BETWEEN-LANGUAGE INTERACTION IN EARLY ACQUISITION OF SPEECH. AN ANALYSIS OF GLIDING BY BILINGUAL PRESCHOOLERS IN SOUTHERN ARIZONA

By

Miriam de la Milagrosa Rodríguez Guerra

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As members of the Dissertation Committee, we certify that we have read the dissertation prepared by: Miriam de la Milagrosa Rodríguez Guerra
titled:

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Sonia Colina ______ Date: Jul 27, 2020
Sonia Colina

Leah C Fabiano-Smith ______ Date: Jul 20, 2020
Leah C Fabiano-Smith

______ Date: Jul 27, 2020
Ana Maria Carvalho

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

We hereby certify that we have read this dissertation prepared under our direction and recommend that it be accepted as fulfilling the dissertation requirement.

Sonia Colina ______ Date: Jul 27, 2020
Sonia Colina
Sonia Colina
Sonia Colina

Leah C Fabiano-Smith ______ Date: Jul 20, 2020
Leah C Fabiano-Smith
Co-Chair
Speech, Language, and Hearing Sciences

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Dedication

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Abstract

Children who grow up in Spanish-English bilingual families in Arizona, US, often start as Spanish-dominant speakers but become English-dominant as they advance in school (Genesee 2004). Two key factors in this language shift are campaigns promoting English monolingualism in schools (Fishman 2013) and lack of understanding of bilingual speech acquisition, resulting sometimes in therapy over-diagnosis (Yavas 1998). The present dissertation contributes to the understanding of bilingual speech sound acquisition, as it explores the distribution of inaccuracies of late-developing sounds by preschoolers undergoing this language shift.

Specifically, this research study investigates the distribution of glides as substituted sounds. Glides present a conflict in the phonologies of bilingual Spanish-English speaking children because of their dual behavior in each language. Spanish glides [j] and [w] share acoustic and phonological features with the high vowels [i] and [u] (Hualde 1997), whereas English includes both sounds [j] and [w] in the consonant inventory (Ladefoged & Johnson 2014). When children have not mastered late-developing sounds, such as rhotics or laterals, they substitute these sounds with easier ones in their inventory. In English, the substitution pattern of gliding ("rabbit" pronounced as [ˈwæbɪt] is frequently found in preschoolers, but it does not occur in monolingual Spanish, where the rothics [r ɾ] are replaced by [l] ("rojo" pronounced as [ˈlo.xo]) or [ð] ([ˈðo.xo]), (Bosch 1983). Taking into account the phonological distributions of glides in English and Spanish, we posed the question, "Do bilingual children show a different substitution pattern of late-developing rhotics and laterals in English?"

This study investigates gliding in Spanish-English bilingual children born and raised in a southwest border region of the U.S. We do so by comparing the single word outputs of 61 typically-developing children from the same preschool with (or without) language exposure. Only 22 of these children exhibited gliding (11 Spanish-English speaking children and 11 English-speaking children). A nonparametric Mann-Whitney U test indicated gliding occurred significantly more often in monolinguals than bilinguals, suggesting between-language interaction ($p = .031$). Results are discussed within the Processing Rich Information from Multidimensional Interactive Representations model (PRIMIR; Curtin et al. 2011a). Through mixed methods analysis with a sociolinguistic approach, this investigation shows evidence of how children create two different phonological systems while acquiring the language, as well as how these languages interact with each other.

CHAPTER 1. Introduction

Latinx children are commonly misdiagnosed by schools when they are not at the expected level of English proficiency as compared to their monolingual peers (Yavas and Goldstein 1988, Morgan et al., 2012). Schoolteachers and clinicians show the first signs of concern when a child exhibits features that may not be common for monolingual English children. These concerns are based on a lack of assessment in their native and dominant language or absence of experience with Spanish-influenced English. There is still a lack of Spanish-English assessment tools that accurately describe and measure bilingual language and speech abilities and proficiencies, and even fewer standardized tests that account for the sociolinguistic variability that bilingual communities exhibit. Because of this lack of sociolinguistic awareness and lack of accurate assessments, Latinx children are overrepresented in the speech-language pathologists' caseloads (Skahan, Watson, Lof, 2007). This representation is caused by misdiagnosis of typically-developing children, and overlooks children who may present with a speech or language disorder.

Additionally, growing up bilingual in Arizona presents another set of obstacles that affect the language maintenance of minority languages Linguistic ideologies and language policies prevent the bilingual community's ability to thrive and celebrate their multiculturalism (Cashman 2013). Specifically, 36% of the population in Arizona identify as Hispanic or Latinx (US Census 2019), but the state has been described as "ideologically opposed to bilingualism" (Cashman 2006). These obstacles stand out when the community shifts from monolingual Spanish to monolingual English by the third generation (Fishman 2006; 2013).

Spanish as a minority language does not receive the majority of the public's support and, instead, is persecuted by the public education system with language policies against minority language maintenance. (Cashman 2009). Taking into account this reality and the fact that it is more likely for Latinx children to raise concerns from their schoolteachers and speech and language pathologists because of the interaction between their languages (Artiles et. al, 2009), it is very difficult for bilingual Spanish-English children to develop and maintain both languages with educational support.

