1997; García de las Bayonas, 2004; Hammerly, 1982; Menke & Face, 2010; Morrison, 2003; Simões, 1996). Prior to discussing the findings of these studies, two theories of L2 Phonological Acquisition are introduced and a few L2 vowel acquisition studies that address age of acquisition and effect of experience are reviewed.

[33] This division of the larger field of phonological acquisition was proposed by Major (2001), who identified four areas of investigation: individual segments, combination of segments (syllables), prosodic features, and global accent (p. 12).

3.4.1 Theories of L2 Phonological Acquisition

Several theories exist that account for features of L2 phonological acquisition, among these theories are Contrastive Analysis (Lado, 1957), the Markedeness Differential Hypothesis (Eckman, 1977), the Ontogeny and Phylogeny Model (OPM) (Major, 1986, 2001), the Perceptual Assimilation Model (Best, 1995), the Similarity Differential Rate Hypothesis (Major & Kim, 1996), and the Speech Learning Model (SLM) (Flege, 1995). Much of the L2 vowel acquisition research has either directly or indirectly addressed tenets of the SLM while the OPM provides the theoretical basis for much of the work in L2 Spanish phonological acquisition. For these reasons, these two models will be the focus here.

Unlike other models of L2 phonological acquisition the OPM, brings together the concepts of similarity, markedness, and style variation, which makes it much more comprehensive. The OPM assumes that three components form a learner's interlanguage system: the L1, the L2, and language universals.[34] Language universals can involve general cognitive processes, linguistic processes, and universal grammar. This component explains interlanguage phenomena that cannot be attributed to either the L1 or L2, and often times it can explain why learners from a variety of language backgrounds present the same developmental patterns and why some features of L2 acquisition are also common to L1 acquisition. The OPM clarifies the relationship between the three interlanguage components with respect to four corollaries: chronology, style, similarity, and markedness.

[34] For Major (2001), interlanguage does not necessarily refer to an intermediate system between the L1 and L2; rather, it is its own system composed of the three components mentioned.

The Chronological Corollary is the most central, each of the others stems from it; it explains the influence of each component at different stages of L2 acquisition. In the beginning stages of L2 acquisition, the influence of the L1 is very strong, blocking the contribution of either the L2 or language universals. As the learner gains exposure to the L2 and realizes that the L1 cannot always be used in place of the L2, language universals and features of the L2 begin to appear in the interlanguage. Consequently, the effect of the L1 becomes less. The influence of language universals and the L2 will continue to increase over a period of time, and then as the L2 becomes more developed, the presence of language universals diminishes. In other words, learners rely completely on L1 transfer initially, but this decreases with time. The influence of the L2 is null in the initial stage of acquisition but continues to strengthen with increased L2 study. Language universals increase during the early stages of acquisition when learners recognize the insufficiency of the L1 but are not yet able to produce the L2 target, and then the influence of universals lessens as learners are able to produce sounds in a native-like way.

The corollaries related to style, similarity, and markedness describe similar shifts in the relative importance of each interlanguage component at any given time. The Stylistic Corollary proposes that as the style becomes more formal, the L1 decreases, the L2 increases, and language universals increase prior to decreasing. When an L2 phenomenon is similar to one in the L1, the Similarity Corollary puts forward that the change in relative positioning of the components is similar, but more gradual, and with marked L2 phenomena, the rate at which the balance shifts again differs. The L2 is slow to increase in marked phenomena; consequently the L1 exerts its presence for a longer period of time, decreasing slowly, and language universals increase rapidly during early stages but then move aside at a much slower pace. In comparison to less-marked phenomena, the role of language universals is greater than that of L1.

Much of the work that has used the OPM for its theoretical base or as an explanation for observed phenomena has been carried out with consonantal sequences. For example, Major (1986) attributes various learner productions of Spanish [r] to language universals. In contrast to this tendency, a milieu of studies designed to test the validity of the hypotheses of the SLM, either directly or indirectly, have considered L2 acquisition of vowels. Like the OPM, the SLM incorporates a variety of notions related to L2 phonological acquisition; the specific postulates and hypotheses of the SLM are presented in Table 3.4.

A number of L2 vowel studies have centered on the relationship between perception and production (e.g., Bohn & Flege, 1997; Escudero & Boersma, 2002; Flege et. al., 1997; Flege et al., 1999; Neufeld, 1988); however, given that this dissertation does not address perception, these studies will not be reviewed here. Work related to the role of similarity (H1, H3, H5), the effect of age (H4), and the effect of experience (H7) on L2 vowel acquisition will be briefly discussed given their relation to the current study.

Table 3.4: Postulates and Hypotheses of the Speech Learning Model

(Flege, 1995, p. 239)

Postulates	
P1	The mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning.
P2	Language-specific aspects of speech sounds are specified in long-term memory representations called *phonetic categories*.
P3	Phonetic categories established in childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones identified as a realization of each category.

P4	Bilinguals strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space.
Hypotheses	
H1	Sounds in the L1 and L2 are related perceptually to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level.
H2	A new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound if bilinguals discern at least some of the phonetic differences between the L1 and L2 sounds.
H3	The greater the perceived dissimilarity between an L2 sound and the closest L1 sound, the more likely it is that phonetic differences between the sounds will be discerned.
H4	The likelihood of phonetic differences between L1 and L2 sounds, and between sounds that are noncontrastive in the L1, being discerned decreases as AOL [Age of Learning] increases.
H5	Category formation for an L2 sound may be blocked by the mechanism of equivalence classification. When this happens, a single phonetic category will be used to process perceptually linked L1 and L2 sounds (diaphones). Eventually, the diaphones will resemble one another in production.
H6	The phonetic category established for L2 sounds by a bilingual may differ from a monolingual's if: 1) the bilingual's category is "deflected" away from an L1 category to maintain phonetic contrast between categories in a common L1-L2 phonological space; or 2) the bilingual's representation is based on different features, or feature weights, than a monolingual's.
H7	The production of a sound eventually corresponds to the properties represented in its phonetic category representation.

3.4.1.1 New vs. similar sounds in the L2

The role of similarity in the acquisition of L2 sounds is one that has been much theorized and researched. An underlying tenet of Contrastive Analysis (Lado, 1957) is that all errors are due to transfer; subsequently, through systematic comparison of two languages, learner errors can be predicted and explained. Contrastive Analysis predicts that cross-language differences hamper L2 acquisition as they present greater difficulty. Such a strong position is not borne out as some predicted errors never occur and not all learner errors can be traced back to the L1. Wode (1983a, 1983b) commented that how structures are seen, as either similar or different, is in the mind of the learner.[35] For transfer to occur, the learner must equate an L2 phenomenon with an L1 phenomenon,

[35] Both the SLM and PAM address how L1 and L2 sounds are related in the mind of the learner.

and not all transfer is negative. L2 elements with high levels of similarity (or which are identical) to L1 elements can successfully transfer, resulting in native-like L2 production. Negative transfer of related features is also a possibility; through learning, however, L2 speakers can overcome the barrier negative transfer presents. Many have theorized that learning a new or dissimilar element is easier than acquiring subtle differences in similar elements (e.g., Major, 1987; Major & Kim, 1996; Young-Scholten, 1985), which is the prediction made by H3 of the SLM.

Much of the criticism directed at this hypothesis is related to how to define similarity or establish levels of similarity (e.g., García de las Bayonas, 2004). Major (2001) comments that the term similar may be more easily definable for phonology than other areas of language; furthermore, he suggests using perceptual, acoustic, articulatory, and orthographic evidence in addition to native speaker and non-native speaker intuitions. Flege (1997) proposes using symbols from the International Phonetic Alphabet (IPA) as a basis for classifying sounds as new or similar. His definitions of new and similar sounds follow from this: similar sounds are represented by the same IPA symbol, even though analyses may show significant, even audible, differences between the two sounds; new sounds are represented by an IPA symbol not used for any sound in the L1. This is in line with the definition proposed specifically for vowels in Bohn and Flege (1992); they defined a new L2 vowel sound as new only if the majority of its productions fell outside the acoustic phonetic vowel space of any L1 vowel. In this way, new and similar sounds must be determined based upon a detailed comparison of specific languages. According to this definition, the five Spanish vowels would be regarded as similar to vowels in

English. Research findings in support of this hypothesis of the SLM are largely inconclusive.

A study conducted with adult female, native English speakers of French found that these L2 speakers produced the French /y/, a new L2 sound, more accurately than the French /u/, a similar sound (Flege & Hillenbrand, 1984). In an intelligibility task, the /y/ productions of both inexperienced and experienced French learners were identified equally well (approx.70%). The /u/ productions of the inexperienced French group were not well understood; only 44.8% of this group's productions of /u/ were correctly identified, as compared to 82.9% of the tokens produced by the experienced learners. Acoustic analyses revealed that variations in F2 values accounted for a majority of the variance in intelligibility scores. The F2 frequencies of both learner groups did not differ significantly from those of native French speakers with respect to French /y/, but there were statistical differences in the F2 frequencies in each group's production of French /u/. Although the productions of the new phone, /y/, were not completely native-like as evidenced by the intelligibility scores, there were fewer differences in non-native speaker and native speaker productions for it than for the similar phone, /u/.

A later study conducted by Flege (1997), in which native Dutch speakers' productions of the English vowels /ɪ, æ, i, u, ʌ, ɒ/ were subjected to both intelligibility and acoustic analyses, obtained similar results for the new L2 vowel, /æ/.[36] The findings suggest that learning of a new vowel is possible given the more intelligible productions of /æ/ by the moderately- and mildly-accented Dutch speakers than the strongly-accented

[36] Native British English speakers were used as the comparison group in this study; for this reason, /ɒ/ is used as opposed to /ɑ/, which is the more common production in American English.

Dutch speakers. Acoustic analyses also revealed that the productions of the two advanced groups did not differ from the productions of native English speakers for this particular vowel.[37] Findings in accordance with the hypothesis that acquisition of similar sounds is difficult were only partially supported in this study. While there were no differences in intelligibility scores between the Dutch speakers' and native English speakers' productions of /i, u, ɒ, ʌ/, there were significant formant frequency differences between the native and non-native speakers for two of the similar vowels, /ɒ/ and /ʌ/. The findings from this study, therefore, support the notion that new L2 sounds can be learned, but only partially support the finding that similar sounds pose a challenge.

In another study, Flege et al. (1997) concluded that their results supported the notion that "the nature of the L1 vowel inventory and its perceived relation to vowels in an L2 influence the extent to which L2 production and perception will improve as non-natives gain experience in their L2" (p. 467). An example from their findings to support this comes from the inexperienced German and Spanish subjects in distinguishing English /ɛ/ and /æ/. They hypothesized that both of these sounds were seen as similar to one sound in German (/ɛ/ or / ɛː/), whereas for native Spanish speakers they were seen as similar to two phonemes, Spanish /e/ and /a/. Attributing the two L2 sounds to one sound in German resulted in German speakers not being able to distinguish between /ɛ/ and /æ/; attributing the L2 sounds to two different L1 phonemes for the native Spanish speakers resulted in them producing larger spectral differences for these vowels than native

[37] There was, however, variability within each group; some subjects in each of the three groups produced this phoneme poorly.

English-speaking subjects. Thus, although the two subject groups behaved differently, both struggled to produce "similar" L2 phones accurately.

In a large-scale study that looked at the age of second language learning on the production of English vowels; Munro et al. (1996) were unable to find any pattern to describe which vowels were produced intelligibly or without an accent by 240 Italian speakers of English. Moreover, the two English vowels which were the most acoustically distant from any Italian vowel, [ɝ] and [æ], did not behave in the same way. [ɝ] was the most poorly produced of the eleven targeted vowels, and [æ] was the second best produced. The authors concluded that in this instance, accurate predictions of how well a vowel will be produced are impossible given the wide variation in learner productions.

The findings from these studies show that great acoustic distance does not guarantee unaccented or accurate productions of vowels; however, there is evidence that individuals are able to learn to produce new sounds. The sometimes contradictory findings related to the acquisition of new and similar sounds can be accounted for by taking into account other principles such as markedness, degree of articulatory difficulty, frequency, etc.

3.4.1.2 The effect of age

Scovel (1969) observed that adults "never seem capable of ridding themselves entirely of a foreign accent" when learning a second language (p. 245); Oyama (1982) compared the rarity of an adult achieving native-like pronunciation to being able to run a 4-minute mile, not impossible but highly unlikely. A substantial body of evidence exists to support the notion that individuals past a certain age are not as successful at mastering pronunciation in a second language as younger individuals (e.g., Guion, 2003; Moyer, 1999; Munro et al., 1996; Oyama, 1982), yet many researchers deny the existence of a biological critical period for native-like second language acquisition (e.g., Bialystock, 2001; Flege, 1995; Long, 1990). Not only do researchers disagree about the existence of a critical period, they also disagree as to the cause of a persistent foreign accent; many different explanations have been proposed to account for the foreign accent that most adults have in their second language. One commonly cited explanation is a loss of neural plasticity (Lennenberg, 1967); other proposed explanations for discrepancies in ultimate attainment result from issues of identity and attitude (e.g., Beebe & Zuengler, 1983; Bolton & Kwok, 1999; Brown & Yule, 1983; Hedgcock & Lefkowitz, 2000; Lefkowitz & Hedgcock, 2002, 2006; Lybeck, 2002; Major, 2004; Mendoza-Denton, 1997, 1999; Tarone, 1978; Zentella, 1997; Zuengler, 1998) or differences in experience and circumstance (e.g., Bialystock, 2001; Krashen et al., 1979; Long, 1990). Differences in experience and circumstance might be related to length of exposure, quantity and quality of input, and the effect of an established phonetic system.

Flege (1995) calls attention to the paradox presented by a critical period for language acquisition, questioning the logic behind a decline in the ability to produce L2 speech segments at the precise time when sensorimotor abilities are generally improving. He suggests instead "the mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning," (P1 of SLM quoted above), hypothesizing that greater experience with a language increases interlingual identification making discerning and establishing new and/or different L2 categories difficult (H4) (Flege, 1995, p. 239). The strength of the L1 is seen in its ability to account for spectral differences in vowel production and perception (e.g., García de las Bayonas, 2004; Munro, 1993). Findings from L2 vowel studies support the notion that L2 speakers who begin learning the L2 earlier have less accented speech and/or more native-like vowel categories (e.g, Guion, 2003; Højen & Flege, 2006; Munro et al., 1996; Walley & Flege, 1999).

Munro et al. (1996) conducted two experiments to investigate the effect of age on the production of English vowels. In these two experiments, 240 Italian speakers of English were divided into 10 groups of 24 based upon the age at which they had arrived in Canada. The first group arrived at a mean 3.1 years of age (range: 1.9 - 4.1) whereas the last group arrived at a mean of 21.5 years of age (range: 20.2 – 23.2). All of the speakers were experienced English speakers, having lived between 15 and 44 years in Canada (mean: 32 years). In the experiment, subjects heard a target word in a carrier phrase; they then had to produce the target word in a different carrier phrase. Eleven Canadian English vowels were tested. In the first experiment, 10 native speakers of Canadian English listened to the vowel productions of all the speakers (productions of 24 native speakers were mixed in as well) and rated the degree of accentedeness of each token on a 5-point scale. In the second experiment, a phonetically trained listener identified each vowel token.

The results of both experiments showed an effect of age. In the first experiment, all raters tended to assign more accented ratings to later arriving Italian speakers; as age of arrival increased, the degree of accent increased. The age at which a foreign accent was detected varied across vowels, with the earliest being 7.5 years and the latest, 15.8. Identification scores from the second experiment were quite high across all groups, especially in comparison with the foreign accent ratings. Nonetheless, the vowel productions of speakers who arrived at a younger age were correctly identified more often than the productions of those who arrived later. Although the differences between groups were less in this experiment than in the first, correct identification decreased as age of arrival increased. This suggests that even though older learners produce vowels with a foreign accent, their productions are intelligible. The authors conclude that "pervasive AOL [age of learning] effects were found on the English vowel productions of the native Italian speakers examined" and that learners who arrived earlier tended to produce unaccented vowels (as judged by native speakers) whereas learners who arrived later were only able to do so for a minority of the vowels (p.331).

It is important to note that native-like pronunciation does not mean that the bilingual's norms are the same as those of a monolingual. Højen and Flege (2006), for example, found that even though early Spanish-speaking, L2 English learners' abilities very closely approximate that of monolingual English speakers, they are not identical. Moreover L2 speaker data tend to be less homogenous and show greater variability than those of native speakers (e.g., Munro, 1993). Researchers argue that it is unreasonable to expect bilinguals' (even early and/or simultaneous) perceptive and productive speech abilities to be the same as that of a monolingual since they have two language systems, not one (e.g., Bialystock, 2001; Grøsjean, 1989; Højen & Flege, 2006).

3.5 L2 Acquisition of Spanish Vowels by Native Speakers of English

As mentioned and demonstrated above, most of the research related to L2 acquisition of vowels has been carried out with L2 learners of English. Additionally, much of the research was conducted with second language learners, not foreign language learners. Only eight studies have investigated, either directly or indirectly, how native English speakers acquire the Spanish monophthongs; seven studies considered production (Cobb, 2009; Cordero et al., 2006; Elliot, 1997; Hammerly, 1982; Menke & Face, 2010; Morrison, 2003; Simões, 1996) while two investigated perception (García de las Bayonas, 2004; Morrison, 2003). Of the seven production studies, only three involved acoustic analysis (Cobb, 2009; Cordero et al., 2006; Menke & Face, 2010). Each of these studies is reviewed in this section in relation to the findings presented in the previous section as well as the predictions made by Stockwell and Bowen (1965).

Based upon a contrastive analysis of the English and Spanish vowel systems, Stockwell and Bowen (1965) predicted that Spanish vowels under weak stress would be the most problematic for native English speakers acquiring the Spanish sound system given the extensive reduction of unstressed vowels in English and the theorized impermissibility of reduction in Spanish. With respect to the five Spanish monophthongs in stressed syllables, they predicted that /a/ will transfer successfully and that /i/, /o/, and /u/ may result in a foreign accent but not misunderstanding. According to these authors, Spanish /e/ poses the greatest possibility for misunderstanding. Substitution of English /ɛ/ will not result in any problems, but different distribution patterns between the two languages ([ɛ] occurs word-finally in Spanish, but not in English) may lead to substitution of a diphthong for this monophthong. This will result in misunderstanding since /e/ and /eɪ/ are contrastive in Spanish as in the words *le* (/le/) and *ley* (/leɪ/).

The first empirical study that included vowels in the analysis was carried out within the framework of Contrastive Analysis. Hammerly (1982) intended to corroborate a hierarchy of difficulty by testing 50 first-semester Spanish students after 45 hours of instruction. Of the 45 hours of instruction, 4 to 5 were focused specifically on pronunciation training through a method of habit formation. The administered pronunciation test had four parts: imitation of known words and phrases, imitation of unfamiliar words and phrases, read aloud of known words and phrases, and read aloud of unknown words and phrases. Forty-five different "pronunciation problems"[38] were tested via these four test parts; the targeted problems were either segmental phonemes or allophones. Of these 45 problems, 11 were related to vowels. The results of this study related to vowels are presented in Table 3.5.

Table 3.5: Vowel Findings from Hammerly (1982)

Rank	Pronunciation Problem	Example	Mean Error
8	/áw/ as [au], not [aʊ], etc.	*aula*	.78
9	/-o/ # as [o], not [oʊ], etc.	*periódico*	.77
11	/-e/ # as [e], not [eɪ], etc.	*no sé*	.75
14	/V́j/ as [V́i], not [V́ɪ], etc.	*hay*	.72
15	/CaC(C)V́/ as [a], no [ə], etc.	*todavía*	.69
20	/…o/+/e…/ → /…we…/	*encuentro en*	.55
23	/V́C(C)as/ as [a], not [ə], etc.	*palabras*	.50
25	/ej/ as [ei], not [eɪ], etc.	*seis*	.48
29	/á/ as [a], not [æ], etc.	*verano*	.33
36	/CérC/ as [ɛ], not [ɚ], etc.	*cerca*	.21
39	/Cást…/ as [a], not [æ], etc.	*lástima*	.16* (.09 in cognates)

(Hammerly, 1982, pp. 30-31)

[38] Hammerly (1982) considers "pronunciation problems" to be "sounds that normally cause the students to have difficulties, i.e., difficulties that have been observed in the course of teaching" (p. 20).

The first column shows how the problem ranked in comparison to the other tested problems; the second column identifies the problem, the third gives an example, and the fourth displays the mean error rate for each problem across all parts of the test in which it appeared. Mean error rate can be interpreted as how often the error is made; if an error were produced in every possible instance, the error rate would be 1.0; if it were never produced, it would be 0.

Based on these findings, vowel errors are relatively frequent in the production of these first-semester learners. It appears that not only did the first-semester learners transfer the English diphthongs [eɪ] and [oʊ] for Spanish monophthongs /e/ and /o/ regularly, but they also transferred the allophonic process of vowel centralization. If centralization is considered to be any movement towards the center of the vowel space, reduction can be seen in the problems ranked 14, 15, 23, and 25, accounting for nearly one-third of the vowel errors. Two of these four possible reduction errors, however, occur in diphthongs; therefore, it may not be reduction per se, but rather insufficient movement toward the front, high vowel. In the only two instances where the reduced vowel [ə] is mentioned, the reduction is from the low vowel /a/. Stockwell and Bowen (1965) suggested that /a/ would transfer successfully, but from these findings it appears that learner realizations often result in either [ə] or [æ], making up 4 of the 11 pronunciation problems targeted. Given that no problems involve Spanish /i/ or /u/, it appears that these two sounds are produced relatively accurately. While these findings shed light on the pronunciation of beginning adult learners, they do not investigate the productions of more advanced learners; it is unclear as a result whether or not native English speakers are able to overcome these initial problems.

Simões (1996) investigated the changes in oral communication skills, specifically fluency, of five adult learners of Spanish. The learners in his study were more advanced, ranging from intermediate low to advanced on the American Council on the Teaching of Foreign Language's (ACTFL) Oral Proficiency Interview (OPI) scale. As a means of measuring fluency, Simões considered vowel accuracy in the oral speech of his five subjects.[39] After their five-week study abroad experience, subjects had improved their oral fluency, but Simões noted three recurrent inappropriate patterns in their speech: vowel reduction or centralization, a lack of linking across word boundaries, and inappropriate hesitation.

Elliot (1997) too looked at the productions of slightly more advanced learners, third-semester university students; thus the subjects in his study had received approximately 2 more semesters of instruction than those in the Hammerly (1982) study. The subjects in the experimental groups received explicit pronunciation instruction for 10-15 minutes each period that touched upon 19 different Spanish allophones; the five Spanish monophthongs were a part of this focused instruction. During pronunciation instruction, students participated in activities that allowed them to focus on the point, place and manner of articulation, contrast the Spanish sound with its English equivalent, and participate in a variety of pronunciation exercises. Subjects took part in both a pre-

[39] Simões (1996) described his process in the following way: "The interpretation of fluency was done according to the rate of delivery, calculated as the ratio of the number of acceptable syllabic nuclei over the duration of phonetic continua in spontaneous oral discourse" (p. 90).

and post-test, producing four different types of speech; their productions were then assigned a nativeness score on a scale of 1-3 by three judges.

Improvement in the production of vowels as a sound class approached statistical significance; taken individually, improvement in the back vowels [o, u] reached statistical significance while improvement in the other three vowels [i, e, a] was not at a statistically significant level. Elliot comments that students might have already acquired the front/central vowels prior to the treatment period and as a result little improvement could be made. Since no pre- and post-test scores are provided, this cannot be verified; given the recurring problems noted in the production of vowels, namely diphthongization of mid vowels, vowel lengthening and centralization, this explanation seems unlikely. With respect to the amount of improvement in the other sound classes (liquids, stops, fricatives, and nasals), vowels fell in the middle, suggesting that improvement in vowels is possible with instruction but that it may be more difficult than with other sounds (liquids and stops). Elliot's findings suggest that improvement in native-like pronunciation of vowels is possible but includes no detail as to how native-like the productions are.

Morrison (2003) compared how native Spanish and Canadian-English speakers perceive Spanish vowels produced by both Spanish speakers and Canadian-English learners of Spanish. All of the English learners of Spanish were relatively inexperienced as they had a mean of approximately 2 years of Spanish study and had never lived in a Spanish-speaking country. English speakers perceived the Spanish vowels /i/, /e/, and /o/ (as produced by Spanish speakers) consistently as /i/, /e/, and /o/ based upon assimilation to English perceptual categories. Perception of /a/ and /u/ was based upon multiple category assimilation (Escudero & Boersma, 2002), corresponding to English /æ/+/ʌ/+/ɒ/+/ɛ/ and /ʊ/+/u/ respectively. In terms of production, English learners of Spanish produced English /i/, /e/, /æ/, /o/, and /u/ for Spanish /i/, /e/, /a/, /o/, and /u/ respectively. The learners also showed less variability than the Spanish speakers, and their vowel productions were correctly identified at a higher rate (96%) than those of Spanish speakers (91%).[40] Spanish /a/, in particular, had a higher identification score for English speakers than Spanish speakers; Morrison explained this surprising result, observing that the /a/ produced by English speakers was longer and lower in the vowel space than that produced by Spanish speakers. In other words, the learners reduced /a/ less than their native speaker counterparts. Learner productions of /o/, however, did evidence centralization, which resulted in their misidentification as /a/ at a rate of 8%.

These findings are somewhat surprising given that it is generally assumed that L2 learners demonstrate greater variability than native speakers (e.g., Munro, 1993) and in light of other research which has suggested vowels to be a difficult sound class for English learners of Spanish to acquire (Cordero et al., 2006; Elliot, 1997; Hammerly, 1982; Menke & Face, 2010). Differences in findings might be able to be explained by considering the difference between accented speech and unintelligible speech (see Munro (2009) for a complete discussion). So even though vowel productions of English learners of Spanish may differ from those of native speakers, these differences do not hinder

[40] Listeners were asked to "indicate the Spanish vowel that was closest to the vowel they heard" as one of five graphic letters: A, E, I, O, or U. Speakers could also identify a vowel as none of the above if it didn't sound like any Spanish vowel (Morrison, 2003, p. 1534).

comprehensibility.[41] In line with the prediction of Stockwell and Bowen (1965), /a/ appears to have transferred successfully; however, productions of /o/ did in some instances result in misunderstanding, which challenges their prediction.

García de las Bayonas (2004) also investigated the differences between native speaker and non-native speaker perceptions of Spanish and English vowels. The perceptions of both groups of learners were compared to the perceptions of the native speaker group (i.e., learners of Spanish-native speakers of Spanish; learners of English-native speakers of English) for both synthesized and natural data. All subjects participated in each of four tasks twice, once in the native language and once in the second language, for a total of eight tasks:

1. Natural speech vowel task: Subjects heard a naturally-produced vowel in isolation and then identified the word that contained the vowel that most resembled the one heard from a list of possibilities.
2. Natural speech word task: Subjects heard a vowel as part of a naturally-produced word and then identified the word that contained the vowel that most resembled the one heard from a list of possibilities.
3. Synthetic speech single match: Participants were presented a chart with 330 synthesized vowel sounds varying along F1 and F2 continua. They were then presented with a list of monosyllabic words, all of which contained the same vowel. They then had to identify the sound in the chart that best exemplified the vowel in the list of words.

[41] Because Morrison (2003) does not provide any specific details regarding acoustic or articulatory differences in the productions of the two groups of speakers , it is not possible to know if and how the vowel productions of the two groups differ.

4. Synthetic speech multiple match: Participants were presented a chart with 330 synthesized vowel sounds varying along F1 and F2 continua. They were then presented with a list of monosyllabic words, all of which contained the same vowel. They then selected all sounds in the chart that were acceptable examples of the vowel in the list of words.

Perception by the native English speakers of the naturally-produced Spanish vowels was very accurate, 94.4% when the vowel was presented in isolation and 96.8% when presented within the context of a word. Native Spanish speakers were 100% accurate for both tasks. Similarly, the native English-speaking learners of Spanish accepted values for synthetic vowels which were spread around the same spectral area identified by the native Spanish speakers. Minor differences were found for formant frequencies of /e/, /u/, /o/, and /a/. More specifically, learners of Spanish selected a Spanish /e/ with higher F1 values, Spanish /u/ and /o/ with higher F2 values, and /a/ with slightly higher F1 and F2 values.

Overall, native English speakers were more accurate in their perception of Spanish vowels than native Spanish speakers were in their perception of English vowels. Despite the high levels of accuracy reached by the learners of Spanish, there were still differences evidenced in their perceptual categories as compared to those of the native Spanish speakers; this is similar to findings obtained with both learners of English (e.g., Bohn & Flege, 1997; Flege et al., 1997; Højen & Flege, 2006) and learners of Spanish (Escudero & Boersma, 2002; Morrison, 2003). García de las Bayonas (2004) comments that her findings only partially support Flege's SLM: the influence of the L1 was evident in the perceptual categories of both groups of non-native speakers albeit to differing degrees (H5), but the L2 learners were generally unable to establish phonetic categories for L2 sounds (P1). She also calls for further clarification in the new-similar distinction, suggesting that new vowels “be defined as those that do not have a counterpart in the L1 within 150 Hertz[42] of F1 or F2” (p. 104). Subsequently, similar vowels are those that do have an equivalent within 150 Hz of an L2 phone. Based on this definition, /a/ would be the only new vowel for English speakers learning Spanish; the other four vowels, /i, e, o, u/ would be similar. This view differs from that of Stockwell and Bowen (1965) who suggest that /a/ transfers successfully from English; for transfer processes to take place, the L1 and L2 features must be linked in some way (Wode, 1983a, 1983b); if they are related in the mind of a learner, the L2 element cannot be new. Despite the different explanations for why, both positions suggest that the Spanish /a/ is generally not problematic for English speakers. Discrepancies such as this illustrate the complexity of labeling relationships between sounds.

The results of García de las Bayonas (2004) suggest that intermediate-advanced level students of Spanish are generally accurate in their perception of Spanish vowels, deviating only slightly from native speaker norms. Given these findings, if hypothesis 7 of the SLM is correct, native English speakers should be able to produce Spanish vowels with formant frequencies similar to those of native speakers and different from their L1

[42] García de las Bayonas (2004) comments that 150 Hz appears to be the minimum spectral distance necessary to differentiate pairs of vowels based on the findings of previous studies. No previous studies are cited or further explanation given however. While this may be a valid measure, more justification is necessary and empirical evidence is needed to support this value.

vowel productions. Cordero et al. (2006) examined the vowel productions[43] of nine female, advanced learners of Spanish, working as bilingual speech-language pathologists. The subjects had begun studying Spanish at an average of 15.1 years of age (range=12-18) and had been studying for approximately 17.8 years (range-7-40). All had spent some time abroad, between 3 and 24 months, with the mean being 11.2 months. Subjects were asked to read aloud 5 times each, 4 Spanish CVCV words in a Spanish carrier phrase and 4 English CVC words in an English carrier phrase, for a total of 40 vowel productions. Individual vowel tokens were selected at random and presented to native Spanish-speaking listener judges who rated the nativeness of each production on a 5-point scale. Additionally, an acoustic analysis was carried out to identify the F1 and F2 frequencies of vowels.

The English and Spanish F1 values of this group of advanced learners did not differ significantly from one another. There was a trend toward slightly higher F1 values for Spanish vowels, but the difference only approached significance. There were differences, however, in the F2 values across the two languages; each of the vowels had lower F2 values in Spanish than English, but the difference only reached significance for /u/. Acoustic analyses therefore reveal minimal differences in the Spanish and English productions of the same vowel; the authors compare these findings to those of Bradlow (1995) in which no significant differences were found in the F1 values and higher F2 values were found for English. Comparisons between the findings of the two studies as presented in two graphic figures, however, show more overlap in the vowel space of the

[43] Only vowels common to the two languages were considered: /i, e, o, u/ in order to be able to compare the formant frequencies across languages. VOT for the voiceless bilabial stop was also investigated in this study; these findings will not be considered here.

English speakers of Spanish in Cordero et al.'s study than in the vowel spaces of English and Spanish monolinguals in Bradlow. Nativeness ratings ranged from 2.31 to 2.75 (5=native speaker), with /o/ being the most native-like and /i/ the least. Findings from both the acoustic analysis and the nativeness rating suggest that these advanced learners are unable to produce native-like vowels in Spanish, maintaining a foreign accent in their speech.

Cobb (2009) also looked at the productions of more advanced learners of Spanish, comparing them to intermediate learners and native speakers. All three speaker groups took part in a delayed repetition task, designed to elicit each of the five Spanish vowels in stressed and unstressed positions. Intermediate learners produced /a/, /e/, and /u/ in tonic positions differently from native speakers while advanced learners only differed from native speakers with respect to /e/, thus demonstrating evidence of learning. In a similar way, advanced learners differed from native speakers on only two atonic vowels: /e/ and /o/ while intermediate learners differed on four: /a/, /e/, /o/, and /u/. Acoustic analyses revealed that the atonic vowels of all three groups were more centralized than their stressed counterparts. The only vowel for which there was a significant interaction of stress and group was /e/. Surprisingly, it is the native speakers who reduced /e/ most and the intermediate learners who reduced it least, with advanced learners demonstrating an intermediary effect. With respect to the cardinal vowels /a/, /i/, and /u/, the intermediate groups did show the greatest amount of centralization, with the advanced learners again falling between the intermediate learners and native speakers. Cobb concludes that/e/ is the most difficult Spanish vowel for English speakers to acquire, a finding which differs from the predictions of Stockwell and Bowen (1965) as well as findings from previous studies (Hammerly, 1982; Morrison, 2003). She also concludes that learning does occur with respect to vowel productions, and that learners who begin second language study after the critical period are not only able to acquire new phonetic contrasts and acoustic characteristics, but also phonetic processes (p. 59).

Menke and Face (2010) similarly investigated a cross-sectional sample of English learners of Spanish. Like Cobb (2009), their findings showed that learners' vowel productions developed over time to approximate the acoustic characteristics of native speakers. Although the vowel space of fourth-semester learners was quite different from that of native speakers (learners' non-back vowels are more back and back vowels are more front, and high vowels are lower), the vowel space of graduating majors and Ph.D. students of Spanish resembled that of native speakers. In fact, only F1 values of /o/ and F2 values of /u/ of graduating majors differed from native speakers while Ph.D. students similarly produced two vowels with statistical differences: F2 of /o/ and F1 of /a/. All speaker groups showed some centralization of atonic vowels like the speakers in Cobb (2009); centralization was greatest on the F2 dimension. Learner groups produced more statistically significant differences than native speakers. Centralization of /a/ occurred on both dimensions, F1 and F2, for learner groups, while native speakers did not show any evidence of centralization of /a/. The authors concluded that development does occur in the vocalic system of English learners of Spanish as there was a great gain in target-like productions between fourth-semester learners and graduating Spanish majors. There was little change beyond this point, as evidenced by few differences between graduating majors and Ph.D. students, despite sizeable differences in years of study. Production of atonic vowels was found to be a concern, in line with previous impressionistic and theoretical accounts (Elliot, 1997; Hammerly, 1982; Simões, 1996; Stockwell & Bowen, 1965).

Given the wide variety in subject populations, research questions, and methodologies employed, it is difficult to draw any general conclusions about the acquisition of Spanish vowels by native English speakers. It appears that the accurate production of Spanish vowels poses a challenge to English-speaking learners of Spanish (Cobb, 2009; Cordero et al., 2006; Hammerly, 1982; Menke & Face, 2010) despite having established similar perceptual targets (García de las Bayonas, 2006; Morrison, 2003). Findings of the relative ease with which specific vowels are acquired are contradictory. While Hammerly's findings might suggest that /i/ and /u/ are easy to acquire, findings from Cordero et al. (2006) suggest that /i/ is particularly difficult, and Cobb (2009) suggests that /e/ is the most difficult vowel to acquire. It becomes obvious therefore, that more research is needed that shows the developmental process learners pass through in their acquisition of Spanish vowels, as well as more detailed information about how the productions of English-speaking learners differ from those of native Spanish speakers. This study intends to begin to address some of these issues.

Chapter 4
Methodology

4.1 Research sites

Research was conducted in two different school districts, each of which hosts an immersion program, in San Antonio. San Antonio is located in central Texas and has a population of just under 1.3 million (U.S. Census Bureau, 2006). Nearly all of the population, 96.3%, identifies with one race, with the majority, 67.7%, self-identifying as white, (U.S. Census Bureau, 2000b). Table 4.1 summarizes the racial demographics of the city.

Table 4.1: Racial Demographics of San Antonio, TX

(U.S. Census Bureau, 2000b)

	Number	**Percent of San Antonio Population**	**Percent of U.S. Population**
One race	1,102,775	96.3	97.6
White	774,708	67.7	75.1
Black or African American	78,120	6.8	12.3
American Indian and Alaska Native	9,584	0.8	0.9
Asian	17,934	1.6	3.6
Native Hawaiian and Other Pacific Islander	1,067	0.1	0.1
Some other race	221,362	19.3	5.5
Two or more races	41,871	3.7	2.4
Hispanic or Latino (of any race)	671,394	58.7	12.5
Mexican	473,420	41.4	n/a
Puerto Rican	7,774	0.7	n/a
Cuban	1,491	0.1	n/a
Other Hispanic or Latino	188,709	16.5	n/a

As of 2000, a majority of residents of San Antonio (58.7%) also identified themselves as Hispanic or Latino. Nearly five times as many people self-identified as Hispanic in San Antonio as across the rest of the United States. Also, roughly 40% of San Antonio's population considers themselves to be Mexican. Based on this information, it becomes apparent that a majority of the city's population recognizes some connection with the Hispanic and/or Latino culture. Moreover, in the state of Texas, approximately 31% of the population over 5 years of age (6,011,000 individuals) speaks a language other than English at home; 86.4% of this group speaks Spanish (U.S. Census Bureau, 2000a).

The presence of the Spanish language, culture, and people in both San Antonio and the state of Texas is obvious from these data. Despite the large numbers, a great deal of controversy surrounds how to best educate limited English-proficient students, specifically whether or not Spanish-speaking children should be schooled in Spanish, English, or a combination of the two (e.g., Heinauer, 2010). Currently, this is a topic of much debate in the Texas legislature, which passed legislation in June of 2007 to establish a dual-language education pilot program in 30 schools across the state of Texas in an attempt to address this issue (Texas Legislature, 2007).

San Antonio was chosen as the site for this dissertation study as the large number of Hispanic, Spanish-speaking residents is likely to promote equal numbers of Spanish-speaking and English-speaking students in the two-way immersion classroom, ensuring that it is a true two-way program. It was also thought that the greater numbers of native

Spanish speakers would also permit for more native Spanish-speaking teachers, controlling for the type and quality of teacher input to a certain extent.

The two districts in which research was conducted, Alamo Heights Independent School District and Northside Independent School District, have well-established immersion programs. Alamo Heights began an early, one-way total immersion program in the fall of 1997; Northside began its early 90:10 two-way immersion program four years later, in 2001. Both programs currently extend into the middle school. Demographic information and program features will be presented for each district separately in this section; Table.4.2 and Table 4.3 summarize the features of the two programs.

4.1.1 Alamo Heights Independent School District

Alamo Heights is a small school district with an early childhood center (pre-K – K), two elementary schools (grades 1-5), one junior high (grades 6-8), and a high school (grades 9-12). Both elementary schools have a one-way immersion program as a strand within the school, one class per grade level. Jones (2005) reported that there were 1,671 students enrolled in the immersion program, grades 1-5. Two-thirds of the students were white and just under a third were Hispanic, 31%. Approximately one-quarter of the immersion students qualify for free and reduced lunch, an indicator of low socioeconomic status. The demographic information of the immersion learner group is representative of the school as a whole (RICIC, 2008). Because more students want to enroll in the program than the program can hold, a lottery system is used to select immersion students. Only students from one elementary school will participate in this study. This particular elementary school houses a bilingual program, and although interaction between the English-speaking Spanish immersion students and the Spanish-speaking bilingual students is not mandated, the principal encourages teachers to plan daily interaction. Most immersion teachers commented that regular, meaningful interaction between the two groups of students does not occur; only at the fourth grade level, do the immersion and bilingual teachers bring students together for instruction on a regular basis.

Students begin the total immersion program in first grade; English is formally introduced as a content area in the second semester of second grade for 30 minutes daily. In third grade, English instruction increases slightly to 30 to 45-minutes daily, and in fourth and fifth grade, there is an hour of English instruction per day. At the middle school, sixth graders study social studies and science in Spanish while seventh graders study social studies and language arts. In eighth grade, immersion students take a Spanish language course, Spanish II Pre-Advanced Placement. Students are expected to continue in the program through fifth grade; upon moving to the middle school, they have the option to continue in the program or transfer to English-medium courses (Alamo Heights ISD, 2008; Jones, 2005). The program sets the goal of native-like proficiency, and the curriculum parallels that which is offered in English-medium classrooms.

4.1.2 Northside Independent School District (NISD)

Like the Alamo Heights program, the NISD program uses an early immersion model; it differs from that of Alamo Heights though in that it is a two-way program and begins in kindergarten. NISD is a larger, rapidly-growing school district with approximately 86,000 students. The school district encompasses 97 schools: 59 elementary (K-5th grade), 15 middle (grades 6-8), 12 high (grades 9-12), and 11 special schools (Northside Independent School District, 2008). Sixty-two percent of the NISD population self-identifies as Hispanic, with an additional 26% identifying as white. The remaining 12% of the student population is African American (8%), Asian/Pacific Islander/Filipino (3%), or other (1%). Only 7% are designated as limited English proficient, and 46% qualify for the free and reduced lunch program (Broad Prize for Urban Education, 2007).

The two-way immersion program in NISD is named *Un mundo dos idiomas-One World Two Languages*; it is located in two elementary schools and one middle school. Students from two language groups, native Spanish speakers and native English speakers, attend class together in this program. Program administrators strive to maintain a balance of native speakers of both languages, but often the balance favors native Spanish-speakers given the large Hispanic population in the neighborhood of the schools. English speakers are only able to enter the program in kindergarten while Spanish speakers can enter at any grade level, depending upon their literacy level in Spanish and their English oral proficiency. Like the Alamo Heights program, immersion in NISD is a program within a larger school, 3 classes per grade level. The elementary immersion school chosen for this study also houses a bilingual program, but there is little interaction between the two programs. During kindergarten and first grade, 90% of instruction is delivered in Spanish, with 10% in English. The amount of English instruction then increases, changing the ratio of Spanish to English to 80:20 in second grade, 70:30 in third grade, and 60:40 in fourth. By the time students reach fifth grade, instruction is evenly split between the two languages. In both sixth and seventh grade, history, science, and Spanish language arts are taught in Spanish. Once students reach eighth grade, they take English language arts in Spanish in addition to science and Spanish language arts. Parent involvement is considered to be an integral component of the program as a six year commitment is expected as is parental volunteerism in a variety of activities to support the program.

Table.4.2: Comparison of Student Demographics by District

	Alamo Heights Independent School District**	**NISD*****
No. of students	4,447	~86,000
No. of schools	5	97
Race		
White	64.32%	26%
Hispanic	31.2%	62%
African American	2.22%	8%
Asian	2.12%	3%
Other	3%*	1%
Free / Reduced Lunch	~25%*	46%
Limited English Proficient	5%*	7%

*Data taken from Jones (2005).
**Numbers were calculated based on information reported separately for each school on MuniNet Guide.
***As reported in Northside Independent School District (2008).

While the goals of the two programs are the same, meeting or exceeding district standards for content areas and high levels of literacy and proficiency in both languages, the two programs have very different looks as a result of the student demographics and the way instruction is divided between the two languages. Table.4.2 and Table 4.3 compare the two districts based upon these two features.

Table 4.3: Comparison of Language Distribution in Immersion Programs by District

	Alamo Heights		NISD	
	Spanish	English	Spanish	English
Kindergarten	NA	NA	90% *6 hrs.**	10%
1st grade	100%	0%	90% *5-6 hrs.*	10%
2nd grade		30 min. / day 2nd semester only	80% *5 hrs.*	20%
3rd grade	*4.5 -5 hrs.*	30-45 min / day	80% *4 hrs.*	20%
4th grade	*5 hrs.*	1 hr / day	70%	30%
5th grade	*4.5 - 5 hrs.*	1 hr / day	60% *2.75 hrs.*	40%
6th grade	Social Studies Science	Math English L.A.	50%	50%
7th grade	Science Spanish L.A.	Math English L.A. Social Studies	Science History Spanish L.A.	Math English/Reading
8th grade	Spanish L.A.	Math English L.A. Social Studies Science	Science English L.A. Spanish L.A.	Math History

NA = not applicable; Alamo Heights does not start immersion until first grade.
*It is common for school districts to report amount of instructional time in each language as a percentage; however, these numbers can be deceiving as students spend a portion of their school day in activities that are not subject matter instruction. For this reason, estimates of amount of instructional time in Spanish are provided in addition to percentages. These numbers, written in italics, are based upon teacher report. First and second grade teachers in the one-way program did not report this information.

4.2 Participants

4.2.1 Student Participants

A cross-sectional sample of first, third, fifth, and seventh grade immersion students enrolled in these two districts made up the subject population for this study. Although longitudinal approaches allow for more detailed descriptions of changes in an individual's interlanguage, data collection is time consuming and does not allow for as many subjects, limiting the conclusions and generalizations that can be drawn. Thus, a cross-sectional approach was used in this study in order to be able to sample a larger population of immersion learners and to avoid potential study attrition.

First, third, fifth, and seventh grade were chosen because they represent different stages in the learning process. For example, first grade marks the relative beginning of both language and content learning whereas fifth grade marks the end of elementary school and the end of the initial commitment to the immersion program.[44] Because many developmental changes occur during the elementary years, the midpoint, third grade, was also selected as an important milestone. Moreover, previous observations have suggested that changes in student language use patterns occur around third grade (e.g., Blanco-Iglesias, Broner, & Tarone, 1995). Including these three grade levels also allows for comparisons to the other phonological studies carried out in the immersion context (Harada, 1999; Snow & Campbell, 1985). Previous research does not consider what happens to student pronunciation beyond sixth grade, thus including middle school students adds a new dimension to our understanding of the phonological skills of immersion learners. The middle school level also introduces an additional factor as students at this level have elected to continue with the program after having fulfilled their initial commitment to the program.

All students at each grade level were invited to participate in the study. In order to participate, students must have met the following criteria: native speaker of English,

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[44] First grade truly marks the beginning of Spanish learning for the English speakers in the Alamo Heights one-way program. In the NISD two-way program, however, native English speakers began Spanish instruction in kindergarten. Thus although subjects in the two programs are in the same grade level, they have received different amounts of Spanish instruction.

began the immersion program in either kindergarten or first grade, and have no known speech-language disorder. A total of 35 students participated from the one-way program (one-way NES), and 23 learners participated from the two-way program (two-way NES). Native Spanish-speaking two-way immersion students at each of the selected grade levels also participated in this study as a control group (two-way NSS). This group was comprised of students whose first language is Spanish. In order to be classified as a native speaker of Spanish, students must have met the following criteria:

- Spanish is their first language (question 8 on the language background questionnaire),
- Spanish is the language of home, used minimally 60-80% of the time (question 11),
- Both parents speak Spanish, with at least one a native speaker of Spanish (questions 28, 30, 43, and 45),
- Listen to parents in Spanish a minimum of 60-80% of the time (question 14), and
- Speak to parents in Spanish a minimum of 40-60% of the time (question 15).

A total of 31 students comprised the native Spanish-speaking control group. A summary of the numbers of participants at each grade level within each language group is presented in Table 4.4.

Including a peer control group is especially important since no acoustic data are available about the vowel productions of either monolingual Spanish or bilingual

Spanish-English children. Native Spanish-speaking two-way immersion students afford the possibility of comparing English-speaking immersion learner productions to those of bilingual peers, who match many of the learner characteristics given that they are the same age, have had the same educational experiences, and are bilingual in Spanish and English. Ortega (2006, 2007) argues that L2 learners should not be compared to monolinguals but to bilingual peers given that a bilingual is not the same as two monolinguals (Grøsjean, 1989). What is more, phonological studies have shown that the productions of bilinguals are not always identical to those of monolinguals (e.g., Cordero et al., 2006; Flege & Hillenbrand, 1984; Harada, 1999). Data from this comparison group is critical in light of the above arguments and given the absence of work examining bilinguals' production of L1 vowels (Bohn & Flege, 1992).

Table 4.4: Number of Participants by Program/Language Group and Grade Level

	One-way NES				**Two-way NES**				**Two-way NSS**			
Grade	**1st**	**3rd**	**5th**	**7th**	**1st**	**3rd**	**5th**	**7th**	**1st**	**3rd**	**5th**	**7th**
Total No. of Participants	10	9	8	8	8	8	4	3	9	9	7	6
Males	4	4	1	2	2	4	2	1	3	1	4	5
Females	5	5	7	6	6	4	2	2	6	8	4	1

Despite sharing a common first language, the two native English speaking groups (one-way NES and two-way NES) are very different with respect to nationality/ethnicity, parent language background, parental views on relative importance of immersion goals, and parental motivation for enrolling their student(s) in immersion. This background information is presented in Table B.1, Table B.2, and Table B.3 in Appendix B for each individual student participant by subject group. Previous research has suggested that one-way (foreign language) immersion programs serve an ethnically and socio-economically homogenous student population, one that is largely Caucasian from middle to upper-middle income families (Freeman et al., 2005; Lindholm-Leary, 2001; Olsen, 1983). The one-way NES students who participated in this study fit this trend. Of the 35 students, all but three identified their nationality as white, Caucasian, American, or United States.[45] Two participants identified as Hispanic, and one indicated a French, Chinese, English mix. The two-way NES group has a very different composition. Of the 23 participants, all but one can be considered Hispanic. The non-Hispanic participant indicated that she was African-American. Of the 22 Hispanic students who made up this group, all but 3 were of Mexican heritage. Of those students not of Mexican ancestry, two were siblings of Nicaraguan descent, and one was of Puerto Rican heritage. This population is in line with the finding that two-way immersion programs in Texas are more likely to have Latinos make up 75% or more of the native English-speaking student population; this occurs in 35% of the two-way immersion programs in Texas versus 13% nationally (Howard & Sugarman, 2001).

Another difference between the groups is the first (or native) language of parents. As shown in Table 4.5, the majority of the native English-speaking students' parents indicated that English was their first language. While only 4 of the 66 (6.1%) one-way NES parents indicated a language other than English as their first, 14 of the 39 (35.9%)

[45] The questionnaire item asked for participants to indicate their nationality (nacionalidad), but most marked ethnicity. Despite the problematic nature of this question, trends can be identified from the responses.

two-way NES parents did so.[46] In other words, 14 of the two-way NES students have at least one parent whose first language is Spanish; however, Spanish is not used regularly in the home, possibly because the other parent is not proficient in Spanish or as a result of other factors. The majority (88.7%) of parents of the two-way NSS group are native speakers of Spanish.

Table 4.5: First language of Parents

		One-way NES	Two-way NES	Two-way NSS
Parent 1	**Spanish**	1	6	31
	English	30	16	3
	Other	3 (2 bilingual Sp/Eng; 1 French)	1 (bilingual Sp/Eng)	0
Parent 2	**Spanish**	0	6	24
	English	32	10	3
	Other	0	1 (bilingual Sp/Eng)	1

Parental knowledge of the two languages also varies across the three language groups.[47] While all of the parents of native English-speaking students know English, the same cannot be said of the parents of the two-way NSS group. Also how many parents know Spanish differs across the three groups. Findings are summarized in Table 4.6 and Table 4.7 below. Only 6% of one-way NES parents claim Spanish as their first language, but 38% have some familiarity with the language. In comparison, a higher relative

[46] The number of parental responses is not double the number of student participants in each group. In some cases, students only had contact with one parent, and in others, parents did not complete fully the background questionnaire.

[47] No measures of proficiency were employed. Parents were asked if they knew Spanish/English, at what age they were first exposed to the language, if they had received formal education in the language, and if they had lived in a Spanish-speaking country. Responses are reported here as recorded on language background questionnaires; however, there are questions as to the reliability of self-report as some parents indicated that they did not know Spanish, but that they spoke Spanish to their child 1-20% of the time.

percentage of two-way NES parents have knowledge of Spanish (78%), signaling a strong affiliation with Spanish within this community. And all but two of the two-way NSS parents speak or know Spanish.[48] Knowledge of English for the two-way NSS parents is limited; almost half (48%) of the two-way NSS parents report not knowing English. This finding speaks to the bilingual nature of San Antonio or minimally the community in which they reside. Given that a large portion of the two-way community does not speak English, it is not as surprising that so many of the NES parents in two-way community know Spanish.

Table 4.6: Parental Knowledge of Spanish

		One-way NES	Two-way NES	Two-way NSS
Parent 1	**Yes**	16 47%	18 78%	34 100%
	No	18 53%	5 22%	0 0%
Parent 2	**Yes**	9 28%	14 78%	27 93%
	No	23 72%	4 22%	2 7%

Parent groups also differ in how they rate the importance of immersion goals and their motivation for enrolling their student(s) in immersion. As part of the language background questionnaire, parents were asked to rate the importance of each of the four goals of immersion education and also motivations for enrolling students in immersion, based upon a 5-point scale in which 1 was unimportant and 5, very important. Findings are reported in Table 4.8 and Table 4.9.

[48] It was indicated that in order to be classified as a native Spanish speaker, both parents had to know Spanish. In the language background questionnaire, it was indicated that these two parents who did not speak Spanish were biological parents, but that students did not have contact with them.

Table 4.7: Parental knowledge of English

		One-way NES	Two-way NES	Two-way NSS
Parent 1	**Yes**	34 100%	23 100%	19 56%
	No	0 0%	0 0%	15 44%
Parent 2	**Yes**	32 100%	18 100%	14 48%
	No	0 0%	0 0%	15 52%

Parents rated each of the four goals as important as evidenced by scores of 4 and above.[49] On average, parents of one-way NES assign the greatest importance to high levels of Spanish proficiency; English language proficiency is regarded as least important. For two-way NES parents, Spanish language proficiency is valued as most important while cross-cultural understanding is least important. Finally, for two-way NSS parents academic achievement is ranked as most important while the other three goals were assigned very similar scores. A series of oneway ANOVA statistical tests show that the only statistically significant difference in ratings across the three program/language groups is in the rating of the importance of Spanish language proficiency. Only one of the pairwise comparisons reaches statistical significance for this goal, that between one-way NES students and two-way NSS students.

Given that all four goals were valued as important or very important by each of the groups, the differences between the goals within a single program/language group are small. The relative importance of developing high levels of English language proficiency

[49] The number of responses does not equal the number of participants in some instances because some participants did not complete this section of the questionnaire.

is less than that of developing Spanish language proficiency in all cases, suggesting that parents may feel confident that students will develop high levels of English language proficiency.

Table 4.8: Parent Ratings of the Importance of Immersion Goals

	One-way NES N=33	Two-way NES N=23	Two-way NSS N=31
Cross-cultural understanding	4.48	4.39	4.56
Spanish language proficiency	4.97	4.87	4.59
English language proficiency	4.39	4.78	4.56
Academic achievement	4.62	4.83	4.72

Parents generally rated as important the many different reasons for enrolling students in a dual language educational program. The two exceptions to this are the importance of school prestige and the ability to communicate with family for one-way NES parents. Given that both schools in the one-way district offer immersion, parents do not have a choice as to what school their child will attend. Also given the linguistic and ethnic makeup of the one-way NES group, Spanish is not necessary to communicate with other members of the family as everyone speaks English. Both of the two-way groups assign a rating of very important to communicating with the community and family. The community immediately surrounding the two-way school reveals a strong Spanish presence in signage and types of commercial businesses, suggesting that Spanish is used regularly within the community. Also given the strong ethnic ties to Mexico for many of the students, it is not surprising that they might need Spanish to communicate with relatives. It is interesting to note, however, that there is also a Spanish-speaking community within the one-way school limits, as evidenced by signage and the presence of a bilingual program in the school.

Table 4.9: Parent Ratings of Motivation for Enrollment

	One-way NES N=33	Two-way NES N=23	Two-way NSS N=32
Future opportunities	4.53	4.83	4.65
Cognitive benefits	4.82	4.95	4.71
School prestige	2.48	4.2	4.32
Communicate with community	4.52	4.91	4.8
Communicate with family	2.79	4.83	4.72

The one commonality across each of the language groups is the parents' desire for students to be successful both academically and in future endeavors. Aside from this there are substantial differences between the two subject groups as well as between the subject groups and the control group. The most notable of these differences involve student nationality/ethnicity and parent language background. Two-way students, both NES and NSS, appear to have stronger ethnic, familial, and potentially linguistic ties to the Spanish-speaking community and world than one-way NES.

4.2.2 Teacher participants

A total of ten teachers participated in this study: four teachers from the one-way program and six teachers from the two-way. Højen and Flege (2006) suggested that differences in L2 input may be a potential source of nonnative-like productions by early L2 learners. Since immersion teachers are in many cases the primary source of proficient

L2 input (Swain & Johnson, 1997), it is important to consider its features.[50] This is especially true in light of the findings of both Cordero et al. (2006) and Harada (1999). Both studies found that the models presented by educational practitioners (speech language pathologists and immersion teachers) do not necessarily reflect monolingual norms. In the case of the English-Spanish speech language pathologists in Cordero et al.'s study, English and Spanish vowels were not significantly different as measured by formant frequencies; based on findings from acoustic comparisons of the vowels in both languages, however, there are differences in formant frequencies between the two languages (e.g., Bradlow, 1995). Japanese immersion teachers, in much the same way, produced significantly longer VOTs and larger closer durations than monolingual children in Harada's study. It can thus not be assumed that the input learners are exposed to is the same as that reported in the literature for monolinguals. By including the productions of teachers, learner pronunciation can be considered in comparison to the input they receive.

In addition to collecting speech samples from teachers, the first language background and country of origin or country of study abroad was identified for each of

[50] Students are exposed to the immersion language through the output of their peers as well. This output is however marked by syntactic, lexical, sociolinguistic, and phonological differences (e.g., Boyd, 1975; Christian et al., 1997; Genesee, 1978a; Harada, 1999; Harley, 1979; Harley & Swain, 1984; Plann, 1979; Potowski, 2005, 2007a; Snow & Campbell, 1985; see Sections 2.4.1 and 2.4.2 above for a more complete discussion).

the immersion language teachers by whom study participants were taught. This information is presented in Table 4.10 below.[51]

Table 4.10: Language Background of Teachers who Taught Study Participants

Program	L1	Spanish-speaking Community in which Resided	Study Participants Taught by Teacher			
			1st	3rd	5th	7th
One-way	Spanish	Dominican Republic	x	x		
	Spanish	Costa Rica		x		
	Spanish	Mexico		x		
	Spanish	Mexico			x	
	English	Mexico			x	x
	Spanish	Guatemala			x	x
	English	Mexico			x	x
	Spanish	Puerto Rico			x	x
	bilingual	Texas				x
	English	Texas				x
Two-way	Spanish	Mexico	x	x		
	Spanish	New Mexico	x			
	Spanish	Texas	x	x		
	Spanish	Texas		x	x	
	Spanish	Texas		x	x	x
	Spanish	Mexico		x	x	
	Spanish	California		x		
	Spanish	Mexico		x		
	English	Honduras		x	x	x
	Spanish	Colombia		x	x	
	English	Costa Rica			x	
	Spanish	unknown			x	
	English	Peru			x	x
	Spanish	Venezuela				x

[51] In some cases, this information was not available. Some teachers no longer taught in the program and current teachers were not familiar with their language history. No information was available for one of the one-way teachers and four of the two-way teachers.

4.3 Tasks/Instruments

Five tasks were completed by all participants: a language background questionnaire, a picture sort, a picture walk, an ability questionnaire, and an attitude survey.[52] Details about the design of each of the tasks are included in this section.

4.3.1 Language Background Questionnaire

A language background questionnaire was distributed to the parents of all student participants. The questionnaire gathered information about student exposure to Spanish, student language use patterns outside of school, and parent language history; it is adapted from the questionnaire used by Harada (1999) (see Appendix C for the English questionnaire and Appendix D for the Spanish version). Previous literature has suggested that classroom-based input is insufficient for native-like L2 production (e.g., Genesee, 1987), and research on the pronunciation abilities of immersion learners has shown this to be true (Harada, 1999). Thus it is important to consider the many individual learner factors that may contribute to more or less native-like productions. While the questionnaire gathers a variety of details about each learner, those that relate to patterns of language use outside of school (i.e., #13-20) are of special interest.

4.3.2 Picture Sort and Picture Walk

All subjects, students and teachers alike, participated in a picture identification task and a picture walk. Samples of learner language fall along a continuum of naturally-occurring to experimentally-elicited (e.g., Ellis & Barkhuizen, 2005; Tarone, 1979,

[52] Parent participants completed the language background questionnaire in most instances. In a few cases, seventh grade students completed their own background questionnaire.

1983); somewhere between these two extremes falls clinically-elicited speech (Ellis & Barkhuizen, 2005).[53] Meaning-focused speech is commonly attributed to the naturally-occurring extreme, and form-focused speech to the experimentally-elicited extreme; tasks used in clinically-elicited speech require that learner resources be allocated more to message conveyance than a specific linguistic outcome. While the vernacular, i.e., speech produced in natural, informal situations, is "the most systematic and least permeable to invasion by both TL [target language] and NL [native language] rules" (Tarone, 1979, p. 185), natural data collection methods can be extremely time-consuming and learners may not produce the targeted linguistic structure in the desired linguistic context. Tarone (1979) argued that it should be the goal of L2 research to describe the vernacular, which cannot be observed via data elicitation techniques. In spite of this, data elicitation techniques persist as the most frequently employed data collection method in applied linguistics research (Nunan, 1992). Ellis and Barkhuizen (2005) contended that clinically-elicited data, as opposed to experimentally-elicited, are valid measures since the attention given to form is subservient to that given to communication. Moreover, they allow for the collection of good data related to specific features. Due to the effect of surrounding segments on the targeted phone, controlling for linguistic context is especially important in phonological studies, and as a result, speech was elicited from subjects rather than collected via natural collection procedures. While the data collected via the picture

[53] Clinically-elicited speech is often collected via completion of a task; learners are provided a context in which to produce L2 output. Experimentally-elicited speech differs in that it often takes the form of an exercise; learner attention is principally oriented to accuracy as they produce a specific, predetermined linguistic feature via a relatively short L2 segment. Role plays, interviews, picture-based narrations, and communicative gap tasks are examples of clinically-elicited tasks; sentence and discourse completion exercises, as well as grammaticality judgments and translations are examples of experimentally-elicited activities.

identification task and the picture walk may not represent the most stable and systematic type of learner speech, these techniques do provide a means for observing a portion of the learners' interlanguage system.

Both Snow and Campbell (1985) and Harada (1999) used a picture identification task to elicit data in their studies of immersion learners' pronunciation, and this technique was found to result in variation between learners. The particular method employed in this study differs from those employed in the previous two studies in that students did not simply identify a word based on a picture prompt, but rather they verbally identified the token animals as they classified them into groups. Thus while data was not naturally occurring, learner attention was more focused on the task of sorting and identifying animals than their pronunciation of the words. Moreover, classifying or grouping is a skill given much attention through the early elementary grades as evidenced by the learning standards for the state of Texas (Texas Education Agency, 1998) and thus is an educational activity familiar to students.

An additional data elicitation technique employed was a picture walk. In a picture walk, student subjects are presented with a series of pictures that represent a story line. Students then narrate a story based on the pictures. This task elicits more connected, extended speech than the picture identification task; again in this task, learner resources were more focused on developing the storyline or message than on form. Nonetheless, the fact that students were in an artificial environment, with an unfamiliar researcher, is likely to result in some attention to form, and the vernacular was not expected to emerge.

Both tasks made use of animal vocabulary since animals are easily depicted and familiar to both younger and older students. Immersion learners are often more confident using the L2 with academic content as opposed to social content given the nature of their language learning experiences (e.g., Genesee, 1978b, 1981a); for this reason it was important that tasks be related to topics learned in school. Animals form part of the Texas Essential Knowledge and Skills (TEKS) for Science. Concepts related to living organisms and specifically animals comprise part of each grade level's science curriculum from kindergarten through seventh grade; some of the specific concepts include the classification of living organisms, life cycles, functions of specific parts of organisms, ecosystems, habitats, how organisms adapt to their environment, and small structural units such as cells (Texas Education Agency, 1998).

All five Spanish vowels were present in the animal tokens selected; additionally each vowel occurred in both stressed and unstressed syllables as well as in both closed and open syllables. The particular animals presented to learners were chosen based upon immersion teachers' ratings of their familiarity to immersion learners. This was a particular concern for the one-way first grade immersion learners as they had been studying the language less than a year. Snow and Campbell (1985) noted that some of their subjects were unable to provide appropriate vocabulary words for the picture cues despite having consulted with teachers and pilot-tested the items. Therefore, in an attempt to avoid this potential methodological pitfall, primary grade immersion teachers at both sites were surveyed to ensure subject familiarity with vocabulary, and as an additional measure, the name of the animal was printed below each picture cue to provide readers with a prompt if needed. A list of animals presented to students as well as the linguistic contexts for each vowel is presented in Appendix E and sample picture cues are provided in Appendix F.

4.3.3 Ability and attitude questionnaires

Hedgcock and Lefkowitz (2000) advised, "as difficult as they are, attitudinal influences should not be overlooked in any empirical account of language learning or in any inquiry into the instructional process" (p. 89). Given that previous studies have found connections between student attitudes toward the second language, culture and people, and pronunciation (e.g., Elliot, 1995a, 1995b; Gatbonton, 1975; Hedgcock & Lefkowitz, 2000; Lybeck, 2002), data was collected in order to be able to account for these influences on the Spanish productions of these learners. Student subjects completed two questionnaires: one that targeted their perceived competence in both languages and one that addressed their attitudes toward Spanish and English, bilingualism, and the immersion program. The attitude questionnaire was developed based upon questions asked in previous studies that attempted to explore student attitudes in second language classrooms (Cazabon, Lambert, & Hall, 1993; Cazabon et al., 1998; Fleming, 2006; Hedgcock & Lefkowitz, 2000; Lambert & Tucker, 1972; Lefkowitz & Hedgcock, 2006; Potowski, 2002). Questionnaires were adapted to meet the cognitive levels and attention spans of learners in each grade level. As a result, first graders completed only the ability survey, and third graders completed only a portion of the attitude questionnaire. All versions of the questionnaires are included in Appendix G and Appendix H.

4.4 Data Collection

Data collection was carried out during the school day by the researcher. The researcher worked with two students from the same grade level simultaneously based upon recommendations for administering oral assessment instruments. These recommendations advise researchers to “provide a stimulating and realistic context”; one way to achieve this is to interview two students at a time (Rhodes & Thompson, 1990, p. 80). Additionally, Thompson (2007) observed that children are more at ease and produce more language when working with a partner than when talking individually with an adult. Thus in order to allow students to be more comfortable and for data collection to seem less artificial, data collection took place in pairs in a quiet room in the school building. All data collection sessions were both audio- and video-recorded.

The researcher first introduced herself to the subjects and then begin an informal conversation with learners about animals, asking questions such as if they have pets, what their favorite animal is, if they’ve ever visited the zoo, etc. She then transitioned into the picture identification/sorting task. Students were asked to sort the picture cards into groups based on a variety of characteristics, such as where the animals live, the class of animals to which they belong, which are scary, etc. After each sort was complete, they were asked to verbally identify each animal in the group. This task was repeated several times so that both students had an opportunity to verbally identify a variety of animals. Students were then asked to narrate a story based on a series of pictures presented to them. Students were allowed to look through the pictures prior to beginning their narration, and they were asked to take turns, so that each student had equal opportunity to recount the depicted events and produce the token words. Finally, the ability and attitude questionnaires were administered to students. A sample outline of a data collection session is provided in Appendix I.

4.5 Analysis

Although subjects participated in two tasks as part of this study, only data from the first task, the picture sort task, were considered in the analysis. Given that the research questions do not address the effect of task type, comparing productions across tasks was not necessary.

The surrounding linguistic context, such as the preceding and following consonant, affects formant frequency. Some even argue that the information conveyed by onsets and offsets is more important than the frequency of the stable portion of the vowel (e.g., Bohn, 1997). In order to minimize any effects created by the surrounding linguistic context, the same tokens were analyzed for each subject. By using the same tokens for each speaker, the same formant measurements and movement can be expected, minimizing the effect that different contexts could have on F1 and F2 averages.

Up to 100 vowel tokens were analyzed for each study participant, 20 for each of the five vowels. For each vowel, a maximum of 10 stressed and 10 unstressed tokens were analyzed, and every attempt was made to balance tokens in closed and open syllables. All tokens occurred between consonants; any articulations in which the interconsonantal context was modified were eliminated from the sample. Although the data elicitation method was designed to elicit 20 tokens of each vowel, with equal numbers of stressed and unstressed tokens, student responses proved to be unpredictable as will be seen in Chapter 5.

4.5.1 Acoustic Analysis

A variety of techniques are available to analyze vowel productions; auditory perceptions of vowels by the researcher can be used to identify productions as can formant measurements. Most early SLA studies relied on phonetic transcription for analysis as access to acoustic analysis programs was limited (e.g., Hammerly, 1982); however, findings based on such analyses are constrained by auditory discrimination abilities as well as inconsistent transcription practices and symbolization across languages. For example, the same IPA symbol may be used to represent two sounds in two different languages but that have systematic differences, i.e. Spanish and English /u/. Torreblanca (1988) commented on the limitations of this analytic technique:

> *el hecho de que dos o más personas transcriban dos o más veces las mismas grabaciones magnetofónicas no elimina totalmente la posibilidad del error acústico, incluso si las transcripciones coinciden: dos o más personas pueden cometer un error acústico con relación a un mismo segmento fonético. El uso del espectrógrafo […] puede disminuir la posibilidad del error acústico en las transcripciones hechas al oído […] Los aparatos pueden mostrarnos diferencias fonéticas imperceptibles para el oído humano* (p. 670).

In line with the suggestion made by Torreblanca (1988) in the above quote, more recent studies are employing acoustic analyses to measure formants and their movement (e.g., Cobb, 2009; Cordero et al., 2006; Menke & Face, 2010). This study follows this recent trend in second language phonological acquisition research.

Through the acoustic analysis, the vowel productions of English-speaking immersion learners can be compared to those of bilingual, native Spanish-speaking peers in order to observe any subtle differences in the frequency at which vowel energy resonates, which in turn signal disparities in how the vowel is produced. The acoustic analysis was carried out using Praat v.4.5.16 signal-processing software. First each vowel token was isolated and extracted from the connected speech sample, then an LPC formant-tracking algorithm (script) was used to measure vowel duration and formant frequency. The script measured F1, F2, and F3 at the midpoint (50%) of the vowel. All statistical outliers were hand checked and corrected as necessary.

4.5.2 Vowel Normalization

Ladefoged and Broadbent (1957) argued that vowels encode a bundle of information: phonemic, anatomical/physiological, and sociolinguistic. All three types of information have been found to affect formant frequencies; for example, work in English has shown the F1, F2, and F3 values of children to be higher than those of adult females, which were in turn higher than those of adult males (Peterson & Barney, 1952; Potter & Steinberg, 1950). [54] In a study such as this, which is focused on the effect of extralinguistic factors on vowel production, variation as a result of

[54] Peterson and Barney (1952) found F1 values of children to be about half an octave higher than those of adult males; the differences between the F2 and F3 values of the two groups were "appreciably higher" (p. 183). In a similar way, Eguchi and Hirsh (1969) observed a gradual decrease in F2 frequencies between the ages of 3 and 13, suggesting that vowels are produced further back in the vowel space the older the children were. With respect to F1 values, they noted that F1 frequencies were generally more stable, showing less change than F2 values.

anatomical/physiological differences in speakers is unwanted. As a result, a vowel normalization procedure was applied in order to make comparisons across speakers of different ages. Disner (1980) and Thomas (2002) identified four general goals of vowel normalization procedures: 1) to eliminate variation caused by physiological differences among speakers, 2) to preserve sociolinguistic, dialectal, or cross-linguistic differences in vowel quality, 3) to preserve phonological distinctions among vowels, and 4) to model the cognitive processes that allow listeners to recognize vowels despite the large amount of individual variation in their production. In this study, the first three goals are most important (For a discussion of the fourth goal, speaker normalization in speech perception, see Johnson (2005)).

In a comparative analysis of 10 different vowel normalization procedures, Adank, Smits & van Hout (2004) identified the Lobanov z-score transformation (Lobanov, 1971) as the best procedure. It effectively factored out physiologically-caused differences while retaining differences caused by sociolinguistic variables. For these reasons, it was employed here. The Lobanov z-score transformation is a vowel-extrinsic procedure, which means that the entire vowel system is taken into account, not just a single token. Such procedures assume that the information required to normalize values is distributed across all the vowel phonemes of a speaker as opposed to vowel-internal procedures which employ only the acoustic information contained within a single vowel token.

The Lobanov method uses the following mathematical equation to calculate z-scores: $F_{n[V]}^{N} = (F_{n[V]} - MEAN_n)/S_n$. In this equation, $F_{n[V]}^{N}$ is the normalized value for $F_{n[V]}$ (i.e., for formant *n* of vowel *V*), $MEAN_n$ is the mean value for formant *n* for the speaker in question and S_n is the standard deviation for the speaker's formant *n*. An on-line vowel normalization and plotting suite, NORM, was used to compute the z-scores (Thomas & Kendall, 2007). Although the output (z-scores) is able to be plotted in the same way as Hertz values, the results are not in Hertz.

4.5.3 Statistical Analyses

All vowel productions are described quantitatively, in terms of mean F1 and F2 values (or z-scores in the case of normalized data). Mean and standard deviations were calculated using SPSS statistical software package v. 14.0. In order to determine the significance of differences between stressed and unstressed productions of a particular vowel, t-tests were carried out in SPSS. Oneway ANOVA tests with accompanying post-hoc Least Significant Difference (LSD) were conducted to determine if F1 and F2 frequency values differed across vowels, across grades, or across program/language groups. Significance was set at $p<0.01$ for all statistical tests.

4.5.4 Native-like and Prototypicality Classifications

In addition to statistical comparisons of formant values, two supplementary measures were employed in order to compare the vowel productions of learners to those of the two-way NSS control group. The first is a classification of each individual token as either native-like or not native-like. Native speakers produce tokens of each vowel with a range of formant values; statistically, 95% of tokens occur within 2 standard deviations of the mean. Because the 2 standard deviation range encompasses 95% of native speaker tokens, this measure served to define the range of values considered to be native-like. The formant values of each learner vowel token were compared to the corresponding two standard deviation ranges; if both formant values were within this range, the token was classified as native-like. If only one of the formants was produced at a frequency within the two standard deviation range or if neither of the formant values were within the identified range, the token was classified as not native-like.

This native-like classification scheme indicates what percentage of learner tokens of each vowel were produced within the range that native speaker tokens are typically produced, but it does not signal how near to the center of this range the tokens are. Taylor (2003) points out that when making linguistic classifications, it is important to determine “how closely the dimensions of the entity approximate to the optimum value” (p. 44). In line with this argument and the Prototype Theory (see Taylor (2003) for an in depth discussion of this theory), it was assumed that certain tokens are better exemplars of each vowel category than others. In order to address the issue of what percentage of learner tokens approximate the best exemplars of each vowel category, every learner token was categorized according to the following prototypicality scheme.

For each grade level, the one standard deviation and two standard deviation ranges were identified based on the NSS data. Each formant value of all student tokens was then compared to these ranges; if the value was within the 1 standard deviation range, it received a score of 2; if the value was outside the 1 standard deviation range but inside the 2 standard deviation range, it received a score of 1, and if it was outside the 2 standard deviation range, it received a score of 0. Every token received two scores, one for each formant. The two scores were then added together to attain one overall prototypicality score. The maximum score for any one token is 4; the minimum, 0. Tokens with a combined score of 4 can be considered to be highly prototypical as both formants are within the 1 standard deviation range; tokens with a combined score of 3, are moderately prototypical as one of the formants is in the 1 standard deviation and one is in the 2 standard deviation range. A score of 2 signals a slightly prototypical production, and scores of 1and 0, non-prototypical articulations. Table 4.11 summarizes the results of the prototypicality coding procedure and its correlation to native-like classifications.

Table 4.11: Results of the Prototypicality Coding Procedure

Label	**Score (F1+F2)**	**Possible Combinations** **2 = 1 st. dev. range** **1 = 2 st.dev. range** **0 = outside 2 st. dev. range**		**Native-like Classification**
		F1	**F2**	
Highly prototypical	4	2	2	Native-like
Moderately prototypical	3	2	1	Native-like
		1	2	Native-like
Slightly prototypical	2	1	1	Native-like
		2	0	Not native-like
		0	2	Not native-like
Non-prototypical	1	1	0	Not native-like
		0	1	Not native-like
Non-prototypical	0	0	0	Not native-like

4.5.5 Correlation between Pronunciation and Attitude and Self-Reported Abilities

In order to account for any differences in attitude toward Spanish, its speakers, and the importance of native-like pronunciation, third, fifth, and seventh grade student participants completed an attitude questionnaire. The questionnaire administered to third graders contained only a portion of the items on the complete questionnaire, which was given to fifth and seventh graders. Student responses to each item were assigned a numerical score: true=1, kind of true=2, kind of false=3, false=4.

Four separate factors were identified from the initial 33 items; a series of questionnaire statements mapped onto each factor as shown in Table 4.12. An attitude score for each factor was then calculated for each learner based upon their responses to the statements following the scoring system outlined in the previous paragraph. Students also self-reported their abilities for a variety of language skills; only responses to item 7 (pronounce Spanish sounds and words) are included in this analysis. Each response was similarly assigned a numeric score: bad=1, kind of bad=2, kind of good=3, good=4. Scores for each attitude factor and self-reported ability were compared statistically across the two NES learner groups through a series of independent samples t-tests in SPSS.

In order to correlate attitudes with pronunciation, an independent measure of pronunciation was necessary. Because it takes into account how native- or target-like each vowel production is, the prototypicality measure described in Section 4.5.5 was employed in the correlation analysis. As described each learner production received a prototypicality score. All of the vowel productions for each learner were averaged to determine a mean prototypicality score for every individual. This score and the attitude and ability scores were then submitted to a Pearson's Correlation analysis in SPSS. When the Pearson correlation coefficient obtained through this analysis reached 0.5 the independent variable (either attitude or ability) was considered to be correlated to pronunciation.

Table 4.12: Questionnaire Items for Each Factor

Factor	Label	3rd Grade Questionnaire Items	5th & 7th Grade Questionnaire Items
1	Positive attitude toward Spanish	1: I like to speak Spanish. 5: I enjoy studying Spanish the way it is taught in school. 12: I enjoy meeting and listening to people who speak Spanish. 14: I am proud to know Spanish.	1: I like to hear people speaking Spanish. 3: I like to speak Spanish. 7: I enjoy studying Spanish the way it is taught in school. 15: I enjoy meeting and listening to people who speak Spanish. 20: I am proud to know Spanish.
2	Recognition of instrumental reasons/motivations for knowing Spanish	3: It is important to know Spanish in San Antonio. 8: I have more friends because I speak Spanish and English. 9: Learning two languages will make you smarter than learning only one language. 10: Learning two languages will help you get better grades. 11: Knowing two languages will help you get a better job when you grow up.	5: It is important to know Spanish in San Antonio. 11: I have more friends because I speak Spanish and English. 12: Learning two languages will make you smarter than learning only one language. 13: Learning two languages will help you get better grades. 14: Knowing two languages will help you get a better job when you grow up.
3	Recognition of the importance of pronunciation	20 : It is important for me to sound like my classmates when I speak Spanish. 21: It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker. 22: I like to pronounce words like my teacher.	27: I can recognize the difference between native-like and non-native pronunciation in Spanish. 28: I don't like when my classmates sound very non-native when they speak Spanish. 31: It is important for me to sound like my classmates when I speak Spanish. 32: It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker. 33: I like to pronounce words like my teacher.
4	Positive rating of pronunciation abilities	19: I feel that I currently have excellent pronunciation skills in Spanish.	25: I feel that I currently have excellent pronunciation skills in Spanish. 26: My pronunciation in Spanish is native-like. 29: My pronunciation in Spanish is better than that of my classmates.

Chapter 5
Results

A total of 7,158 student participant vowel tokens were analyzed as part of this study. The tokens analyzed are grouped according to grade level, phoneme, and lexical stress in Table 5.1. Despite an experimental procedure designed to elicit equal numbers of each vowel, equal numbers were not attained. Student participants responded in unanticipated ways to the pre-designed prompts. For example, when asked *¿Qué animales viven en Tejas naturalmente?* 'What animals live naturally in Texas?', some students responded with unanticipated animals such as *un elefante* 'an elephant', *un canguro* 'a kangaroo', *un camello* 'a camel', and *un pingüino* 'a penguin'. In the same way, all anticipated responses were not given for each question; in some instances, students appeared to avoid less familiar or more difficult words such as *rinoceronte* 'rhinoceros', and in others, they did not identify all the animals pre-determined by the researcher as possible answers. And, for some animals, students provided different lexical tokens than the ones provided by the researcher: *chango* instead of *mono* 'monkey', *víbora* or *serpiente* instead of *culebra* 'snake', *aves* instead of *pájaros* 'birds'.[55] Finally, the token *canguro* 'kangaroo' appeared to be particularly prone to anglicized pronunciations: [kaŋgəɹú] or [keɪŋgəɹú] vs. [kaŋgúɾo], which changed the vowels produced and their position. Very English-like pronunciations of this token were not included in the analysis. All of these factors affected the frequency with which each phoneme was produced.

[55] These lexical variants were incorporated into the coding scheme and analyzed.

The low, central vowel /a/ was produced most frequently by the participants, and the high, back vowel /u/ was produced least frequently, 24.2% of the tokens and 11.8% respectively. The incidence of occurrence of each phone is in line with frequency analyses of Spanish, which have found /u/ to be the least common vowel phoneme in both written and spoken Spanish and /a/ to be the most common phone in written and second most common in oral (Alarcos Llorach, 1961; Delattre, 1965; Guirao & Borzone de Manrique, 1972; Moreno Sandoval et al., 2008; Navarro Tomás, 1946;Quilis & Esgueva, 1980; Zipf & Rogers, 1939).

Table 5.1: Vowel Tokens Analyzed

		One-way NES				**Two-way NES**				**Two-way NSS**				**Total**
		1st	**3rd**	**5th**	**7th**	**1st**	**3rd**	**5th**	**7th**	**1st**	**3rd**	**5th**	**7th**	
/i/	**stressed**	88	90	79	75	71	75	39	25	84	86	76	54	842
	unstressed	94	87	73	71	66	68	36	21	74	66	71	52	779
/e/	**stressed**	89	88	82	78	74	80	40	26	79	81	77	51	845
	unstressed	64	66	47	54	36	55	25	10	57	43	44	39	540
/a/	**stressed**	100	90	81	80	77	78	37	29	89	90	80	58	889
	unstressed	95	89	79	75	76	75	39	21	77	83	76	59	842
/o/	**stressed**	78	83	67	66	61	63	31	16	70	54	59	44	692
	unstressed	100	90	86	79	74	79	36	28	89	88	79	57	885
/u/	**stressed**	53	59	45	44	34	48	22	11	52	46	41	31	486
	unstressed	30	40	39	36	37	32	20	10	30	35	30	17	356
Total		791	782	678	658	606	653	325	197	701	672	633	462	7158

In this chapter, results are presented according to the research questions, which are restated here for reference:

1. Do the vowel productions of native English-speaking learners in Spanish immersion programs differ from those of native Spanish-speaking learners? If so, how?

2. Do the vowel productions of native English-speaking learners in a one-way foreign language immersion context differ from those of English-speaking learners in a two-way immersion context? If so, how?
3. Does this sound class develop over time? If so, how?
4. Do the vowel productions of immersion learners differ from those of immersion teachers? If so, how?
5. Is there a relationship between attitudes toward Spanish and English and the pronunciation of Spanish vowels by immersion learners? If so, what does it look like?

Section 5.1 addresses Research Questions 1 and 2 by comparing the three language/program groups at each grade level. Section 5.2 looks at how the vocalic systems of the two NES groups develop over time in comparison to that of the NSS comparison group, Research Question 3. In Section 5.3 the vowel productions of the learner groups are compared to those of their immersion teachers (Research Question 4), and finally student responses to the attitude survey are reported in Section 5.4 with respect to their correlation to vowel articulations (Research Question 5).

5.1 Effect of Program on Vowel Productions

In this section, if and how the vowel productions of NES students in immersion programs differ from those of Spanish-English bilingual peers (Research Question 1) is considered alongside the question of whether program model has an impact on vowel productions of NES students (Research Question 2). Results from each of the three language/program groups are presented according to grade level. Within each subsection, findings are reported for mean formant values, effect of lexical stress, and overall native-like scores.

5.1.1 Vowel Productions of First Grade Groups

5.1.1.1 Formant Values of First Grade Groups

A total of 27 first graders participated in this study – 10 one-way NES, 8 two-way NES, and 9 two-way NSS. Mean formant values, the range within which 95% of all productions occur (i.e., within 2 standard deviations of the mean), and standard deviations for each of the groups are presented in Table 5.2. Individual vowel charts for each program/language group are available in Figure J.1, Figure J.2, and Figure J.3 in Appendix J; a combined plot of the three groups is provided in Figure 5.1 to facilitate comparisons.

The vowel space of each of the NES learner groups differs from that of the NSS peer comparison group on the F1 dimension. In particular, the vowel space of the NSS group occupies less space on the high-low dimension than that of one-way NES and two-way NES primarily as a result of a lower mean F1 frequency for /a/ by this group. The NES groups produce /a/ with a F1 value that approaches 900 Hz whereas the mean F1 value of the two-way NSS peer group is 737 Hz. The effect of this difference is a lower F1 limit, which results in the lower end of the vowel space being higher and a subsequent overall shrinking of the vowel space on this dimension.

Figure 5.1: First Grade Formant Values According to Program/Language Group

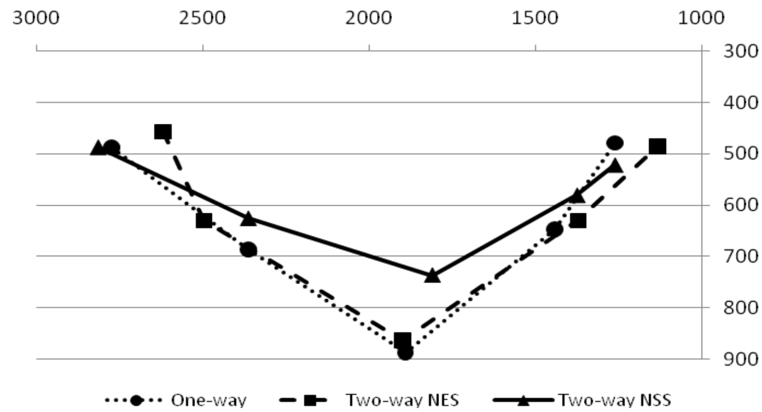


Table 5.2: First Grade Formant Values According to Program/Language Group

			One-way NES	Two-way NES	Two-way NSS
/i/	F1	mean	488	457	487
		range	334-642	303-611	345-629
		s.d.	77	77	71
	F2	mean	2773	2619	2812
		range	1867-3679	1435-3803	1858-3766
		s.d.	453	592	477
/e/	F1	mean	686	630	626
		range	438-934	396-864	456-796
		s.d.	124	117	85
	F2	mean	2363	2496	2362
		range	1853-2873	1836-3156	1726-2998
		s.d.	255	330	318
/a/	F1	mean	887	864	737
		range	519-1255	504-1224	409-1065
		s.d.	184	180	164
	F2	mean	1890	1899	1810
		range	1316-2464	1399-2399	1040-2580
		s.d.	287	250	385
/o/	F1	mean	647	630	581
		range	403-891	348-878	377-785
		s.d.	122	124	102
	F2	mean	1433	1372	1376
		range	755-2111	788-1956	740-2012
		s.d.	339	292	318
/u/	F1	mean	479	486	522
		range	293-665	342-630	370-674
		s.d.	93	72	76
	F2	mean	1262	1139	1262
		range	704-1820	599-1409	624-1900
		s.d.	279	270	319

Another difference observable in Figure 5.1 is the relative distance between the two back vowels /o/ and /u/. The articulations of /o/ and /u/ by the two-way NSS first grade group are located very near to one another in the acoustic vowel space; the articulations of these same vowels by both of the NES first grade groups are situated further apart on both the F1 and F2 dimension. Contrasting the range of formant values for these vowels provides further evidence for this observation. There is considerable overlap in the F1 frequencies between /o/ and /u/ as produced by the NSS group; both vowels have first formants produced within the 377-674 Hz range, which is nearly the entire range of /u/. This suggests that /o/ is prone to being articulated with /u/-like F1 frequencies. Similarly for the F2, overlap in the range of values occurs between 740-1900 Hz; each of the vowels occupies only approximately 100 Hz of additional acoustic space on one end of this range. The sizeable amount of overlap and the small regions of sole occupancy point to little differentiation between these two vowels as produced by the NSS group.

Statistical analysis validates these observations for the F2 dimension as differences do not reach statistical significance in post-hoc LSD analyses (p=0.026).[56] The two NES groups demonstrate less overlap in formant frequency for these two vowels. One-way NES' productions of /o/ and /u/ overlap from 403-665 on F1 and 755 to 1820 on F2. The productions of the two-way NES group overlap from 348-630 on F1 and 788-1409 on F2. Although the overlapping ranges take up most of the range of values for /u/ on the F2 dimension for one-way NES learners and the F1 dimension for two-way

[56] All results from one-way ANOVA tests and accompanying post-hoc LSD tests to compare F1 and F2 values across vowels within each program/language group are available in Appendix J.

NES learners, the amount of combined overlap of the two dimensions is less. Moreover, F1 and F2 values for the two vowels differ significantly for both learner groups.

The productions of the two NES groups are not identical. The productions diverge considerably from one another with respect to the high vowels, /i/ and /u/. The two-way NES group produces these two vowels with lower F2 values, which results in a more-backed plot of their mean value. Lower F2 values may be the result of a more backed tongue position or greater lip rounding. Also the two-way NES group produces all vowels, with the exception of /u/, with lower F1 values than the one-way NES group. The most notable of these differences appears to be with the front, mid vowel /e/.

Many of these observations are supported by statistical analyses. Results of oneway ANOVA and accompanying post-hoc LSD analyses are presented in Table 5.3. Most (8 of 10) of the formant frequencies show significant differences across the three program/language groups; the only measurement that does not show any significant differences across the groups is F2 of /a/. It is the two-way NES group that presents the largest number of significant paired comparisons, 12 of 20 (2 comparisons per formant * 2 formants per vowel * 5 vowels = 20 comparisons), with the largest portion of these being with the two-way NSS group (7 of 10 comparisons).The one-way NES group presents fewer differences with the native speaker comparison group than the two-way NES group does, 4 compared to 7. Interestingly, the one-way NES groups exhibits more significant differences with the two-way NES group than they do with the two-way NSS group, 5 and 4 respectively. These findings point to not only differences between the NES groups and the NSS group, but also to differences between the two NES groups. In other words, the vowel productions of the one-way NES group and the two-way NES group show several differences. These differences impact how productions compare to those of NSS peers, with the two-way NES group presenting more differences with the NSS group than the one-way group does.