This dissertation aims to contribute to our understanding of bilingual speech acquisition by analyzing glides, shared sounds in English and Spanish, specifically in the context of the phonological substitution pattern of gliding. Gliding is a common substitution for rhotics and laterals by children who have not acquired them yet. For instance, a monolingual English child with gliding may produce the word *rabbit* as [w]*abbit*, alternating the rhotic [ɹ] for the labiovelar glide [w]. While it is well known that this phonological substitution is common until the age of 5 among monolingual English children, it has not been explored from a bilingual perspective. The phonological process of gliding is considered an "error" as it is a substitution pattern that deviates from the adult-like model of the word. Gliding replaces rhotics and laterals for glides, sounds that are the latest-developing sounds for monolingual English and bilingual English preschoolers (Fabiano-Smith and Goldstein 2010a). For monolingual English children, this phonological error will eventually disappear once the child has solidified their phonological system, specifically the production of rhotics and laterals.

An important contrast between Spanish and English patterns of language acquisition is the fact that in Spanish, the rhotics and laterals are not replaced by glides but for other sounds, such as the approximant [ð] or the alternation among trill-tap-lateral sounds (words as *rojo* pronounced as [ð]*ojo* or [ɾ]*ojo*). Given that gliding only happens in English, and Spanish presents other phonological substitutions, one could assume that a bilingual child who is exposed to

Spanish and English will create two different "error tracks" to separate the phonological systems and phonological substitution patterns according to each language.

It is crucial to keep in mind that glides are acoustically shared sounds in English and Spanish. Glides appear in English as part of the consonant inventory, but in Spanish, they are non-consonantal allophones of the high vowels /i/ and /u/. Moreover, Spanish glides surface in vocalic sequences with other adjacent vowels and become obstruents when they appear in onset position. Because glides are speech sounds that are shared in English and Spanish, but differ in phonological representation in the phonological systems of English and Spanish, the phonological error pattern of gliding is a variable worthy of study that can contribute to our understanding of bilingual phonology development.

The present study analyzes the speech productions of preschoolers from Southern Arizona with and without exposure to Spanish at home. The first aim of this study is to analyze the English phonological substitution pattern of gliding, an understudied phonological substitution pattern in this population, taking into account the words that may trigger gliding, as well as the type of glide (labiovelar or palatal) that replaces the rhotics and lateral and to see whether rhotics have more substitution errors than laterals. Additionally, this study explores the accuracy rate for both rhotics and laterals in English and error patterns other than gliding that affect these sounds. The analysis offers an overview of other substitutions that may be relevant for the acquisition of rhotics and laterals, as well as provides an analysis of bilingual speech acquisition. We analyze the behavior of late-developing rhotics and laterals by comparing preschoolers with or without exposure to Spanish as a minority language. Lastly, the current study investigates the socio-cultural components that may have an effect on the production of these late-developing sounds for the Spanish-speaking children with exposure to Spanish at home. Sociolinguistic variables such as home language exposure and the language the participant spoke with their siblings will be taken into account to determine if the input and output of these children may correlate with the production of rhotics and laterals.

This dissertation is structured as follows. Chapter 2 reviews the relevant literature that motivates this study. This chapter is divided into different subsections that discuss the linguistic situation in Arizona, the state of the field in the early bilingual acquisition of speech, the sociolinguistic components that have been found to impact the early acquisition of speech, the status of glides, and culminates in the research questions motivating the present study. The methodology is described in chapter 3, with a detailed explanation of all the ways data were collected and. Chapter 4 offers the findings of this study, followed by the discussion of these results in chapter 5. Lastly, chapter 6 provides concluding remarks and future directions.

CHAPTER 2. Literature Review

2.1. Linguistic and Educational Setting for Early Acquisition of Bilingual Speech

Spanish is the most commonly spoken non-English language among US households, with 41.5 million speakers ages five and older (U.S. Census, 2018). The Southwestern US includes eight of the ten cities with the largest Hispanic population in the country (Ennis et al. 2011, in Escobar and Potowski 2015, p. 26). Specifically, Arizona is the fourth state with the largest Latinx population in the Southwestern US. In Arizona, about 31.6% of the population identifies as Latino/Hispanic, with 20.4% of the population maintaining Spanish as their home language (U.S. census, 2019), providing evidence of their ethnolinguistic vitality (Cashman 2009). Research shows that the closer a community is to the border, the more likely it will be bilingual, in this case, in Spanish and English (Escobar and Potowski 2015 2015, p.29). A great example of this is Pima County, the south-central region of Arizona right on the US-Mexican border, with a population of about one million, of which 37.6% identifies as Hispanic or Latino (U.S. Census Bureau, 2018).