Table 5.3: Oneway ANOVA Results for Across Program/Language Comparisons of Formant Frequency

		One-way ANOVA Results	Significant post-hoc comparisons and p-values
/i/	**F1**	*F(2,474)=7.91, p<0.001	*one-way NES – two-way NES, p<0.001 one-way NES – two-way NSS, p=0.983 *two-way NES – two-way NSS, p<0.001
	F2	*F(2,474)=5.928, p=0.003	*one-way NES – two-way NES, p=0.007 one-way NES – two-way NSS, p=0.478 *two-way NES – two-way NSS, p=0.001
/e/	**F1**	*F(2,396)=13.270, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.817
	F2	*F(2,396)=7.902, p<0.001	*one-way NES – two-way NES, p<0.001 one-way NES – two-way NSS, p=0.962 *two-way NES – two-way NSS, p=0.001
/a/	**F1**	*F(2,511)=35.846, p<0.001	one-way NES – two-way NES, p=0.249 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
	F2	F(2,511)=4.072, p=0.018	one-way NES – two-way NES, p=0.815 one-way NES – two-way NSS, p=0.015 two-way NES – two-way NSS, p=0.012
/o/	**F1**	*F(2,469)=14.361, p<0.001	one-way NES – two-way NES, p=0.203 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
	F2	F(2,469)=2.595, p=0.076	one-way NES – two-way NES, p=0.052 one-way NES – two-way NSS, p=0.054 two-way NES – two-way NSS, p=0.920
/u/	**F1**	*F(2,233)=6.579, p=0.002	one-way NES – two-way NES, p=0.599 *one-way NES – two-way NSS, p=0.001 *two-way NES – two-way NSS, p=0.007
	F2	*F(2,233)=4.806, p=0.009	*one-way NES – two-way NES, p=0.007 one-way NES – two-way NSS, p=0.989 *two-way NES – two-way NSS, p=0.007

*significant at the p<0.01 level

Through the general observations and statistical analysis, it can be seen that the two NES learner groups show differences in their vowel productions already in first grade; these differences are primarily in the articulations of the front vowels and the high, back vowel.The two NES learner groups pattern similarly in comparison to the NSS comparison group in their F1 values of /a/, /o/, and /u/.

5.1.1.2 Comparison of Native-like and Prototypical Ratings of First Grade Groups

Another way to compare the vowel productions of the learner groups to the NSS peer group is through an examination of how many articulations fall within the range of productions of the NSS group. The formant values of each learner production were compared to the range of NSS values (within 2 standard deviations of the mean); if the frequency at which both formants was produced fell within the 2 standard deviation range of NSS frequencies, the token is considered to be native-like for this analysis. If only one of the formant values or if neither of the formants was within the range of NSS values, the token is considered to be not native-like. Table 5.4 displays the results of this binary distinction for the first grade learner groups.[57]

Table 5.4: Percentage of First Grade Native-like and not Native-like Tokens According to Vowel and Program/Language Group

	NSS Range		One-way NES		Two-way NES	
	F1	**F2**	**Native-like**	**Not Native-like**	**Native-like**	**Not Native-like**
/i/	345-629	1858-3766	95.6%	4.4%	83.9%	16.1%
/e/	456-796	1726-2998	83.8%	16.2%	86.4%	13.6%
/a/	409-1065	1040-2580	84.1%	15.9%	85%	15%
/o/	377-785	740-2012	84.4%	15.6%	87.4%	12.6%
/u/	370-674	624-1900	79.5%	20.5%	94.4%	5.6%
Average			**85.5%**	**14.5%**	**87.4%**	**12.6%**

[57] Results from the two-way NSS group are not included in Table 5.4 or any of the subsequent tables to report native-like percentages. Native speaker speech is variable, and in order to avoid placing prescriptive evaluations on the speech of native speakers, they were not included in this analysis. Statistically, only 95% of tokens fall within 2 standard deviations of the mean. Given that two measures (F1 and F2) are combined into one for the purpose of this analysis, it would be anticipated that less than 95% of all NSS productions be classified as “native-like” through this procedure. The productions that fall outside the native-like range are statistical outliers; in some cases, they may be mispronunciations (i.e., /e/ for /o/) and in others, non-prototypical articulations.

Both NES learner groups produce a relatively high percentage of native-like tokens; the two-way NES first grade group does, however, present a slightly higher relative percentage of native-like tokens than the one-way NES group, 87.42% and 85.48% respectively. The two groups also exhibit differences with the relative rankings of the five vowel phonemes; the vowels with the highest and lowest relative percentages of native-like productions are the opposite. The high, front vowel /i/ is produced within the range of native-like values most frequently by the one-way NES group (95.6%) while for the two-way NES group it presents the lowest percentage of native-like productions (83.9%). In a similar way, /u/ is the vowel to fall within the native-like range most regularly by the two-way NES (94.4%) while it is has the lowest percentage of native-like productions for the one-way NES group (79.5%). Another difference between the two NES learner groups is the variability across vowel phonemes; the one-way NES group shows slightly more variability in native-like classification than the two-way NES group. The percentages of native-like productions exhibit a range of approximately 15% for the one-way NES group in comparison to about 10% for the two-way NES group.

Given the relatively high percentages of native-like classifications across both groups and the large range of native-like values, a more detailed coding scheme was employed to determine the percentage of learner productions which fell within the sphere of most prototypical NSS values. While all productions within 2 standard deviations of the mean might be judged to be "acceptable" tokens of a specific vowel, productions within a narrower range of values would be considered to be better exemplars. For this reason, a more detailed coding scheme was employed to determine whether tokens were within 1 standard deviation of the NSS mean, 2 standard deviations of the NSS mean, or outside the native-like range of values. Each token was coded twice, once for F1 and once for F2. If formant values were within 1 standard deviation of the mean, they received a score of 2; within 2 standard deviations, a score of 1; outside 2 standard deviations, a score of 0. The sum of the two formant measurements is what is reported here in Table 5.5. A maximum of 4 points is possible for each token; a score of 4 signifies that both formants were within 1 standard deviation of the NSS mean. A score of 0 means that neither formant was within 2 standard deviations of the mean; intermediate scores of 3, 2, or 1 represent various combinations of formant scorings.

Table 5.5 : Prototypicality Scores of First Grade Productions According to Vowel and Program/Language Group

		4	**3**	**2**	**1**	**0**
One-way NES	**/i/**	39.6%	46.7%	12.6%	0.5%	0.5%
	/e/	51.9%	28.6%	15.6%	2.6%	1.3%
	/a/	45.6%	36.9%	8.2%	7.2%	2.1%
	/o/	51.4%	30.2%	11.2%	4.5%	2.8%
	/u/	50.6	25.3%	16.9%	7.2%	0%
	average	**47.8%**	**33.5%**	**12.9%**	**4.4%**	**1.3%**
Two-way NES	**/i/**	31.4%	40.9%	23.4%	3.6%	0.7%
	/e/	28.2%	41.8%	22.7%	5.5%	1.8%
	/a/	47.1%	33.3%	15.7%	3.9%	0%
	/o/	54.1%	29.6%	11.1%	3.7%	2.8%
	/u/	49.3%	26.8%	21.1%	2.8%	0%
	average	**42.0%**	**24.5%**	**18.8%**	**3.9%**	**1.1%**
Two-way NSS	**/i/**	55.1%	27.8%	12.7%	4.4%	0%
	/e/	50%	31.6%	16.2%	2.2%	0%
	/a/	45.8%	39.2%	12%	3%	0%
	/o/	51.6%	35.8%	11.3%	1.3%	0%
	/u/	52.4%	26.8%	34.1%	3.7%	0%
	average	**51.0%**	**28.6%**	**17.3%**	**2.9%**	**0%**

As is to be expected, the two-way NSS group has the highest percentage of highly prototypical productions (combined score of 4), just over 50% of all their tokens fall within 1 standard deviation of the mean for the respective vowels. The relative percentage of tokens in this same range for the two NES learner groups is less, 47.82%

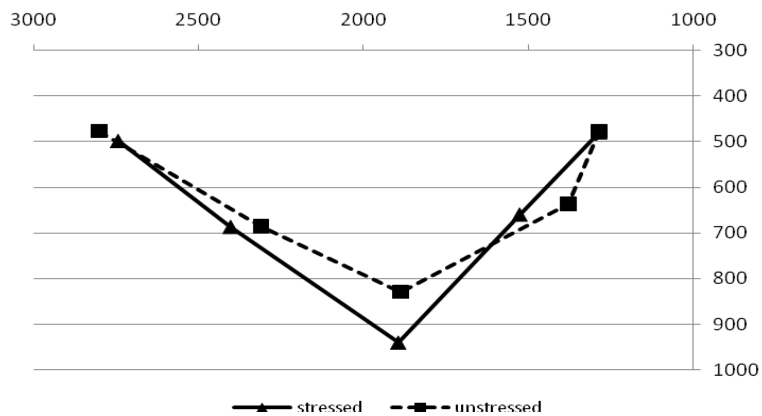
for the one-way NES group and 42.02% for the two-way NES group. This finding is in line with the statistical analyses reported earlier which revealed that more statistically significant differences existed between the two-way NES group and the two-way NSS group than between the one-way NES group and the two-way NSS group. Overall, however, both learner groups produce a large portion of the vowels within the sphere of highly prototypical tokens; a greater relative percentage of tokens achieve a rating of "4" than any other score across all groups. In spite of having a greater relative percentage of tokens with a score of 4, the one-way NES group has a higher percentage of productions with scores of 1 or 0 than the two-way NES group. This is in line with the observation made previously that greater variability is observed in the productions of one-way NES first graders compared to those of two-way NSS first graders.

As was shown in the reporting of results for the binary classification of native-like and not native-like, there are differences between the groups in the scores specific vowels earn. Of the five vowels, /i/ has the greatest relative percentage of highly prototypical productions and /a/ the least for the two-way NSS group. Neither of the two learner groups produce this same pattern. In fact, the one-way NES group goes against this pattern for /i/, as this is the vowel with the lowest percentage of tokens with a score of 4. The one-way NES first grade group has the greatest relative percentage of /e/ tokens receiving highly prototypical scores whereas /e/ has lowest percentage for the two-way NES group. The vowel with the greatest percentage of highly prototypical tokens for the two-way NES group is /o/.

5.1.1.3 Effect of Lexical Stress on Vowel Productions of First Grade Groups

Vowels in unstressed syllables have been theorized to pose a special challenge for English speakers learning Spanish as a second language (e.g., Stockwell & Bowen, 1965); for this reason they are considered as part of this analysis. Although productions in stressed syllables comprised a slightly larger portion of the analyzed sample, the percentage of tokens in tonic syllables never exceeded 53% for any one of the first grade groups. Plots of the stressed and unstressed vowel spaces for each of the three first grade program/language groups are available here in Figure 5.2-Figure 5.4; corresponding numerical data are available in Appendix J.

Figure 5.2: Formant Values of One-way NES First Graders According to Syllable Stress



All three groups of first graders tend to produce vowels in atonic syllables more to the center of the vowel space than corresponding productions in tonic syllables. This can be observed visually in the vowel charts as the unstressed vowel space regularly falls inside the stressed vowel space. The one-way NES group produces a few notable exceptions to this trend; both /i/ and /o/ in atonic syllables present formant values more to the outside of the vowel space. More specifically /i/ in atonic syllables has a lower mean

F1frequency and a higher F2 frequency, suggesting a higher, more fronted articulation in atonic syllables; /o/, on the other hand, has lower F1 and F2 values in unstressed syllables, signaling a higher, more backed articulation. These two vowels consequently do not show any signs of centralization in unstressed syllables.

Figure 5.3: Formant Values of Two-way NES First Graders According to Syllable Stress

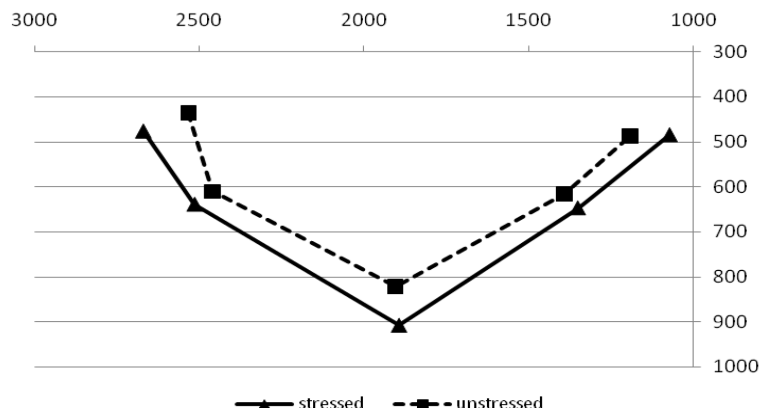
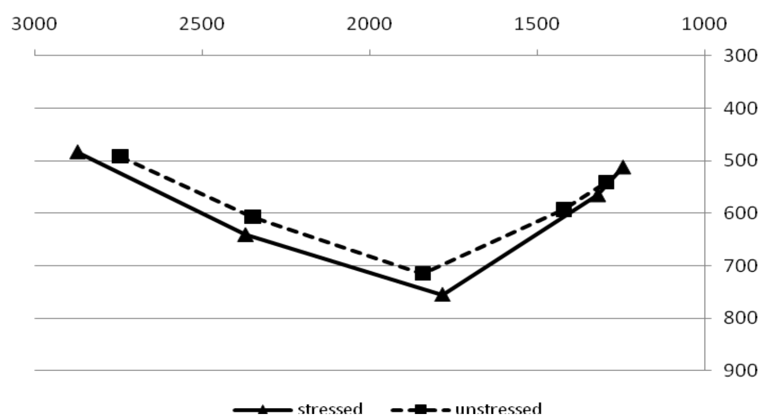


Figure 5.4: Formant Values of Two-way NSS First Graders According to Syllable Stress



Few of the differences observed reach statistical significance for the first grade groups.[58] The two-way NSS first grade group does not produce any statistically significant differences in formant values according to syllable stress; this finding indicates that the differences observed in Figure 5.4 are not at a significant level and that there is not a relationship between lexical stress and formant values for the NSS comparison group. For both of the two NES learner groups, two formant measurements show significant differences according to syllable stress. For the one-way NES group, F1 of /a/ ($t=4.407$, $p<0.001$, $df=193$) and F2 of /o/ ($t=2.837$, $p=0.005$, $df=126.844$) differ significantly according to lexical stress. While /a/ shows centralization on the high-low dimension, /o/ is not centralized in atonic syllables as it is produced "outside" its tonic counterpart. Significant differences for the two-way NES group are found for F1 values of /i/ and /a/ (/i/: $t=3.887$, $p<0.001$, $df=135$; /a/: $t=3.599$, $p<0.001$, $df=151$). Both vowels are produced with lower F1 values (suggesting a higher tongue position) in atonic syllables; this points to centralization of /a/ but not /i/, for it, like the /o/ of the one-way NES, presents a more "extreme" value in atonic syllables.

5.1.1.4 Summary of Vowel Productions of First Grade Groups

In the preceding sections, it was reported that the two-way NSS first grade group has a smaller vowel space than both the one-way NES and two-way NES first grade groups. Specifically, /a/ is produced by the two-way NSS group with significantly smaller F1 values. The NES learner groups were also found to show greater differentiation of the two back vowels, /o/ and /u/, as compared to the two-way NSS comparison group. More

[58] A series of independent samples t-tests were run to determine whether differences in formant values were significant at the $p<0.01$ level. Only the p-values of differences that reach significance are reported here and signaled in Table J.4Table J.6 in Appendix J.

significant differences were found between the formant values of the two-way NES group and those of the two-way NSS group than between the one-way NES group and the two-way NSS group.

Findings from native-like and prototypical classification analyses are not completely in line with this last finding. A greater relative percentage of tokens produced by two-way NES fall within the native-like range established by the two-way NSS group as compared to the one-way NES group; this appears to contradict the finding that two-way NES differs from two-way NSS on more measures. Once the native-like tokens are further classified according to levels of prototypicality, however, this apparent contradiction can be explained. A greater percentage of one-way NES productions fall within the range of "highly prototypical" than two-way NES productions. This suggests that although productions of two-way NES more regularly fall within the range of native-like productions, fewer of them are located closer to the center of this range, which could explain why statistical analyses point to significant differences between formant measurements of the two two-way groups.

Finally, it was shown that vowels are not produced with significant differences in formant values by the two-way NSS first grade group between stressed and unstressed syllables, but that NES learner groups do show some differentiation according to syllable stress. Few differences – only two for each program/language group – reach statistical significance, however. Both NES learner groups reveal a tendency to centralize /a/ on the high-low dimension.

5.1.2 Vowel Productions of Third Grade Groups

5.1.2.1 Formant Values of Third Grade Groups

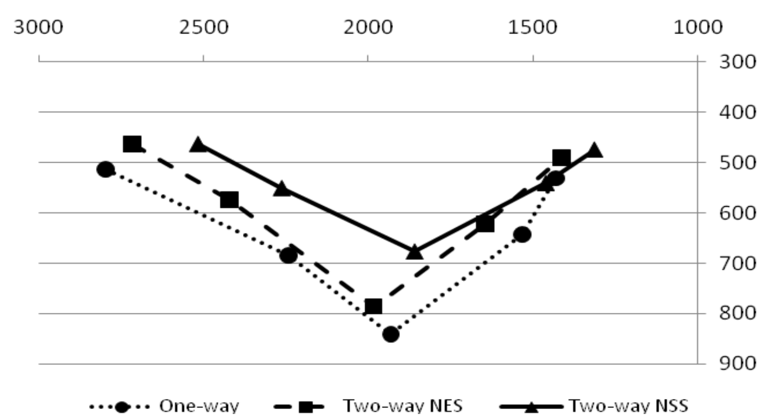
The twenty-six third graders – 9 one-way NES, 8 two-way NES, and 9 two-way NSS – to participate in this study produced 2107 vowels for analysis. Table 5.6 displays mean formant values, the 2 standard deviation ranges, and standard deviations for each vowel according to program/language group. Mean formant values are also plotted in a combined vowel chart in Figure 5.5; individual vowel charts for each program are available in Figure K.1, Figure K.2, and Figure K.3 in Appendix K. Results of statistical tests to compare F1 and F2 values across program/language groups are presented in Table 5.7.

There are several differences in the vowel productions of the Spanish vowels by the three third grade program/language groups as seen in Table 5.6 and Figure 5.5. First, the amount of space occupied on the F1 dimension is less for the two-way NSS group than the two NES groups. The high vowels show similar mean F1 values across the groups, but the mean F1 values of the low vowel /a/ are quite different. While the mean F1 values of /a/ for the two NES groups are on either side of 800, the mean F1 frequency for the native speaker comparison group is less than 700; this difference effectively shrinks the amount of high-low space taken up.

Table 5.6 : Third Grade Formant Values According to Program/Language Group

			One-way NES	**Two-way NES**	**Two-way NSS**
/i/	**F1**	**mean**	514	463	434
		range	360-668	153-1236	334-534
		s.d.	77	155	50
	F2	**mean**	2773	2716	2522
		range	1867-3679	2050-3382	1506-3538
		s.d.	453	333	508
/e/	**F1**	**mean**	686	574	551
		range	438-934	388-760	381-721
		s.d.	124	93	85
	F2	**mean**	2363	2421	2263
		range	1853-2873	1997-2845	1753-2773
		s.d.	255	212	255
/a/	**F1**	**mean**	887	786	676
		range	519-1255	402-1170	378-974
		s.d.	184	192	149
	F2	**mean**	1890	1983	1860
		range	1316-2464	1231-2735	1382-2338
		s.d.	287	376	239
/o/	**F1**	**mean**	647	622	541
		range	403-891	282-962	375-707
		s.d.	122	170	83
	F2	**mean**	1433	1644	1462
		range	755-2111	682-2606	838-2086
		s.d.	339	481	312
/u/	**F1**	**mean**	479	490	475
		range	293-665	362-618	349-601
		s.d.	93	64	63
	F2	**mean**	1262	1413	1315
		range	704-1820	703-2123	711-1919
		s.d.	279	355	302

Figure 5.5 : Third Grade Formant Values According to Program/Language Group



Second, there are differences in F2 values of the non-back vowels. The two NES groups produce /i/, /e/, and /a/ with greater mean F2 values than the two-way NSS peer group. The effect of this difference is that these vowels are more fronted and the vowel space is consequently more expanded on the F2 dimension for the two NES learner groups. Despite the differences in mean formant values there is considerable overlap in the range of frequencies at which the F2 are produced by these three groups. For example, mean F2 values of /i/ show a difference of greater than 200 Hz between the two NES groups and the two-way NSS group. Because of the relatively large degree of variability in these productions (as measured by standard deviation), the productions do overlap. F2 values of one-way NES and two-way NSS overlap between 1867 and 3538 Hz while the entire range of of two-way NES F2 values are encompassed within that of the two-way NSS group.

Third, the mean formant frequencies of the two-way NSS group for the two back vowels are very close together in the acoustic vowel space, much closer than those of the two NES groups. In fact, differences in F1 values of these two vowels as produced by the two-way NSS group are non-significant (p=0.02) in a post-hoc LSD test. Both vowels also have lower mean F1 values for the NSS group than the corresponding articulations of the NES groups. As a result of these two tendencies, the two-way NSS mean formant values of /o/ and /u/ occupy the same portion of the vowel space as the NES groups' /u/. This is particularly noticeable when the 2 standard deviation range of values is considered. The space occupied by /o/ productions of the two-way NSS group occupies a sizeable portion of the /u/ space of the NES groups on both F1 and F2 dimensions. More specifically, NSS F1 values of /u/ demonstrate overlap with one-way NES F1 values of

/o/ between 375 and 665 Hz, all but approximately 100 Hz of the range of one-way NES values. Similarly, two-way NSS F2 values of /u/ coincide with those of two-way NES of /o/ between 838 and 2086 Hz, again the vast majority of the NES range of values. This overlap could imply that learner productions of /o/ would be confused for /u/; however, without a percerptual study of the learner vowel productions, this cannot be verified.

While the vowel spaces of the two NES learner groups resemble one another in both shape and location, there are differences on both dimensions. The one-way NES group produces each of the five vowels with larger mean F1 values. In addition, their articulations of the front vowels have greater mean F2 values, and their pronunciations of the non-front vowels have smaller mean F2 values. The effect of this is that the vowel space of the two-way NES group falls inside that of the one-way NES group, and generally, the productions of the two-way NES group fall between those of the one-way NES group and the two-way NSS group. Consequently, the productions of the two-way NES appear to more closely approximate those of the two-way NSS group.

Table 5.7 : Oneway ANOVA Results Summary for Third Grade Across Program/Language Comparisons of Formant Frequency

		One-way ANOVA Results	**Significant post-hoc comparisons and p-values**
/i/	**F1**	F(2,469)=2.5, p=0.083	one-way NES – two-way NES, p=0.058 one-way NES – two-way NSS, p=0.057 two-way NES – two-way NSS, p=0.983
	F2	*F(2,469)=18.061, p<0.001	one-way NES – two-way NES, p=0.1 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
/e/	**F1**	*F(2,410)=73.244, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.067
	F2	*F(2,410)=22.656, p<0.001	*one-way NES – two-way NES, p<0.001 one-way NES – two-way NSS, p=0.438 *two-way NES – two-way NSS, p<0.001
/a/	**F1**	*F(2,502)=41.791, p<0.001	*one-way NES – two-way NES, p=0.003 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001

	F2	*F(2,502)=7.365, p=0.001	one-way NES – two-way NES, p=0.102 one-way NES – two-way NSS, p=0.023 *two-way NES – two-way NSS, p<0.001
/o/	**F1**	*F(2,464)=26.827, p<0.001	one-way NES – two-way NES, p=0.144 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
	F2	*F(2,454)=7.816, p<0.001	one-way NES – two-way NES, p=0.013 one-way NES – two-way NSS, p=0.108 *two-way NES – two-way NSS, p<0.001
/u/	**F1**	*F(2,257)=13.869, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.217
	F2	F(2,257)=2.967, p=0.053	one-way NES – two-way NES, p=0.732 one-way NES – two-way NSS, p=0.022 two-way NES – two-way NSS, p=0.063

*significant at the p<0.01 level

Findings from one ANOVA and post-hoc LSD paired comparison statistical tests validate these observations in part. Differences in formant frequency are significant across the three program/language groups for 8 of the 10 formant measurements; there are not significant differences in F1 values of /i/ or F2 values of /u/. The number of significant post-hoc paired comparisons is approximately equal across the three groups. The two-way NES group and two-way NSS group differ on 6 measures whereas there are only 5 significant differences between the one-way NES group and each of the other two-way groups. The fact that there are roughly equal numbers of significant differences and that the paired differences which reach significance occur with different measurements suggests that the three groups produce vowels in somewhat distinct ways.

5.1.2.2 Comparison of Native-like and Prototypical Ratings of Third Grade Groups

Another way of comparing learner productions to those of native speakers is to examine whether the productions of learners fall within the range of values produced by native speaker peers. In Table 5.8, the relative percentage of learner tokens to fall within two standard deviations of the two-way NSS group mean is presented according to vowel.

Table 5.8 : Percentage of Third Grade Native-like and Not Native-like Tokens According to Vowel and Program/Language Group

	NSS Range		One-way NES		Two-way NES	
	F1	**F2**	**Native-like**	**Not Native-like**	**Native-like**	**Not Native-like**
/i/	334-534	1506-3538	69.5%	30.5%	83.2%	16.8%
/e/	381-721	1753-2773	59.1%	40.9%	88.9%	11.1%
/a/	378-974	1382-2338	72.6%	27.4%	75.2%	24.8%
/o/	375-707	838-2086	67.6%	32.4%	74.6%	25.4%
/u/	349-601	711-1919	84.8%	15.2%	90%	10%
Average			**70.7%**	**29.3%**	**82.4%**	**17.6%**

Across all five vowels, the two-way NES group produces a higher percentage within the native speaker range than the one-way NES group; this is evident in comparisons of each individual vowel as well as the average across vowels. On average, the two-way NES group produces 12% more tokens in the native speaker range of values than the one-way NES group. When comparing individual percentages for individual vowels, the percentages vary considerably; while a difference of only 2.6% separates the two groups on /a/, the difference in percentage of native-like productions of /e/ is 29.8%.

One commonality across the two learner groups is the vowel with the highest relative percentage of native-like productions: /u/; one-way NES third graders produce /u/ in the range of native speaker values approximately 85% of the time while two-way NES third grader produce it with native-like values in 90% of the instances. This suggests that learner productions of /u/ resemble those of the NSS group. The two groups differ with respect to the vowel with the lowest percentage of native-like articulations; /e/ is the lowest for the one-way NES group at 59.1% while /a/ is the lowest for the two-way NES group at 75.2%.

Within the relatively large range of values identified as native-like, there is a more narrow range within which the most prototypical exemplars are located. Each token was assigned a prototypicality score based on whether each formant measurement fell within one standard deviation of the NSS mean, two standard deviations, or outside two standard deviations. The highest prototypicality score, 4, reflects both F1 and F2 being within 1 standard deviation of the NSS mean; the lowest rating, 0, signifies that both formants fell outside the 2 standard deviation range. Scores according to vowel and program/language group are presented for the third grade groups in Table 5.9.

The native speaker group produces the highest percentage of tokens with highly prototypical ratings; more than 80% of all tokens produced by the two-way NSS group achieved ratings of 4 or 3. Of the two learner groups, the two-way NES group has a greater percentage of tokens with scores of 4 or 3 than the one-way NES group, 75.7% versus 61.3%. This indicates that more of the vowels produced by the two-way NES group have formants at frequencies that would make them good exemplars of Spanish vowels.

There are differences across the groups as to which vowels have the highest prototypicality score. For the two-way NSS group, /o/ has the highest percentage of tokens with a rating of 4; the two-way NES group produces /e/ with the highest percentage of tokens with a score of 4. This particular vowel, /e/, has the lowest percentage of highly prototypical tokens as produced by the one-way NES, signaling a difference in the two learner groups. The one-way NES group exhibits relatively low percentages of /i/ and /e/ with ratings of 4, particularly when the relative percentages are compared to the other vowels; of the five vowels, the combined percentage of tokens with ratings of 4 and 3 are lower for these two vowels than the others. The one-way NES group is most successful with /u/; of the five vowels, it is this vowel that has the highest percentage of tokens with scores of 4 and 3. Nearly 75% of all /u/ tokens produced by this group fall near to the center of the sphere of native speaker productions, compared to 54.3% for /i/ and only 50.6% for /e/.

Table 5.9 : Prototypicality Scores of Third Grade Productions According to Vowel and Program/Language Group

		4	**3**	**2**	**1**	**0**
One-way NES	**/i/**	24.9%	29.4%	32.2%	13.6%	0%
	/e/	18.8%	31.8%	40.3%	9.1%	0%
	/a/	30.7%	35.2%	23.5%	7.3%	3.4%
	/o/	32.9%	28.3%	27.7%	7.5%	3.5%
	/u/	35.4%	39.4%	17.2%	3%	5.1%
	average	**28.5%**	**32.8%**	**28.2%**	**8.1%**	**2.4%**
Two-way NES	**/i/**	41.3%	35%	20.3%	3.5%	0%
	/e/	47.4%	37%	11.1%	3.7%	0.7%
	/a/	32%	36.6%	21.6%	5.9%	3.9%
	/o/	31%	38%	18.3%	7.7%	4.9%
	/u/	46.3%	33.8%	16.3%	3.8%	0%
	average	**39.6%**	**36.1%**	**17.5%**	**4.9%**	**1.9%**
Two-way NSS	**/i/**	41.4%	40.1%	16.4%	2%	0%
	/e/	42.7%	43.5%	12.9%	0.9%	0%
	/a/	42.8%	45.1%	10.4%	1.7%	0%
	/o/	47.9%	43.7%	5.6%	2.8%	0%
	/u/	35.8%	49.4%	13.6%	0%	1.2%
	average	**42.1%**	**44.4%**	**11.8%**	**1.5%**	**0.2%**

The groups also differ with respect to which vowel most frequently receives a score of 0. Very few of the productions of the two-way NSS group, less than 2%, receive scores of 1 or 0; the learner groups produce a higher percentage of tokens that fall outside the range of prototypical vowels. Interestingly, the vowel with the greatest relative percentage of 0 tokens for the one-way NES group is /u/, the same vowel that had the highest percentage of prototypical tokens. This apparent contradiction indicates some inconsistency on the part of this learner group with this particular vowel. The two-way NES group produces approximately 12% of /o/ tokens outside the prototypical range of values (scores of 1 or 0). Although /o/ is not the vowel with the highest percentage of 0 ratings for the one-way NES group, approximately 10% of /o/ tokens merit scores of either 1 or 0. Together the findings from the two learner groups point to some level of struggle with the back vowels as these show high levels of non-prototypical productions across the two groups.

5.1.2.3 Effect of Lexical Stress on Vowel Productions of Third Grade Groups

In light of the presence of different phonetic and phonological processes to affect unstressed vowels in Spanish and English (see Stockwell & Bowen, 1965 or Cobb, 2009 for more complete discussions of this), it is important to look at any differences in vowel productions that occur between tonic and atonic syllables. The third grade sample is comprised of roughly equal numbers of stressed and unstressed vowels, 53% and 47% respectively. Mean formant measurements and standard deviations are presented in numeric format for each program/language group in Appendix K. Here, in Figure 5.6 - Figure 5.8, the stressed and unstressed productions of each vowel are plotted for each of the third grade groups.

Figure 5.6 : Formant Values of One-way NES Third Graders According to Syllable Stress

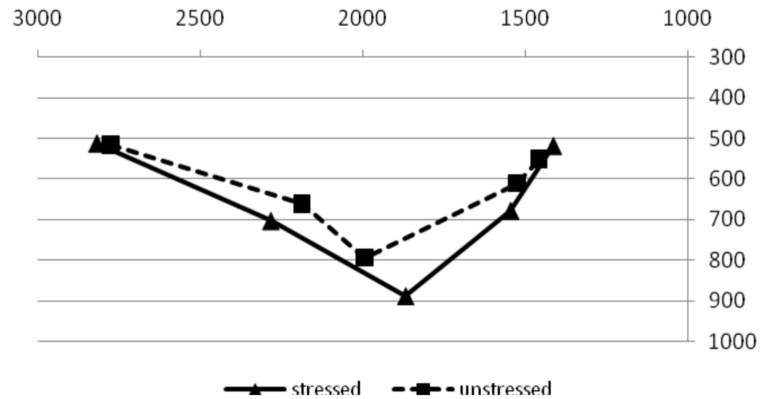


Figure 5.7 : Formant Values of Two-way NES Third Graders According to Syllable Stress

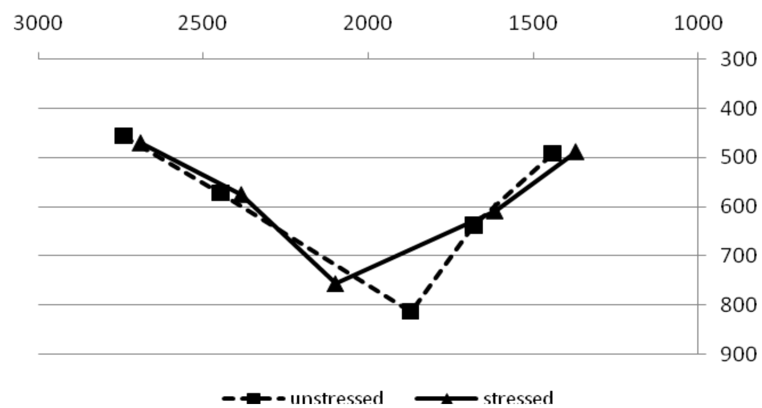
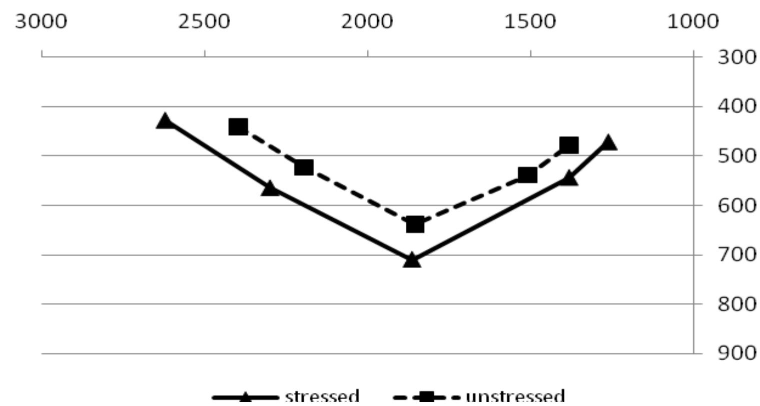


Figure 5.8: Formant Values of Two-way NSS Third Graders According to Syllable Stress



Across the three program/language groups, a majority of productions of unstressed vowels fall more to the center of the vowel space than the corresponding stressed vowel. The two-way NSS group best exemplifies this trend as the entire unstressed vowel space is encompassed by the stressed vowel space as seen in Figure 5.8. The two-way NES group is the group to conform least to this trend as formant measurements for both back vowels situate atonic productions more to the outside of the vowel space than the equivalent tonic productions. Moreover, although atonic /a/ is produced by this group of learners with a lower F1 value (consistent with unstressed vowel centralization), it also has a higher F2 frequency, which is not in line with centralization of unstressed vowels. This is true of /a/ as produced by the one-way NES group as well. So although there is a tendency for vowels produced in unstressed syllables to fall toward the center of the vowel space, it does not hold in all instances.

A series of t-tests were run to examine the significance of observed differences between stressed and unstressed productions. The one-way NES third grade group and the two-way NSS group produce the same number of statistically significant differences.

The two-way NES group produces fewer significant differences in stressed and unstressed vowels, only one, F2 of /a/. The significant differences of the one-way NES group and the two-way NSS group coincide only on F1 of /a/; while the NSS group also exhibits difference in F2 values of /i/ and F1 values of /e/ according to lexical stress, the one-way, NES group presents differences in F2 values of /a/ and F1 values of /o/.

All groups evidence difference in formant frequency for /a/ according to syllable stress, but the particular formant affected is not consistent across the three groups. In addition, the two-way NES group shows less of an effect of stress than either of the other two groups.

5.1.2.4 Summary of Vowel Productions of Third Grade Groups

Through an examination of mean formant values and the acoustic vowel space of each group, it was found that the vowel space of the two-way NSS group is smaller than that of the NES learner groups. The larger size of the learner vowel spaces occurs on both dimensions as the mean F1 values of /a/ for the two NES groups are greater as are the F2 values of the non-back vowels. When the productions of each learner group were compared to the NSS group separately, the two-way NES group evidenced more significant differences, suggesting that their vowel productions differ more from those of native speakers than the productions of one-way NES learner do at the third grade level. In spite of a greater number of significant differences in formant values, the two-way NES group exhibits higher percentages of native-like and highly prototypical vowel tokens. This suggests that the productions of one-way learners are more variable, falling more to the periphery of the NSS vowel space than the productions of the two-way NES group.

The one-way NES group appears to particularly struggle to produce front vowels, /i/ and /e/, in a native and/or prototypical way. These two vowels present low native-like and prototypicality ratings and they both demonstrate significant differences for one of the formant values. The back vowels, /o/ and /u/, also appear to pose a challenge for the two learner groups as evidenced by low prototypicality ratings. This challenge could be a result of the learner groups attempting to maintain a distinction between the vowels, on both the F1 and F2 dimensions, whereas the native speaker group does not. As was seen in Figure K.3 and through the statistical analyses presented in Table K.3 in Appendix K, only the F2 values of /o/ and /u/ are significantly different, F1 values are not. Formant values of the NES learner groups tend to differ significantly from the NSS group on only one of the dimensions for each vowel, this difference appears to be enough to position a higher percentage of tokens of /o/ and /u/ outside prototypical range (but still inside the native-like range).

Vowel productions of all three groups register some effect of lexical stress; however, few of the differences reach statistical significance. The one-way NES group patterns more like the two-way NSS comparison group with respect to number of significant differences in formant values according to syllable stress, but with the exception of one, F1 values of /a/, these differences occur on different formant measures. The two-way NES group only presents one significant difference in formant frequency according to syllable stress, F1 of /a/. The effect of stress on F1 of /a/, common to all three program/language groups, could explain the similar native-like and prototypicality scores for the two NES groups for this vowel. The native-like or prototypicality scores of the two-way NES do not appear to be negatively impacted by the differing effects of stress as compared to the two-way NSS group.

5.1.3 Vowel Productions of Fifth Grade Groups

5.1.3.1 Formant Values of Fifth Grade Groups

The fifth grade groups produced 1636 tokens for analysis; the distribution of the tokens across the three language/program groups is not equal however. Because there were only three two-way NES fifth grade participants, fewer tokens make up their sample. In Table 5.10, mean formant values, the two standard deviation range, and standard deviation values for each vowel are presented according to program/language group for each vowel. Figure 5.9 depicts these data graphically in the form of a vowel chart. Individual vowel charts and statistical analyses of formant frequencies across vowels for each program/language participant group are available in Appendix L.

From the vowel charts plotted in Figure 5.9, it becomes evident that the two two-way immersion groups produce vowels that occupy a similar portion of the acoustic vowel space. In comparison to the one-way NES group, their respective vowel spaces are smaller on the F1 dimension. The mean F1 values of the two two-way groups for all the vowels is lower than the corresponding mean of the one-way NES group, but it is particularly noteworthy for /a/ in that the difference is approximately 200 Hz. With respect to mean F2 values, these two groups tend to produce vowels with lower F2 frequencies. Although the two-way groups demonstrate some common differences with respect to the one-way NES group, they are not identical. The mean F2 value for each of the vowels, with the exception of /u/, is greater in the articulations of the two-way NES group; the greatest difference is in the production of /i/. Also the two back vowels of the two-way NES group are located further apart in the acoustic space than the corresponding vowels as produced by the NSS group, which are located in close proximity to one another. F2 frequencies of these two vowels, /o/ and /u/, do not differ at a statistically significant level (p=0.18).

Table 5.10 : Fifth Grade Formant Values According to Program/Language Group

			One-way NES	Two-way NES	Two-way NSS
/i/	F1	mean	504	434	419
		range	288-614	282-586	325-513
		s.d.	108	76	47
	F2	mean	2690	2626	2286
		range	1822-3126	1744-3508	1408-3164
		s.d.	434	441	439
/e/	F1	mean	671	553	560
		range	455-781	417-689	366-754
		s.d.	108	68	97
	F2	mean	2224	2225	2132
		range	1696-2490	1783-2667	1690-2574
		s.d.	264	221	221
/a/	F1	mean	886	721	708
		range	612-1025	443-999	384-1032
		s.d.	137	139	162
	F2	mean	1866	1717	1688
		range	1364-2119	1159-2275	1102-2274
		s.d.	251	279	293
/o/	F1	mean	658	579	520
		range	432-773	359-799	346-694
		s.d.	113	110	87
	F2	mean	1456	1431	1299
		range	680-1846	615-2247	795-1803
		s.d.	388	408	252
/u/	F1	mean	482	424	462
		range	336-557	318-530	344-580
		s.d.	73	53	59
	F2	mean	1400	1186	1237
		range	894-1655	518-1854	673-1801
		s.d.	253	334	282

Figure 5.9 : Fifth Grade Formant Values According to Program/Language Group

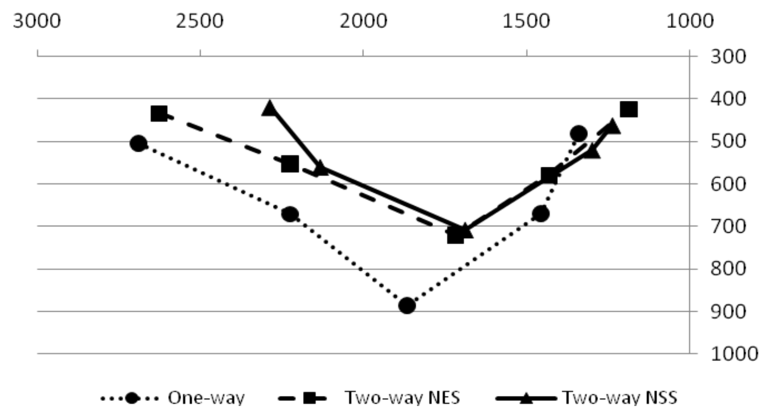


Table 5.11 : Oneway ANOVA Results Summary for Fifth Grade Across Program Comparisons for Formant Frequency

		One-way ANOVA Results	Significant post-hoc comparisons and p-values
/i/	**F1**	*F(2,371)=44.291, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.189
	F2	*F(2,371)=34.825, p<0.001	one-way NES – two-way NES, p=0.294 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
/e/	**F1**	*F(2,312)=52.037, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.611
	F2	*F(2,312)=5.569, p=0.004	one-way NES – two-way NES, p=0.96 *one-way NES – two-way NSS, p=0.003 two-way NES – two-way NSS, p=0.011
/a/	**F1**	*F(2,389)=65.699, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.519
	F2	*F(2,389)=18.149, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.455
/o/	**F1**	*F(2,355)=66, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
	F2	*F(2,355)=7.992, p<0.001	one-way NES – two-way NES, p=0.624 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.011
/u/	**F1**	*F(2,194)=11.497, p<0.001	*one-way NES – two-way NES, p<0.001 one-way NES – two-way NSS, p=0.061 *two-way NES – two-way NSS, p=0.002
	F2	*F(2,194)=10.399, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.349

*significant at the p<0.01 level

Results of statistical tests, presented in Table 5.11, confirm that there are differences in the formant frequencies across groups and that the productions of the two-way NES group more closely resemble those of the NSS control group. Differences in all of the formant measurements reach statistical significance when the three groups are considered; the majority of these differences, however, result from significant paired differences between each of the two-way groups and the one-way NES group. The one-way NES group differs from the two-way NES group on 7 of the 10 measures and from the two-way NSS group on 9 of the 10. The number of significant differences between the one-way NES group and the two-way group are more than double the number of significant differences that exist between the two-way NES group and the two-way NSS group.

5.1.3.2 Comparison of Native-like and Prototypical Ratings of Fifth Grade Groups

Each learner token was coded as either native-like or not native-like depending upon whether both formants frequencies fell within the two standard deviation range of native speakers or not. The relative percentage of tokens to be classified as native-like and not native-like are presented according to vowel and program/language group in Table 5.12 for the one-way NES and two-way NES fifth grade groups.

The percentage of native-like tokens produced is higher for the two-way NES group than the one-way NES group; this is true for both the average percentage and the respective percentages for each vowel. The same two vowels show the highest percentages of native-like productions for the two learner groups, /a/ and /u/. The two groups differ, however, with respect to which vowel presents the lowest percentage of native-like productions; the one-way NES group produce /i/ in a native-like way least frequently while the two-way NES group produces /o/ with the lowest percentage of native-like tokens. A similar trend is presented by prototypicality scores of the fifth grade groups, which are displayed in Table 5.13.

Table 5.12: Percentage of Fifth Grade Native-like and Not Native-like Tokens According to Vowel and Program/lNaguage Group

	NSS Range		One-way NES		Two-way NES	
	F1	**F2**	**Native-like**	**Not Native-like**	**Native-like**	**Not Native-like**
/i/	325-513	1408-3164	61.8%	38.2%	82.7%	17.3%
/e/	366-754	1690-2574	73.6%	26.4%	92.3%	7.7%
/a/	384-1032	1102-2274	84.4%	15.6%	96.1%	3.9%
/o/	346-694	795-1803	64.7%	35.3%	73.1%	26.9%
/u/	344-580	673-1801	90.5%	9.5%	95.2%	4.8%
Average			**75%**	**25%**	**87.9%**	**12.1%**

Table 5.13 : Prototypicality Scores of Fifth Grade Productions According to Vowel and Program/Language Group

		4	3	2	1	0
One-way NES	**/i/**	23.7%	26.3%	27.6%	14.5%	7.9%
	/e/	30.2%	31.8%	29.5%	7%	1.6%
	/a/	34.4%	38.1%	19.4%	7.5%	0.6%
	/o/	21.6%	39.2%	22.9%	7.8%	8.5%
	/u/	59.5%	23.8%	9.5%	7.1%	0%
	average	**33.9%**	**31.8%**	**21.8%**	**8.8%**	**3.7%**
Two-way NES	**/i/**	28%	46.7%	14.7%	8%	2.7%
	/e/	56.9%	32.3%	7.7%	3.1%	0%
	/a/	64.5%	25%	7.9%	2.6%	0%
	/o/	43.3%	26.9%	17.9%	4.5%	7.5%
	/u/	35.7%	52.4%	11.9%	0%	0%
	average	**45.7%**	**36.6%**	**12%**	**3.6%**	**2%**
Two-way NSS	**/i/**	42.9%	41.5%	15%	0.7%	0%
	/e/	52.9%	28.9%	14%	3.3%	0.8%
	/a/	51.9%	39.1%	4.5%	4.5%	0%
	/o/	47.8%	38.4%	10.1%	3.6%	0%
	/u/	49.3%	38%	11.3%	0%	1.4%
	average	**49%**	**37.2%**	**11%**	**2.4%**	**0.4%**

The percentage of tokens with prototypical scores of either 4 or 3 is higher for the two-way NES group than the one-way NES group, 82.3% and 65.7% respectively. The percentage of highly prototypical tokens produced by the two-way NES group is only slightly less than that of the two-way NSS comparison group, 86.2%. The other way to consider these trends is through an examination of the relative percentage of tokens with scores of 2, 1, or 0, which represent less prototypical or non-prototypical productions; the percentage of tokens produced by the one-way NES group that fall on this end of the continuum is higher than that of the two-way NES group and two-way NSS group.

Of the five vowels, the two high vowels, /i/ and /u/, appear to present the highest degree of difficulty for the one-way NES group as they have low relative percentages of tokens classified as 4 and a comparatively high percentage of tokens with scores of 1 or 0. A similar trend does not hold for the two-way NES group. For this learner group, the vowel which appears to pose the greatest challenge is /i/; however, the severity of this challenge does not appear to be as great. For although it has the lowest percentage of tokens with a score of 4, the percentage of tokens with a rating of 3 is high. Moreover, approximately 10% of /i/ tokens have scores of 1 or 0, a percentage less than that of /o/. The native speaker group shows some variation across vowels, but the amount of variation is less than that presented by the learner groups.

5.1.3.3 Effect of Lexical Stress on Vowel Productions of Fifth Grade Groups

In this section, how formant values vary according to the lexical stress of the syllable is considered. Vowel charts for each program/language group are included within this section as Figure 5.10, Figure 5.11, and Figure 5.12; mean formant values according to syllable stress are plotted in these vowel charts. Numerical data with statistically significant differences signaled are available in Table L.4 - Table L.6 in Appendix L.

Figure 5.10 : Formant Values of One-way NES Fifth Graders According to Syllable Stress

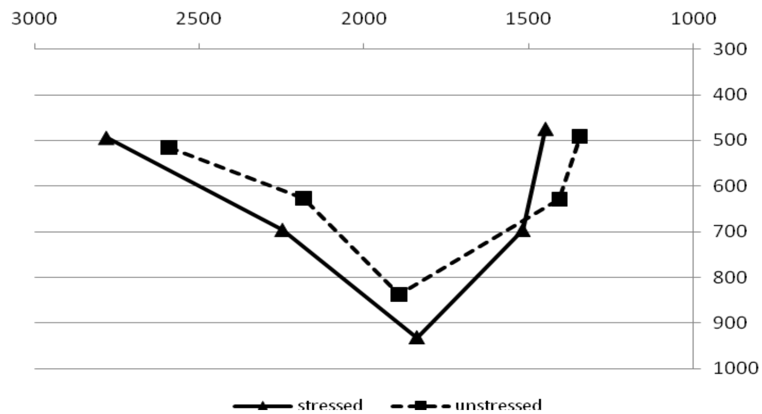


Figure 5.11 : Formant Values of Two-way NES Fifth Graders According to Syllable Stress

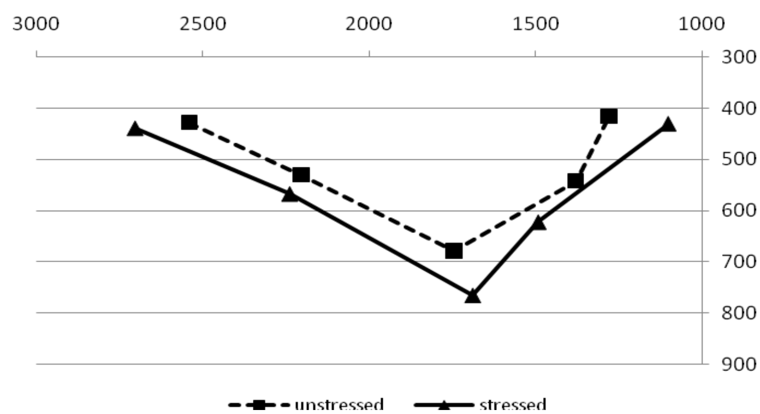
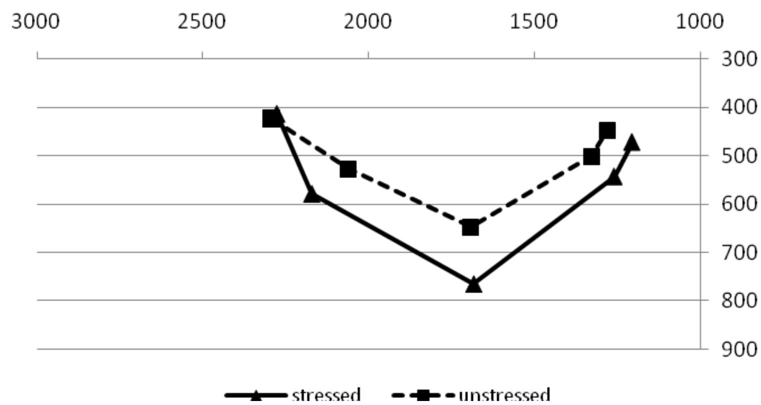


Figure 5.12: Formant Values of Two-way NSS Fifth Graders According to Syllable Stress



With the exception of the back vowels for the one-way NES group and /i/ for the two-way NSS group, mean formant values of vowels in unstressed syllables fall inside the space delimited by vowels in stressed syllables. Of the three program/language groups, the two-way NSS group produces the greatest number of significant differences according to lexical stress; both /e/ and /a/ have statistically different F1 and F2 values for stressed and unstressed syllables (/e/ F1 t=2.841, p=0.005, df=119; /e/ F2 t=2.72, p=0.008, df=119; /a/ F1: t=4.813, p<0.001, df=154; /a/ F2: t=7.035, p<0.001, df=154) while /o/ shows differences only in F1 values (t=2.852, p=0.005, df=136). One-way NES fifth grade students produce significant differences on four formant measurements; three of the four coincide with differences observed for the two-way NSS group: F1 of /e/ (t=3.591, p<0.001, df=127)), F1 of /a/ (t=4.604, p<0.001, df=158), and F1 of /o/ (t=4.501, p<0.001, df=151). The fourth significant difference is found in F2 values of /i/ (2.775, p=0.006, df=150). The two-way NES fifth grade group produces only two significant differences, but both correspond to differences in the two-way NSS comparison group: F1 of /a/ (t=2.825, p=0.006, df=74) and /o/ (t=3.188, p=0.002, df=65). These findings indicate that it is the one-way NES group that more closely approximates the two-way NSS group with respect to the allophonic process of unstressed vowel reduction.

5.1.3.4 Summary of Findings of Fifth Grade Groups

Taken altogether, the findings presented in this section indicate that the vowel productions of the two-way NES group more closely approximate those of the two-way NSS comparison group than those of the one-way NES group do. More specifically, the vowel spaces of the two two-way groups resemble one another in size, shape, and location in the acoustic vowel space. These similarities are reflected in a smaller number of significant differences in formant values; the two-way NES group differs from the two-way NSS group on 3 formant measurements whereas the one-way NES group differs from the native speaker comparison group on 8 formant measurements.

In a similar way, the two-way NES group exhibits higher relative percentages of native-like tokens and highly prototypical tokens. The one-way NES group demonstrates considerable variability across vowels with respect to relative percentage of native-like tokens and prototypicality scores. The two high vowels, /i/ and /u/, appear to pose a particular challenge to this learner group as evident in the particularly low prototypicality scores and three of the four formant comparisons reaching statistical significance. The one-way NES group does resemble the two-way NSS group with respect to the effect of lexical stress on vowel productions as both groups exhibit differences in F1 frequencies of /e/, /a/, and /o/. Findings related to the two-way NES group must be interpreted with caution, however, as only 4 students comprised this participant group.

5.1.4 Vowel Productions of Seventh Grade Groups

5.1.4.1 Formant Values of Seventh Grade Groups

The 17 seventh grade participants produced 1317 vowel tokens for analysis. The distribution of these tokens across the three groups is unequal given that only 3 individuals comprised the two-way NES group. The mean, 2 standard deviation range, and standard deviation of each formant measurement are presented according to vowel for each program/language group in Table 5.14. The mean formant values of each group are plotted in Figure 5.13 to facilitate comparison of the location of each vowel phone and the shape of the vowel space. Individual vowel plots and results of oneway ANOVA tests to compare formant frequencies across vowels are presented in Figure M.1- Figure M.3 and Table M.1 - Table M.3 in Appendix M.

Figure 5.13: Seventh Grade Formant Values According to Program/Language Group

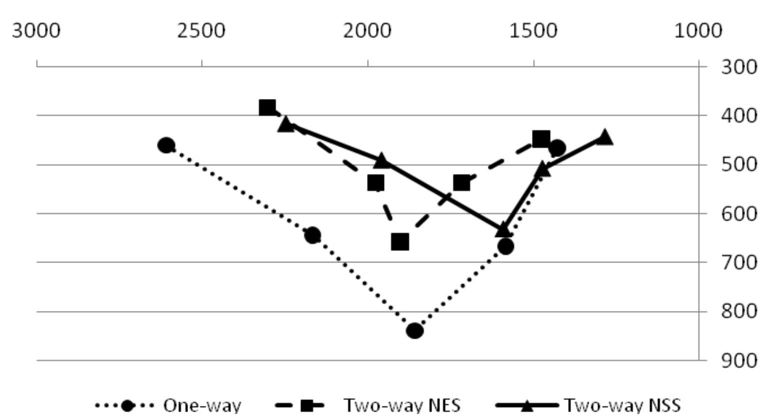


Table 5.14: Seventh Grade Formant Values According to Program/Language Group

			One-way NES	Two-way NES	Two-way NSS
/i/	F1	mean	460	383	416
		range	298-543	217-549	300-532
		s.d.	81	83	58
	F2	mean	2608	2303	2248
		range	2014-2907	1735-2871	1550-2946
		s.d.	297	284	349
/e/	F1	mean	644	537	491
		range	490-723	419-655	357-625
		s.d.	77	59	67
	F2	mean	2166	1976	1959
		range	1704-2399	1472-2480	1571-2347
		s.d.	231	252	194
/a/	F1	mean	839	657	632
		range	581-970	449-865	334-930
		s.d.	129	104	149
	F2	mean	1859	1902	1591
		range	1363-2109	1300-2504	1181-2001
		s.d.	248	301	205
/o/	F1	mean	663	537	508
		range	429-782	393-681	294-722
		s.d.	117	72	107
	F2	mean	1584	1717	1473
		range	820-1968	867-2567	733-2213
		s.d.	382	425	370
/u/	F1	mean	465	448	443
		range	349-525	310-586	337-549
		s.d.	58	69	53
	F2	mean	1428	1477	1284
		range	990-1649	1021-1933	662-1906
		s.d.	219	228	311

The shape of each group's vowel space is similar in that the mid vowels fall slightly more to the center of the vowel triangle causing a bend in the sides; however, the size and location of each differs. First, the vowel space of the one-way NES group is much expanded in comparison to those of the two two-way groups; it occupies more space on both the F1 and F2 dimension. The difference between the mean formant values of the one-way NES group and each of the two-way groups is greatest for /a/ on the F1 dimension and /i/ on the F2 dimension. The smallest differences are in the mean formant values of /u/. Second, despite greater similarity in size, shape, and location between the two-way NES group and two-way NSS group, the two-way NES group still exhibits some differences from this native speaker peer group. The most noticeable difference is that all vowels as produced by the two-way NES group have greater mean F2 values. For some vowels, the difference is relatively small, but for others such as /a/ and /o/, the difference is much larger.

Table 5.15: Oneway ANOVA Results Summary for Seventh Grade Across Program/Language Comparisons of Formant Frequency

		One-way ANOVA Results	**Significant post-hoc comparisons and p-values**
/i/	**F1**	*F(2,295)=22.993, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.012
	F2	*F(2,295)=44.897, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.317
/e/	**F1**	*F(2,255)=130.088, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p=0.001
	F2	*F(2,255)=26.827, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.7
/a/	**F1**	*F(2,319)=91.934, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.267
	F2	*F(2,319)=49.532, p<0.001	one-way NES – two-way NES, p=0.275 *one-way NES – two-way NSS, p<0.001 *two-way NES – two-way NSS, p<0.001
/o/	**F1**	*F(2,287)=67.221, p<0.001	*one-way NES – two-way NES, p<0.001 *one-way NES – two-way NSS, p<0.001 two-way NES – two-way NSS, p=0.142
	F2	*F(2,287)=6.520, p=0.002	one-way NES – two-way NES, p=0.045 one-way NES – two-way NSS, p=0.027 *two-way NES – two-way NSS, p=0.001
/u/	**F1**	F(2,146)=2.27, p=0.107	one-way NES – two-way NES, p=0.237 one-way NES – two-way NSS, p=0.044 two-way NES – two-way NSS, p=0.763
	F2	*F(2,146)=6.317, p=0.002	one-way NES – two-way NES, p=0.432 *one-way NES – two-way NSS, p=0.002 *two-way NES – two-way NSS, p=0.004

*significant at the p<0.01 level

Statistical tests support these observations. Results of oneway ANOVA tests and post-hoc LSD paired comparisons for each formant measurement are presented in Table

5.15. First, all formants, with the exception of F2 of /u/, present significant differences across the three program/language groups. Second, the one-way NES group exhibits the greatest number of significant paired comparisons of the three groups; 14 of the 20 potential comparisons (2 comparisons per formant * 2 formants per vowel * 5 vowels) reach statistical significance. These 14 significant comparisons are split between the two two-way groups, with slightly more being with the two-way NSS group than the two-way NES group, 8 and 6 respectively. Fewer statistically significant differences exist between the two-way NES and two-way NSS group; only 4 of the 10 possible differences reach significance. This indicates that the one-way NES group produces the majority of vowel in a significantly different way than both the two-way NES group and the two-way NSS group; the two-way NES group displays some difference in vowel productions from the two-way NSS group, but the number is fewer.

5.1.4.2 Comparison of Native-like and Prototypical Ratings of Seventh Grade Groups

Each of the learner tokens was classified as either native-like or not native-like based upon whether it fell within the two-way NSS group 2 standard deviation range for both formant values. The percentage of tokens to be classified as native-like and not native-like are presented in Table 5.16 for both of the two NES learner groups according to vowel. The two-way NES group exhibits a higher percentage of native-like vowel tokens for each of the five vowels than the one-way NES group; subsequently, their overall average of native-like tokens is notably higher, 81% as compared to 65.8%. The two-way NES seventh grade learners also exhibit little variability in native-like percentages across the vowels; the difference between the vowel with the greatest percentage of native-like tokens, /e/, and that with the lowest percentage, /a/, is approximately 23%. The one-way NES group presents a much larger range of values, from 92.5% for /u/ to a mere 33.3% for /e/, a difference of nearly 60%.

Table 5.16: Percentage of Seventh Grade Native-like and Not Native-like Tokens According to Vowel and Program/Language Group

	NSS Range		One-way NES		Two-way NES	
	F1	**F2**	**Native-like**	**Not Native-like**	**Native-like**	**Not Native-like**
/i/	300-532	1550-2946	78.1%	21.9%	82.6%	17.4%
/e/	357-625	1571-2347	33.3%	66.7%	88.9%	11.1%
/a/	334-930	1181-2001	52.9%	47.1%	66%	34%
/o/	294-722	733-2213	72.4%	27.6%	86.4%	13.6%
/u/	337-549	662-1906	92.5%	7.5%	81%	19%
Average			**65.8%**	**34.2%**	**81%**	**19%**

In addition to being classified as either native-like or not native-like, all tokens were scored for how close to the center of the NSS range they were located. Those tokens located closer to the NSS mean for both formants received higher prototypicality scores than those which fell further from the center or were located outside the NSS two standard deviation range. Prototypicality scores for each program/language group are displayed in Table 5.17 according to vowel.

Of the two NES learner groups, the two-way group more closely approximates the NSS group with respect to the relative percentage of tokens to receive each score. Just over half of the tokens produced by two-way NSS seventh graders scored a 4 on the prototypicality scale, 52.4%; the percentage of two-way NES tokens to receive the same score is slightly less, 46%, while that of the one-way NES seventh grade group is appreciably less, only 21.5%. The relative percentage of tokens to earn a prototypicality score of 3 is similar across all three seventh grade groups; the one-way NES group has a much higher percentage of tokens to receive lower prototypicality scores – 2, 1, or 0 – than either of the other two groups. The percentage of tokens to receive each of these scores is at least double that of the two-way NES group.

Table 5.17: Prototypicality Scores of Seventh Grade Productions According to Vowel and Program/Language Group

		4	3	2	1	0
One-way NES	/i/	23.3%	42.5%	26%	6.8%	1.4%
	/e/	5.3%	15.9%	39.4%	28.8%	10.6%
	/a/	9%	27.1%	47.1%	11.6%	5.2%
	/o/	23.4%	40.7%	23.4%	7.6%	4.8%
	/u/	46.3%	38.3%	12.5%	2.5%	0%
	average	**21.5%**	**33%**	**29.7%**	**11.5%**	**4.4%**
Two-way NES	/i/	47.8%	30.4%	13.0%	8.7%	0%
	/e/	44.4%	41.7%	2.8%	5.6%	5.6%
	/a/	40%	24%	26%	10%	0%
	/o/	50%	36.4%	9.1%	4.5%	0%
	/u/	47.6%	28.6%	19.0%	0%	4.8%
	average	**46%**	**32.2%**	**14%**	**5.8%**	**2.1%**
Two-way NSS	/i/	49.1%	36.8%	9.4%	4.7%	0%
	/e/	50%	34.4%	13.3%	1.1%	1.1%
	/a/	52.1%	34.2%	11.1%	0.9%	1.7%
	/o/	54.5%	36.6%	4%	5%	0%
	/u/	56.3%	29.2%	6.3%	8.3%	0%
	average	**52.4%**	**34.2%**	**8.8%**	**4%**	**0.6%**

As was seen with the native-like classifications, the one-way NES group also presents much greater variability across the vowels than the two-way NES group. Both /e/ and /a/ have a very low percentage of tokens, less than 10% in both cases, to receive prototypicality scores of 4. These two vowels present one extreme while /u/ presents another as approximately 46% of tokens receive a score of /u/, a percentage that resembles that of the two-way NES group. Of the two vowels to receive particularly low prototypicality scores, /e/ evidences lower percentages than /a/ for each of the top three scores – 4, 3, and 2. Nearly 40% of all /e/ tokens are scored as either 1 or 0; in other words, they do not approximate the prototypical /e/ of the two-way NSS group at all.

5.1.4.3 Effect of Lexical Stress on Vowel Productions of Seventh Grade Groups

In this section, how lexical stress affects formant values is considered. Individual vowel charts, Figure 5.14 - Figure 5.16, display the tonic and atonic vowel systems for each program/language group. Numerical data are available in Table M.4 - Table M.6 in Appendix M; in these tables statistically significant differences are marked.

Figure 5.14: Formant Values of One-way NES Seventh Graders According to Syllable Stress

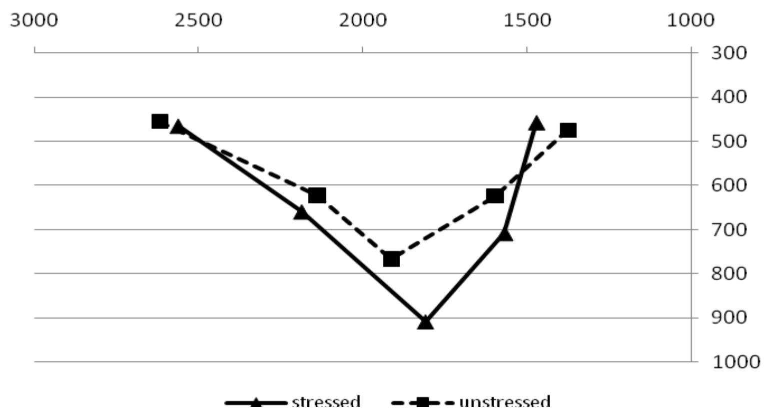
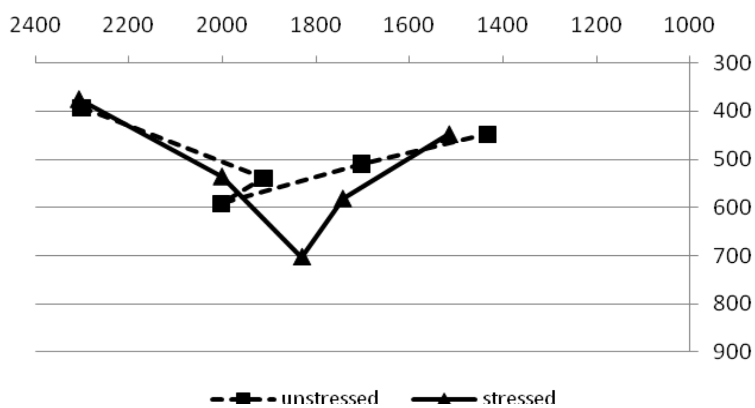
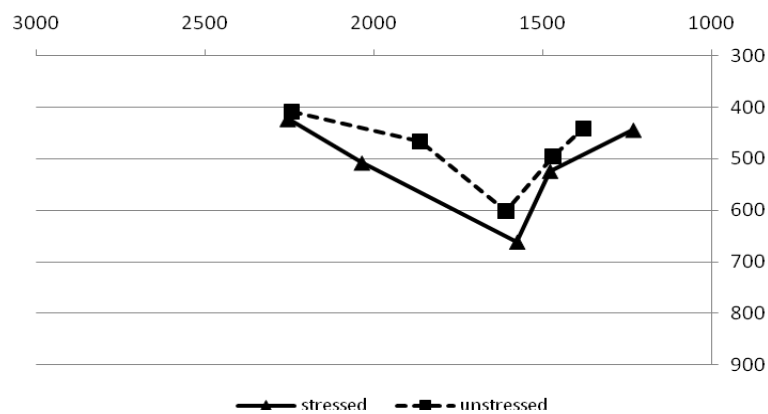


Figure 5.15: Formant Values of Two-way NES Seventh Graders According to Syllable Stress



Although many of the mean values of atonic vowels fall inside those of tonic productions, the vowel phonemes to most consistently exhibit this trend across all three groups are the non-high vowels, /e/, /a/, and /o/. The one exception to this is the unstressed /a/ of the two-way NES group, which is extremely fronted, having greater F2 values. With only a few notable exceptions, the acoustic distance between tonic and atonic productions is relatively minimal. Along these lines, few of the differences reach statistical significance, particularly for the two-way NES and two-way NSS groups.

Figure 5.16: Formant Values of Two-way NSS Seventh Graders According to Syllable Stress



The only vowel as produced by the two-way NSS seventh grade group to evidence an effect of lexical stress is /e/; both F1 and F2 show statistical differences according to lexical stress (F1: t=3.004, p=0.003, df=88; F2: t=4.616, p<0.001, df=88). The two-way NES group also produces two significant differences, but the two do not coincide on one vowel. Both /a/ and /o/ (/a/ t=4.404, p<0.001, df=48; /o/ t=3.589, p=0.001, df=42) have significantly different F1 values based upon syllable stress; in both cases F1 values are less in atonic syllables. Although there is a sizable differences in F2 values of /a/ in line with syllable stress, the difference does not reach statistical significance (t=-2.055, p=0.045, df=48).

The one-way NES group presents more statistically significant differences than either of the other two groups. In general, the space occupied by atonic productions takes up less of the high-low (F1) dimension than that of stressed vowel productions. More specifically, the non-high vowels in atonic syllables are produced with lower F1 values; the difference in F1 values for each of these vowels reaches statistical significance (/e/: $t=2.665$, $p=0.009$, $df=130$; /a/: $t=8.196$, $p<0.001$, $df=153$; /o/: $t=4.904$, $p<0.001$, $df=143$). Also, the non-high vowels also appear to be more centralized on the F2 dimension; however, differences in F2 values are only statistically significant for /a/ ($t=-2.648$, $p=0.009$, $df=153$).

Although the two-way NES group more closely resembles the NSS comparison group with respect to the number of statistically significant differences in formant values, the differences do not occur with the same vowel(s). The two NES learner groups both produce statistically significant differences in /a/ and /o/, neither of which evidence difference in the productions of the two-way NSS group. The only vowel to exhibit significant difference based upon lexical stress in the speech of the NSS group is /e/. One-way NES seventh graders also produce /e/ with significant differences according to syllable stress; however, the differences are only on the F1 dimension for the learner group whereas they occur on both dimensions for the NSS group.

5.1.4.4 Summary of Findings of Seventh Grade Groups

The two NES learner group present very different trends with respect to how they compare to the two-way NSS comparison group. Vowel productions of the two-way NES group resemble those of the native speaker peer comparison group; this is evident in the small number of statistically significant differences in formant values between the two groups and the relatively high percentage of two-way NES tokens to be classified as native-like. Moreover, the two groups have similar percentages of tokens to receive high prototypicality scores. One difference between the groups is how lexical stress impacts vowel productions; whereas /e/ is affected on both dimensions for the NSS group, /a/ and /o/ evidence an influence of stress on the F1 dimension for the two-way NES group. Of the four formant values to present statistically significant differences between these two groups (refer to Table 5.15), three are found for /e/, /a/, and /o/. The differences in lexical stress patterns could account for these.

The vowel productions of the one-way NES group resemble those of the NSS group very little. As a result of several significant differences in formant values, the two vowel spaces have very different shapes and sizes in addition to occupying different portions of the acoustic vowel space. Also the productions of the one-way NES group are classified as native-like less than their two-way NES counterparts, and they evidence low prototypicality scores. Particularly noteworthy are the low percentages for /e/ in these two areas. While part of this may be attributable to differing impacts of lexical stress on this particular vowel, it is more likely that the difference results from the productions having different articulatory correlates. In opposition to the challenge /e/ appears to present is /u/, which this group of learners is relatively accurate in producing.

5.2 Development Over (Apparent) Time

Students who enroll in elementary language immersion programs tend to make a long-term commitment to the program and to learning the language. It is expected that students’ skills in the immersion language will increase and become more native-like with increased time in the program. Research into development of other language skills has shown, however, that language development often plateaus in upper grades. For these reasons, in addition to establishing a developmental sequence for L2 acquisition of Spanish vowels, it is important to consider how learner productions change with a greater number of years of study (Research Question 3).

Development will be approached with respect to how the learner groups compare to the native speaker comparison group at each grade level. Examining differences or changes in productions across grade levels alone is not as informative as considering how comparisons to the bilingual peer target develop or change as grade level increases. By comparing learner groups to the native speaker peer group, it is possible to discover whether learners move toward the peer target, move away from it, overshoot it, etc.

Within this section, development of each of the two learner groups will first be addressed separately (Sections 5.2.1 and 5.2.2) and then comparisons will be drawn between the two (Section 5.2.3). Within each of these subsections, three areas will be explored: comparisons of formant values, native-like classifications and prototypicality scores, and effect of lexical stress.

5.2.1 One-way NES' Development Over (Apparent) Time

5.2.1.1 One-way NES' Development Over (Apparent) Time – Formant Values

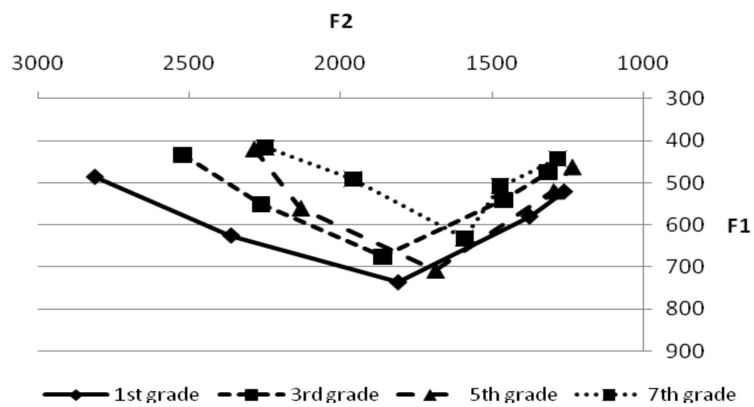
In previous sections, the formant values of one-way NES at each grade level were compared to those of same-age native Spanish-speaking peers enrolled in two-way immersion programs. In this section, the number of significant differences and the specific formants to present significant differences will be considered across grade levels within the one-way NES group.

The first grade group presents the fewest number of significant differences, 4, with the two-way NSS group; each of the other grade level groups produces more statistically significant differences with the NSS peer group. The increase from one grade level to the next is not consistent. For example, the increase from first to third grade is minimal, from 4 to 5, but between third and fifth grade, the increase is substantial, from 5 to 9. Then between fifth and seventh grade, there is a small decrease in the number of significant differences with the two-way NSS peer group, from 9 to 8. Thus while there is a general increase in the number of significant differences between first and seventh grade, the largest change occurs between third and fifth grade.

Looking across the four grade level groups, there is a tendency for the productions of the one-way NES groups to have greater formant frequencies than the two-way NSS groups. Considered from the perspective of the acoustic vowel space, this tends to mean that the vowels are located lower and more towards the “front” of the vowel space. Initially, in first grade, the differences are only significant on the F1 dimension in first grade, but in fifth and seventh grade, the significant differences have extended to both formants.

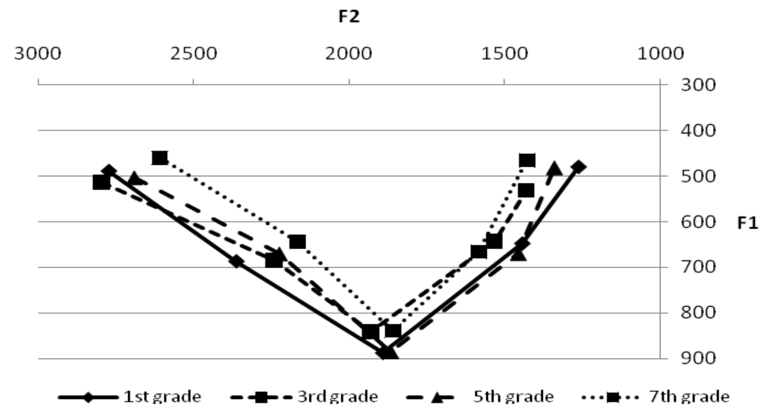
These findings could mean that the one-way NES group is moving away from the two-way NSS norm, but this is not necessarily the case. The formant frequencies of the two-way NSS group change considerably as grade level increases as can be observed in Figure 5.17. From first to seventh grade, the vowel space of the NSS peer group, shrinks and shifts upward in the acoustic space. This difference appears to be greatest for the front vowels, which have much lower F2 values in the upper grades. The one-way NES groups do not demonstrate such changes (see Figure 5.18). Changes in the Spanish vowel productions of the one-way NES groups across grade levels appear to be much less than those of the two-way NSS groups. So it is not that the one-way group is moving away from the native speaker target, but rather their system fails to change and the distance between their productions and the moving native speaker target increases over time.

Figure 5.17: Comparison of Two-way NSS Vowel Productions Across Grade Levels



Across the grade levels, the most consistent differences between the one-way NES group and the two-way NSS group occur with /i/, /e/, /a/, and /o/. With the exception of /i/ at the first grade level, learner F1 values for each of these vowels differs significantly from NSS values at each of the grade levels. In addition, many of the differences in F2 frequencies reach statistical significance, particularly at the fifth and seventh grade levels. Fewer differences are found for /u/; in the lower grades, first and third, differences in F1 frequencies are significant, and in the upper grades, differences in F2 values reach significance. These findings are in line with the observation that the non-back vowels of the two-way NSS groups become higher and more back as grade level increases, creating more distance in articulation of them between the one-way NES and two-way NSS groups as grade level increases.

Figure 5.18: Comparison of One-way NES Vowel Productions Across Grade Levels



5.2.1.2 One-way NES' Development Over (Apparent) Time – Native-like Ratings and Prototypicality Scores

Additional measures to compare the vowel productions of the one-way NES learner groups to those of the two-way NSS peer comparison groups are native-like classifications and prototypicality scores. What changes are observed on these two measures across the four one-way NES grade level groups are presented in this section.

The percentage of tokens classified as native-like and not native-like were presented previously according to vowel for each individual grade level (see Table 5.4, Table 5.8, Table 5.12, and Table 5.16); these data are combined into one table here to facilitate comparisons across the grade levels. In Table 5.18, the percentage of one-way NES learner tokens of each vowel phoneme to be classified as native-like is presented by grade level group. From first to seventh grade, the average percentage of tokens to be classified as native-like decreases approximately 20%; the decrease is not linear as fifth graders have a higher average percentage of native-like tokens than third graders, 75% and 70.72% respectively.

Table 5.18: Percentage of Native-like Tokens Produced by One-way NES Learners According to Vowel and Grade Level

	/i/	/e/	/a/	/o/	/u/	average
1st grade	95.6%	83.8%	84.1%	84.4%	79.5%	**85.5%**
3rd grade	69.5%	59.1%	72.6%	67.6%	84.8%	**70.7%**
5th grade	61.8%	73.6%	84.4%	64.7%	90.5%	**75%**
7th grade	78.1%	33.3%	52.9%	72.4%	92.5%	**65.8%**

The decrease in percentage of native-like tokens is most dramatic for the front, mid vowel, /e/. From first to seventh grade, there is a 50% decline in the percentage of tokens to be classified as native-like. As observed for the overall percentages, the decrease is not linear as fifth graders produce a higher proportion of native-like tokens than either third or seventh graders. What is striking is the very low percentage of seventh grade /e/ tokens to fall in the native-like range. Although not quite as severe, there are also sizeable decreases in the relative percentage of native-like tokens of /i/ and /a/ as grade level increases.

The high, back vowel /u/ presents a different pattern than the other vowels; it is the only vowel to evidence an increase in native-like classifications as grade level increases. The increase is linear, showing a gradual increase from one grade level to the next, totaling 13% from first to seventh grade.

Prototypicality scores demonstrate a similar trend to that observed for the percentage of tokens classified as native-like. The percentage of tokens to receive each prototypicality rating were presented previously for each grade level in Table 5.5, Table 5.9, Table 5.13, and Table 5.17; the one-way NES data from these tables are re-reported here in Table 5.19 for comparison purposes. Between first and seventh grade, the percentage of tokens to receive prototypicality scores of 4 decreases from 47.8% to 21.5%, a decline of 26.3%. As observed with native-like classifications, however, the path is not linear as fifth graders produce a higher percentage of tokens with a score of 4 than the third grade group. This increase is most likely due to sizeable increases in prototypicality for both /e/ and /u/. In contrast to the overall decrease in the percentage of highly prototypical productions, there is a linear increase in the percentage of non-prototypical productions, those with a score of 1 or 0. The percentage of tokens with scores of 2 also increases from first to seventh grade, with the largest increase occurring between first and third. The percentage of moderately prototypical tokens, scores of 3, evidences little change across the grade levels.

Table 5.19: Prototypicality Scores of One-way NES Learners According to Grade Level

		4	**3**	**2**	**1**	**0**
1st grade	/i/	39.6%	46.7%	12.6%	0.5%	0.5%
	/e/	51.9%	28.6%	15.6%	2.6%	1.3%
	/a/	45.6%	36.9%	8.2%	7.2%	2.1%
	/o/	51.4%	30.2%	11.2%	4.5%	2.8%
	/u/	50.6	25.3%	16.9%	7.2%	0%
	average	**47.8%**	**33.5%**	**12.9%**	**4.4%**	**1.3%**
3rd grade	**/i/**	24.9%	29.4%	32.2%	13.6%	0%
	/e/	18.8%	31.8%	40.3%	9.1%	0%
	/a/	30.7%	35.2%	23.5%	7.3%	3.4%
	/o/	32.9%	28.3%	27.7%	7.5%	3.5%
	/u/	35.4%	39.4%	17.2%	3%	5.1%
	average	**28.5%**	**32.8%**	**28.2%**	**8.1%**	**2.4%**
5th grade	**/i/**	23.7%	26.3%	27.6%	14.5%	7.9%
	/e/	30.2%	31.8%	29.5%	7%	1.6%
	/a/	34.4%	38.1%	19.4%	7.5%	0.6%
	/o/	21.6%	39.2%	22.9%	7.8%	8.5%
	/u/	59.5%	23.8%	9.5%	7.1%	0%
	average	**33.9%**	**31.8%**	**21.8%**	**8.8%**	**3.7%**
7th grad	**/i/**	23.3%	42.5%	26%	6.8%	1.4%
	/e/	5.3%	15.9%	39.4%	28.8%	10.6%
	/a/	9%	27.1%	47.1%	11.6%	5.2%
	/o/	23.4%	40.7%	23.4%	7.6%	4.8%
	/u/	46.3%	38.3%	12.5%	2.5%	0%
	average	**21.5%**	**33%**	**29.7%**	**11.5%**	**4.4%**

With respect to individual vowel phonemes, the most severe reduction in percentage of highly prototypical tokens occurs for /e/ and /o/, both of which evidence a decrease of more than 35%. Subsequently, these two vowels present the highest percentage of non-prototypical productions. The vowel with the least amount of overall change in highly prototypical tokens is /u/, although there is fluctuation, particularly in the third and fifth grade groups.

5.2.1.3 One-way NES' Development Over (Apparent) Time – Effect of Lexical Stress

The impact of lexical stress on the Spanish vowel productions of one-way NES students is greater in the upper grades than in the lower grades. Between first and seventh grade, the number of statistically significant differences in formant values between stressed and unstressed syllables increases from 1 to 4. Across the four grade level groups, two vowels consistently exhibit differences in formant values in line with syllable stress: /a/ and /o/. F1 values of /o/ are consistently and significantly less in atonic syllables than in tonic syllables; this holds for all four grade level groups. In a similar way, F1 values of /a/ are less in atonic syllables for all grade level groups; however, the difference does not reach significance in first grade. The third and seventh grade groups also produce /a/ with significantly greater F2 values.

The two-way NSS group also evidences change with respect to how lexical stress affects formant values. The first grade group does not produce any statistically significant differences in formant values with respect to syllable stress, but each of the other grade level groups does. A difference between the learner group and the NSS comparison groups is which vowels are impacted. Whereas /a/ and /o/ are most impacted in the speech of the one-way NES group, /e/ exhibits the most consistent differences in the speech of the two-way NSS group. In third grade, atonic tokens of /e/ have F1 values which are significantly less than the corresponding tonic tokens. In fifth and seventh grade, the same differences are observed in F1 values but there are also significant differences in F2 values; F2 values are less in atonic syllables than in tonic syllables for these two grade level groups. Therefore, while lexical stress is a factor in vowel formant values for both program/language groups, it impacts different vowels for each group.

5.2.1.4 Summary of One-way NES' Development Over (Apparent) Time

Examining how the vowel productions of one-way NES compare to those of two-way NSS across grade levels reveals that the one-way NES group becomes less native-like as grade level increases. This trend presents itself through an increase in the number of statistically significant differences in formant values and a decrease in the percentage of tokens classified as native-like and highly prototypical. Given the moving target presented by the two-way NSS group, the implication is not that this learner group moves away from the NSS target but that their vowel system does not develop in the same way as that of native speaker peers.

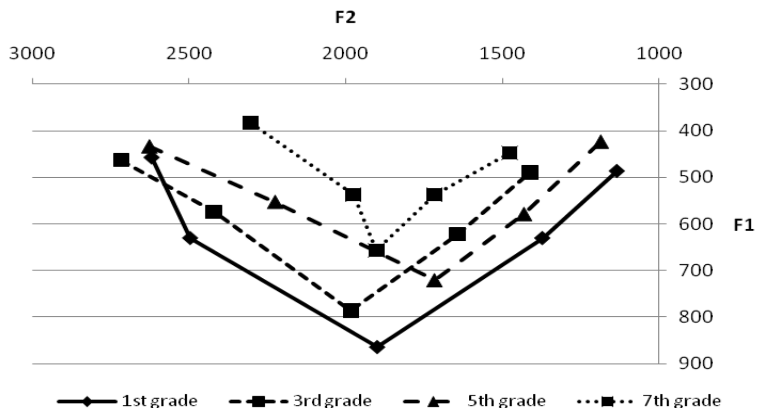
5.2.2 Two-way NES' Development Over (Apparent) Time

5.2.2.1 Two-way NES' Development Over (Apparent) Time – Formant Values

Comparisons were made in previous sections between the two-way NES group and two-way NSS group at each grade level. In this section, the specific formant measurements to evidence significant differences and the overall number of significant differences is considered across the four two-way NES grade level groups.

Much like the trend observed for the two-way NSS groups' vowel spaces in Figure 5.17, the vowel space of the two-way NES groups shrinks over time (see Figure 5.19). The reduction in size of the vowel space results from greater F1 frequencies in the lower grades in addition to the front vowels having greater F2 values and the back vowels having lower F2 values. In other words, as grade level increases, F1 frequency tends to decrease, the F2 frequency of front vowels tends to decrease, and the F2 frequency of back vowels tends to increase. The combined effect of these changes is a smaller vowel space which is positioned higher.

Figure 5.19: Comparison of Two-way NES Vowel Productions Across Grade Levels



Although differences exist between the two two-way groups, the NES learner group presents a similar developmental trajectory. In fact, the number of significant differences between this learner group and the two-way NSS peer group decreases from first to seventh grade. There are 7 significant differences in first grade, 6 in third grade, 3 in fifth grade, and 4 in seventh grade. The most significant change appears to occur between third and fifth grade. No one formant measurement presents significant differences across all grade level groups, nor is the direction of difference (i.e., greater formant values) consistent. Of the five vowels, /e/ presents the fewest significant differences, 3, and /o/ presents the most, 5.

5.2.2.2 Two-way NES' Development Over (Apparent) Time – Native-like Ratings and Prototypicality Scores

Like comparisons of significant differences in formant values, the percentage of tokens classified as native-like or highly prototypical can signal change in how closely the vowel productions of two-way NES students approximate those of two-way NSS students. Data reported previously for each individual grade level in Table 5.4, Table 5.8, Table 5.12, and Table 5.16 are combined here in Table 5.20 for comparison purposes.

Table 5.20: Percentage of Native-like Tokens Produced by Two-way NES Learners According to Vowel and Grade Level

	/i/	**/e/**	**/a/**	**/o/**	**/u/**	**average**
1st grade	83.9%	86.4%	85%	87.4%	94.4%	**87.4%**
3rd grade	83.2%	88.9%	75.2%	74.6%	90%	**82.4%**
5th grade	82.7%	92.3%	96.1%	73.1%	95.2%	**87.9%**
7th grade	82.6%	88.9%	66%	86.4%	81%	**81%**

The average percentage of native-like tokens produced by two-way NES students decreases slightly, less than 7%, from first to seventh grade; the trajectory is not linear however as the fifth grader group has the highest average percentage of native-like tokens, 87.9%, while the seventh grade group has the lowest average percentage, 81%. Of the five vowels, /a/ presents the greatest variability in percentages, ranging from 96.1% to 66%, which is the lowest percentage of native-like tokens produced across all phonemes and grade levels. In contrast, the two front vowels, /i/ and /e/, present relatively little variability in percentages across grade levels. The amount of variability for the back vowels, /o/ and /u/, falls between the extreme variability of /a/ and the relative stability of /i/ and /e/. For /o/, the third and fifth grade learner groups have lower percentages than the first and seventh grade groups while it is the seventh grade group that presents the lowest percentage of native-like /u/ tokens.

Given the relatively high percentage of native-like tokens produced at all grade levels, it is useful to compare how close to center of the range of NSS values each token falls. Findings of how prototypical two-way NES learner productions were presented previously for each grade level in Table 5.5, Table 5.9, Table 5.13, and Table 5.17. Table 5.21 presents only data from the two-way NES to allow for comparisons to be made across the grade level groups. Overall, the average number of tokens to be rated as highly prototypical, or receive a score of 4, increases from first to seventh grade although the increase is slight, approximately 4%, and does not follow a linear trajectory. Similarly, the average percentage of moderately prototypical tokens, scores of 3, increase between first and seventh grade; third and fifth graders, however, present the highest percentages. The amount of change in the percentage of tokens with prototypicality scores of 2, 1, or 0 is less; nonetheless, there is a decrease in slightly prototypical tokens, scores of 2, and an increase in non-prototypical productions, scores of 1 and 0.

Each of the vowels has more than 60% of its tokens produced in the highly or moderately prototypical range across all grade levels, the majority are above 70%. And no one vowel at any grade level has more than 12% of its tokens outside the prototypical range. There is not a consistent trend across grade levels as to which vowels have the highest, or lowest, scores of prototypicality; in general, however, a larger percentage of non-high vowel tokens (/e/, /a, and /o/) are classified as not prototypical than the high vowel tokens. This tendency is in line with the observation that /a/ and /o/ have slightly lower percentage of native-like tokens than the other vowels. Given that /e/ generally has higher relative percentages of native-like and highly prototypical tokens, this could mean that productions of /e/ either very closely approximate those of native speaker or they differ greatly. In other words, relatively few tokens fall in the gray area.

Table 5.21: Prototypicality Scores of Two-way NES Learners According to Vowel and Grade Level

		4	**3**	**2**	**1**	**0**
1st grade	/i/	31.4%	40.9%	23.4%	3.6%	0.7%
	/e/	28.2%	41.8%	22.7%	5.5%	1.8%
	/a/	47.1%	33.3%	15.7%	3.9%	0%
	/o/	54.1%	29.6%	11.1%	3.7%	2.8%
	/u/	49.3%	26.8%	21.1%	2.8%	0%
	average	**42.0%**	**24.5%**	**18.8%**	**3.9%**	**1.1%**
3rd grade	**/i/**	41.3%	35%	20.3%	3.5%	0%
	/e/	47.4%	37%	11.1%	3.7%	0.7%
	/a/	32%	36.6%	21.6%	5.9%	3.9%
	/o/	31%	38%	18.3%	7.7%	4.9%
	/u/	46.3%	33.8%	16.3%	3.8%	0%
	average	**39.6%**	**36.1%**	**17.5%**	**4.9%**	**1.9%**
5th grade	**/i/**	28%	46.7%	14.7%	8%	2.7%
	/e/	56.9%	32.3%	7.7%	3.1%	0%
	/a/	64.5%	25%	7.9%	2.6%	0%
	/o/	43.3%	26.9%	17.9%	4.5%	7.5%
	/u/	35.7%	52.4%	11.9%	0%	0%
	average	**45.7%**	**36.6%**	**12%**	**3.6%**	**2%**
7th grad	**/i/**	47.8%	30.4%	13.0%	8.7%	0%
	/e/	44.4%	41.7%	2.8%	5.6%	5.6%
	/a/	40%	24%	26%	10%	0%
	/o/	50%	36.4%	9.1%	4.5%	0%
	/u/	47.6%	28.6%	19.0%	0%	4.8%
	average	**46%**	**32.2%**	**14%**	**5.8%**	**2.1%**

5.2.2.3 Two-way NES' Development Over (Apparent) Time – Effect of Lexical Stress

Very few significant differences exist in the formant values of vowels produced by two-way NES in tonic syllables and those produced in atonic syllables. With the exception of first grade, the number of significant differences produced by the two-way NES group is equal to or less than those of the two-way NSS comparison group. The majority, 4 of 6, of the significant differences in formant values produced by the two-way group occur in articulation of /a/; of these 4 differences, 3 are with F1 values. The remaining two differences are in F1 values of /o/. Only two of these differences coincide with differences found in the two-way NSS groups: F1 of /a/ and /o/ in fifth grade. As discussed in Section 5.2.1.3, two-way NSS tend to show an effect of lexical stress in their articulations of /e/, not /a/ and /o/ as the NES do. Taken together, these findings point to differing effects of lexical stress on the two two-way groups.

5.2.2.4 Summary of Two-way NES' Development Over (Apparent) Time

These findings indicate the vowel productions of the two-way NES group become more like those of their native speaker peers over time. This is supported by the findings that there are fewer significant differences in formant values and higher percentages of native-like and highly or moderately prototypical tokens in the upper grades. Although there is an overall increase from first to seventh grade, the vowel system of the fifth grade group is that which most closely resembles that of NSS peers. These findings must be interpreted with caution as both of the upper grade level groups were comprised of few participants.

Of the five vowels, it could be argued that /a/ is the most challenging for this group. Half of the comparisons of formant measurements reach statistical significance and it presents the greatest variability in native-like classification. The apparent difficulty observed for this particular vowel could be related to the differing manifestation of lexical stress in the productions of the two groups. Three of the four instances in which statistically significant differences are observed in articulations with respect to lexical stress coincide with significant differences in overall mean formant values between the two-way NES and two-way NSS groups. The high vowels, /i/ and /u/, show much less variability in native-like classifications and appear to be relatively immune to differences in formant values as a result of lexical stress. These findings suggest that although the two-way NES groups do not regularly produce differences in formant values as a result of differences in lexical stress, lexical stress does serve as a distinguishing factor between the two-way NES group and the two-way NSS group.

5.2.3 Development over Time – Effect of Program

In the previous sections it was found that the vowel productions of one-way NES learners differ more from those of the native speaker comparison group in the upper grade levels than in the lower grade levels. The opposite was found for the two-way NES learner group; the vowels of this group become more native-like in the upper grades. For both learner groups, the most sizeable change occurs between third and fifth grade, suggesting that this time is a period of transition.

The primary difference between the two programs is the amount of contact with native speakers of Spanish. Given that the "target" presented by the two-way NSS peer groups changes at each grade level, this could account for the different trends observed in the learner groups. The productions of the one-way NES group, which does not have regular contact with the two-way NSS peer group, exhibit more differences from those of the comparison group over time whereas the vowels of the two-way NES group, which does have regular contact with the comparison group, become more like those of their native speaking peers.

5.3 Comparison of Student Vowel Productions to Immersion Teacher Productions

Much of the input immersion learners receive comes from their teachers; for this reason, it is important to explore what this input looks like and how closely learners approximate it (Research Question 4). Ten immersion teachers, 4 from the one-way program and 6 from the two-way program, participated in this study. The demographic details of these participants were presented in Section 4.2.2 and Appendix B.

A total of 835 vowel tokens were produced by the ten teacher participants for analysis. The specific number of tokens according to phoneme and stress are displayed in Table 5.22. In line with the trend found for the student groups, the vowel with the greatest number of tokens analyzed is /a/ and that with the least is /u/. More tokens overall were produced in tonic syllables than atonic syllables, with particularly few productions of unstressed /e/ and /u/ submitted for analysis.

Table 5.22: Teacher Vowel Tokens Analyzed

	/i/	**/e/**	**/a/**	**/o/**	**/u/**	**total**
stressed	89	99	100	90	62	440
unstressed	93	58	98	97	49	395
total	182	157	198	187	111	835

In this section, the productions of each student group are compared to those of the teacher group. Because of the different age of the speakers being compared and the presumable subsequent difference in vocal tract length, normalized z-scores will be employed to make comparisons across groups. The unnormalized formant frequencies for the teacher group can be found in Table N.1 in Appendix N. The two comparison groups, two-way NSS students and immersion teachers, are compared first in Section 5.3.1, followed by a comparison of the teacher group to one-way NES groups in Section 5.3.2 and two-way NES groups in Section 5.3.3. Comparison findings are then summarized in Section 5.3.4.

5.3.1 Comparison of Vowel Productions of Two-way NSS Students and Immersion Teachers

Both the two-way NSS groups and the immersion teacher group serve as comparisons for the vowel productions of the two NES learner groups; the two groups are compared here in order to explore any differences that might exist between them. Normalized data for each of the groups are reported in Table 5.23 and Table 5.24; mean z-scores for each of the four two-way NSS grade level groups and the teacher group are plotted on the same graph in

The normalized vowel space of the teacher group overlaps considerably with that of first, third, and fifth graders. Most notably, teacher productions of the mid vowels /e/ and /o/ appear to coincide with those of these grade level groups; for /i/, teacher articulations of /i/ correspond to that of the first grade group more closely than the other grade level groups. Of the five vowels, NSS students and teachers appear to differ most in their articulation of /u/. Less overlap is observed between the teacher group and the two-way NSS seventh grade group. In particular, the mid vowels of the seventh grade group fall inside those of the teacher group, and /a/ has a lower F2 value.

Figure 5.20 for a visual comparison. Z-scores are the result of the Lobanov vowel normalization procedure described in Section 4.5.2. Z-scores can be interpreted much like unnormalized Hertz values; lower F1 z-scores are plotted higher on the vertical axis, and lower F2 z-scores are plotted to the right side of the horizontal axis. Results of the statistical analyses are presented in Table 5.25.

Table 5.23: Normalized Formant Values of Teacher Participants

	/i/ n=182		/e/ n=157		/a/ n=198		/o/ n=187		/u/ n=111	
	mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
F1 (Hz)	-0.93	0.47	-0.02	0.44	1.26	0.71	0.1	0.66	-0.88	0.42
F2 (Hz)	1.22	0.57	0.64	0.36	-0.1	0.35	-0.87	0.54	-1.26	0.38

The normalized vowel space of the teacher group overlaps considerably with that of first, third, and fifth graders. Most notably, teacher productions of the mid vowels /e/ and /o/ appear to coincide with those of these grade level groups; for /i/, teacher articulations of /i/ correspond to that of the first grade group more closely than the other grade level groups. Of the five vowels, NSS students and teachers appear to differ most in their articulation of /u/. Less overlap is observed between the teacher group and the two-way NSS seventh grade group. In particular, the mid vowels of the seventh grade group fall inside those of the teacher group, and /a/ has a lower F2 value.

Figure 5.20: Comparison of Two-way NSS Students and Immersion Teachers, Z-scores

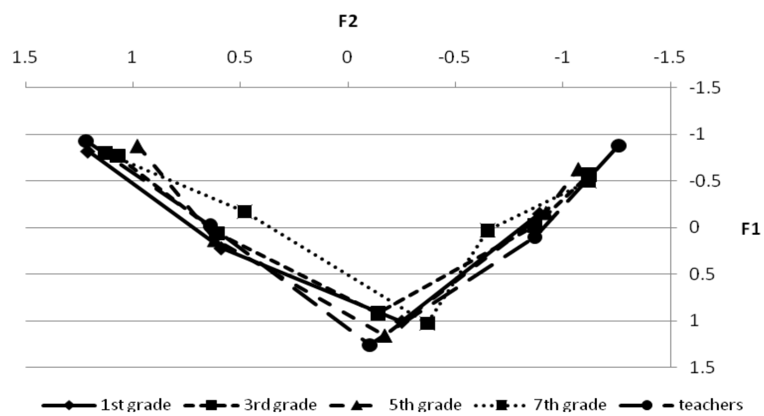


Table 5.24: Two-way NSS Normalized Formant Values According to Grade Level

			1st Grade	3rd Grade	5th Grade	7th Grade
/i/	**F1**	**mean**	-0.82	-0.77	-0.88	-0.8
		s.d.	0.49	0.89	0.31	0.43
	F2	**mean**	1.21	1.07	0.98	1.13
		s.d.	0.62	0.89	0.83	0.72
/e/	**F1**	**mean**	0.22	0.06	0.13	-0.17
		s.d.	0.58	0.63	0.56	0.64
	F2	**mean**	0.59	0.61	0.72	0.47
		s.d.	0.43	0.37	0.42	0.47
/a/	**F1**	**mean**	1.01	0.92	1.16	1.03
		s.d.	1.12	1.0	1.05	0.97
	F2	**mean**	-0.25	-0.14	-0.17	-0.37
		s.d.	0.56	0.44	0.55	0.47
/o/	**F1**	**mean**	-0.15	-0.02	-0.16	0.03
		s.d.	0.67	0.57	0.53	0.78
	F2	**mean**	-0.89	-0.87	-0.92	-0.65
		s.d.	0.47	0.54	0.47	0.81
/u/	**F1**	**mean**	-0.55	-0.57	-0.63	-0.46
		s.d.	0.55	0.48	0.35	0.75
	F2	**mean**	-1.06	-1.12	-1.07	-1.06
		s.d.	0.45	0.53	0.58	0.61

A statistical comparison of z-scores across all groups considered in this analysis reveal that the differences in value are statistically significant for 7 of the 10 formant measures. The measurements that do not show significant differences are F1 of /e/, F2 of /a/, and F1 of /o/. What i The normalized vowel space of the teacher group overlaps considerably with that of first, third, and fifth graders. Most notably, teacher productions of the mid vowels /e/ and /o/ appear to coincide with those of these grade level groups; for /i/, teacher articulations of /i/ correspond to that of the first grade group more closely than the other grade level groups. Of the five vowels, NSS students and teachers appear to differ most in their articulation of /u/. Less overlap is observed between the teacher group and the two-way NSS seventh grade group. In particular, the mid vowels of the seventh grade group fall inside those of the teacher group, and /a/ has a lower F2 value.

s of interest is that all grade level groups behave similarly in comparison to the teacher group; where one grade level group differs significantly from the teacher group, all grade level groups differ significantly from the teacher group. These findings suggest that bilingual teachers and bilingual peers produce some vowels with different characteristics. The implication of this finding is that NES learners of Spanish, particularly those in two-way programs, receive varied input.

Both teachers and two-way NSS students exhibit an effect of lexical stress in their vowel productions.[59] Across groups the acoustic space outlined by tonic productions contains atonic productions; the specific formants to evidence significant differences according to syllable stress vary across the groups however. No group produces more than four statistically significant differences. The fifth grade group and the teacher group produce more significant differences in formant frequency according to syllable stress, 4 compared to 2 for the seventh grade group and 0 for the first grade group. For student groups, /e/ is the most consistently affected vowel – presenting differences in F1 values in the speech of third graders and F1 and F2 values in the speech of fifth and seventh graders. For the teacher group, /a/ is the most “affected” vowel, displaying differences on both formant measurements; F2 values of /i/ and /e/ also display an effect of stress in the speech of immersion teachers. So while the two bilingual comparison groups present some similarities with respect to lexical stress, difference in formant values of /e/, the two-way NSS student group does not completely mirror the teacher group.

[59] Details about the impact of lexical stress on grade level groups vowel productions can be found in Sections 5.1.1.3, 5.1.2.3, 5.1.3.3, and 5.1.4.3 and Appendix J, Appendix K, Appendix L, and Appendix M. Numerical data and a vowel chart for teachers that present formant values according to syllable stress are available in Table N.2 and Figure N.1 in Appendix N.

Table 5.25: Oneway ANOVA Results Summary, Teacher vs. Two-way NSS Students Comparison of Normalized Z-scores According to Vowel

		One-way ANOVA Results	Significant post-hoc comparisons and p-values
/i/	**F1**	*F(4,2640)=39.172, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,2645)=66.392, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/e/	**F1**	F(4,2615)=0.02, p=0.999	1st p=0.859; 3rd p=0.859 5th p=0.86; 7th p=0.786
	F2	*F(4,2620)=15.975, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/a/	**F1**	*F(4,2656)=76.036, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	F(4,2661)=0.483, p=0.748	1st p=0.202; 3rd p=0.204 5th p=0.207; 7th p=0.227
/o/	**F1**	F(4,2645)=0.466, p=0.761	1st p=0.205; 3rd p=0.207 5th p=0.21; 7th p=0.274
	F2	*F(4,2650)=34.932, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/u/	**F1**	*F(4,2569)=21.318, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,2574)=43.839, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001

*significant at the p<0.01 level

The two comparison groups to participate in this study, two-way NSS students and immersion teachers, present significant differences in both formant frequencies and the effect of lexical stress. An important finding is that the two-way NSS seventh grade group differs more from the teacher group than some of the other grade level groups, most notably the fifth graders, although differences do not reach statistical significance. Various explanations are possible for this phenomenon; seventh graders may want to differentiate their speech from that of adult models as a means of exerting their adolescent identity. Or teachers could be modifying their natural speech to meet the needs of a diverse student population in a classroom environment, potentially slowing their speech down and/or placing greater emphasis on specific syllables which could have the effect of not only elongating the duration of vowels, but also modifying the frequencies at which vowels are produced. Although the task was designed to elicit more spontaneous, connected speech, the location of the interview (a classroom) and the educational nature of the task may have elicited "teacher talk" as opposed to the vernacular. A third potential explanation is the different linguistic backgrounds of the groups; despite high levels of proficiency on the part of the teacher group, the group is far from homogenous. Half of the teachers grew up in bilingual communities in San Antonio, much like the students who comprise the two-way NSS group; the other half were either born and raised in a Spanish-speaking country or are native English speakers with extensive time abroad. Such factors could influence vowel productions, but the heterogeneity of the teacher group falls outside the scope of this dissertation. These issues will be explored further in Chapter 6.

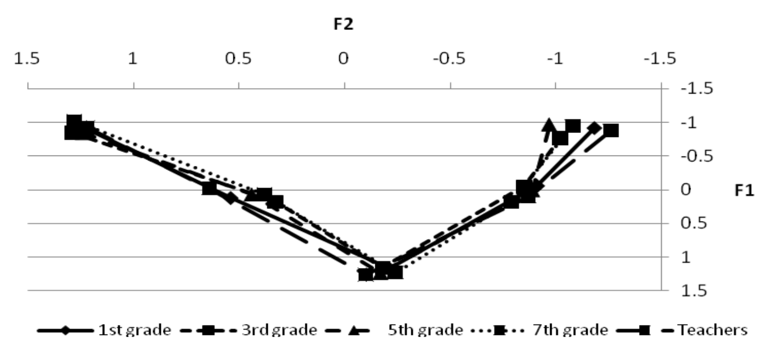
5.3.2 Comparison of Vowel Productions of One-way NES Students and Immersion Teachers

The primary source of auditory highly proficient immersion language input for students in one-way programs is the teacher. Although students do receive input from other sources - their classmates, guests in the classroom, other professionals in the school, audio or video recordings, etc., the teacher is central. The vowel productions of the one-way NES group and the immersion teacher group are compared in this section. Normalized values for the one-way NES learner group are reported in Table 5.26; z-scores for the teacher group were presented in Table 5.23 in the previous section. A vowel chart with the plots of each one-way NES grade level group and the teacher group is available in Figure 5.21.

Table 5.26: One-way NES Normalized Formant Values According to Grade Level

			1st Grade	3rd Grade	5th Grade	7th Grade
/i/	**F1**	**mean**	-0.88	-0.85	-0.84	-1.02
		s.d.	0.4	0.49	0.59	0.43
	F2	**mean**	1.2	1.29	1.24	1.28
		s.d.	0.71	0.66	0.71	0.59
/e/	**F1**	**mean**	0.12	0.18	0.07	0.07
		s.d.	0.6	0.6	0.54	0.41
	F2	**mean**	0.54	0.33	0.44	0.38
		s.d.	0.37	0.38	0.44	0.43
/a/	**F1**	**mean**	1.17	1.16	1.24	1.23
		s.d.	0.87	0.94	0.7	0.67
	F2	**mean**	-0.21	-0.18	-0.17	-0.24
		s.d.	0.43	0.43	0.43	0.49
/o/	**F1**	**mean**	-0.06	-0.05	0.01	0.18
		s.d.	0.61	0.64	0.63	0.67
	F2	**mean**	-0.91	-0.85	-0.89	-0.79
		s.d.	0.52	0.64	0.66	0.74
/u/	**F1**	**mean**	-0.92	-0.77	-0.97	-0.95
		s.d.	0.43	0.48	0.41	0.31
	F2	**mean**	-1.18	-1.02	-0.97	-1.08
		s.d.	0.41	0.55	0.41	0.41

Figure 5.21: Comparison of One-way NES Students and Immersion Teachers, Z-scores



There is considerable overlap in the z-scores of the one-way NES student groups and the immersion teacher groups. The greatest differences are found for F1 and F2 values of /e/, F2 values of /a/, and F2 values of /u/. Teacher productions of both /e/ and /a/ have greater F2 z-scores whereas teacher productions of /u/ have lower F2 z-scores. A consistent difference between teachers and student groups is also found for F1 z-scores of /e/; teachers produce /e/ with smaller z-scores as compared to students. The amount of separation between teacher and learner groups appears to be much less for /i/ and /o/. Not all of these observed differences are statistically significant; results of oneway ANOVA tests and the post-hoc LSD paired comparison of the teacher group to each grade level group are presented in Table 5.27. Learner groups pattern similarly in comparison to the teacher group; when there is a significant difference, the differences are significant between the teacher group and each of the grade level groups. Significant differences are found in the F1 and F2 values of /i/ and /u/, F2 values of /e/ and /o/, and F1 values of /a/.

These findings suggest that one-way NES learners do not produce vowels in the same way as their immersion teachers; in particular the high vowels vary on both formant measurements. The other vowels differ on only one of the two dimensions. Also, learners' productions do not approximate those of teachers more in the upper grades in the lower grades; all grade level groups pattern the same statistically in comparison to the teacher group, suggesting that development toward the teacher target does not occur.

With respect to the effect of lexical stress on vowel productions, learners do become more like their teachers. As was shown in Section 5.2.1.3, the number of significant differences in formant values between stressed and unstressed syllables increases across grade levels in the one-way NES group. Fifth and seventh grade groups produce four significant differences according to syllable stress; four measurements also exhibit differences according to lexical stress in the vowel productions of immersion teachers. For both learners and teachers alike, /a/ exhibits significant differences most consistently. Teachers, third, and seventh graders differentiate productions on both F1 and F2 dimensions whereas first and fifth graders show differences only on the F1 dimension. In spite of this similarity, lexical stress does manifest itself slightly differently in the speech of the learner and teacher groups. In the productions of the learner groups, there are more differences on the F1 dimension than the F2 dimension, 8 compared to 3. The opposite is true for the teacher group; most significant differences in teacher productions occur on the F2 dimension, 3 compared to 1. So while lexical stress has a common effect on productions of /a/ for the two groups, its overall impact is different.

Table 5.27: Oneway ANOVA Results Summary, Teacher vs. One-way NES Students Comparison of Normalized F1 and F2 Values According to Vowel

		One-way ANOVA Results	Significant post-hoc comparisons and p-values
/i/	**F1**	*F(4,3088)=39.126, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,3088)=66.618, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/e/	**F1**	F(4,3063)=0.009, p=1.00	1st p=0.858; 3rd p=0.858 5th p=0.86; 7th p=0.86
	F2	*F(4,3063)=15.911, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/a/	**F1**	*F(4,3104)=76.716, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	F(4,3104)=0.484, p=0.748	1st p=0.199; 3rd p=0.199 5th p=0.206; 7th p=0.208
/o/	**F1**	F(4,3093)=0.476, p=0.754	1st p=0.201; 3rd p=0.201 5th p=0.208; 7th p=0.209
	F2	*F(4,3093)=35.041, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/u/	**F1**	*F(4,3017)=21.259, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,3017)=48.873, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001

*significant at the p<0.01 level

In summary, despite the presence of some similarities in the productions of one-way NES learners and the immersion teacher group, several differences are noteworthy. The normalized formant values of learner groups and the teacher group differ on 7 of 10 measures. The upper grade levels do not exhibit fewer differences than the lower grade level groups in this dimension, but they do with respect to the influence of lexical stress. In other words, although movement is not observed toward the formant values of teachers, the way in which lexical stress influences productions does change. One-way learners in upper grades evidence a similar influence of lexical stress on production as teachers.

5.3.3 Comparison of Vowel Productions of Two-way NES Students and Immersion Teachers

Learners in two-way programs have two principal sources of more proficient input in Spanish, their teachers and their native speaking peers. How the vowel productions of students in two-way programs compare to their peers was described in previous sections; this section considers how their vowels compare to those of their teachers. Normalized z-scores for the teacher group were presented in Table 5.23 in Section 5.3.1; Table 5.28 in this section displays the z-scores for the two-way NES group according to grade level. Vowel charts of the normalized learner and teacher values are plotted on the same chart in Figure 5.22.

The productions of the teacher group appear to resemble those of the third and fifth grade groups for /i/ and /e/ and be very similar to those of the first grade and third grade groups for /a/, /o/, and /u/. The vowel space of the seventh grade group presents the greatest deviation from that of the teacher group in terms of position of the formants. More specifically, the vowel space of the two-way NES seventh grade group is narrower than that of the teacher group. There is considerable distance in the z-scores of the mid vowels between these two groups. When z-scores are compared statistically, however, the learner groups all pattern identically to the teacher group. If there are statistical differences in a formant measurement across groups, all learner groups show statistical differences in post-hoc paired comparisons. Results of oneway ANOVA and post-hoc LSD tests are available in Table 5.29. Statistically significant differences exist between the teacher group and all of the two-way NES grade level groups for F1 and F2 of /i/ and /u/, F2 of /e/ of /o/, and F1 of /a/. What is striking about these results is that the two high vowels pattern similarly as do the two mid vowels; /a/ does not pattern with either of the two vowel groups.

Table 5.28: Two-way NES Normalized Formant Values According to Grade Level

			1st Grade	3rd Grade	5th Grade	7th Grade
/i/	**F1**	**mean**	-0.92	-0.79	-0.83	-1.1
		s.d.	0.34	0.68	0.55	0.63
	F2	**mean**	0.99	1.06	1.17	0.94
		s.d.	0.84	0.52	0.69	0.74
/e/	**F1**	**mean**	-0.01	-0.13	0.0	0.13
		s.d.	0.53	0.54	0.43	0.49
	F2	**mean**	0.81	0.59	0.54	0.94
		s.d.	0.42	0.4	0.34	0.59
/a/	**F1**	**mean**	1.2	1.06	1.18	1.06
		s.d.	0.85	1.04	0.84	0.77
	F2	**mean**	-0.1	-0.19	-0.31	-0.06
		s.d.	0.38	0.66	0.44	0.76
/o/	**F1**	**mean**	-0.0	0.11	0.16	0.12
		s.d.	0.65	0.75	0.72	0.59
	F2	**mean**	-0.91	-0.78	-0.76	-0.51
		s.d.	0.44	0.81	0.69	1.05
/u/	**F1**	**mean**	-0.78	-0.6	-0.92	-0.6
		s.d.	0.4	0.33	0.42	0.47
	F2	**mean**	-1.24	-1.13	-1.16	-1.06
		s.d.	0.43	0.59	0.52	0.58

Figure 5.22: Comparison of Two-way NES Students and Immersion Teachers, Z-scores

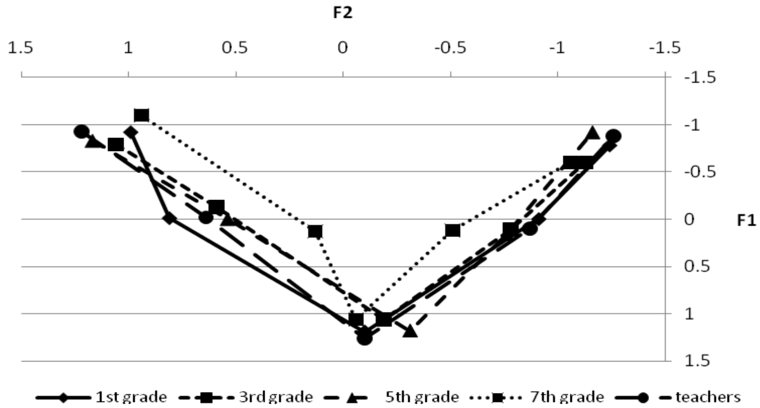


Table 5.29: Oneway ANOVA Results Summary, Teacher vs. Two-way NES Students Comparison of Normalized F1 and F2 Values According to Vowel

		One-way ANOVA Results	Significant post-hoc comparisons and p-values
/i/	**F1**	*F(4,1958)=38.778, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,1958)=65.743, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/e/	**F1**	F(4,1933)=0.009, p=1.0	1st p=0.86; 3rd p=0.859 5th p=0.871; 7th p=0.882
	F2	*F(4,1933)=15.913, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/a/	**F1**	*F(4,1974)=75.099, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	F(4,1974)=0.481, p=0.75	1st p=0.204; 3rd p=0.2 5th p=0.249; 7th p=0.302
/o/	**F1**	F(4,1963)=0.467, p=0.76	1st p=0.209; 3rd p=0.205 5th p=0.252; 7th p=0.303
	F2	*F(4,1963)=34.617, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
/u/	**F1**	*F(4,1887)=21.158, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001
	F2	*F(4,1887)=43.699, p<0.001	*1st p<0.001; *3rd p<0.001 *5th p<0.001; *7th p<0.001

*significant at the p<0.01 level

Plots of the stressed and unstressed productions of two-way NES students and immersion teachers resemble one another in that the unstressed productions regularly fall inside those of stressed productions.[60] However, the respective statistical comparisons reveal different trends. Fewer of the differences in the learner vowel productions reach statistical significance than those of the teacher group. The most consistent across the learner groups is /a/, but each grade level demonstrates a difference in production according to lexical stress on only one dimension; the teacher group produces /a/ with different F1 and F2 frequencies depending on syllable stress. The teacher group also produces /i/ and /e/ with centralized F2 values in atonic syllables; only the first grade group shows any differentiation in production based on stress for these vowels (F1 of /i/), the other groups evidence no centralization of the front vowels.

Statistically, each of the two-way NES grade level groups patterns similarly in comparison to the teacher group, which suggests that the vowel productions of this group of learners do not become more similar to those of their teachers as grade level increases. Although the seventh grade group patterns similarly to the other grade level groups statitically, their productions appear to diverge the most from the teacher model; specifically their vowel space is of a different size and shape. While, on one hand, this finding is surprising given that this particular group of learners has had the greatest exposure to teacher input, more time learning in Spanish, and presumably has the greatest control over articulations as a result of being older, it must be interpreted with caution as only three participants made up this learner group, which may have impacted the statistical analysis.

[60] These plots were presented previously. Figure 5.3, Figure 5.7, Figure 5.11, Figure 5.15 have the vowel charts for the two-way NES learner groups while the numeric data is presented in Appendix J, Appendix K, Appendix L, and Appendix M. Both the numeric data and vowel plot for the teacher group are available in Appendix N.

5.3.4 Summary of Comparison of Student Groups to Immersion Teacher Group

All student groups, without regard for grade level or program/language background, pattern the same in statistical comparisons to the immersion teacher group: the high vowels, /i/ and /u/ show differences on both formants; the mid vowels, /e/ and /o/, show differences in F2 values, and /a/ shows differences on the F1 dimension. The direction of difference for each formant measurement, however, is rarely consistent across all grade level and program/language groups. The direction of difference between teachers and students is only the same for F2 of /u/, for which teachers have a smaller mean z-score, and F1 of /a/, for which teachers have a larger mean z-score. For all other formant measurements, there are exceptions to the general tendency; either individual grade level groups or whole program/language groups present a different pattern.

5.4 Attitude and Pronunciation

Language and language learning attitudes have been found to play a role in the acquisition of L2 pronunciation (e.g., Elliot, 1995a, 1995b; Gatbonton, 1975; Hedgcock & Lefkowitz, 2000; Lybeck, 2002). For this reason, third, fifth, and seventh grade student participants completed an attitude questionnaire to determine whether differences in attitudes could account for differences found across program/language groups and to explore any potential correlations between attitude and pronunciation (Research Question 5). First grade participants did not complete the questionnaire due to cognitive limitations and time constraints. The complete questionnaire contained 33 items; fifth and seventh graders had the opportunity to respond to all 33 items while third graders only responded to 22 due to time restrictions. NES learner mean responses to each item according to program and grade level are available in Table O.1 in Appendix O.

From the 33 items, four potential factors, related to attitudes toward Spanish and pronunciation, were identified:

Factor 1: Positive attitude toward Spanish

Factor 2: Recognition of instrumental reasons/motivations for knowing Spanish

Factor 3: Recognition of the importance of pronunciation

Factor 4: Positive rating of pronunciation abilities

Table 5.30, presented previously as Table 4.12 in Section 4.5.5, summarizes the questionnaire items that mapped onto each of the four factors. Individual student responses to each item were first scored (1=true, 2=kind of true, 3=kind of false, 4=false) and the sum of the individual items scores for each factor was determined. Reliability tests were run to determine "the repeatability of the behavior elicited by the test and the consistency of the resultant scores" (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education [AERA/APA/NCME], 1999, p. 31). Reliability of the four attitude factors for the third grade groups is $\alpha(4) = -0.208$ and for the combined sample of fifth and seventh grade groups, $\alpha(4)=0.847$. The measures for the third grade group have a low reliability statistic, suggesting that the results may not be able to be repeated; this could potentially be a result of a small sample size and also few items mapping onto specific factors. Another potential reason for the discrepancy is the cognitive level of the third grade students, which could have impacted their understanding of the questions and in turn the reliability of their responses. The reliability score for the fifth and seventh grade group is much higher, signaling that the attitude scores for each factor are likely repeatable. Mean scores for each NES grade level are presented according to program in Table 5.31.

All student participants also completed a self-report of language skills in both English and Spanish (available in Appendix C and Appendix D); this self-report contained 10 items, only results from item 7 (pronounce Spanish sounds and words) are reported in this dissertation. Mean self-ratings for each individual NES learner participant are reported in Table O.2 in Appendix O; mean scores for each grade level group according to program type are included in Table 5.31.

Table 5.30: Questionnaire Items for Each Factor

Factor	Label	3rd Grade Questionnaire Items	5th & 7th Grade Questionnaire Items
1	Positive attitude toward Spanish	1: I like to speak Spanish. 5: I enjoy studying Spanish the way it is taught in school. 12: I enjoy meeting and listening to people who speak Spanish. 14: I am proud to know Spanish.	1: I like to hear people speaking Spanish. 3: I like to speak Spanish. 7: I enjoy studying Spanish the way it is taught in school. 15: I enjoy meeting and listening to people who speak Spanish. 20: I am proud to know Spanish.
2	Recognition of instrumental reasons/motivations for knowing Spanish	3: It is important to know Spanish in San Antonio. 8: I have more friends because I speak Spanish and English. 9: Learning two languages will make you smarter than learning only one language. 10: Learning two languages will help you get better grades. 11: Knowing two languages will help you get a better job when you grow up.	5: It is important to know Spanish in San Antonio. 11: I have more friends because I speak Spanish and English. 12: Learning two languages will make you smarter than learning only one language. 13: Learning two languages will help you get better grades. 14: Knowing two languages will help you get a better job when you grow up.
3	Recognition of the importance of pronunciation	20 : It is important for me to sound like my classmates when I speak Spanish. 21: It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker. 22: I like to pronounce words like my teacher.	27: I can recognize the difference between native-like and non-native pronunciation in Spanish. 28: I don't like when my classmates sound very non-native when they speak Spanish. 31: It is important for me to sound like my classmates when I speak Spanish.

Factor	Label	3rd Grade Questionnaire Items	5th & 7th Grade Questionnaire Items
3	Recognition of the importance of pronunciation		32: It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker. 33: I like to pronounce words like my teacher.
4	Positive rating of pronunciation abilities	19: I feel that I currently have excellent pronunciation skills in Spanish.	25: I feel that I currently have excellent pronunciation skills in Spanish. 26: My pronunciation in Spanish is native-like. 29: My pronunciation in Spanish is better than that of my classmates.

Table 5.31: Mean Attitude Factor Scores of NES Students According to Program and Grade Level

Grade	**Program**	**Factor 1** mean (s.d.)	**Factor 2** mean (s.d.)	**Factor 3** mean (s.d.)	**Factor 4** mean (s.d.)	**Ability Self-Rating** mean (s.d.)
1st	**Poss. range**	n/a	n/a	n/a	n/a	1-4
	one-way	n/a	n/a	n/a	n/a	3.2 (0.919)
	two-way	n/a	n/a	n/a	n/a	3.88 (0.354)
3rd	**Poss. range**	4-16	5-20	3-12	1-4	1-4
	one-way	5.89 (2.472)	7.78 (1.563)	6.22 (1.563)	1.67 (0.5)	3.33 (0.707)
	two-way	5.25 (1.165)	7.13 (1.458)	5.88 (2.1)	1.88 (0.641)	3.38 (0.744)
5th	**Poss. range**	5-20	5-20	5-20	3-12	1-4
	one-way	6.88 (3.682)	6.13 (3.399)	9.13 (5.167)	5.63 (3.204)	3.38 (1.408)
	two-way	6.0 (1.414)	7.75 (2.363)	10.00 (3.651)	6.75 (1.258)	3.75 (0.5)
7th	**Poss. range**	5-20	5-20	5-20	3-12	1-4
	one-way	7.13 (3.643)	8.13 (4.549)	9.13 (5.083)	5.88 (2.696)	2.88 (1.246)
	two-way	8.33 (2.887)	6.67 (1.528)	11.00 (3.606)	6.33 (2.517)	3.33 (0.577)

The number of questionnaire items varies across grade level groups and factors; the possible range of values for each factor according to grade level group is included in

Table 5.31. Lower scores signal higher (more true) ratings of each factor. For example, a score of 4 or 5 for Factor 1 would signal a more positive attitude toward Spanish than a score between 16 and 20. With respect to the self-report of pronunciation abilities, scores can range from 1 (bad) to 4 (good). For this particular item, a higher score signals a higher self-rating.

Although the first grade participants did not complete the attitude questionnaire, they did self-rate their language abilities. The two-way NES first grade group reports that their pronunciation is "good" more often than the one-way NES group as reflected in a higher group mean, 3.88 as compared to 3.2. The difference does not reach statistical significance. Comparing the one-way NES and two-way NES third grade groups, there is a trend for students in the two-way program to have slightly more positive attitudes (lower mean scores) toward each of the factors. The one exception to this is the rating of pronunciation abilities (Factor 4), for which the one-way NES presents lower scores (i.e., more positive ratings of their own pronunciation abilities). On the self-report of abilities, in contrast, the two-way NES third grade group rated their pronunciation abilities slightly higher; however, the difference is minimal. None of the observed differences reach statistical significance. The opposite trend is presented by the fifth grade group; the scores of the one-way NES group are lower (i.e., greater recognition of instrumental reasons for knowing Spanish, greater importance of pronunciation, and more positive ratings of pronunciation abilities) than those of the two-way group with the exception of Factor 1, positive attitude toward Spanish. As was seen with the third grade group, the rating of pronunciation abilities is higher for the two-way group on the self-report instrument. Again, none of the differences are at a statistically significant level. The seventh grade group presents a similar trend as the fifth grade group in that the mean factor scores are lower for the one-way NES group than the two-way group; Factor 2, recognition of instrumental reasons/motivations for knowing Spanish, has a higher score with the two-way group, 8.13 vs. 6.67. Again the two-way group reports more positive self-ratings of pronunciation abilities on the abilities self-report instrument. None of the differences between the two seventh grade NES learner groups reach statistical significance. Looking across the grade levels, the one-way group reports an increase in pronunciation abilities between first and fifth grade, but in seventh grade the group mean decreases. The two-way learner group presents a back and forth pattern, but they tend to be relatively high. Comparing changes in factor scores across grade levels is not possible given the different number of items included on the questionnaire for the third grade group.

The lack of statistical difference between the groups suggests that their attitudes toward Spanish and the role of pronunciation are similar across the two groups. In general, mean scores for each factor are near the lower end of the range of possible scores, which suggests that these NES immersion learners have a positive attitude toward Spanish, recognize its instrumental value in their community and for their future, recognize the importance of pronunciation, and evaluate their pronunciation abilities positively. Of the four factors, Factor 3, which considered the relative importance of pronunciation, received the highest scores, suggesting that learners do not place as much emphasis on pronunciation-related skills or value it as much as other aspects of the language. Nonetheless, immersion learners, with the notable exception of one-way NES seventh graders, tend to rate their pronunciation as “kind of good” or better.

The purpose of exploring learner attitudes was to consider how they related to pronunciation abilities. In order to explore this relationship, an independent measure of pronunciation ability was needed. A mean prototypicality score was calculated for each learner participant in line with the criteria described in Sections 4.5.5 and 4.5.6. Mean scores for each individual participant as well as each grade level are available in Table O.3 in Appendix O. The mean scores for each grade level group are in line with trends presented in previous sections that saw the two-way NES group produce a higher percentage of highly prototypical tokens as grade level increased and one-way NES produce a lower percentage of highly prototypical tokens as grade level increased. Pearson's Correlation was then used to determine if individual participants' factor or self-rated pronunciation ability scores correlated with their pronunciation ability, measured via the mean prototypicality score. Results of the correlation analysis are presented in Table 5.32.

The correlation coefficients are generally very low, which indicate that the relationship between the individual factors and pronunciation score is weak. The one exception to this is the relationship between Factor 2 and pronunciation in the group of third grade learners, which has a negative correlation. This signals that as the score for Factor 2 increases (lower recognition of the instrumental reasons or motivations for knowing Spanish), the pronunciation score decreases. This correlation does reach statistical significance at the $p<0.05$ level. This factor, however, only shows correlation with pronunciation for the third grade group, not the fifth and seventh grade combined group. These findings suggest that overall there is not a relationship between attitude or self-report of pronunciation, as measured by these questionnaires, and the prototypical pronunciation of vowels by immersion learners.

Table 5.32: Findings of Pearson's Correlation Tests

Correlation of pronunciation score (prototypicality mean) to:	Grade Level(s)	Pearson Correlation Coefficient	Sig.
Factor 1: Positive attitude toward Spanish	3	r(15)=0.036	p=0.891
Factor 2: Recognition of instrumental reasons/ motivations for knowing Spanish	3	r(15)=-0.538	p=0.026*
Factor 3: Recognition of the importance of pronunciation	3	r(15)=0.06	p=0.82
Factor 4: Positive rating of pronunciation abilities	3	r(15)=0.201	p=0.722
Factor 1: Positive attitude toward Spanish	5 & 7	r(21)=0.023	p=0.918
Factor 2: Recognition of instrumental reasons/ motivations for knowing Spanish	5 & 7	r(21)=-0.045	p=0.838
Factor 3: Recognition of the importance of pronunciation	5 & 7	r(21)=0.096	p=0.663
Factor 4: Positive rating of pronunciation abilities	5 & 7	r(21)=0.159	p=0.469
Ability Self-Rating	1, 3, 5 & 7	r(56)=0.117	p=0.382

*significant at the $p<0.05$ level

Chapter 6
Discussion and Conclusions

This final chapter of the dissertation discusses the findings of the current study as a means of addressing the general question that prompted this research: How do native English speaking immersion learners in immersion programs produce Spanish vowels? Organized around the five research questions which guided this investigation, the discussion summarizes and elaborates on the specific findings presented in the previous chapter, connecting them to previous work on L2 vowels and language immersion education. Based upon this discussion, conclusions are offered. The dissertation ends with the implications of these findings for pedagogical practice and program development as well as, suggestions for future research based on the limitations of the current study.

6.1 Do the vowel productions of native English-speaking learners in Spanish immersion programs differ from those of native Spanish-speaking peers? If so, how?

This question will be answered by summarizing findings reported in the previous chapter; the discussion will address the system as a whole first and then individual vowels. Formant values, native-like and prototypicality classifications, and lexical stress will all be touched upon in the discussion. As the results of the current study are reviewed, they will be related to other empirical work on L2 acquisition of Spanish vowels.

The acoustic space occupied by vowel systems of the two-way NSS group is smaller than that of both NES learner groups across all grade levels with only one exception, the two-way NES group which presents a vowel space of similar size in seventh grade. The smaller vowel space results from differences on both the high-low and front-back dimension. Differences in size on the F1 (high-low) dimension are primarily a consequence of the learner groups producing /a/ at a higher frequency. Differences in size on the front-back dimension are largely attributable to greater F2 values for the front vowels, /i/ and /e/, in the productions of the NES learner groups. The location of the vowel system also differs across the program/language groups, in part as a consequence of the different sizes of the vowel systems; those of the two-way NSS groups are located higher and further back in the vowel space than those of NES learners.

The relatively larger vowel space of the NES learners of Spanish could be a result of transfer from English. The graphic representation of the relationship between the Spanish and English vowel systems made by Delattre (1965) suggests that the Spanish vowel system is slightly narrower on the horizontal plane and that its vertical position is slightly higher. Findings from Bradlow (1995) generally echo these observations[61]; she proposed a language-specific base-of-articulation effect to account for the differences in the two systems. Based on these observations, transfer of English-language vowel norms to the articulation of Spanish vowels would result in more fronted articulations and a more extreme lower boundary to the system. In part, this is what is observed for the NES learners of Spanish. Greater F1 values of /a/ result in a lower limit to the vowel space, and there is a tendency for all vowels to be produced with higher F2 frequencies, especially the front vowels.[62]

This finding differs from that of Menke and Face (2010). In that study, the vowel space of intermediate adult learners was much reduced in comparison to that of native

[61] Bradlow does not include the low, central vowel /a/ in her study.

[62] There are some notable exceptions to these trends. The two-way NES fifth and seventh grade groups do not show the same differences in F1 values of /a/ as the other NES groups, and /u/ productions of two-way NES first and fifth graders have lower mean F2 frequencies than the corresponding NSS group.

speakers; more advanced learners expanded the size of their vowel system so that it resembled that of the native Spanish-speaking comparison group. So while the size of the vowel system increased with more advanced, adult learners, it was never found to exceed that of the native speakers to the same degree as the child learners in this study. The difference between these two groups of learners may be attributable to both age differences similar to those found in Guion (2003) and context of learning.

NES immersion learners, accustomed to a crowded L1 vocalic system, may be striving to maintain maximum difference between the vowels. Even though Spanish has fewer vowels and consequently less need to maximize the distance between the vowels, learners may transfer this property from English. Both Dispersion-Focalization Theory (Schwartz et al., 1997) and the Theory of Adaptive Dispersion (Liljencrants and Lindblom, 1972; Lindblom, 1983, 1986; Lindblom and Engstrand, 1989) put forward that the vowels of any give language system are organized in such away so as to curtail the likelihood of perceptual confusion. That is to say, languages with larger vowel inventories will occupy more acoustic vowel space as a means of lessening perceptual overlap between vowels. Consequently, the point vowels in a "crowded" system such as English will have more extreme tongue positions, and subsequently more extreme formant values, than point vowels in a less crowded system such as Spanish. Given the close proximity of English /i, a, u/ to other vowel phonemes such as /ɪ, ʊ, æ, ɔ, ʌ/, articulation of them requires more distinct formant values than in Spanish. These theories have found support, at least in part, in other studies that investigated Spanish and English vowels (Bradlow, 1995; Cordero et al., 2006; Flege, 1989).

In work with Quechua-Spanish bilinguals in Peru, Guion (2003) found evidence for bidirectional influence of L1 and L2 phonetic systems that is in line with dispersion theories. Only simultaneous bilinguals were able to establish vowel categories identical to those of monolingual speakers of each language; L2 learners of Spanish who acquired the new L2 sounds (Spanish /e/ and /o/) produced the high vowels in their native Quechua language, with lower F1 values. Moreover, the Quechua low vowel, /a/ was produced differently than the Spanish low vowel. Guion interprets these findings as evidence for "the need for sufficient discrimination" (p. 123); she concludes that the introduction of a second phonetic system to an already established phonetic system prompts reorganization in order to maintain perceptual distance. Such reorganization was observed in early and mid bilinguals.[63]

The size and position of each program/language group's vowel system is directly correlated to the frequency at which the formants of each vowel are produced. Each of the vowels will be considered independently of the others, starting with the high, front vowel /i/. The two NES groups present different trends with respect to this vowel. Whereas the one-way NES group differs more from the two-way NSS group as grade level increases, the two-way NES group differs less. In spite of this difference, there is a tendency on the part of both groups to produce /i/ with greater F1 and F2 values[64]; this reflects a lower, more fronted tongue position in articulatory terms. The percentage of /i/ tokens classified as native-like and highly prototypical present moderate values in

[63] Early bilinguals began learning Spanish between the ages of 5 and 7, and mid bilinguals started learning Spanish between the ages of 9 and 13.
[64] Two-way NES first graders present an exception to this trend for they produce /i/ with lower F1 and F2 values than their two-way NSS counterparts.

comparison to the other vowels, which suggests that this particular vowel is neither particularly easy nor particularly challenging for NES learners of Spanish.

Cobb (2009) proposed that /i/ is the most easily acquired vowel phoneme by NES learners of Spanish; findings from Menke and Face (2010) partially support this notion in that advanced learner groups produce /i/ with similar formant values to native speakers. Intermediate learners, the fourth-semester group in Menke and Face (2010), do not produce /i/ with native-like values, however, which suggests that acquisition of /i/ is not guaranteed or automatic. Findings from that study do not point to particular difficulty or ease in the acquisition by adult learners of this phoneme when considered in isolation, similar to the current study of children.

With respect to the mid, front vowel /e/, findings are somewhat similar as were found with /i/; the two NES groups behave differently in comparison to the NSS group. There is a trend for the NES learners to produce /e/ with greater F1 and F2 values; however, many of the differences do not reach statistical significance. The one-way NES first and third grade groups' F1 values of /e/ differ significantly from those of the two-way NSS peer groups'; in fifth and seventh grade, differences in F1 and F2 frequencies are significant. The two-way NES group, on the other hand, produces /e/ with significantly higher F2 values in first and third grade and in seventh grade, with significantly higher F1 values. The percentage of native-like classifications and prototypicality scores of 4 for the one-way NES group are generally low, in most cases lower than the overall average.[65] The trend for two-way NES group is different; this learner group produces a greater than

[65] The one-way NES first grade group presents an exception to this trend; 51.9% of their /e/ tokens have a protoypicality score of 4, a percentage higher than the average for all vowels for this group, 47.8%.

average percentage of tokens in the native-like range, and the percentage of tokens with a prototypicality score of 4 hovers around the average.[66]

The difficulty exhibited by the one-way NES group in their acquisition of this vowel is in line with theoretical and empirical works which have proposed that Spanish /e/ is a challenge to acquire (Cobb, 2009; Flege et al., 1997; Morrison, 2003; Stockwell & Bowen, 1965). The proposed difficulty with Spanish /e/ stems from its overlap with two categories in English (Flege et al., 1997; Morrison, 2003; Stockwell & Bowen, 1965) and its status as a diphthong in English (Flege et al., 1997; Stockwell & Bowen, 1965). Although measurements were not taken at multiple points in the vowel to be able to comment on whether learner productions were diphthongs or monophthongs, the mean formant frequencies of the one-way NES group tend to be higher than those of the two-way NSS comparison group on both F1 and F2. One potential explanation for this is that the L1 phonemic distinction is being born out in the L2; in order to retain the distinctiveness of Spanish /e/, in light of its partial overlap with English /ɪ/ and /ɛ/, learners produce it with more extreme formant values.

Stockwell and Bowen (1965) proposed that /a/ would transfer successfully from English to Spanish; however, significant differences are observed in the formant values of /a/ between NES learners of Spanish and the NSS comparison group, across all grades for the one-way NES group and in the lower grades in the two-way NES group. Although not all differences reach statistical significance, the NES groups produce /a/ with greater F1 and F2 values, suggesting a lower, more fronted articulation. With the exception of

[66] As with the one-way NES group, the first grade group does not conform to this trend. For both percentage of native-like tokens and percentage of tokens with a prototypicality score of 4, they produce a lower relative percentage of tokens than the average for all vowels.

seventh grade, the percentage of learner tokens produced with native-like formant values is relatively high for both groups, but the percentage of tokens to receive 4 points on the prototypicality rating scale is less, and neither group presents a consistent pattern with respect to the other vowels.

Despite the presence of statistically significant differences, /a/ does not appear to present a higher degree of challenge than any other vowel for this learner group, a finding that is consistent with the prediction of Stockwell and Bowen (1965). The considerably greater F1 and F2 frequencies at which /a/ is produced by the learner groups cannot be explained through transfer as the low vowels in the two languages have similar F1 values, and English /a/ is more back (lower F2 values). Morrison (2003) observed a similar tendency in adult, beginning learners of Spanish. In his study, learner perception of Spanish /a/ corresponded to four English categories - /æ, ʌ, ɒ, ɛ/; learner production of /a/ corresponded to the English /æ/ category and was articulated lower in the vowel space than that of native speakers, a finding similar to that of learner productions in this study. In line with the high native-like classification of /a/ for these learners, the /a/ productions of the learners in Morrison's study received high identification scores.

Cobb (2009) observed differences in formant values between intermediate learners and native speakers, but advanced learners had shifted productions to reflect native norms. In a similar way, advanced learners in Menke and Face (2010) evidenced learning as they too moved toward the native speaker target for /a/. Immersion learners in the present study, particularly those in the one-way program, do not evidence the same learning as the adult learners in the above studies. Nonetheless, a relatively high proportion of /a/ tokens are native-like, suggesting that this vowel, despite evidencing different formant values may be acceptable given the wide range of native speaker values.

A consistent observation made in the previous chapter was that the position of the two back vowels, /o/ and /u/, was much closer together in the speech of the two-way NSS groups than in that of the two NES learner groups. In the case of the third grade groups, the /u/ productions of the two-way NSS group showed considerable overlap with those of /o/ by the NES learner groups. The greater distance between the vowels in the speech of NES may be attributable to their desire to maintain two distinct categories for the L2 sounds, which in English, their L1, share space with a third phoneme, /ʊ/. Of the 10 significant differences in formant values between the NES groups and the two-way NSS comparison group, 7 are the result of the NES groups producing the first formant at a higher frequency. Delattre (1965) and Bradlow (1995) differ in their relative positioning of /o/ in the two languages; Delattre referenced a greater F1 value for /o/ in Spanish than in English while Bradlow found the opposite, a greater F1 value in English. So whether the higher F1 frequencies in the speech of the learner groups are the result of transfer from English is unclear.

Another much cited difference between the two languages is that English /o/ is most typically realized as a diphthong, [oʊ] (Bradlow, 1995; Delattre, 1965; Ladefoged, 2006; Stockwell & Bowen, 1965). Given that only one measurement was taken for these vowels, whether learner groups are producing a diphthong as opposed to a monophthong remains unanswered. If the learner groups were producing a diphthong, the likely effect would be smaller F1 and F2 values at the point when measurements were taken (correlating with the movement to a higher, more back articulation for the second portion of the diphthong). This is the opposite of what is observed in the learner data in this study. As was mentioned for /a/, a possible explanation for the greater F1 values may be overcompensation; in their attempt to avoid producing the English diphthong, learners overshoot the target. Although /o/ is not as easy to acquire as /i/ according to Cobb (2009), few significant differences are found between adult learner groups and native speakers in either Cobb (2009) or Menke and Face (2010). It follows thus that immersion learners struggle more with this vowel than adult learners.

Fewer differences are observed between NES productions of /u/ and those of the two-way NSS comparison groups. The fewest number of statistical differences are found between NES and NSS on this vowel and both the percentage of native-like tokens and tokens with a prototypicality score of 4 tend to be high.[67] How learner productions compare to those of native speaker peers varies both in which formant presents significant differences and the direction of the difference. Nonetheless, there is a tendency for learners to produce /u/ with smaller F1 values and greater F2 values. The work of both Delattre (1965) and Bradlow (1995) points to Spanish /u/ having smaller F1 and F2 frequencies. F1 frequencies of NES learners surpass the native speaker target, again presenting a more extreme value. F2 frequencies do not follow suit as the learners have, in most cases, yet to hit the target. The differences between the learner and native speaker groups are small, however, and it can be argued that this is the vowel with which learners are most successful or that is most native-like. These findings resemble results from work with adult learners which find that those with advanced proficiency evidence

[67] The two exceptions to this are the one-way NES first grade group, which has its lowest native-like rating occur with /u/, and the two-way NES fifth grade group, which has a lower percentage of /u/ tokens receiving a prototypicality score of 4 than the average for all vowels.

few differences from native speakers in their production of /u/ (Cobb, 2009; Menke & Face, 2010).

Another often cited difference between the vowel systems of the two languages is the role of unstressed vowel reduction, an allophonic process in English resulting in centralization and a phonetic process in Spanish tied to vowel shortening, devoicing, elision, and in fewer instances centralization. Stockwell and Bowen (1965) theorized that vowels under weak stress would present the greatest challenge to NES learners of Spanish based upon these differences. Native speaker participants in this study did evidence some centralization of atonic vowels, particularly with /e/. This is in line with the native speaker control subjects in Cobb (2009) and Menke and Face (2010) and similar to earlier accounts which cited /e/ as evidencing the most reduction of all the Spanish vowels (Canellada de Zamora and Zamora Vicente, 1960; Delforge, 2008; Gordon, 1980; Lipski, 1990; Lope Blanch, 1963).[68] These findings do call into question, however, the conclusions of Willis (2005), which is the only study to date to have acoustically investigated the vowel productions of the Spanish-English bilingual population in the American Southwest. Willis concluded that centralization, as a result of contact with English, is not a feature of the Spanish of this dialect group; however, his analysis did not include /e/, considering instead only formant frequency differences for /a/.

The two learner groups do not follow suit. Although the amount of significant centralization for the two-way NES group is small overall, the most consistent differences are found between stressed and unstressed productions of /a/. The one-way

[68] Reduction in these accounts does not necessarily imply centralization but rather other phonetic processes – devoicing, elision, and shortening.

NES group, which registers the most number of significant differences between stressed and unstressed vowels, also frequently centralizes atonic /a/. Centralization of /a/ by the one-way NES groups is most regular on the F1 dimension, but also reaches significance on the F2 dimension for the third and seventh grade groups. The differences in lexical stress between the learner and native speaker groups likely contribute to the differences in formant values and the lower native-like and prototypicality scores in some instances. The one-way NES group also regularly produces /o/ with significantly smaller F1 values in atonic syllables.

Findings from the present child learner groups parallel those from previous research on adult L2 Spanish vowel acquisition. Hammerly (1982), Simões (1996), and Elliot (1997) all observed unstressed vowel centralization in learner productions of Spanish vowels; Hammerly (1982) specifically cited centralization of /a/ as a "pronunciation problem." Similarly, findings from Menke and Face (2010), an acoustic study to look at the effect of lexical stress on vowel production, point to centralization of /a/ on both the horizontal and vertical dimension across three adult learner groups – fourth-semester university students, graduating Spanish majors, and Ph.D. learners of Spanish. The presence of unstressed /a/ centralization across diverse learner groups and analytical techniques indicates that it is a feature common to the speech of English learners of Spanish.

Centralization of English /a/ to [ə] in atonic syllables is common in English, and some even reference reduction of /a/ to be stronger than that of other vowels (e.g., Willis, 2005); thus the observed centralization of unstressed Spanish /a/ likely results from transfer of an L1 phonological process. In his Ontogeny Model, Major (1987) theorized that transfer processes decrease over time; however, even advanced learners, such as the upper grade level NES groups in the current study and the graduating Spanish majors and Ph.D. students in Menke and Face (2010), retain this mark of foreign accent in their Spanish speech. In contrast to these findings, advanced learners in Cobb (2009) did not differ from native speakers in their production of unstressed /a/. A different method of analysis may in part account for this different finding. Cobb (2009) did not measure or identify whether the formant frequencies of /a/ differed according to lexical stress; rather, she only compared atonic learner productions to atonic native speaker productions. And while the atonic productions of /a/ for the intermediate group did differ from those of native speakers, those of advanced learners did not.

For Cobb (2009), the most salient difference between the speech of the native speaker group and the learners, particularly intermediate learners, was unstressed /e/. The native speaker and intermediate learner groups differed in their productions of atonic /e/; while the native speaker group centralized this particular vowel, the learner groups did not. The advanced learners reduced /e/ at an intermediate level in comparison to the other two groups, more than the intermediate learners but less than native speakers. Immersion learner productions resemble those of the advanced learners in Cobb (2009) in that atonic /e/ is centralized, but not enough to reach statistical significance as the productions of the native speaker groups do; in this sense, the learners present an intermediate stage of development. The findings from this study and those of Cobb (2009) differ from those of Menke and Face (2010), in which all three learner groups did centralize /e/ on the F2 dimension, like the native speaker group.

The immersion learners in this study also evidenced centralization of atonic /o/, similar to the Ph.D. students in Menke and Face (2010) and the beginning learners in Morrison (2003). Findings from the participants in this study point to differences in F1 values for /o/ based on syllable stress; the direction of difference, however, is in opposition to what would be expected for confusion with /a/ as found in Morrison (2003). Learners in this study produce atonic /o/ with smaller F1values, suggesting a higher tongue position, not the lower tongue position necessary for overlap with /a/.

Throughout this discussion it has become evident that NES immersion learners do produce Spanish vowels differently from the native Spanish-speaking peers. In general, the vowel spaces of the learner groups are larger than those of the two-way NSS students and the point vowels present more extreme acoustic positions (more front, more back, higher, lower). This finding can be explained through transfer of an L1 phonetic tendency to maximize the articulatory distance between vowels so as to minimize perceptual confusion. This tendency is similarly observed in the learners' productions of /o/ and /u/, which are located at a greater acoustic distance from one another than the native speaker equivalents. In this way, findings from this study support dispersion theory.

Another important finding is that immersion learners transfer L1 allophonic processes even in the upper grade levels. The OPM would predict that transfer of unstressed vowel centralization would decrease with increased time of study and/or greater L2 proficiency; however, significant centralization of /a/, most notably on the F1 dimension, is present in the speech of NES learners at all grade levels with the exception of first grade in the one-way program. Because the NSS comparison groups tend to not centralize /a/ in the same way, it is likely that this feature of the learners' L2 speech is a result of transfer from the

L1. The observed differences in F2 frequencies for /o/ based upon syllable stress in the productions of many of the NES groups can also be attributable to transfer.

Although the NES immersion learners present little evidence of direct transfer of L1 acoustic properties in their speech, the findings that there is transfer of L1 phonetic tendencies and phonological processes go against the tenets of the OPM. In neither the one-way or the two-way group is there less centralization of unstressed vowels in the upper grades, nor does either group produce evidence of acquisition of unstressed reduction of /e/, which would signal an increase in native like productions. The findings from this study do not completely call into question this theory however as the upper grade level groups in the two-way program do move toward the NSS targets, as will be discussed in the following sections, which indicates learning of the L2 phonetic properties. The one-way group, on the other hand, does not evidence the same learning.

6.2 Do the vowel productions of native English-speaking learners in a one-way foreign language immersion context differ from those of English-speaking learners in a two-way immersion context? If so, how? Does this sound class develop over time? If so, how?

As referenced in the previous section, the two NES learner groups, the one-way group and the two-way group, do produce Spanish vowels differently. Because the differences in productions of the two groups change according to grade level, the specific details of how the two groups differ will be elaborated in this section through a discussion of how the vowel system develops over (apparent) time. In this way, Research Questions 2 and 3 will be addressed simultaneously.

The amount of difference between the one-way NES groups and the two-way NES groups increases from the lower grade levels to the upper grade levels. This is observed visually in Figure 5.1, Figure 5.5, Figure 5.9, and Figure 5.13 in the previous chapter as well as statistically; a summary of the number of significant differences between each program/language group is available in Table 6.1. The vowel spaces of the two NES groups resemble one another with respect to size and location in first grade; the largest differences appear with the high vowels. Statistically, the two groups differ on 5 of the 10 formant measurements. In third grade, the vowel spaces of the two groups still resemble one another, but that of the two-way NES is slightly narrower and slightly higher in the vowel space. Statistically, the two groups differ on 4 of 10 measures. By fifth grade, more separation between the two learner groups is observable; although the shape of the vowel spaces is still similar, they are located in different portions of the acoustic vowel space. The greater observable difference is confirmed statistically in that the two groups differ on seven measures. The amount of distance between the two vowel systems is great by seventh grade, and they do not resemble one another in shape, size, or location. The one exception is /u/, the formants of which are produced at similar frequencies by the two groups. In terms of statistical comparisons, 6 of the 10 formant measures differ significantly.

Table 6.1: Summary of the Number of Statistical Differences between Program/Language Groups at Each Grade Level

Original Group		One-way NES		Two-way NES		Two-way NSS	
Comparison Group		Two-way NES	Two-way NSS	One-way NES	Two-way NSS	One-way NES	Two-way NSS
Grade Level	1st	5	4	5	7	4	7
	3rd	4	5	4	6	5	6
	5th	7	9	7	3	9	3
	7th	6	8	6	4	8	4

It is somewhat surprising that in first grade there are 5 statistically significant differences between the two NES groups. Differences in the exposure of the students to Spanish may play a role in this. First, in the two-way program, Spanish instruction begins in kindergarten whereas in the one-way program immersion in Spanish does not begin until first grade. Consequently, the two-way NES first graders have had a year of additional exposure to Spanish; at the time data was collected, they were finishing their second year of Spanish study while the one-way NES first graders were only finishing their first. Second, two-way NES students also have more ethnic ties to the Spanish language and hear more Spanish outside of school than one-way NES speakers. Only 5.7% of the one-way NES participants identified themselves as Hispanic compared to 95.6% of the two-way NES participants. The ethnic ties to the Hispanic, or in this case Mexican-American, community is also reflected in the linguistic background of their parents, 78% of two-way NES students' parents indicated having some knowledge of Spanish and 35.9% are native speakers of Spanish. The percentages in the one-way community are much lower, 38% of parents know Spanish and only 6% are native speakers. The greater familiarity with Spanish on the part of the two-way NES parent population results in greater exposure to Spanish outside the classroom, be it in the home or in the larger community. (See Appendix P for information about exposure to Spanish outside of school for each of the two learner groups).

The greater exposure to Spanish, both in and out of the immersion classroom, has not resulted in the two-way NES group "outperforming" the one-way NES group at the first grade level. More of the two-way NES productions differ statistically from the two-way NSS peer group than those of the one-way NES, 7 compared to 4. Models of L2 phonological acquisition recognize that development in the L2 does not follow a linear path; in other words, learners may pronounce L2 sounds in a less native-like way during a period of time as they develop their L2 sound system. Major's (2000) OPM accounts for this phenomenon through the interaction of the three interlanguage components. Learner productions do not directly switch from L1-like to L2-like; language universals also play a role, impacting the developmental sequence of L2 sounds. These two learner groups are likely at different stages of development, subsequently the relative proportion of each of these three components differs in each group's interlanguage system. The two-way NES first grade group, despite being further in the process, has less native-like vowel productions, than the one-way NES group.

Given the different linguistic makeup of the two groups' families, it is also possible that their English vowel systems vary. Studies of the English pronunciations of Spanish speakers in the United States have pointed to variation in their articulation of specific English sounds. Some of the features unique to Chicano English include but are not limited to: initial consonant cluster reduction, /z/ devoicing, raising and lowering of /ɪ/ in final *–ing*, final clear /l/, and /ʌ/ realized as /a/ (Galindo, 1993; Santa Ana & Bayley, 2004).[69] It is possible that the English vocalic systems of these two learner groups differ and that they do not share a common starting point for their acquisition of the L2, but this is beyond the scope of this dissertation and requires further study.

In third grade, there is one less significant difference between the two NES groups; this slight shift is also reflected in the number of differences between each of the learner groups and the two-way NSS comparison group. The smaller number of differences in formant values between the NES groups narrows the gap between the one-way NES group and the two-way NES group with respect to how they compare to the two-way

[69] Historically Chicano English was defined as "a variety of English that is obviously influenced by Spanish and that has low prestige in most circles, but that nevertheless is independent of Spanish" (Metcalf, 1974, p. 53). Santa Ana (1993) and Fought (2003) reserve the use of Chicano English to refer to the variety of English used by native speakers of English, as opposed to Spanish-English bilinguals.

NSS group. The number of differences is nearly equal across the two learner groups; however, the formants that show differences vary. The one-way group differs from the NSS group more on F1 values whereas the two-way group differs more on F2 values. The fewer differences on the F1 dimension on the part of the two-way NES group suggest that they are in the process of acquiring the slightly higher positioning of the vowels in the acoustic space.

The greatest change in how the three program/language groups compare to one another occurs between third and fifth grade. The vowel space of the two-way NES fifth grade group, made up of only four participants, shifts up in the vowel space so that its relative positioning resembles that of the two-way NSS fifth grade group. The one-way NES fifth grade group does not show a similar movement. Consequently, the number of differences between the two NES learner groups increases at this grade level. The number of differences with the NSS peer group also changes in accordance with this; the two-way NES group shows fewer differences in fifth grade than in either first or third, and the one-way NES group evidences more differences. The one-way NES and two-way NES groups now differ on 9 of the 10 formant measures, whereas the two-way NES and two-way NSS groups differ on only 3.

The timing of this change is in line with observations made in the immersion context, that between third and fifth grade early, total one-way immersion learners begin to resist using the minority language with English-speaking peers (Blanco-Iglesias et al., 1995; Tarone & Swain, 1995). Additional research has found that in fifth grade, use of the minority language, Spanish, is more frequently used during interactions which include the teacher as an interlocutor (teacher-directed, whole class discussions, or pair or group work when the teacher is nearby) and for discussing academic content (Broner, 2000; Fortune, 2001; Potowski, 2002, 2004). Tarone and Swain (1995) suggested that the change in language use practices may reflect the students' emerging adolescent identity, which they are unable to create through the immersion language. Another possible explanation for the shift away from the immersion language is the amount of instructional time devoted to each language. In the upper elementary grades, the amount of content instruction in English increases; consequently, students are receiving less input in the minority language. It is also possible that the novelty of the immersion language lessens and subsequently students become less excited to use it.

Research on phonological development in the immersion classroom also found that this period was a turning point for one-way immersion students, in both Spanish and Japanese. Third grade one-way NES Spanish immersion were found in Snow and Campbell (1985) to receive significantly higher ratings on a native-like scale than sixth grade students from the same program. In the only other acoustic study to date of the pronunciations of one-way NES Japanese immersion learners, Harada (1999) reported that the fifth grade participants produced voiceless stops with longer VOTs than monolingual peers and first and third graders enrolled in the same program.[70] The findings from the one-way NES group in the present study resonate with the observed shift away from the immersion language in the upper elementary grades and the finding that students in upper grades have less native-like pronunciations than those in lower grades.

[70] Japanese voiceless stops have shorter VOTs than their equivalents in English. A more target-like pronunciation of Japanese would result in shorter VOTs.

The two-way NES fifth grade group does not follow the same trend. This group of learners more closely approximates their NSS peer group in their pronunciation of the Spanish vowels than two-way NES students in lower grades and their one-way NES peers. This particular group of learners presents the fewest number of differences with the two-way NSS group of any of the learner groups. The movement of this group of learners toward the native speaker target suggests that they have in fact learned to produce the Spanish vowels in a native-like way.

Previous reports of pronunciation abilities in immersion programs have been primarily limited to the one-way NES learner group; there are no systematic studies of phonological development in two-way programs. Fortune and Arrabo (2006) reported pronunciation ratings of NES learners in a modified two-way program.[71] In that study, similar to in the current study, the NES approached the ratings of their NSS peers. The findings from this study, in conjunction with those from previous research, signal that the L2 phonological development of immersion learners may vary depending on the program context. A significant difference between the two program models is the presence of native Spanish speakers in the classroom with the NES learners in the two-way context. Although other studies have shown that their presence does not guarantee increased use of the minority language (Fleming, 2006; Fortune, 2001; Potowski, 2002, 2004) or superior gains in other areas of the linguistic system (Christian et al., 1997; Potowski, 2005, 2007a, 2007b), these findings indicate that their presence may be enough to

[71] This particular program adhered to instructional and pedagogical practices of one-way foreign language immersion programs but had a student population more typical of a two way program. That is, a percentage of the student population was comprised of native Spanish speakers. The program self-identified as a one-way program with two-way admissions.

promote more native-like pronunciation patterns, particularly when the L2 learners are from the same ethnic group.

Little change is observed between the fifth grade and seventh grade learner groups. The number of differences between the one-way NES group and the two-way NES group decreases by one. There is a change of one statistical difference between each of the NES groups and the two-way NSS comparison group as well, an increase of one by the two-way NES group and a decrease of one by the one-way NES group.

It is important to point out that the one-way NES group is not moving away from the native speaker target; rather their system shows little change over time. Unlike the systems of the two-way groups, which demonstrate substantial change in formant values over time, that of the one-way NES group shows little. Figure 6.1 below exemplifies this statement. The vowel spaces of all four one-way NES grade level groups are plotted on the same chart, and while there are differences between the grade level groups and while the seventh grade group does have a narrower, more highly-positioned vowel system, the change across grade levels is minimal when compared to that of the two-way NES or two-way NSS groups (Figure 6.2 and Figure 6.3 respectively). The two-way NSS group presents a moving target as can be observed in Figure 6.3. Given that the one-way NES students have less regular contact with a similar peer group, it is not surprising that their system evidences less change.

Figure 6.1: Vowel Productions of One-way NES According to Grade Level

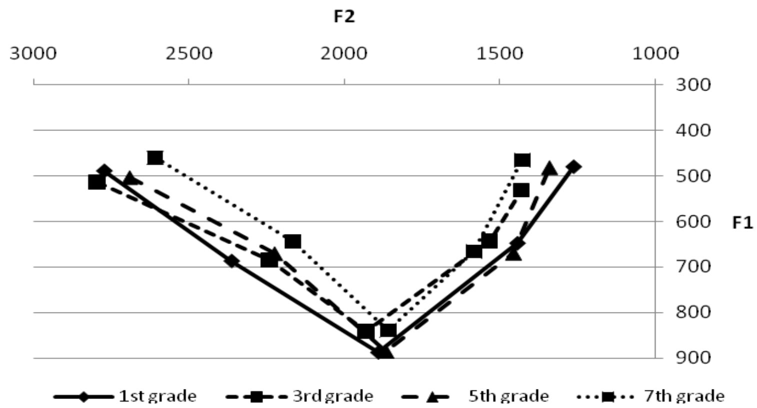


Figure 6.2: Vowel Productions of Two-way NES According to Grade Level

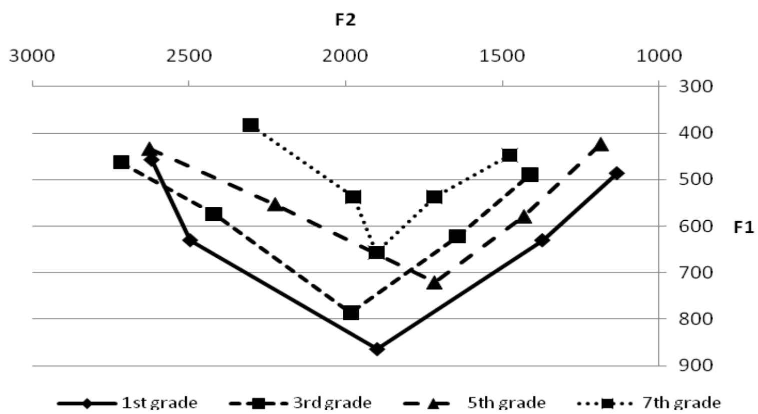
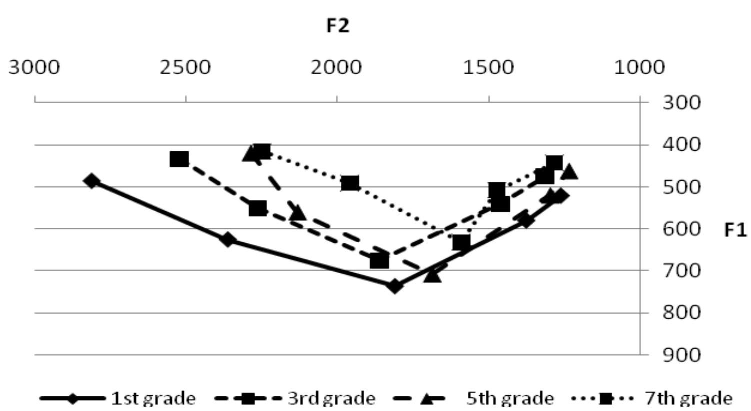


Figure 6.3: Vowel Productions of Two-way NSS According to Grade Level



In addition to contact with NSS peers in the classroom, the two-way NES group also has greater contact with native speakers of Spanish outside of school and more ethnic ties to the Spanish language. These factors likely explain the difference between the two groups, particularly because there are few differences in attitude toward Spanish, English, and their speakers, as will be explored further in Section 6.4. The increased exposure to Spanish outside of school (see Appendix P) increases the quantity of input and also potentially provides learners with input of a different quality. Given the familial ties to Spanish and the high percentage of two-way NES parents with Spanish as their L1, it is conceivable that these learners also overheard Spanish as infants and young children. Recent research has documented a positive effect of hearing[72] a non-native language prior to the early elementary years[73] for both perception (Oh, Jun, Knightly & Au, 2002; Tees & Werker, 1984) and production (Au, Knightly, Jun & Oh, 2002; Au, Oh, Knightly, Jun & Romo, 2007; Knightly, Jun, Oh & Au, 2003) of the non-native language later in life. More specifically, native English-speaking adult L2 learners of Spanish who had heard Spanish during childhood produced word-initial and word-medial voiceless stops with more native-like VOTs than typical adult L2 learners. In addition, these learners spirantized voiced consonants more often and received more native-like accent ratings (Au et al., 2002; Knightly et al., 2003). Although no empirical work has looked at the effect of hearing Spanish prior to the onset of schooling on vowel productions, it is plausible that early exposure to Spanish in the home poses an advantage for vowel production as well. Consequently, although there is a potential effect of program, more

[72] In these studies, participants who spoke the language during childhood were separated from those who produced little, if any, speech in the non-native language.
[73] The studies vary in the specific age at which a dramatic decrease in the amount of the non-native language occurs, ranging from 5 to 7.

research is needed that controls for quantity and quality of input in and out of the classroom in order to definitively make this conclusion.

6.3 Do the vowel productions of immersion learners differ from those of immersion teachers? If so, how?

One of the explanations cited for the differences observed between immersion learners and monolingual peer speakers of the immersion language is the input received from teachers (Boyd, 1975; Harada, 1999; Valdés, 1997). In order to account for the input the student participants in this study receive, a group of 10 immersion teachers, from both the one-way and two-way program, partook in this study, completing the same tasks as the student participants.

All of the student groups, irrespective of program/language designation and grade level, pattern the same in comparison to the immersion teacher group. Statistically significant differences exist in normalized formant values across groups and in post-hoc LSD comparisons of each program/language grade level group to the teacher group for F1 and F2 of /i/ and /u/, F2 of /e/ and /o/, and F1 of /a/. It is somewhat surprising that all groups pattern identically in statistical terms given the differences attested between program/language groups, but what this suggests is that the student groups produce vowels in a manner distinct from that of teachers.

The finding that no one program/language group patterns more like the teacher group than any other is noteworthy given that the presumed higher levels of Spanish proficiency and greater exposure to native speakers on the part of both teachers and two-way NSS students could be assumed to lead to more similar pronunciations. The finding that the vowel productions of these two comparison groups differ significantly indicates that the Spanish that English-speaking immersion learners are exposed to is highly variable, particularly for those students in two-way programs. The implication of this is that learners do not have a consistent model from which to create a mental representation of the Spanish vowels; their mental representations of these L2 vowels then must account for both targets. The two-way NES student group patterns more like their native Spanish-speaking peers than the teachers with whom they are in contact, a finding which indicates a peer group may have a greater influence on pronunciation than a teacher group, especially for pre-adolescent and adolescent learners. This is supported also by the finding that the one-way NES learners do not produce vowels more similarly to the teacher group than the two-way NSS comparison group, with whom they have limited contact. Hedgcock and Lefkowitz (2000) reported that university foreign language students felt some uneasiness producing native-like French in the presence of peers; similar feelings were reported by high school and university students of Spanish (Lefkowitz & Hedgcock, 2006). The authors suggest that these results are an indicator of learner inhibitions toward and difficulty constructing an identity as a legitimate speaker of the foreign language. Although students in this study generally report wanting to sound like their teacher and like a native speaker of Spanish, the one-way NES learners may struggle to create an identity as a legitimate speaker of Spanish. As a result, they do not conform to the target model presented to them by their teachers.

Despite research which has shown that teacher talk comprises a large portion of immersion classroom language, students are receiving auditory input from their peers as well. While in the two-way bilingual classroom, NES students receive native speaker input from peers, in the one-way foreign language classroom, the peer group is comprised solely of other L2 learners of the language. Consequently, these learners are consistently exposed to non-native models of language. Lyster (1987) named the language typical of one-way immersion classrooms “immersion speak,” describing it as comprehensible but marked by fossilized errors. Although Lyster was referencing the lexical and syntactic features, the same could be argued to hold for phonological aspects in the one-way classroom. Because little if any attention is given to pronunciation, learners may not recognize that their speech differs in subtle ways from that of their teachers. The greater amount of native speaker (or native-like in the case of some of the teachers) input in the two-way immersion context limits the amount of non-native language the two-way NES are exposed to, which could explain the differences between the two groups.

A second important finding is that the individual grade level groups do not show any difference in how they pattern with respect to their teachers. L2 phonological theories that posit greater length of time studying a language translates into the development of more target-like pronunciation would suggest that the productions of the seventh grade groups would be more like those of their teachers than those of students in lower grades.[74] Although not a statistically significant trend, it is actually the seventh grade groups which differ most from the teacher group with respect to location of vowels in the vowel space as observed in

The normalized vowel space of the teacher group overlaps considerably with that of first, third, and fifth graders. Most notably, teacher productions of the mid vowels /e/ and /o/ appear to coincide with those of these grade level groups; for /i/, teacher articulations of /i/ correspond to that of the first grade group more closely than the other

[74] This minimally could be argued for the one-way immersion context. Given the differences between the two-way NSS students and teachers and the finding that the two-way NES students pattern more like their peers than their teachers, the expectation that their pronunciations be more like their teachers may be less plausible.

grade level groups. Of the five vowels, NSS students and teachers appear to differ most in their articulation of /u/. Less overlap is observed between the teacher group and the two-way NSS seventh grade group. In particular, the mid vowels of the seventh grade group fall inside those of the teacher group, and /a/ has a lower F2 value.

Figure 5.20, Figure 5.21, and Figure 5.22. Previous work has shown that adolescents differentiate their speech patterns from those of adults, in part to exert their own identity (e.g., Labov, 1973; Labov, Cohen, Robins & Lewis, 1968). Tarone and Swain (1995) suggested that such an adolescent identity is what influences learners' resistance to using the immersion language with peers and in social interactions. If, however, the phonetic awareness of students is not developed in the classroom, this explanation may not be plausible as they may not notice or attend to specific features of their teachers' pronunciation.

An implication for SLA researchers to come out of the finding that NSS students and teacher groups differ in their pronunciations is that L2 speech should be compared to multiple groups and not held to one particular standard. There has been a recent trend in SLA research to compare L2 learners to bilinguals as opposed to monolinguals, but this finding highlights one complexity of this comparison – bilinguals are clearly not a homogenous group. Although there are likely many similarities between the pronunciation of the NSS student group and the teacher group in other sound classes, for this particular sound class, comparing learners to only one group would not have led to as deep an understanding of the intricacies of NES immersion learners' vowel productions.

6.4 Is there a relationship between attitudes toward Spanish and English and the pronunciation of Spanish vowels by immersion learners? If so, what does it look like?

Learner attitudes toward the second language, its speakers, native and non-native accents, and language learning as well as motivation have been found to affect L2 acquisition in general (e.g., Oller, Hudson & Fei Liu, 1977; Pierson, Fu & Lee, 1980) in addition to L2 pronunciation (e.g., Dalton-Puffer, Kaltenboeck & Smit, 1997; Elliot, 1995; Hedgcock & Lefkowitz, 2000; Lefkowitz & Hedgcock, 2006; Lybeck, 2002; Morgan, 1997; Smit, 2002; Smit & Dalton, 1997; Zuengler, 1998). In order to account for the effect of any potential differences in attitude toward Spanish and its speakers or differing motivations for pronunciation learning, an attitude questionnaire was designed and administered to third, fifth, and seventh grade participants. Analysis of student responses to this instrument revealed positive attitudes toward Spanish and its speakers on the part of study participants; this finding is in line with previous research which has found immersion learners to demonstrate cross-cultural sensitivity and favorable attitudes toward bilingualism and diversity (Christian et al., 1997; Genesee, 1978b, 1987; Lindholm-Leary, 2001). The attitudes of the two NES learner groups do not differ significantly; of the 88 comparisons made between the two groups, only four reached statistical significance. The four items to which the learner groups responded differently varied across the grade levels.

The original questionnaire items were combined into four factors related to positive attitudes toward Spanish, recognition of its instrumental value, and pronunciation, more specifically its importance and self-ratings of pronunciation abilities. In addition, students self-reported their ability to pronounce Spanish words and sounds through a skills self-evaluation. No differences were found between same-grade peers in the two different immersion programs for any of these factors. Individual attitude and ability scores were then correlated with a pronunciation measure, each individual's mean prototypicality score. Only one significant correlation was found between the attitude/ability measures and the pronunciation measure: recognition of instrumental motivations/reasons for learning Spanish and third grade pronunciation scores. From this, it becomes evident that differences in attitude or self-evaluation of L2 pronunciation ability do not explain observed differences in pronunciation.

The number of studies to engage the intersection of attitude, motivation, or identity and L2 pronunciation has increased in recent years (e.g., Dalton-Puffer, et al., 1997; Elliot, 1995a, 1995b; Hedgcock & Lefkowtiz, 2000; Lefkowitz & Hedgcock, 2002, 2006; Lybeck, 2002; Major, 2004; Morgan, 1997); however, all of them deal with adult or adolescent learners. Child L2 learners may have yet to associate certain linguistic patterns with specific social groups or develop strong attitudes toward a certain language and its speakers. The fact that children's linguistic identities are less firmly established than those of adults is sometimes used to explain child-adult differences in L2 acquisition (e.g., Brown, 1987; Long, 1990). Consequently, the correlations that have been previously found between attitude and L2 pronunciation may not be applicable to the child L2 learner. Findings from this study, specifically those from the first and third grade groups, lend credence to this conclusion as few differences in attitude are observed across programs or across grade levels. The lack of correlation between attitudes and pronunciation at the fifth and seventh grade level is surprising based upon previous work which has shown pre-adolescents to have a highly consistent vernacular by the age of 9

(Labov, 1973) and to be sensitive to the expression of identity through linguistic resources (e.g., Wolf, 1984).

The lack of difference between the two fifth and seventh grade learner groups is similarly unexpected; greater ethnic affiliation with the Spanish-speaking community in addition to greater contact with native-speaking peers would presumably lead to more positive attitudes.[75] The effect of educational programs such as two-way immersion programs on English-dominant second or third generation speakers of Spanish has yet to be systematically investigated. Valdés (forthcoming) observed little interaction between the two language groups outside the school day and the exclusion of English-dominant speakers from the social groups of the native Spanish-speakers.[76] Such lack of integration into Spanish social networks could explain the lack of difference in attitudes. It is possible that despite their Mexican ancestry, the English-dominant two-way immersion population is not fully integrated into the Spanish-speaking social circles, as was the case with one of Valdés' granddaughters. Nonetheless, there is a trend for the two-way NES to report slightly more positive attitudes and greater abilities with respect to pronunciation[77] which is not in line with this argument. Including more participants in the upper grade levels and investigating a variety of English-dominant two-way immersion learner populations would help to disentangle this question.

Previous work on L2 phonological acquisition with younger learners, in particular that conducted in language immersion settings, has not considered attitude or motivation

[75] However, attitudes overall were extremely positive which may contribute to the lack of statistical difference along with the small sample size in the two-way NES program.
[76] The observations reported by Valdés (forthcoming) are based upon the "learning stories" (Pavlenko, 2001) of her two English-dominant granddaughters.
[77] The lack of significance may be attributable to small sample sizes, particularly in the case of the two-way NES groups at these grade levels.

as part of the research design. Nonetheless, Harada (1999) does briefly discuss socio–psychological factors and their potential influence on the less native-like pronunciations of fifth grade Japanese immersion learners as compared to third grade learners. Harada hypothesized that the student participants in his study always felt some degree of peer pressure when speaking Japanese with or in front of their peers, which in turn inhibited their use of Japanese in class and hindered them from acquiring a native-like pronunciation. This hypothesis corresponds to much of the work carried out with older learners. Quotes from two high school student participants in the Lefkowitz and Hedgcock (2002) study exemplify the embarrassment that can result from poor pronunciation and the power given to those with "good" pronunciation:

> I – I know that like, you know, when I'm saying something in class and I pronounce it wrong, I feel stup- you know I – I don't really feel stupid, but I feel kind of embarrassed because I know that you know that's just something that we've learned a long time ago and, you know I should- (p. 233)

> …people…look up to, people that speak better, in a, in a better way. I mean, I, you know, when I think of somebody that doesn't speak well, I think that they're not, very smart, or that they, y'know, need to practice more, so you kind of, put them on a lower level than somebody that can speak really well… (p. 228)

Harada (1999) conjectured that the amount of peer pressure placed on individual students increased between third and fifth grade, implying that the fifth grade study participants were more inhibited and consequently had less native-like pronunciation.

The students in this study do not report a change in desire to sound like their classmates, native speakers, or their classroom teachers from third to fifth grade or from fifth to seventh grade on the attitude questionnaire (items 31-33). This finding is somewhat surprising given that previous research from both the one-way and two-way context has revealed a preference for English in the late elementary grades (Blanco-Iglesias, et al. 1995; Broner, 2000; Fortune, 2001; Potowski, 2002) and reports that high school and university foreign language learners do not regard themselves as legitimate speakers of the L2 (Hedgcock & Lefkowitz, 2000; Lefkowitz & Hedgcock, 2006). It is possible that the perspective of the participants does shift during these years but that the attitude questionnaire employed in this study was not sensitive enough to capture it. It is also possible that these particular learners do not experience greater pressure to conform to a non-native norm in the upper elementary/middle school years. The highly bilingual nature of the larger community or specific classroom or program practices may contribute to students' professed desire to sound native-like.

6.5 Conclusions

The purpose of this study was to describe how Spanish immersion students produce the Spanish vowels while examining development over (apparent) time and considering the effect of program and attitude. Several conclusions can be drawn from the findings of this study and the subsequent discussion.

First, early exposure does not guarantee native-like pronunciation. Numerous studies have found that early exposure to a second language leads to more native-like pronunciation (e.g., DeKeyser, 2000; Flege et al., 1999; Højen & Flege, 2006; Munro et al., 1996; Scovel, 1969); however, findings from this study and others (e.g., Bosch, Costa & Sabastián-Galles, 2000; Guion, 2003; Sebastián-Galles & Soto-Faraco, 1999) indicate that exposure by the age of 6 does not result in automatic target-like vowel articulations even at more advanced levels of study. In fact, the one-way learner groups show more significant differences with the native Spanish-speaking peer group than have been reported between adult learners of Spanish and native speakers (Cobb, 2009; Menke & Face, 2010).

Although learners do not directly transfer acoustic features of the English equivalents of the Spanish vowels, two phonological properties of the L1 system do appear to influence learner productions. The first is a property which stems from dispersion theory; given the many vowel phonemes in English, speakers have a tendency to maximize the distance between them as a means of minimizing the perceptual burden. NES learners in this study maintained greater distances between the five vowels in Spanish than NSS peers. The second property is unstressed vowel centralization. Learners do not centralize Spanish unstressed vowels to [ə] as in English, but some significant distinctions are maintained between atonic and tonic variants. The low, central vowel /a/ is most affected by this L1 phonological process, particularly on the F1 dimension.

A second important finding to come out of this research is that the type of immersion program may impact phonological acquisition. Two-way NES students approximate NSS peer vowel productions by seventh grade whereas one-way NES students do not. Two-way programs are designed so as to provide language-minority learners a quality educational experience, but they serve a dual function as they also provide the language-majority students with an enriched educational experience by allowing them the opportunity to learn a second language. In order to meet these two goals, two-way immersion programs bring together NES and NSS students. The increased contact with NSS peers may provide learners with more highly proficient input while limiting the amount of exposure to "immersion speak". However, differences between the two NES learner populations are conflated with program model. In comparison to the one-way NES participants, the two-way NES learners have greater ethnic ties to the Spanish language, have parents with greater knowledge of Spanish (in some cases they are native speakers of Spanish), and hear more Spanish outside of the classroom. Consequently, greater gains in target-like pronunciation cannot solely be attributed to contact with NSS peers in the classroom. From this it becomes clear that the input received in the one-way immersion classroom is insufficient for development of native-like pronunciation; more input, whether it is from native speaking peers in the classroom or family and friends outside the classroom, promotes more native-like vowel pronunciations. Differing attitudes, a variable found in other studies to affect acquisition of L2 pronunciation, was not found to correlate with pronunciation in this study. Specifically, the two learner groups were not found to vary with respect to their attitudes toward Spanish, its speakers, its importance or the importance of pronunciation.

A third conclusion which can be drawn from the findings of this study is that L2 learner speech should not be held to one standard. Historically, L2 learners were compared to a monolingual standard; in light of recent research which has shown the acoustic properties of monolingual and bilingual speakers to differ, there has been a shift to using bilingual comparison groups. However, the two bilingual comparison groups to participate in this study, a peer group and a teacher group, were found to produce vowels with different acoustic properties. Including more than one comparison group enhances our understanding of how learner productions develop and potentially why.

6.6 Pedagogical Implications

Prior to the "shift in emphasis from language knowledge to language use" (Tschriner, 1996, p.1) that occurred in foreign language instruction with the advent of the Communicative Approach, pronunciation occupied a central role in both theories of oral language proficiency and approaches to L2 teaching. In approaches such as the Audiolingual Method and the Silent Way, pronunciation was regarded as a necessary linguistic skill, and emphasis was placed on the accurate production of specific segments in isolated sounds or words. Within the Communicative Approach, however, pronunciation tends to be given little attention if any; Pennington and Richards (1986) comment, "pronunciation…has come to be regarded as of limited importance in a communicatively oriented curriculum" (p.207). The same can said to be true of content-based language curricula and immersion programs. Elliot (1995b) notes that "teachers tend to view pronunciation as the least useful of the basic language skills and therefore they generally sacrifice teaching pronunciation in order to spend valuable class time on other areas of the language" (p. 531). He attributes this practice to the belief that pronunciation is more difficult to develop than other language skills while others such as Tarone (2005) have attributed the absence of pronunciation instruction to a belief that accurate, or native-like, pronunciation is impossible. In the past twenty years or so, a surge has occurred in the number of studies to investigate the effectiveness of pronunciation or phonetic training on L2 phonological acquisition (e.g., Arteaga, 2000; Castino, 1996; Elliot, 1997; Gonzalez-Bueno, 1997; Lord, 2005, 2008; Terrell, 1989). The findings from this study argue for the need for attention to pronunciation in immersion classrooms, particularly in the absence of native speaker models; exposure to the L2 is insufficient to develop native-like pronunciation even at an early age.

The majority of studies to investigate the effectiveness of various instructional activities on L2 pronunciation have been conducted in university classrooms, either language classes or phonetics classes. The applicability of the specific methods to elementary immersion classrooms has yet to be verified. Elementary immersion classrooms present two distinct challenges to the instructional strategies presented in much of this research. First, the young age of learners has cognitive and physiological consequences. As a result of differences in cognitive development, learners may not be able to attend to the same details as adolescent or adult learners; instructional activities must therefore be adapted to meet their cognitive level. Children also pass through a series of physical development stages that impact their accuracy in hitting articulatory targets and ability to produce certain sounds. For example, instruction as to how to pronounce /ɾ/, /r/, /l/, and consonant clusters may not be as effective in first grade as in third or fifth grade as even native speakers are still working on producing these sounds at this age (Bailey, 1982; Evans, 1974; Gonzalez, 1978; Mason, Smith, & Hinshaw, 1976). Second, immersion programs are content-driven, not just content-based, language programs; in other words, content is the central focus of instruction. In well-designed, well-implemented programs, language development is planned for and attended to, but language development is driven by content objectives. Pronunciation instruction would need to be incorporated into this framework.

Immersion teachers are likely already incorporating some phonological awareness and pronunciation training in their instruction, particularly as part of the Language Arts curriculum. For instance, phonemic distinctions, such as those between “r” and “rr” or “n” and “ñ”, are likely a part of the literacy curriculum in early grades. Findings from both learner groups, but the one-way NES group in particular, suggest that current practices are insufficient. Morin (2007) references a few activities appropriate for elementary-aged students that move beyond the segmental level (p. 351-352)[78]:

- Attention can be drawn to lexical stress by having students “jump up” on the stressed syllable of content vocabulary. This activity could be particularly useful for words that require an orthographic accent mark as students can associate the physical movement of jumping with the upward direction of the written accent.
- Focus can be given to intonation contours during a class read aloud. Students receive a copy of a short text to be read aloud with all the punctuation removed. As the teacher reads the text aloud, students, either individually or as a group, write in the punctuation marks that correspond to the intonation pattern produced by the teacher.

In the upper elementary grades, activities found to be successful with university learners could be adapted to meet the cognitive level of students. A few features common to proposed and/or researched activities are attention to cross-language differences,

[78] The original ideas of Morin (2007) have been adapted slightly to fit a content-driven classroom as opposed to a traditional, elementary foreign language classroom.

opportunities to discriminate between native and non-native pronunciations, and opportunities to analyze one's own speech (Arteaga, 2000; Counselman, 2010; Lord, 2005, 2008; Terrell, 1989).

Whatever the instruction might look like, the focus must move beyond pronunciations that result in miscommunication or unintelligibility, such as [peɾo] instead of [perro] ('but' instead of 'dog') or [leɪ] instead of [le] ('law' instead of 'him/her' (indirect object)) to include allophones and suprasegmentals. Unfortunately, many teachers are not prepared to teach pronunciation as part of class (Gregory, 2005) in spite of the inclusion of phonological knowledge about the L2 in the ACTFL/NCATE Program Standards for the Preparation of Foreign Language Teachers (2002). To address this need, teacher training programs are beginning to include a phonetics and phonology course as part of the required coursework (e.g., Gregory, 2005; Morin, 2007). In order for teachers to be able to provide effective pronunciation training, they need to be given the opportunity to develop their own knowledge of the immersion language's phonological system as well as an understanding of how to teach L2 pronunciation. The ideal method for meeting this need would be through a full-semester course in teacher preparation or graduate programs; however, financial and time constraints may limit the feasibility of this option. Other options include a series of in-service workshops, on-line courses, or self-instruction.

Another pedagogical implication is related to how instruction is delivered to students. The Speech Language Model (Flege, 1995) puts forth that accurate perceptual targets are necessary for accurate production of L2 phones. Most classrooms, however, are noisy (Knecht, Nelson, Whitelaw & Feth, 2002) which has been shown to affect learning (e.g., Hygge, Evans & Bullinger, 1996; Stansfeld et al., 2005); children are more affected by classroom noise than adults (e.g., Nelson, Soli & Seltz, 2002; Stelmachowicz, Hoover, Lewis, Kortekaas & Pittman, 2000) and children learning through an L2 show an even greater need for favorable classroom acoustics (e.g., Gelnett, Sumida & Soli, 1994; Nelson, Kohnert, Sabur & Shaw, 2005).[79] For instance, while all student participants in Nelson et al. (2005) performed more poorly on a word discrimination task in noisy conditions than in quiet conditions, the effect of noise on response accuracy was more severe for Spanish-speaking learners of English than native English speakers. Whereas English speakers showed an average decline of 2.2% in noisy conditions, the L2 learners of English responded less accurately at an average rate of 10.5%. The accuracy of L2 learners was poorest on the task which required participants to discriminate sounds which are contrastive in English (their L2) but not Spanish (their L1). The researchers commented that although few vowel contrasts were included in the research design, they were particularly difficult for both student groups. It follows from these findings that classroom acoustics can have detrimental effects on the learning – both content and language – of all learners, but most especially those learning through a second language.

Nelson et al. (2005) conclude that educators "should increase the saliency of the acoustic signal" across the curriculum; this recommendation is perhaps most pertinent during language arts instruction when attention is focused on language and literacy development (227). While ideally all schools would revamp classrooms to conform to the American National Standards Institute's (2002) standard for classroom acoustics, this is

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[79] Kohnert (2004) describes classroom noise as unwanted sounds in the classroom, identifying four sources of such noise: building services and utilities (heating/cooling system, buzz from lights, etc.), noise from outside the building (airplanes, sirens, traffic, etc.), noise generated inside the building (hallway traffic, other classrooms, etc.), and noise within the classroom (movement, talking, etc.).

unlikely as a result of financial constraints. Through collaboration with educational specialists such as speech language pathologists or audiologists, classroom teachers can work to manage sound levels in classrooms. In order to minimize the amount of external noise entering the classroom, teachers can close doors and windows; turning off HVAC systems and other mechanical apparatus such as computers during active listening portions of instruction is another step teachers can take to control noise levels. Many teachers are also placing tennis balls or pads on the bottom of chairs to reduce their impact on classroom acoustics. Finally, employing some sort of sound amplification system can increase the signal-to-noise ratio; systems can be as simple as a microphone or much more complex. Research into the impact of sound amplification systems on learning has pointed to potential learning benefits for L2 learners (e.g., Eriks-Brophy & Ayukawa, 2000) and may have implications as well for L2 phonological acquisition.

Findings from this study also highlight the advantage two-way NES learners have with respect to phonological acquisition as a result of increased native speaker input, both in and out of school. Consequently, one-way programs could potentially improve the phonological abilities of their students by providing students with more opportunities to interact with NSS peers. Some schools which house one-way foreign language programs also host transitional bilingual programs. Through combined instruction or collaborative projects, learners in both programs would have more contact with native speakers of other languages, thus providing them with a peer model.[80] Advances in technology can

[80] The one-way program in this study did house a transitional bilingual program. Although teachers were encouraged to collaborate and provide opportunities for meaningful interaction between the two groups of students, it generally did not occur on a regular basis. Only the fourth grade teacher indicated that she and the bilingual teacher brought students together for instruction.

also allow students to have language partners in another school across town, across the country, or across the world.

6.7 Limitations of Present Study and Directions for Future Research

As with any study, this study is limited by the methodology employed. Because data was collected in a controlled setting, no conclusions can be drawn about the pronunciation of these immersion learners in a natural, informal setting. Given the relatively small amount of background noise acceptable in order to carry out an acoustical analysis, collecting natural, classroom data was not possible. Consequently, the speech analyzed in this study is not the vernacular. Future studies could try to access the student vernacular by investigating peer-peer classroom interactions.

Also, because a cross-sectional sample was taken, any changes in learner productions across grade levels are in apparent time, not real time. As a result, any stages learners pass through may be blurred or obscured by the cross-sectional design. A longitudinal study of a small sample of immersion learners would allow for individual changes in pronunciation to be observed. Such a study would ideally track learner productions from the beginning of their language study through high school, documenting the type, quality, and quantity of input received in and outside of school as well as any changes in learner attitudes toward school, the immersion program, and the immersion language in a more detailed manner.

One of the assumptions of this study is that the student populations are similar with respect to anatomy, specifically the characteristics of their vocal tracts. Controlling for body stature, gender, and vocal tract size would increase the reliability of the findings.

This is especially important at the upper elementary and secondary level as adolescents undergo maturational changes which affect formant frequency.

Another limitation is that the study only investigates the productions of 90:10 and total immersion students; the 50:50 and partial immersion student populations are missing from this study. While previous studies have shown the L2 skills of these particular populations to lag behind those of 90:10 and total immersion students, whether the same holds true for phonological abilities remains to be answered.

Several features of the learner populations and the sociocultural context limit the generalizability of the conclusions to other groups. Specifically, the two NES learner groups presented very different demographics, particularly with respect to ethnicity and socioeconomic status. Moreover, the sample size of the fifth and seventh grade two-way NES groups was small, 4 and 3 respectively. Future investigations should consider two-way NES populations with fewer ethnic ties to Spanish as this could potentially be a confounding factor. Also, the highly bilingual nature of San Antonio provided a unique sociocultural context for this study; it could be argued that the two-way NES learners are in an L2, not foreign language, environment; additional studies that look at phonological development in both program models in a less bilingual context, more of a foreign language environment, may yield different results.

Another limitation of the study is the result of the method of analysis; Munro (1993) noted a drawback to using acoustic analysis is that discrepancies in formant measurements may not be what cause native listeners to perceive non-native speakers' vowels as accented; in other words the degree of importance of formant frequency differences is unknown. For this reason, Munro (1993), Bohn (1997), and Flege et al.

(1996) argue against solely using formant measurements; they propose employing native speaker identifications or ratings in addition to formant measurement as a means of triangulating the data. Given the young age of the participant population and the lack of consensus as to what cues in the speech signal they attend to while processing speech, peer ratings of the “nativeness” of individual token were not carried out. This is an area for future investigation.

Vowels are only one class of many sound classes to make up a phonological system. Work with adult L2 learners of Spanish has pointed to rhotics and stop consonants as other classes that learners produce with an accent (Díaz-Campos, 2004; Elliot, 1997; González-Bueno, 1997; Face & Menke, 2009; Shively, 2008; Waltmunson, 2006; Zampini, 1994), these sounds could form the basis of analysis for future investigations. By looking across a range of sounds, a more complete depiction of immersion learner’s interlanguage phonological system can be obtained.

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Appendix A

Phonological Milestones for Spanish-speaking Children

Age	Skill	Source
12-14 mos.	Rank order of first 10 vowels in Spanish-speaking infants 1) [ɛ], 2) [æ], 3) [e], 4) [i], 5) [a], 6) [ʌ], 7) [ʊ], 8) [u], 9) [ɪ], 10) [o]	Oller & Eilers (1982)
18 mos.	Mastered (90%+) 5 basic Spanish vowels Good production of oral & nasal stops and glides Fair production of voiceless fricatives Poor production of affricate, voiced spirants & liquids	Maez (1981)
24 mos.	Fricatives continue to be in transition Lateral [l] and trill [r] still being acquired, [l] further along than [r]	Gonzalez (1983)
5 years	/g/, /f/, /s/, /ɲ/, /ɾ/ and /r/ continue to pose challenges	Acevedo, 1991; de la Fuente, 1985; Fantini, 1985; Gonzalez, 1978; Mason et al., 1976; Summers, 1982
1st grade	Inconsistent production of [x], [s], and [ð] [ʧ] [ɾ], [r], [l] and some consonant clusters	Gonzalez (1978), Mason et al., (1976) Evans (1974) Bailey (1982)

Information presented in the last two rows was cited in a review of phonological development presented in Goldstein (1995).

Appendix B

Student Participant Demographics

In Tables 1, 2, and 3 the following abbreviations are used:

Gender: male (m), female (f)

Birthplace: Official state abbreviations are used; for those born in Mexico, MX is employed

Parent 1 and 2:
First language (L1): Spanish (S), English (E)
Knowledge of Spanish (Span): yes (y), no (n)
Knowledge of English (Eng): yes (y), no (n)

Goals:
Scale of 1 (unimportant) to 5 (very important)

1- Develop high levels of cross cultural understanding
2- Develop high levels of Spanish language skills
3- Develop high levels of English language skills
4- High levels of academic achievement

Motivations:
Scale of 1 (unimportant) to 5 (very important)

1- Future professional/employment opportunities
2- Cognitive benefits associated with bilingualism
3- Prestige of school
4- Ability to communicate with others in community
5- Ability to communicate with family members/friends

Table B.1: One-way NES Participant Background Information

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Birthplace**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
A1-1	1	f	TX	E	n	y	E	n	y	3	5	3	4	5	5	2	5	4
A1-2	1	m	TX	E	n	y	E	n	y	5	5	5	5	5	5	5	5	1
A1-3	1	f	TX	E	n	y	E	n	y	5	5	5	5	5	5	4	5	3
A1-4	1	m	CA	E	n	y	E	n	y	5	5	5	5	3	5	3	5	2
A1-5	1	f	TX	E	y	y	E	n	y	5	5	3	5	3	5	2	4	2
A1-6	1	f	TX	E	y	y				5	5	5	5	5	5	1	5	5
A1-7	1	m	TX	E	n	y	E	n	y	4	5	2	4	5	5	2	5	1
A1-8	1	f	TX	E	y	y	E	n	y	5	5	5	5	5	5	1	5	3
A1-9	1	f	TX	B	y	y	E	y	y	5	5	5	5	4	5	3	5	5
A1-10	1	m	TX	E	n	y	E	y	y	4	5	4	4	5	4	3	4	5
A3-1	3	f	TX	E	y	y	E	n	y	5	5	4	5	5	5	2	5	2
A3-2	3	m	TX	E	n	y	E	y	y	5	5	5	5	5	5	5	5	5
A3-3	3	m	TX	E	n	y	E	n	y	5	5	4	5	5	5	3	5	3
A3-4	3	f	TX	E	y	y	E	n	y	5	5	5	5	5	5	1	5	5
A3-5	3	m	TX	O	y	y	E	n	y	5	5	5	5	5	5	4	5	4
A3-6	3	f	TX	E	n	y	E	y	y	4	5	5	5	5	5	3	5	3
A3-7	3	f	OR	E	y	y	E	y	y	5	5	4	4	4	5	1	4	4
A3-8	3	m	TX	E	n	y	E	n	y	5	4	4	3	5	5	1	4	1
A3-9	3	f	CA	E	y	y	E	y	y	4	5	4	4	4	4	3	5	3
A5-1	5	f	TX	E	n	y				5	5	5	5	5	4	3	3	1
A5-2	5	m	TX	E	n	y	E	n	y	2	5	1	3	4	5	1	5	1
A5-3	5	f	TX	B	y	y	E	y	y	5	5	5	5	5	5	3	3	3
A5-4	5	f	TX	E	n	y	E	n	y	4	5	5	4	4	4	1	5	2
A5-5	5	f	TX	E	y	y	E	n	y	5	5	5	5	5	5	1	4	1
A5-6	5	f	TX	E	n	y	E	n	y	5	5	5	5	5	5	3	5	1
A5-7	5	f	TX															
A5-8	5	f	TX	E	y	y	E	n	y	5	5	5	5	5	5	3	4	4

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Birthplace**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
A7-1	7	f	TX	E	y	y	E	n	y	5	5	5	5	4	5	3	4	3
A7-2	7	m	FL	E	n	y	E	n	y	4	5	5	5	5	5	3	3	1
A7-3	7	f	CA	E	n	y	E	n	y	2	5	3	3	4	4	1	5	1
A7-4	7	f	TX	S	y	y	E	y	y	5	5	5	5	4	5	2	5	5
A7-5	7	f	TX	E	y	y	E	n	y				5	5				
A7-6	7	f	TX	E	n	y	E	y	y	4	5	5	4	3	5	2	4	2
A7-7	7	f	TX	E	y	y	E	n	y	5	5	5	5	4	5	4	4	4

Table B.2: Two-way NES Participant Background Information

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Birthplace**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
N1-1	1	f	TX	E	n	y	E	y	y	5	5	5	5	4	5	5	4	3
N1-13	1	f	TX	B	y	y	E	n	y	3	5	4	5	5	5	2	5	4
N1-15	1	f	CA	S	y	y	B	y	y	2	5	5	5	5	5		5	5
N1-18	1	f	TX	E	y	y	E	y	y	5	5	5	5	5	5	4	5	5
N1-2	1	f	TX	S	y	y				5	5	5	5	5	5	5	5	5
N1-5	1	m	TX	S	y	y	E	y	y	5	5	5	5	5	5	5	5	5
N1-6	1	f	TX	E	y	y				5	5	5	5	5	5	5	5	5
N1-9	1	m	CA	E	y	y	E	y	y	5	5	5	5	5	5	4	5	5
N3-1	3	m	OH	E	y	y	E	n	y	5	5	5	5	5	5	2	5	3
N3-12	3	m	TX	E	y	y	E	n	y	3	5	4	5	5	5	2	5	4
N3-13	3	m	TX	E	y	y	S	y	y	4	4	4	4	5	4	4	5	5
N3-16	3	f	TX	S	y	y	S	y	y	3	5	5	5	5	5	5	5	5
N3-2	3	f	TX	E	y	y	E	n	y	4	4	4	4	5	5	5	5	5
N3-4	3	f	TX	E	y	y	S	y	y	5	5	5	5	4			5	5
N3-5	3	m	CA	E	n	y				5	5	5	5	5	5	3	5	5

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Birthplace**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
N3-8	3	f	TX	E	n	y	S	y	y	5	5	5	5	5	5	5	5	5
N3-9	3	f	TX	S	y	y	E	y	y	4	5	5	5	5	5	3	4	5
N5-3	5	m	TX	E	y	y				5	5	5	5	5	5	5	5	5
N5-4	5	m	CA	S	y	y	E	y	y	5	5	5	5	5	5	5	5	5
N5-5	5	f	TX		y	y		y	y	4	5	5	5	3	5	4	5	5
N5-6	5	f	TX	E	n	y	E	n	y	5	5	5	4	5	5	5	5	5
N7-2	7	f	CA	E	n	y	S	y	y	5	5	5	5	5	5	3	5	5
N7-6	7	m	TX	E	y	y	S	y	y	4	4	4	4	5	5		5	5
N7-8	7	f	TX	E	y	y				5	5	5	5	5	5	5	5	5

Table B.3: Two-way NSS Participant Background Information

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Nation.**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
N1-10	1	f	TX															
N1-11	1	m	OH	E	y	y	E	n	y	5	5	5	5	5	5	2	5	5
N1-12	1	f	CA	S	y	y	S	y	y	4	4	5	4	4	3	5	5	5
N1-14	1	f	CA	S	y	n				5	5	5	5	5	5	5	5	5
N1-16	1	m	CA	S	y	y	S	y	y	4	4	4	4	3	4	4	4	4
N1-17	1	f	TX	S	y	n	S	y	n	5	5	5	5	5	5	4	5	5
N1-3	1	m	MX	S	y	y	S	y	n	5	5	5	5	5	5	4	5	4
N1-4	1	m	TX	S	y	y	S	y	n	5	5	5	5	5	5		5	5
N1-7	1	f	TX	S	y	y	S	y	y	5	5	3	5	5	5	5	5	5
N1-8	1	f	TX	S	y	n	B	y	y	5	5	5	5	5	5	5	5	5
N3-10	3	f	MX	S	y	y	S	y	y	2	1	1	1	1	2	3	2	2
N3-11	3	f	MX	S	y	n	S	y	n		5				5			
N3-14	3	f	TX	S	y	n	S	y	n	4	4	4	5	5	5	5	4	5

				Parent 1			Parent 2			Goals				Motivations				
Subject	**Grade**	**Gender**	**Nation.**	**L1**	**Span**	**Eng**	**L1**	**Span**	**Eng**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
N3-15	3	f	MX	S	y	y	S	y	n	5		5	5	5	4	5	5	5
N3-17	3	m	MX	S	y	y				3	5	5	4					
N3-18	3	m	TX	S	y	y		y	n	4	5	4	5	5	5	5	5	5
N3-19	3	f	TX	S	y	n	S	y	n	5	5	5	5	5	5	4	5	5
N3-3	3	f	TX	S	y	n				5	5	5	5	5	5	5	5	5
N3-6	3	f	MX	S	y	y	S	y	n	5	3	5	5	3	5	3	5	5
N3-7	3	f	TX	S	y	n	S	y	n	4	5	5	5	4	4	5	5	5
N5-1	5	m	TX	S	y	n	S	y	n									
N5-11	5	m	TX	S	y	y	S	y	y	5	5	5	5	5	5	3	5	5
N5-12	5	f	MX	S	y	n	S	y	n	4	4	4	4	4	4	4	4	4
N5-13	5	f	TX	S	y	y	S	y	y	5	4	5	5	5	5	5	5	5
N5-2	5	f	TX	S	y	n				5	5	5	5	5	5	5	5	5
N5-7	5	f	MX	S	y	n	S	y	n	5	5	5	5	5	5	5	5	5
N5-8	5	m	MX	S	y	n				5	5	5	5	5				
N5-9	5	m	TX	S	y	y	S	y	y	5	5	5	5	5	5	5	5	5
N7-1	7	m	TX	E	y	y	S	y	y	5	5	5	5	5	5	5	5	5
N7-3	7	m	TX	S	y	n	S	y	n	5	5	5	5	5	5	5	5	5
N7-4	7	m	TX	S	y	y	E	y	y	5	5	5	5	5	5	5	5	5
N7-5	7	f	TX	S	y	n	S	y	n	2	3	1	4	5	5		5	
N7-7	7	m	MX	S	y	y	S	y	y	5	5	5	5	5	5	3	5	5
N7-9	7	m	TX	S	y	y	S	y	y	5	5	5	5	5	5	5	5	5

In Table 4 the following abbreviations are used:

Gender: male (m), female (f)

Birthplace: Official state abbreviations are used; for those born in Mexico, MX is employed

First Language (L1): Spanish (S), English (E), Bilingual/Both (B)

Parent 1 and 2:
First language (L1): Spanish (S), English (E)

Table B.4: Teacher Background Information

Subject	Gender	Birthplace	L1	Parent 1 L1	Parent 2 L1	Time Abroad	Grade Taught	Years Taught in Program	Other Grades Taught in Program
AT1	f	TX	S	S	E	-	7 & 8	6	5
AT2	f	MX	S	S	S	30 yrs.	3	4	n/a
AT3	f	NJ	E	E	E	21 yrs.	4	9	n/a
AT4	f	TX	S	S	S	-	5	1	n/a
NT1	m	LA	E	E	S	27 yrs.	3	10	n/a
NT2	f	Colombia	S	S	S	15 yrs.	3	4	n/a
NT4	m	TX	B	E	S	-	2	3	n/a
NT5	f	TX	S	S	S	-	2	23	n/a
NT6	f	NY	B	S	E	3 mos.	K	8	1
NT7	f	TX	S	S	S	-	1	1	n/a

Appendix C

Linguistic Background Questionnaire – English Version

Language Background Information Questionnaire

The following information will be used only for my research on how Spanish Immersion children learn the Spanish language. All information provided here is strictly confidential. If there any questions you find too sensitive, you do not need to answer them. Please take a few minutes to fill in this form and return it to me. Thank you for your understanding and cooperation.

I. Information on YOUR CHILD

1. Student Name: ____

2. Gender: ❑ Female ❑ Male

3. Age: __________

4. Grade: ___________

5. Birthplace: _________________________ (city), _____________________ (country)

6. Has your child lived for more than 6 months in a Spanish-speaking country or any other country? Please indicate the city, the country, his/her age when he/she began to live there, and the length of residence.

________________ (city), _________________ (country), _______ (age), __________ (length)

________________ (city), _________________ (country), _______ (age), __________ (length)

7. Nationality: ____________________

Language Background on YOUR CHILD

8. First (native) language: ❑ English ❑ Spanish ❑ Other: ____________________

Other language(s) spoken and/or understood well: _______________________________

9. Age at which student began speaking ________________

10. Does the student have any known speech or language impairments? ❑ yes ❑ no

If yes, please list: ____

11. What language does your child most frequently speak at home? _______________

12. Amount of time your child speaks <u>English</u> outside of school. (Check one)
❑ 0% ❑1– 20% ❑ 20 – 40% ❑ 40 – 60% ❑ 60 – 80% ❑ 80 – 100%

13. Amount of time your child speaks <u>Spanish</u> outside of school. (Check one)
❑ 0% ❑1– 20% ❑ 20 – 40% ❑ 40 – 60% ❑ 60 – 80% ❑ 80 – 100%

14. Does your child have opportunities to listen to Spanish outside of school?
❑ no ❑ yes
If yes, what/whom does he/she listen to? Please indicate the percentage of time he/she listens to each in Spanish.

LANGUAGE	**WHAT/WHOM**	**AMOUNT OF TIME**					
		0%	**1 – 20%**	**20 – 40%**	**40 – 60%**	**60 – 80%**	**80 – 100%**
SPANISH	mother						
	father						
	siblings						
	grandparents						
	neighbors						
	friends						
	radio						
	audio or video tapes						
	TV or movies						
	other: _______						

15. What language(s) does your child use when speaking with the following people? Please indicate the percentage of time spent speaking to each individual in each language.

LANGUAGE	WHO	AMOUNT OF TIME					
		0%	1 – 20%	20 – 40%	40 – 60%	60 – 80%	80 – 100%
SPANISH	mother						
	father						
	siblings						
	grandparents						
	neighbors						
	friends						
	other: _______						
ENGLISH	mother						
	father						
	siblings						
	grandparents						
	neighbors						
	friends						
	other: _______						

16. Did your child begin to learn Spanish or was he/she exposed to Spanish before he/she entered the Spanish immersion program? ❑ no ❑yes

If yes, indicate the age of first exposure to Spanish. _____________

17. When did your child begin the Spanish Immersion Program?
_____ (grade) _____(age)

18. Who were your child's Spanish immersion teachers?

Kindergarten: ___________________________________
1st grade: ______________________________________
2nd grade: ______________________________________
3rd grade: ______________________________________
4th grade: ______________________________________
5th grade: ______________________________________
6th grade: ______________________________________
7th grade: ______________________________________

19. How important are each of the goals of immersion education to you? Please rate the importance of each of the following goals on a scale of 1 to 5, with 1 being unimportant and 5 being very important.

Develop high levels of cross cultural understanding	1	2	3	4	5
Develop high levels of Spanish language skills	1	2	3	4	5

Develop high levels of English language skills	1	2	3	4	5
High levels of academic achievement	1	2	3	4	5

20. What motivated you to enroll your child in a Spanish immersion program? Please rate the importance of each of the following motivations on a scale of 1 to 5, with 1 being unimportant and 5 being very important.

Future professional/employment opportunities	1	2	3	4	5
Cognitive benefits associated with bilingualism	1	2	3	4	5
Prestige of school	1	2	3	4	5
Ability to communicate with others in community	1	2	3	4	5
Ability to communicate with family members/friends	1	2	3	4	5
Other (please specify):	1	2	3	4	5

Foreign Travel

21. Has the student ever studied, traveled or lived in a Spanish-speaking country?

❑ Yes ❑ No

If you answered "no" to Question #21, jump ahead to Question #24.

22. **In total**, how many months has the student spent studying, traveling and/or living in a
Spanish-speaking country or countries? ________________________________

23. For each of the times the learner has studied, traveled or lived in a Spanish-speaking country, indicate (1) whether he/she took Spanish language classes, and (2) how often on average he/she had an extended conversation (i.e., for 30 minutes or more) in Spanish with native or fluent speakers of Spanish.

Trip #1

a. Country: ______________________ b. Length of stay: ______________________

c. Did the learner take Spanish language classes during this trip? ❑ Yes ❑ No

d. On average, how often did he/she have an extended conversation (i.e., for 30 minutes or more) in Spanish with native or fluent speakers of Spanish?
❑ Every day ❑ Every couple of days ❑ Once per week ❑ Once per month ❑ Infrequently

Trip #2

a. Country: ______________________ b. Length of stay: ______________________

c. Did the learner take Spanish language classes during this trip? ❑ Yes ❑ No

d. On average, how often did he/she have an extended conversation (i.e., for 30 minutes or more) in Spanish with native or fluent speakers of Spanish?
❑ Every day ❑ Every couple of days ❑ Once per week ❑ Once per month ❑ Infrequently

II. INFORMATION ON PARENT/GUARDIAN 1:

24. Name: ___________________________relation to student: _____________________

25. Birth place: ____________________(city), __________________________ (country)

26. Where was the child's parent/guardian brought up? (i.e. Where did he/she spend his/her childhood?)
____

27. Parent/guardian's nationality: _________________________________

28. Parent/guardian's native language: ___________________________________

29. Other language(s) parent/guardian speaks and understands well
____

30. Does the child's parent/guardian speak Spanish? ❑ Yes ❑ No (If no, skip 31 and 32)

31. How old was the child's parent/guardian when he/she was first exposed to or learned Spanish? If Spanish is the first language, please answer 0. __________ (age)

32. Did the child's parent/guardian receive formal education in Spanish?
❑ Yes ❑ No
If yes, in what grades? _______________________________

33. If the child's parent/guardian lived in a Spanish-speaking country, at what age did he/she begin his/her residence there and how long was his/her length of residence?
starting age of residence: __________ length of residence: _________

34. Does the child's parent/guardian speak English? ❑ Yes ❑ No (If no, skip 35 and 36)

35. How old was the child's parent/guardian when h/she was first exposed to or learned English? If English is the first language, please answer 0. __________ (age)

36. Did the child's parent/guardian receive formal education in English?
❑ Yes ❑ No
If yes, in what grades? _______________________________

37. What was the child's parent/guardian's starting age of residence in an English-speaking country and his/her length of residence?
starting age of residence: _________ length of residence: __________

38. What language does the child's parent/guardian most frequently speak at home? ___

III. INFORMATION ON PARENT/GUARDIAN 2:

39. Name: ___________________________relation to student: _____________________

40. Birth place: _____________________(city), __________________________ (country)

41. Where was the child's parent/guardian brought up? (i.e. Where did he/she spend his/her childhood?)
____

42. Parent/guardian's nationality: _________________________________

43. Parent/guardian's native language: __________________________________

44. Other language(s) parent/guardian speaks and understands well __________________

45. Does the child's parent/guardian speak Spanish? ❑ Yes ❑ No (If no, skip 46 and 47)

46. How old was the child's parent/guardian when he/she was first exposed to or learned Spanish? If Spanish is the first language, please answer 0. __________ (age)

47. Did the child's parent/guardian receive formal education in Spanish?
❑ Yes ❑ No
If yes, in what grades? _______________________________

48. If the child's parent/guardian lived in a Spanish-speaking country, at what age did he/she begin his/her residence there and how long was his/her length of residence?
starting age of residence: __________ length of residence: _________

49. Does the child's parent/guardian speak English? ❑ Yes ❑ No (If no, skip 50 and 51)

50. How old was the child's parent/guardian when he/she was first exposed to or learned English? If English is the first language, please answer 0. __________ (age)

51. Did the child's parent/guardian receive formal education in English?
❑ Yes ❑ No
If yes, in what grades? _______________________________

52. What was the child's parent/guardian's starting age of residence in an English-speaking country and his/her length of residence?
starting age of residence: _________ length of residence: __________

53. What language does the child's parent/guardian most frequently speak at home? ___

IV. INFORMATION ON OTHERS IN HOUSEHOLD

54. Are there other individuals who live in the student's home? __________
    If yes, who? (please indicate relation to student)

____

55. What language does the child most regularly use with each of these individuals?

____

Appendix D

Linguistic Background Questionnaire – Spanish Version

Cuestionario sobre el desarrollo lingüístico

El siguiente cuestionario es parte de una investigación que tiene como objetivo analizar cómo los estudiantes en un programa de inmersión aprenden español. La información que usted provea en este cuestionario será solamente usada para uso exclusivo de esta investigación. Toda la información es confidencial. No tiene que contestar preguntas que usted considere personales o inapropiadas. Le rogamos por favor que tome unos minutos de su tiempo para completar este cuestionario y, una vez acabado, entréguelo de nuevo al profesor.

Muchas gracias por su cooperación.

I. Información sobre SU HIJO

1. Nombre del estudiante: ____

2. Género: ❑ Mujer ❑ Varón

3. Edad: __________

4. Año/Grado escolar: ___________

5. Lugar de nacimiento: ___________________ (ciudad), __________________ (país)

6. ¿Ha vivido su hijo más de 6 meses en un país de habla hispana o en cualquier otro país? Por favor indique la ciudad, el país, edad en la que vivió allá y tiempo de residencia.

____________ (ciudad), _____________ (país), _______ (edad), __________ (tiempo de residencia)

____________ (ciudad), _____________ (país), _______ (edad), __________ (tiempo de residencia)

7. Nacionalidad: ____________________

Desarrollo lingüístico de SU HIJO

8. Primera lengua (materna): ❑ inglés ❑ español ❑ otro: ____________________

Otras lenguas que hable o entienda bien: ___________________________________

9. Edad a que empezó a hablar _______________

10. ¿Tiene el estudiante un impedimento en su habla o sobre la lengua? ❑ sí ❑ no

Si la respuesta es "sí", por favor indique el tipo de
impedimento_________________________

11. ¿Qué lengua habla su hijo principalmente en casa? ____________________

12. Porcentaje de tiempo que su hijo habla inglés fuera de clase. (Marca uno)
❑ 0% ❑1– 20% ❑ 20 – 40% ❑ 40 – 60% ❑ 60 – 80% ❑ 80 – 100%

13. Porcentaje de tiempo que su hijo habla español fuera de clase. (Marca uno)
❑ 0% ❑1– 20% ❑ 20 – 40% ❑ 40 – 60% ❑ 60 – 80% ❑ 80 – 100%

14. ¿Tiene su hijo oportunidades de escuchar español fuera de clase? ❑ no ❑ sí
Si la respuesta es "sí", ¿a quién o qué escucha? Por favor indique aproximadamente el porcentaje de tiempo que escucha español:

IDIOMA	**QUE/QUIEN**	**PORCENTAJE DE TIEMPO**					
		0%	**1 – 20%**	**20 – 40%**	**40 – 60%**	**60 – 80%**	**80 – 100%**
ESPAÑOL	madre						
	padre						
	hermanos						
	abuelos						
	vecinos						
	amigos						
	La radio						
	cintas auditivas or videos						
	TV or películas						
	otros:_______						

15. ¿Qué idioma(s) usa su hijo al hablar con las siguientes personas?
Por favor indique el porcentaje de tiempo que habla con cada persona en cada lengua.

IDIOMA	**QUIEN**	**PORCENTAJE DE TIEMPO**					
		0%	**1 – 20%**	**20 – 40%**	**40 – 60%**	**60 – 80%**	**80 – 100%**
ESPAÑOL	madre						
	padre						
	hermanos						
	abuelos						
	vecinos						
	amigos						
	otros ________						
INGLES	madre						
	padre						
	hermanos						
	abuelos						
	vecinos						
	amigos						
	otros _________						

16. ¿Empezó a aprender español antes de entrar en el programa de inmersión?
❑ no ❑sí

Si la respuesta es "sí", indique la edad en que su hijo fue expuesto por primera vez al español: ____________

17. ¿Cuándo empezó su hijo el programa de inmersión? _____ (grado) _____ (edad)

18. ¿Quiénes han sido los maestros de español de su estudiante?
Kinder: ______________________________________
1er grado: _____________________________________
2do grado: _____________________________________
3er grado: _____________________________________
4to grado: _____________________________________
5to grado: _____________________________________
6to grado: _____________________________________
7to grado: _____________________________________

19. ¿Cuán importantes son cada meta del programa de inmersión a Usted? Por favor califique la importancia de cada meta en una escala de 1 a 5.
1 representa no importante y 5, muy importante.

Desarrollo de conocimiento de otras culturas	1	2	3	4	5
Desarrollo de las habilidades lingüísticas en español	1	2	3	4	5
Desarrollo de las habilidades lingüísticas en inglés	1	2	3	4	5
Un alto nivel de conocimiento académico	1	2	3	4	5

20. ¿Por qué matriculó a su estudiante en el programa de inmersión? Por favor califique la importancia de cada motivación a continuación en una escala de 1 a 5.
1 representa no importante y 5, muy importante.

Las oportunidades profesionales o de empleo	1	2	3	4	5
Las ventajas cognitivas asociadas con el bilingüismo	1	2	3	4	5
El prestigio del colegio	1	2	3	4	5
La capacidad de comunicarse con otros en la comunidad	1	2	3	4	5
La capacidad de comunicarse con familiares o amigos	1	2	3	4	5
Otro (por favor indique la motivación):	1	2	3	4	5

Viajes al extranjero

21. ¿Ha estudiado, viajado o vivido el estudiante en un país de habla hispana?

❑ Sí ❑ No

Si ha respondido “no” a la pregunta #21, NO responda las preguntas #22y #23.

22. ¿Cuántos meses **en total** ha pasado el estudiante estudiando, viajando o viviendo en un país de habla hispana? ________________________________

23. Para cada viaje, indique (1) si hizo cursos de lengua en español y (2) con qué frecuencia tuvo conversaciones extendidas (más de 30 minutos) en español con nativo hablantes.

Viaje #1
a. País: ____________________________ b. Tiempo de estancia: _______________

c. ¿Hizo cursos de español durante el viaje? ❑ Sí ❑ No

d. Por lo general, ¿con qué frecuencia tuvo una conversación extendida (i.e., más de 30 minutos) en español con un nativo hablante?

❑ cada día ❑ unos 2-4 días a la semana ❑ una vez a la semana

❑ una vez al mes ❑ raras veces

Viaje #2
a. País: ___________________________ b. Tiempo de estancia: _______________

c. ¿Hizo cursos de español durante el viaje? ❑ Sí ❑ No

d. Por lo general, ¿con qué frecuencia tuvo una conversación extendida (i.e., más de 30 minutos) en español con un nativo hablante?

❑ cada día ❑ unos 2-4 días a la semana ❑ una vez a la semana
❑ una vez al mes ❑ raras veces

II. INFORMACION SOBRE PADRE / TUTOR 1:

24. Nombre: _________________________Relación al estudiante _______________

25. Lugar de nacimiento: ____________________(ciudad), _________________ (país)

26. ¿En qué lugar se crió? (i.e. ¿Dónde pasó su infancia?) _____________________

27. Nacionalidad: ________________________________

28. Primera lengua: _________________________________

29. Otros idiomas que hable y/o entienda bien: ____________________________

30. ¿Habla español el padre / tutor 1? ❑ Sí ❑ No (Si su respuesta es "no", no conteste las preguntas #31 y #32)

31. ¿Cuántos años tenía cuando fue expuesto al español por primera vez? Si el español es la lengua materna, indique 0. __________ (edad)

32. ¿Recibió educación formal en español? ❑ Sí ❑ No
Si la respuesta es "sí", indique los años escolares. _____________________________

33. Si ha vivido en un país de habla hispana, ¿a qué edad empezó a vivir allí? ¿Cuánto tiempo vivió allí?
edad: __________ tiempo de residencia: _________

34. ¿Habla inglés el padre / tutor 1? ❑ Sí ❑ No (Si responde "no", no conteste las preguntas #35 y #36)

35. ¿Cuántos años tenía cuando fue expuesto al inglés por primera vez? Si la lengua materna es inglés, por favor indique 0. __________ (edad)

36. ¿Recibió educación formal en inglés? ❑ Sí ❑ No
Si la respuesta es "sí", indique en qué años escolares.
____

37. Si ha vivido en un país de habla inglesa, ¿a qué edad empezó a vivir allí? ¿Cuánto tiempo vivió allí?
edad: __________ tiempo de residencia: _________

38. ¿Qué idioma principalmente habla en casa? _______________

III. INFORMACION SOBRE <u>EL PADRE / TUTOR 2</u>:

39. Nombre: ___________________________Relación al estudiante ________________

40. Lugar de nacimiento: _____________________(ciudad), ____________________ (país)

41. ¿Dónde se crió? (i.e. ¿Dónde pasó su infancia?) ________________________

42. Nacionalidad: __________________________________

43. Lengua materna: __________________________________

44. Otros idiomas que hable y/o entienda bien: _____________________________

45. ¿Habla español ek padre / tutor 2? ❑ Sí ❑ No
(Si su respuesta es "no", no responda las preguntas #46 y #47)

46. ¿Cuántos años tenía cuando fue expuesto al español por primera vez? Si el español es la primera lengua, indique 0. __________ (edad)

47. ¿Recibió educación formal en español? ❑ Sí ❑ No
Si la respuesta es "sí", indique en qué años escolares. ______________________________

48. Si ha vivido en un país de habla hispana, ¿a qué edad empezó a vivir allí? ¿Cuánto tiempo vivió allí?
edad: __________ tiempo de residencia: _________

49. ¿Habla inglés el padre / tutor 2? ❑ Sí ❑ No (Si la respuesta es "no", no responda las preguntas #50 y #51)

50. ¿Cuántos años tenía cuando fue expuesto al inglés por primera vez? Si inglés es la primera lengua, por favor indique 0. __________ (edad)

51. ¿Recibió educación formal en inglés? ❑ Sí ❑ No
Si la respuesta es sí, indique en qué años escolares
____

52. Si ha vivido en un país de habla inglesa, ¿a qué edad empezó a vivir allí? ¿Cuánto tiempo vivió allí?

edad: __________ tiempo de residencia: _________

53. ¿Qué idioma habla principalmente en casa? ______________

IV. INFORMACION SOBRE OTROS QUE VIVEN EN CASA

54. ¿Hay otros con quienes vive el estudiante? __________

Si la respuesta es sí, ¿quién? (Por favor indique la relación al estudiante.)

____

55. ¿Qué lengua usa el estudiante con mayor regularidad con cada uno?

____

Appendix E

Possible Animal Tokens according to the Linguistic Context of Vowels

Token	vowel	stress	open/closed
cab**a**llo	a	s	o
elef**a**nte	a	s	c
p**á**jaro	a	s	o
c**a**bra	a	s	o
jir**a**fa	a	s	o
v**a**ca	a	s	o
g**a**to	a	s	o
p**a**to	a	s	o
r**a**na	a	s	o
ar**a**ña	a	s	o
c**a**ballo	a	u	o
páj**a**ro	a	u	o
c**a**nguro	a	u	c
c**a**mello	a	u	o
g**a**llina	a	u	o
m**a**riposa	a	u	o
hipopót**a**mo	a	u	o

Token	vowel	stress	open/closed
con**e**jo	e	s	o
cul**e**bra	e	s	o
p**e**z	e	s	c
ov**e**ja	e	s	o
cam**e**llo	e	s	o
p**e**rro	e	s	o
c**e**bra	e	s	o
el**e**fante	e	u	o
d**e**lfin	e	u	c

Token	vowel	stress	open/closed
t**i**gre	i	s	o
cocodr**i**lo	i	s	o
gall**i**na	i	s	o
gor**i**la	i	s	o
delf**í**n	i	s	c
horm**i**ga	i	s	o
j**i**rafa	I	u	o
r**i**noceronte	i	u	o
p**i**ngüino	i	u	c
mar**i**posa	i	u	o

Token	vowel	stress	open/closed
rinocer**o**nte	o	s	c
m**o**no	o	s	o
marip**o**sa	o	s	o
tibur**ó**n	o	s	c
hipop**ó**tamo	o	s	o
c**o**nejo	o	u	o
c**o**codrilo	o	u	o
coc**o**drilo	o	u	o
rin**o**cerante	o	u	o
g**o**rila	o	u	o
hip**o**pótamo	o	u	o

Token	vowel	stress	open/closed
or**u**ga	u	s	o
tort**u**ga	u	s	o
cang**u**ro	u	s	o
c**u**lebra	u	u	o
tib**u**rón	u	u	o

Appendix F

Sample Animal Picture Cards

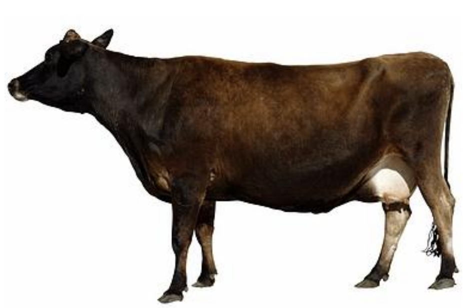
Pictures will be printed individually on larger sheets of paper in color for the actual task.

un conejo

una jirafa

una culebra

una oveja



una vaca

una oruga

Appendix G

Attitude Questionnaires – English Versions

Fifth and Seventh Grade Questionnaire

Here are some sentences written about Spanish and English. Please tell me what you think about them by putting a checkmark in the column that you agree with. There are no wrong answers. Please be as honest as you can.

Please choose ONE answer for each sentence.

	True	**Kind of true**	**Kind of false**	**False**
1. I like to hear people speaking Spanish.				
2. I like to hear people speaking English.				
3. I like to speak Spanish.				
4. I like to speak English.				
5. It is important to know Spanish in San Antonio.				
6. It is important to know English in San Antonio.				
7. I enjoy studying Spanish the way it is taught in school.				
8. Spanish is difficult.				
9. English is difficult.				
10. I would be happy at a school that did not teach Spanish.				
11. I have more friends because I speak Spanish and English.				
12. Learning two languages will make you smarter than learning only one language.				
13. Learning two languages will help you get better grades.				
14. Knowing two languages will help you get a better job when you grow up.				
15. I enjoy meeting and listening to people who speak Spanish.				
16. I speak Spanish better than I speak English.				
17. I speak English better than I speak Spanish.				

	True	Kind of true	Kind of false	False
18. I could be a “good teacher” of Spanish.				
19. English is the only language I need.				
20. I am proud to know Spanish.				
21. People make fun of me for speaking Spanish.				
22. I would be just as happy if I had been born in to a Spanish-speaking home.				
23. All Americans speak English.				
24. Americans speak Spanish.				
25. I feel that I currently have excellent pronunciation skills in Spanish.				
26. My pronunciation in Spanish is native-like.				
27. I can recognize the difference between native-like and non-native pronunciation in Spanish				
28. I don’t like when my classmates sound very non-native when they speak Spanish.				
29. My pronunciation in Spanish is better than that of my classmates.				
30. Occasionally, I avoid sounding like a native speaker of Spanish.				
31. It is important for me to sound like my classmates when I speak Spanish.				
32. It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker.				
33. I like to pronounce words like my teacher.				

Third Grade Questionnaire

Here are some sentences written about Spanish and English. Please tell me what you think about them by putting a checkmark in the column that you agree with. There are no wrong answers. Please be as honest as you can.

Please choose ONE answer for each sentence.

	True	**Kind of true**	**Kind of false**	**False**
1. I like to speak Spanish.				
2. I like to speak English.				
3. It is important to know Spanish in San Antonio.				
4. It is important to know English in San Antonio.				
5. I enjoy studying Spanish the way it is taught in school.				
6. Spanish is difficult.				
7. English is difficult.				
8. I have more friends because I speak Spanish and English.				
9. Learning two languages will make you smarter than learning only one language.				
10. Learning two languages will help you get better grades.				
11. Knowing two languages will help you get a better job when you grow up.				
12. I enjoy meeting and listening to people who speak Spanish.				
13. English is the only language I need.				
14. I am proud to know Spanish.				
15. People make fun of me for speaking Spanish.				
16. I would be just as happy if I had been born in to a Spanish-speaking home.				
17. All Americans speak English.				
18. Americans speak Spanish.				
19. I feel that I currently have excellent pronunciation skills in Spanish.				

	True	Kind of true	Kind of false	False
20. It is important for me to sound like my classmates when I speak Spanish.				
21. It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker.				
22. I like to pronounce words like my teacher.				

Ability Survey

Please rate how well you are able to do each activity. Make a mark in the column that best represents your opinión. There are not right or wrong answers. Please be as honest as you can.

Please, choose ONE option for each activity.

	Bad	A little bad	A little good	Good
1. schoolwork in Spanish				
2. schoolwork in English				
3. read in Spanish				
4. read in English				
5. write in Spanish				
6. write in English				
7. pronouce Spanish sounds and words				
8. pronounce English sounds and words				
9. speak in Spanish				
10. speak in English				

Appendix H

Attitude Questionnaires – Spanish Versions

Fifth and Seventh Grade Questionnaire

Aquí hay unas opciones sobre el español. Por favor, dime qué piensas, poniendo una marca en la columna que mejor representa tu opinión. No hay respuestas incorrectas. Por favor, sé lo más honesto que puedas.

Por favor, elige UNA opción para cada oración.

	Cierto	**Un poco cierto**	**Un poco falso**	**Falso**
1. Me encanta que la gente hable español.				
2. Me encanta que la gente hable inglés.				
3. Me gusta hablar español				
4. Me gusta hablar inglés.				
5. Es importante saber español en San Antonio.				
6. Es importante saber inglés en San Antonio.				
7. Me gustan cómo enseñan el español en la escuela.				
8. El español es difícil.				
9. El inglés es difícil.				
10. Estaría feliz en una escuela que no enseñara español.				
11. Como hablo español e inglés entonces tengo más amigos.				
12. Saber dos idiomas lo hace a uno más inteligente que saber sólo uno.				
13. Saber dos idiomas le ayuda obtener mejores notas.				
14. Saber dos idiomas le ayuda conseguir mejor trabajo cuando sea mayor.				
15. Me gusta conocer y escuchar a gente que habla español.				
16. Hablo español mejor que hablo inglés.				
17. Hablo inglés mejor que hablo español.				

	Cierto	**Un poco cierto**	**Un poco falso**	**Falso**
18. Podría ser un "buen maestro" de español.				
19. El inglés es el único idioma que necesito.				
20. Estoy orgulloso de saber español.				
21. La gente se ríe de mí porque hablo español.				
22. Estaría igual de feliz si naciera en una familia que hablara inglés.				
23. Todos los estadounidenses hablan inglés.				
24. Los estadounidenses hablan español.				
25. Tengo habilidades excelentes de pronunciar en español.				
26. La manera en que pronuncio los sonidos en español es como un nativo hablante.				
27. Puedo reconocer la diferencia entre las pronunciaciones nativas y no nativas.				
28. No me gusta cuando mis compañeros de clase suenen no nativo al hablar español.				
29. Mi pronunciación de sonidos en español es mejor que el de mis compañeros de clase.				
30. Ocasionalmente, evito hablar como un nativohablante del español.				
31. Es importante a mí hablar como otros compañeros de clase cuando hablo español.				
32. Es importante a mí desarrollar una pronunciación excelente en español para sonar como nativohablante.				
33. Me gusta pronunciar palabras como mi maestro/a.				

Third Grade Questionnaire

Aquí hay unas opciones sobre el español. Por favor, dime qué piensas, poniendo una marca en la columna que mejor representa tu opinión. No hay respuestas incorrectas. Por favor, sé lo más honesto que puedas.

Por favor, elige UNA opción para cada oración.

	Cierto	**Un poco cierto**	**Un poco falso**	**Falso**
1. Me gusta hablar el español				
2. Me gusta hablar el inglés.				
3. Es importante saber el español en San Antonio.				
4. Es importante saber el inglés en San Antonio.				
5. Me gustan cómo enseñan el español en la escuela.				
6. El español es difícil.				
7. El inglés es difícil.				
8. Como hablo español e inglés entonces tengo más amigos.				
9. Saber dos idiomas lo hace a uno más inteligente que saber sólo uno.				
10. Saber dos idiomas le ayuda obtener mejores notas.				
11. Saber dos idiomas le ayuda conseguir mejor trabajo cuando sea mayor.				
12. Me gusta conocer y escuchar a gente que habla español.				
13. El inglés es el único idioma que necesito.				
14. Estoy orgulloso de saber español.				
15. La gente se ríe de mí porque hablo español.				
16. Estaría igual de feliz si naciera en una familia que hablara inglés.				
17. Todos los estadounidenses hablan inglés.				
18. Los estadounidenses hablan español.				
19. Tengo habilidades excelentes de pronunciar en español.				
20. Es importante a mí hablar como otros compañeros de clase cuando hablo español.				

	Cierto	**Un poco cierto**	**Un poco falso**	**Falso**
21. Es importante a mí desarrollar una pronunciación excelente en español para sonar como nativo hablante.				
22. Me gusta pronunciar palabras como mi maestro/a.				

Ability Survey

Por favor, califica cuán bien realizas cada actividad. Pon una marca en la columna que mejor representa tu opinión. No hay respuestas incorrectas. Por favor, sé lo más honesto que puedas.

Por favor, elige UNA opción para cada actividad.

	Mal	**Un poquito mal**	**Un poquito bien**	**Bien**
1. las tareas escolares en español				
2. las tareas escolares en inglés				
3. leer en español				
4. leer en inglés				
5. escribir en español				
6. escribir en inglés				
7. pronunciar los sonidos y palabras del español				
8. pronunciar los sonidos y palabras del inglés				
9. hablar en español				
10. hablar en inglés				

Appendix I

Outline of Data Collection Procedures

Greet students

Informal conversation about animals

Ex: ¿Te gustan los animales? ¿Cuál es tu favorito/preferido?

¿Tienes una mascota en casa? ¿Cómo se llama? ¿Cómo es?

¿Has tenido alguna vez una experiencia inolvidable con algun animal?

Picture identification/sorting task

Ex: ¿Qué animales viven en el agua? ¿Cuáles se encuentran en una granja?

¿Cuáles se encuentran en un zoológico?

¿Cuáles son mamíferos? ¿Cuáles pueden volar? ¿Cuáles son reptiles? ¿Cuáles son insectos?

¿Cuáles son herbívoros (o comen plantas)? ¿Cuáles son carnívoros (o se comen a otros animales)?

¿Cuáles nacen de huevos?

¿Cuáles te dan miedo? ¿Cuáles te gustarían tener como mascota?

Picture walk

Narrate a story based on a series of pictures

Cool down conversation

¿Qué has aprendido de los animales este año?

Appendix J
First Grade Productions

Figure J.1: Mean Formant Values of One-way NES First Graders

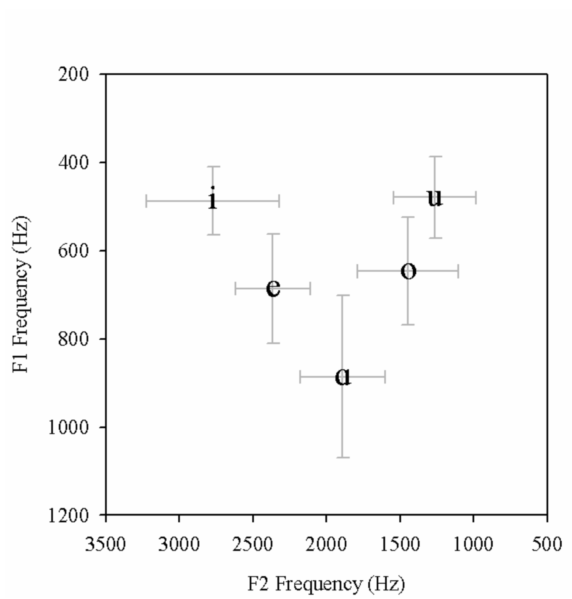


Table J.1: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, One-way NES First Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,786)=267.927, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.006; e-u, p<0.001 i-o, p<0.001; i-u, p=0.629 o-u, p<0.001
F2	F(4,786)=506.633, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Figure J.2 : Mean Formant Values of Two-way NES First Graders

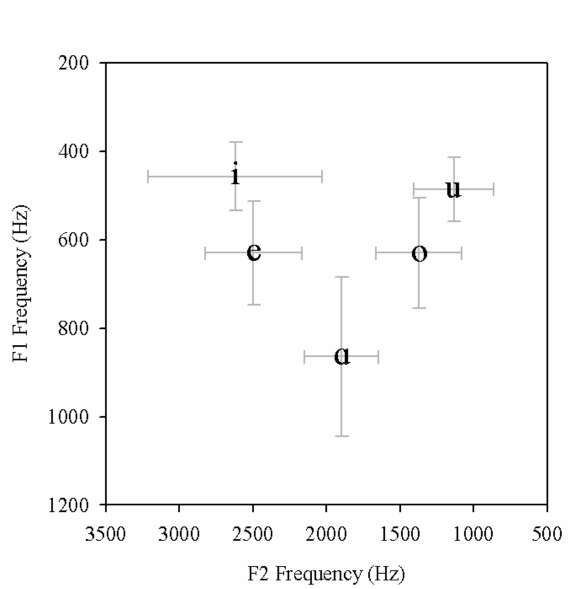


Table J.2: Oneway ANOVA Results Summary for across Vowel Comparisons of F1 and F2, Two-way NES First Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,601)=216.604, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.977; e-u, p<0.001 i-o, p<0.001; i-u, p=0.12 o-u, p<0.001
F2	F(4,601)=328.312, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p=0.011; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Figure J.3: Mean Formant Values of Two-way NSS First Graders

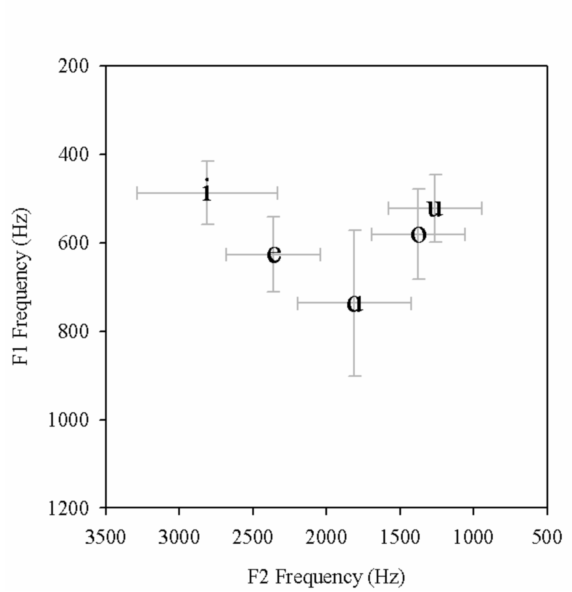


Table J.3: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NSS First Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,696)=120.108, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p=0.02 o-u, p<0.001
F2	F(4,6967)=415.435, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.026

Table J.4: Formant Values of One-way NES First Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1(Hz)**	499	83	687	119	940	173	660	156	480	82
	F2 (Hz)	2743	447	2402	168	1894	333	1527	402	1249	255
unstressed	**F1(Hz)**	477	71	685	133	829*	179	637	87	477	111
	F2 (Hz)	2801	459	2310	336	1887	230	1378*	265	1284	321

*difference between stressed and unstressed is significant at p<0.01 level

Table J.5: Formant Values of Two-way NES First Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1 (Hz)**	477	73	639	119	907	189	647	145	485	77
	F2 (Hz)	2700	592	2514	339	1893	229	1350	319	1071	281
unstressed	**F1 (Hz)**	436*	76	610	113	821*	160	616	103	487	69
	F2 (Hz)	2532	583	2459	310	1904	271	1391	267	1191	250

*difference between stressed and unstressed is significant at p<0.01 level

Table J.6: Formant Values of Two-way NSS First Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1(Hz)**	483	70	641	90	755	180	565	94	512	64
	F2 (Hz)	2872	458	2371	322	1783	372	1319	295	1244	333
unstressed	**F1(Hz)**	492	72	607	73	715	142	593	106	541	90
	F2 (Hz)	2744	493	2349	315	1841	400	1420	330	1293	295

*difference between stressed and unstressed is significant at p<0.01 level

Appendix K

Third Grade Productions

Figure K.1: Mean Formant Values of One-way NES Third Graders

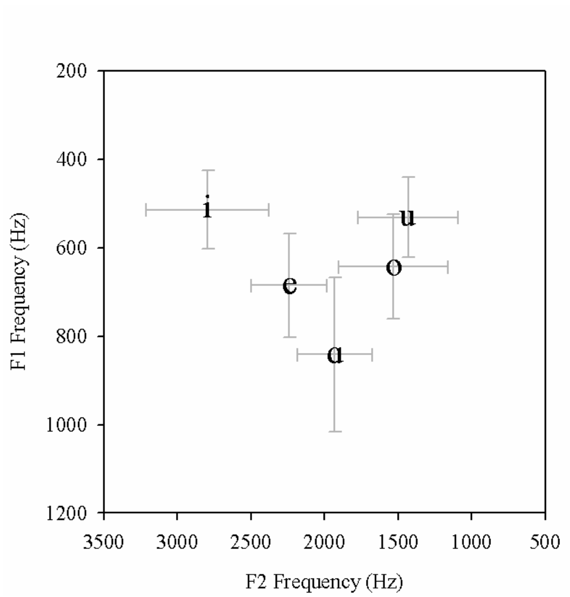


Table K.1: Onway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, One-way NES Third Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,777)=182.796, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.003; e-u, p<0.001 i-o, p<0.001; i-u, p=0.266 o-u, p<0.001
F2	F(4,777)=422.165, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.015

Figure K.2: Mean Formant Values of Two-way NES Third Graders

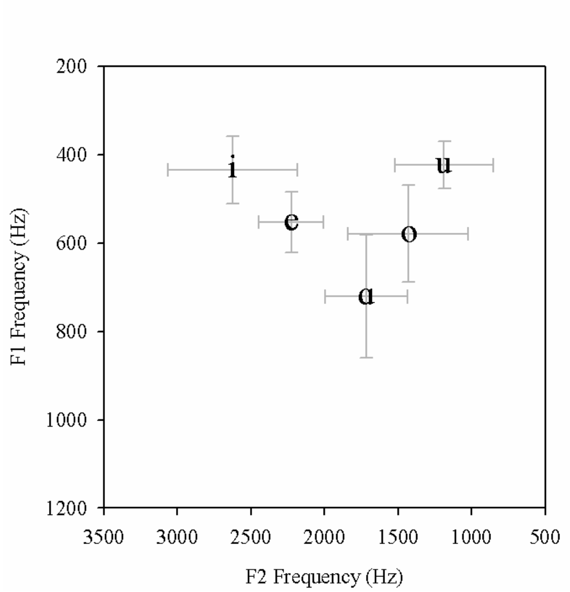


Table K.2: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NES Third Graders

	One-way ANOVA Results	**Significant post-hoc comparisons and p-values**
F1	F(4,648)=100.653, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.008; e-u, p<0.001 i-o, p<0.001; i-u, p=0.208 o-u, p<0.001
F2	F(4,648)=259.689, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Figure K.3: Mean Formant Values of Two-way NSS Third Graders

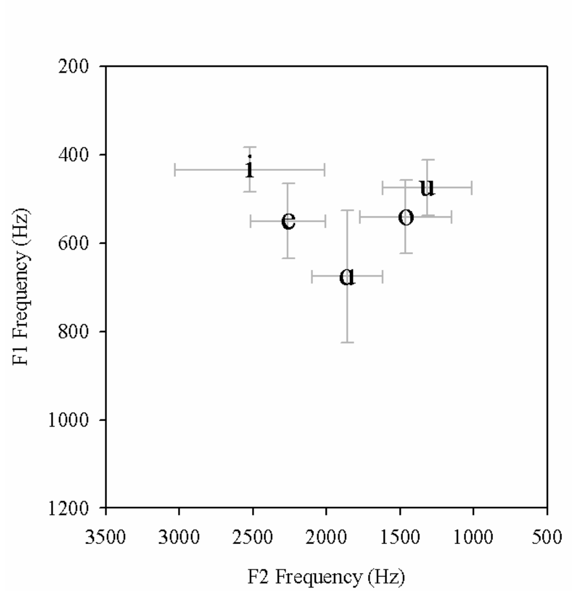


Table K.3: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NSS Third Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,667)=26.214, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.694; e-u, p=0.009 i-o, p=0.001; i-u, p=0.691 o-u, p=0.02
F2	F(4,667)=274.959, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.002

Table K.4: Formant Values of One-way NES Third Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1 (Hz)**	512	101	703	115	888	164	678	117	518	76
	F2 (Hz)	2817	437	662	116	1867	231	1544	418	1413	292
unstressed	**F1 (Hz)**	516	75	2282	222	794*	173	611*	110	551	107
	F2 (hz)	2774	399	2186	293	1994*	265	1524	325	1457	403

*difference between stressed and unstressed is significant at p<0.01 level

Table K.5: Formant Values of Two-way NES Third Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1 (Hz)**	456	115	572	89	813	134	638	126	492	67
	F2 (Hz)	2741	353	2447	222	1872	321	1680	516	1442	388
unstressed	**F1 (Hz)**	471	191	576	99	757	236	609	198	487	61
	F2 (Hz)	2689	309	2384	193	2099*	396	1616	452	1371	300

*difference between stressed and unstressed is significant at p<0.01 level

Table K.6: Formant Values of Two-way NSS Third Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	**F1 (Hz)**	428	51	565	90	710	141	544	97	472	64
	F2 (Hz)	2619	528	2299	243	1864	217	1383	286	1263	328
unstressed	**F1 (Hz)**	441	48	523*	67	638*	149	539	74	478	63
	F2 (Hz)	2383*	456	2196	265	1855	262	1510	319	1383	252

*difference between stressed and unstressed is significant at p<0.01 level

Appendix L
Fifth Grade Vowel Productions

Figure L.1: Mean Formant Values of One-way NES Fifth Graders

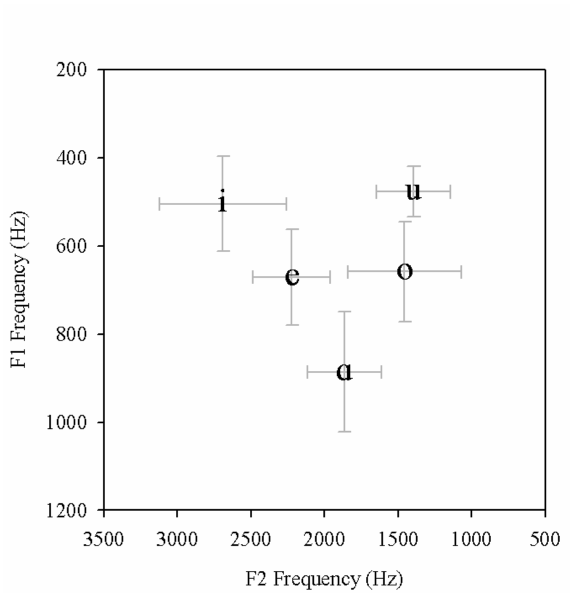


Table L.1: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, One-way NES Fifth Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,673)=0.857, p=0.489	a-e, p=1.0; a-i, p=1.0; a-o, p=0.133; a-u, p=1.0 e-i, p=1.0; e-o, p=0.155; e-u, p=1.0 i-o, p=0.138; i-u, p=1.0 o-u, p=0.211
F2	F(4,673)=349.452, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.219

Figure L.2: Mean Formant Values of Two-way NES Fifth Graders

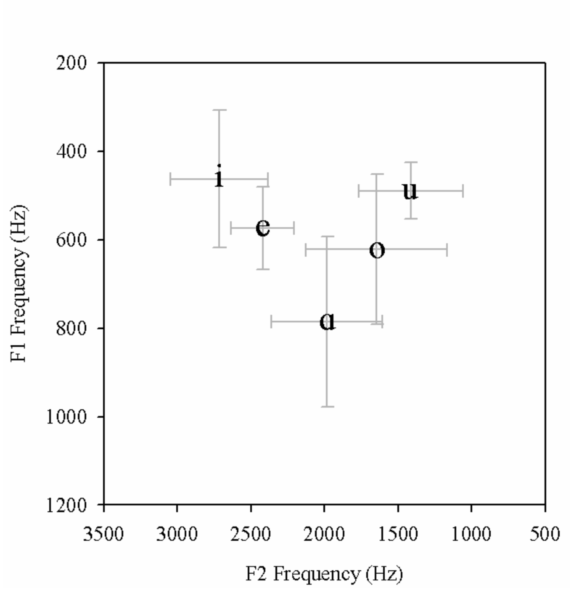


Table L.2: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NES Fifth Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,320)=102.942, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.125; e-u, p<0.001 i-o, p<0.001; i-u, p=0.584 o-u, p<0.001
F2	F(4,320)=174.95, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Figure L.3: Mean Formant Values of Two-way NSS Fifth Graders

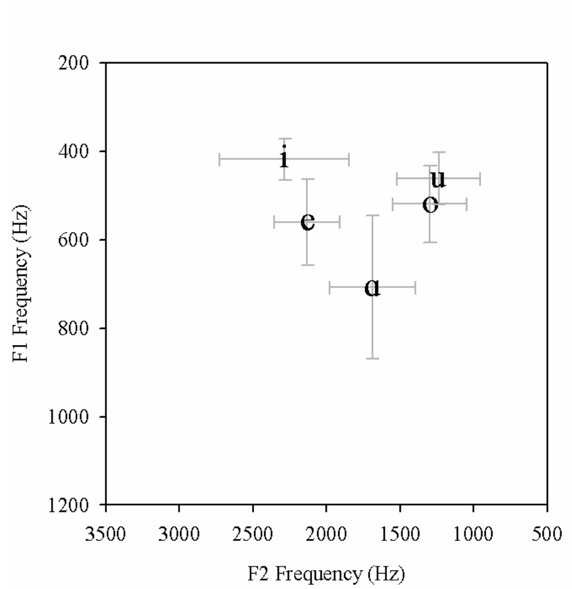


Table L.3: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NSS Fifth Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,628)=164.292, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.002; e-u, p<0.001 i-o, p<0.001; i-u, p=0.004 o-u, p<0.001
F2	F(4,628)=271.994, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.18

Table L.4: Formant Values of One-way NES Fifth Graders According to Syllable Stress

		/i/		**/e/**		**/a/**		**/o/**		**/u/**	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	494	92	696	116	932	133	696	124	474	49
	F2 (Hz)	2782	414	2247	200	1839	224	1518	488	1448	248
unstressed	F1 (Hz)	516	123	627*	76	838*	125	629*	96	491	93
	F2 (Hz)	2591*	435	2183	347	1893	274	1407	280	1344	251

*difference between stressed and unstressed is significant at p<0.01 level

Table L.5: Formant Values of Two-way NES Fifth Grders according to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	439	58	567	68	765	141	622	123	430	56
	F2 (Hz)	2704	405	2239	249	1688	311	1491	417	1100	427
unstressed	F1 (Hz)	428	92	530	64	679*	125	542*	81	416	50
	F2 (Hz)	2540	468	2204	168	1744	246	1379	399	1280	145

*difference between stressed and unstressed is significant at p<0.01 level

Table L.6: Formant Values of Two-way NSS Fifth Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	414	45	579	92	765	157	543	90	472	66
	F2 (Hz)	2278	459	2172	206	1683	228	1260	235	1206	255
unstressed	F1 (Hz)	423	49	528*	98	648*	145	502*	81	448	44
	F2 (Hz)	2294	420	2061*	231	1693	350	1328	262	1281	316

*difference between stressed and unstressed is significant at p<0.01 level

Appendix M

Seventh Grade Vowel Productions

Figure M.1: Mean Formant Values of One-way NES Seventh Graders

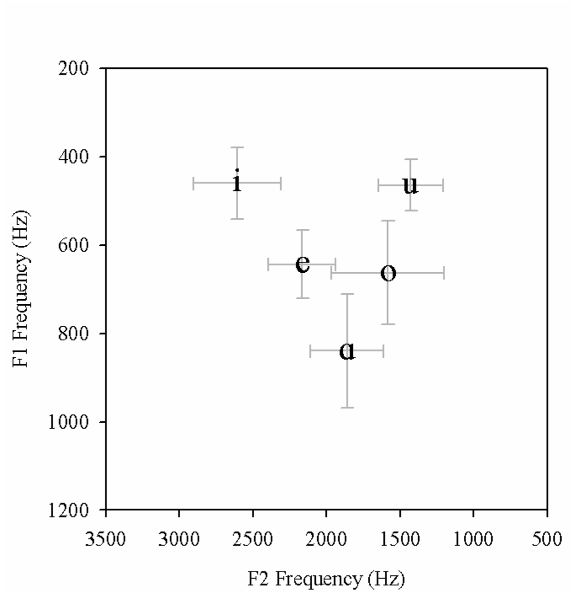


Table M.1: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, One-way NES Seventh Graders

	One-way ANOVA Results	**Significant post-hoc comparisons and p-values**
F1	F(4,653)=334.327, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.124; e-u, p<0.001 i-o, p<0.001; i-u, p=0.729 o-u, p<0.001
F2	F(4,653)=337.019, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Figure M.2: Mean Formant Values of Two-way NES Seventh Graders

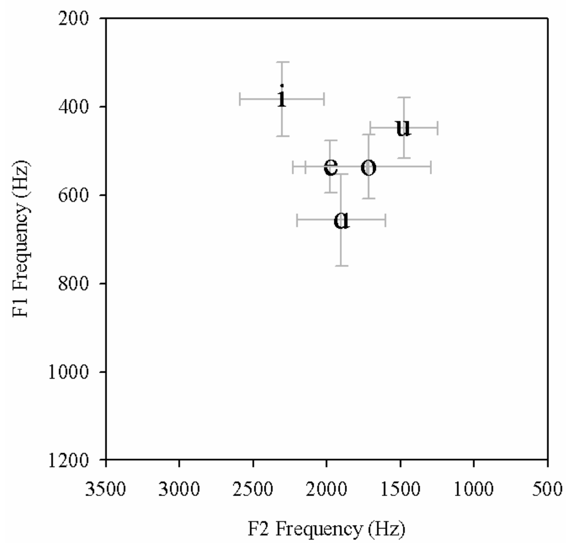


Table M.2: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NES Seventh Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,192)=72.036, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.992; e-u, p<0.001 i-o, p<0.001; i-u, p=0.003 o-u, p<0.001
F2	F(4,192)=32.230, p<0.001	a-e, p=0.284; a-i, p<0.001; a-o, p=0.005; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p=0.005

Figure M.3: Mean Formant Values of Two-way NSS Seventh Graders

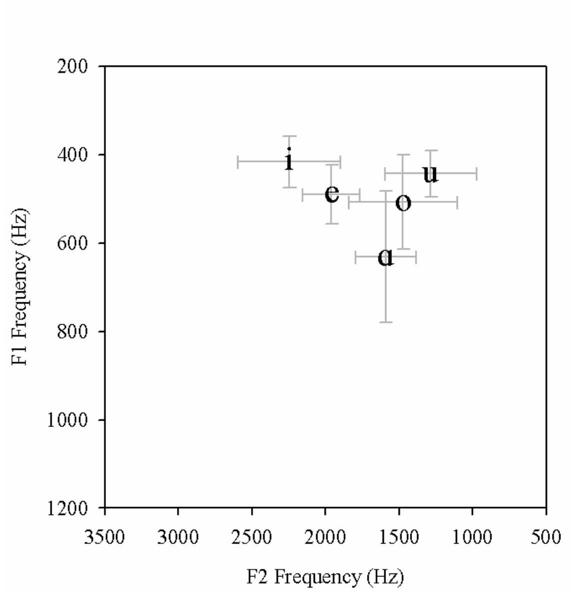


Table M.3: Oneway ANOVA Results Summary for Across Vowel Comparisons of F1 and F2, Two-way NSS Seventh Graders

	One-way ANOVA Results	Significant post-hoc comparisons and p-values
F1	F(4,457)=72.382, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p<0.001; a-u, p<0.001 e-i, p<0.001; e-o, p=0.236; e-u, p=0.009 i-o, p<0.001; i-u, p=0.118 o-u, p<0.001
F2	F(4,457)=149.359, p<0.001	a-e, p<0.001; a-i, p<0.001; a-o, p=0.003; a-u, p<0.001 e-i, p<0.001; e-o, p<0.001; e-u, p<0.001 i-o, p<0.001; i-u, p<0.001 o-u, p<0.001

Table M.4: Formant Values of One-way NES Seventh graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	465	87	659	68	908	103	708	126	457	63
	F2 (Hz)	2600	295	2185	197	1809	208	1568	420	1471	230
unstressed	F1 (Hz)	455	75	623*	86	766*	112	625*	95	475	50
	F2 (Hz)	2617	300	2139	272	1912*	277	1597	349	1374	195

*difference between stressed and unstressed is significant at p<0.01 level

Table M.5: Formant Values of Two-way NES Seventh Graders According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	375	85	536	54	703	98	582	83	448	74
	F2 (Hz)	2306	307	2001	231	1830	287	1743	589	1516	221
unstressed	F1 (Hz)	393	82	539	75	592*	74	510*	50	448	67
	F2 (Hz)	2301	262	1912	302	2002	298	1702	308	1433	240

*difference between stressed and unstressed is significant at p<0.01 level

Table M.6: Formant Values of Two-way NSS Seventh Graders According to Syllable Stress

		/i/		**/e/**		**/a/**		**/o/**		**/u/**	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1 (Hz)	423	59	508	67	662	138	524	100	444	52
	F2 (Hz)	2253	409	2034	187	1575	199	1478	412	1232	302
unstressed	F1 (Hz)	409	57	467*	60	602	154	495	112	442	57
	F2 (Hz)	2242	277	1862*	157	1607	212	1468	338	1379	312

*difference between stressed and unstressed is significant at p<0.01 level

Appendix N

Teacher Vowel Productions

Table N.1: Unnormalized F1 and F2 Values of Teacher Participants

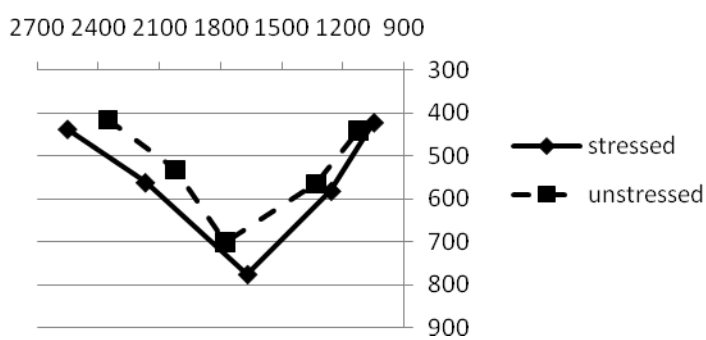
	/i/ n=182		/e/ n=157		/a/ n=198		/o/ n=187		/u/ n=111	
	mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
F1 (Hz)	426.16	79	551.1	82.59	739.55	118.66	573.1	104.53	430.08	68.9
F2 (Hz)	2447.9	350.68	2114.5	247.87	1716.62	221.91	1296.42	298.18	1093.37	218.01

Table N.2: Unnormalized Formant Values of Teachers According to Syllable Stress

		/i/		/e/		/a/		/o/		/u/	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
stressed	F1(Hz)	437	82	562	87	777	119	582	98	422	71
	F2 (Hz)	2548	347	2168	241	1668	213	1259	297	1051	223
unstressed	F1(Hz)	416	75	532	71	701*	106	565	110	441	65
	F2 (Hz)	2352*	329	2024*	234	1776*	221	1331	297	1125	201

*difference between stressed and unstressed is significant at p<0.01 level

Figure N.1: Formant Values of Immersion Teachers According to Syllable Stress



Appendix O

Attitude and Pronunciation

Table O.1: Responses to Attitude Questionnaire According to Program and Grade Level

(1=true, 2=kind of true, 3=kind of false, 4=false)

	One-way NES			Two-way NES		
	3rd gr. mean (s.d.)	**5th gr.** mean (s.d.)	**7th gr.** mean (s.d.)	**3rd gr.** mean (s.d.)	**5th gr.** mean (s.d.)	**7th gr.** mean (s.d.)
1. I like to hear people speaking Spanish.	n/a	1.86 (1.069)	1.86 (0.69)	n/a	1.25 (0.5)	1.33 (0.577)
2. I like to hear people speaking English.	n/a	1.0 (0.0)	1.0 (0.0)	n/a	1.0 (0.0)	2.0 (1.732)
3. I like to speak Spanish.	1.56 (0.726)	2.0 (0.577)	1.57 (0.535)	1.63 (0.744)	1.25 (0.5)	1.67 (1.155)
4. I like to speak English.	1.13 (0.354)	1.0 (0.00)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (0.707)
5. It is important to know Spanish in San Antonio.	1.89 (0.601)	1.33 (0.516)	1.57 (0.787)	1.25** (0.463)	1.25 (0.5)	1.33 (0.577)
6. It is important to know English in San Antonio.	1.11 (0.333)	1.0 (0.0)	1.14 (0.378)	1.63 (1.061)	1.2 (0.5)	1.33 (0.577)
7. I enjoy studying Spanish the way it is taught in school.	1.33 (0.707)	1.14 (0.378)	1.83 (0.753)	1.5 (0.535)	1.25 (0.5)	2.33 (1.528)
8. Spanish is difficult.	2.78 (0.833)	2.57 (0.787)	2.71 (0.756)	3.29 (0.756)	3.5 (1.0)	3.33 (1.155)
9. English is difficult.	4.0 (0.0)	4.0 (0.0)	3.14 (1.215)	3.71 (0.756)	4.0 (0.0)	3.0 (1.732)
10. I would be happy at a school that did not teach Spanish.	n/a	3.57 (1.134)	3.0 (1.0)	n/a	4.0 (0.0)	4.0 (0.0)
11. I have more friends because I speak Spanish and English.	2.0 (1.323)	2.29 (1.38)	2.86 (1.215)	1.88 (1.126)	2.5* (1.732)	1.0 (0.0)
12. Learning two languages will make you smarter than learning only one language.	1.22 (0.441)	1.29 (0.488)	1.86 (1.069)	1.25 (0.463)	1.25 (0.5)	2.0 (1.0)
13. Learning two languages will help you get better grades.	1.33 (0.5)	1.14 (0.378)	2.0 (1.0)	1.63 (0.744)	1.75 (0.957)	1.33 (0.577)
14. Knowing two languages will help you get a better job when you grow up.	1.33 (0.5)	1.14 (0.378)	1.0 (0.0)	1.13 (0.354)	1.0 (0.0)	1.0 (0.0)
15. I enjoy meeting and listening to people who speak Spanish.	1.78 (0.833)	2.17 (0.983)	1.57 (0.787)	1.5 (0.548)	1.0 (0.0)	2.0** (1.0)
16. I speak Spanish better than I speak English.	n/a	3.71 (0.488)	4.0 (0.0)	n/a	3.5 (1.0)	2.0 (1.732)
17. I speak English better than I speak Spanish.	n/a	1.43 (1.134)	1.0 (0.0)	n/a	1.75 (1.5)	2.33 (1.155)

	One-way NES			Two-way NES		
	3rd gr. mean (s.d.)	**5th gr.** mean (s.d.)	**7th gr.** mean (s.d.)	**3rd gr.** mean (s.d.)	**5th gr.** mean (s.d.)	**7th gr.** mean (s.d.)
18. I could be a "good teacher" of Spanish.	n/a	2.14 (1.069)	2.29 (0.951)	n/a	1.75 (0.5)	2.33 (1.528)
19. English is the only language I need.	3.56 (0.527)	3.86 (0.378)	3.71 (0.488)	3.63 (0.744)	4.0 (0.0)	3.0 (1.732)
20. I am proud to know Spanish.	1.22 (0.667)	1.0 (0.0)	1.57 (0.787)	1.0 (0.0)	1.25 (0.5)	1.0 (0.0)
21. People make fun of me for speaking Spanish.	3.67 (0.707)	4.0 (0.0)	4.0 (0.0)	4.0 (0.0)	4.0 (0.0)	3.0 (1.732)
22. I would be just as happy if I had been born in to a Spanish-speaking home.	2.78 (0.972)	2.86 (1.345)	2.43 (1.134)	2.88 (1.356)	2.25 (0.5)	3.67 (0.577)
23. All Americans speak English.	3.56 (0.726)	3.0 (1.291)	3.86 (0.378)	3.5 (1.069)	3.25 (0.957)	3.33 (0.577)
24. Americans speak Spanish.	1.56 (1.014)	2.29 (1.38)	2.0 (0.816)	3.25* (1.035)	1.75 (0.5)	1.67 (0.577)
25. I feel that I currently have excellent pronunciation skills in Spanish.	1.67 (0.5)	1.71 (0.756)	1.86 (0.378)	1.88 (0.641)	1.25 (0.5)	2.33 (1.155)
26. My pronunciation in Spanish is native-like.	n/a	2.57 (1.397)	2.86 (0.9)	n/a	1.75 (0.5)	2.5 (0.707)
27. I can recognize the difference between native-like and non-native pronunciation in Spanish.	n/a	1.14 (0.378)	1.57 (0.535)	n/a	1.5 (0.577)	2.0 (1.0)
28. I don't like when my classmates sound very non-native when they speak Spanish.	n/a	2.71 (1.604)	2.71 (1.38)	n/a	2.5 (1.0)	2.67 (1.528)
29. My pronunciation in Spanish is better than that of my classmates.	n/a	2.5 (1.378)	2.0 (0.816)	n/a	3.75 (0.5)	2.33 (1.155)
30. Occasionally, I avoid sounding like a native speaker of Spanish.	n/a	2.83 (1.329)	2.71 (1.38)	n/a	2.5 (1.732)	3.67 (0.577)
31. It is important for me to sound like my classmates when I speak Spanish.	2.89 (1.364)	2.67 (1.366)	2.6 (1.342)	2.63 (1.188)	2.25 (1.258)	2.33 (1.528)
32. It is important to me to develop excellent pronunciation in Spanish so that I can sound like a native speaker.	1.67 (0.5)	2.17 (1.472)	2.14 (1.215)	1.5 (0.535)	1.75 (0.957)	1.67 (0.577)
33. I like to pronounce words like my teacher.	1.67 (0.866)	2.43 (1.397)	2.14 (1.069)	1.75 (1.035)	2.0 (1.155)	2.33 (1.528)

*Difference between one-way and two-way same grade groups is significant at $p<0.01$
**Difference between one-way and two-way same grade groups is significant at $p<0.05$

Table O.2: Factor Scores According to Speaker

		Subject	Factor 1	Factor 2	Factor 3	Factor 4	Self-Rating of Ability
One-way NES	1st grade	A1-1	n/a	n/a	n/a	n/a	1
		A1-2	n/a	n/a	n/a	n/a	4
		A1-3	n/a	n/a	n/a	n/a	4
		A1-4	n/a	n/a	n/a	n/a	3
		A1-5	n/a	n/a	n/a	n/a	3
		A1-6	n/a	n/a	n/a	n/a	4
		A1-7	n/a	n/a	n/a	n/a	3
		A1-8	n/a	n/a	n/a	n/a	3
		A1-9	n/a	n/a	n/a	n/a	4
		A1-10	n/a	n/a	n/a	n/a	3
		Average	n/a	n/a	n/a	n/a	**3.2**
	3rd grade	A3-1	4	7	6	2	1
		A3-2	5	8	5	2	4
		A3-3	11	6	6	2	4
		A3-4	9	7	8	2	3
		A3-5	5	6	4	1	3
		A3-6	6	9	7	2	4
		A3-7	4	8	6	1	3
		A3-8	4	11	5	1	3
		A3-9	5	8	9	2	4
		Average	**4**	**7**	**6**	**2**	**3**
	5th grade	A5-1	8	7	15	11	4
		A5-2	7	8	15	6	4
		A5-3	4	5	7	4	4
		A5-4	6	5	8	6	4
		A5-5	12	7	11	6	4
		A5-6	10	12	5	4	3
		A5-7	0	0	0	0	0
		A5-8	8	5	12	8	4
		Average	**6.875**	**6.125**	**9.125**	**5.625**	**3.375**
	7th grade	A7-1	7	6	6	5	4
		A7-2	12	9	14	8	3
		A7-3	10	10	7	8	3
		A7-4	8	6	9	5	3
		A7-5	6	10	8	7	3
		A7-6	0	0	0	0	0
		A7-7	5	16	15	8	4
		A7-8	9	8	14	6	3
		Average	**7.125**	**8.125**	**9.125**	**5.875**	**2.875**
Two-way NES	1st grade	N1-1	n/a	n/a	n/a	n/a	4
		N1-2	n/a	n/a	n/a	n/a	4
		N1-5	n/a	n/a	n/a	n/a	4
		N1-9	n/a	n/a	n/a	n/a	4
		N1-13	n/a	n/a	n/a	n/a	3
		N1-18	n/a	n/a	n/a	n/a	4
		N1-6	n/a	n/a	n/a	n/a	4
		N1-15	n/a	n/a	n/a	n/a	4
		Average	**n/a**	**n/a**	**n/a**	**n/a**	**3.875**
	gr	N3-1	4	8	4	2	4

		Subject	Factor 1	Factor 2	Factor 3	Factor 4	Self-Rating of Ability
		N3-2	6	9	4	2	4
		N3-4	5	7	5	1	3
		N3-5	4	5	7	1	4
		N3-8	4	5	10	2	3
		N3-9	7	7	4	3	3
		N3-12	6	8	7	2	2
		N3-13	6	8	6	2	4
		Average	**5.25**	**7.125**	**5.875**	**1.875**	**3.375**
	5th grade	N5-3	5	6	12	5	4
		N5-4	5	6	6	7	4
		N5-5	8	11	14	8	3
		N5-6	6	8	8	7	4
		Average	**6**	**7.75**	**10**	**6.75**	**3.75**
	7th grade	N7-2	10	8	10	9	3
		N7-6	5	5	8	4	4
		N7-8	10	7	15	6	3
		Average	**8.333**	**6.667**	**11**	**6.333**	**3.333**

Table O.3: Mean Prototypicality score According to Speaker

		Subject	Mean Prototypicality Score
One-way NES	1st grade	A1-1	3.411765
		A1-2	3.148649
		A1-3	3.397436
		A1-4	3.077922
		A1-5	3.116883
		A1-6	3.291139
		A1-7	3.011628
		A1-8	3.527027
		A1-9	3.494253
		A1-10	2.710526
		Average	**3.219**
	3rd grade	A3-1	3.02381
		A3-2	2.681319
		A3-3	2.60241
		A3-4	3.211765
		A3-5	3.214286
		A3-6	2.873563
		A3-7	2.808989
		A3-8	2.010638
		A3-9	2.458824
		Average	**2.765**
	5th grade	A5-1	3
		A5-2	2.952381
		A5-3	2.846154
		A5-4	2.411765
		A5-5	3.202128
		A5-6	2.647887
		A5-7	2.626667
		A5-8	2.567308
		Average	**2.782**
	7th grade	A7-1	2.549451
		A7-2	2.19403
		A7-3	2.510417
		A7-4	2.821918
		A7-5	2.819444
		A7-6	2.555556
		A7-7	2.406977
		A7-8	2.163043
		Average	**2.503**
Two-way NES	1st grade	N1-1	3.227848
		N1-2	2.987179
		N1-5	3.166667
		N1-9	3.382353
		N1-13	3.494382
		N1-18	2.712329
		N1-6	2.886076
		N1-15	3.189873

		Subject	Mean Prototypicality Score
		Average	**3.131**
	3rd grade	N3-1	3.108696
		N3-2	2.873563
		N3-4	3.15493
		N3-5	2.724638
		N3-8	3.297872
		N3-9	2.94382
		N3-12	2.986842
		N3-13	3.157303
		Average	**3.031**
	5th grade	N5-3	3.109589
		N5-4	3.351351
		N5-5	3.313953
		N5-6	3.043478
		Average	**3.205**
	7th grade	N7-2	3.205882
		N7-6	3.064516
		N7-8	3.134328
		Average	**3.135**

Appendix P

Reported Exposure of Learners to Spanish Outside of School

The figures reported here are based upon responses to question #X on the language background questionnaire. Not all participants responded to each item; consequently, the number of responses does not equal the total number of participants in many instances.

The number of responses for possible source of exposure according to is indicated in the tables below according to the amount of time Spanish is heard from this source.

Table P.1: Response to the Question: Does the Student have Opportunities to Hear Spanish Outside of School?

	Yes	No	No response
One-way NES (N=35)	28	5	2
Two-way NES (N=23)	23	0	0

Table P.2: Exposure of One-way NES Learner Group to Spanish Outside of School

		0%	1-20%	20-40%	40-60%	60-80%	80-100%
Source of Exposure to Spanish	mother	8	19	1			
	father	17	9				
	siblings	11	15	1			
	grandparents	18	8	1		1	
	neighbors	21	2	3			
	friends	10	13	3			
	radio	20	6				
	audio or video tapes	18	10				
	TV or movies	12	16				
	other:						
	maid, nanny, employees		4				
	nanny, caretaker			2			
	housekeeper				1		
	Mexico					1	
	nanny						1

Table P.3: Exposure of Two-way NES Learner Group to Spanish Outside of School

		0%	1-20%	20-40%	40-60%	60-80%	80-100%
Source of Exposure to Spanish	mother	6	7	6	1		2
	father	8	6	5	1		1
	siblings	12	3	1		1	1
	grandparents	2	5	7	3	3	3
	neighbors	14	2	4	1	1	
	friends	10	5	2	1	1	1
	radio	10	4	4	1		1
	audio or video tapes	9	3	3	2	1	
	TV or movies	6	6	6		3	1
	other:						
	aunt		1				
	reading			1			
	books				1		