Even though the numbers of Spanish speakers are high, the state of Arizona engages in policies and practices that prevent bilingual speakers from maintaining their minority language and expressing their multiculturalism freely compared to other states in the Southwestern US. Spanish maintenance as a family language is at risk in the US since education steers the younger generation towards English monolingualism (Fishman, 2013). Arizona has a unique sociopolitical climate that shapes the language ideology of Spanish speakers (Cashman 2009). Campaigns that promote English monolingualism are prevalent in the state, threatening the linguistic vitality and status of Spanish in Arizona (Fishman, 2013). Arizona has been described as a state “ideologically opposed to bilingualism and multilingualism” (Cashman 2006, 2009), with an "active campaign against the public support of the language, which is part of a larger moral panic about immigration" (Cashman 2009). Policies such as Proposition 108, 203, and 103 have promoted the primacy of English in the classroom, with no room for minority languages in public schools. On November 8, 1988, with 50.5 % of the vote, Arizona narrowly passed Proposition 108, which required official government business to be conducted only in English. The main argument in favor of this amendment was that English was under attack as bilingualism was creating cultural fragmentation in the community (Combs et al. 2005). Proposition 203, which was backed by the same argument and supported English immersion education by prohibiting bilingual education for language minorities, was passed on November 7, 2000. After these two policies pushed English as the language of the state, Arizona became an "English-only" state on November 8, 2006, when Proposition 103 was approved by 74% of votes. This legislation was seen to be the strictest English-only legislation in the country at the time, as it included an amendment to the state constitution prohibiting the use of languages other than English in the public sector (Crawford 1997, in Cashman 2009). At this point, English was the mandated language for schools, the public sector, and became the state's official language, prohibiting resulting in a lack of support of minority languages.

One year after Arizona pursued "English-only" status, the federal educational law "No Child Left Behind" Act (NCLB) was signed during the Bush Administration. NCLB abolished any remnants of public bilingual education from the federal educational system. This Act was a version of the previous "Elementary and Secondary Education Act," established during the Johnson Administration in the 1960s that aimed for federal funding to provide educational materials and resources for professional development to underserved schoolchildren (Thomas & Brady 2016). The NCLB created new structure, goals, incentives, and penalties with "accountability plans" that promoted access to public education for all children but also English-mainly approaches for non-speakers of English. NCLB also created proficiency requirements in subjects such as English, math, arts, and sciences across the nation. In order to meet the requirement, the federal government boosted resources to states with lower income --Arizona being one of them-- with the purpose of helping the state achieve better academic performance. Even though NCLB was designed to create a sense of educational equality across the nation, it granted insufficient flexibility to states to meet the national standards. In a state such as Arizona, where the language policies were already pushing monolingualism on multilingual children with little support in their minority language, the pressure to meet these national standards increased. The "Every Student Succeeds" Act (ESSA), an amendment to NCLB, passed in December 2015 during the Obama administration, as a reaction to the realities of the country at the time. ESSA redirected the federal government's role in education after NCLB, giving more decision power to the states, but doing nothing to ensure that the outstanding needs of low-income students would be met (Black 2017). Specifically, in Arizona, the elimination of bilingual education put the Latinx community at a disadvantage to meet these federal standards. In sum, meeting national standards set by acts such as NCLB or ESSA was (and still is) particularly difficult for states that still do not support students from diverse backgrounds and do not favor minority languages. In a state with decidedly anti-bilingual language policies like Arizona (Cashman, 2009), meeting the standards and helping diverse students succeed was particularly challenging under NCLB and ESSA.

Educational policies affect not only how children maintain language, but also how they acquire language. Research has indicated that within the first year of life children develop language-specific speech perception skills when they are exposed to a bilingual community

(Bosch and Sebastián Gallés 2003), and that earlier exposure to the L2 may affect proficiency in their L1 (Bedore, Peña, Griffin and Hixon 2016; Ruiz-Felter, Cooperson, Bedore and Peña 2015). Under existing educational policies, such as those of Arizona, where children are immersed in English education with little support for their home language, many children who grew up in bilingual families begin as Spanish-dominant speakers and shift towards English-dominant speakers after their first years in school (Genesee et al., 2004). The transition from dominance in one language to dominance in the other can mimic Developmental Language Disorder (DLD), placing bilingual children in danger of misdiagnosis of communication disorders (Anderson, 2004). State public schools rush English language learners (ELL) to acquire a new language in order to meet national standards in English, disregarding how bilingual children go about acquiring their two languages.

The different acquisitional paths of bilingual children may lead to a belief that bilingual children are not learning adequately when compared to their monolingual peers (Kupisch and Rothman 2016). For instance, the National Clearinghouse for English Language Acquisition (2007) has stated that English language learners (ELL) do not perform as well as monolingual children in reading (and related subjects) and math. Such claims result in assumptions that English language learners have a deficiency compared to their monolingual peers in reading, math, and other subjects, or that bilingualism is correlated with lower IQ or cognitive deficiencies (Kupisch and Rothman, 2016).

Alt et al. (2013) aimed to question that particular claim by investigating whether ELL would show any difference in math skills if they were able to use their dominant language rather than only English, and they found that, indeed, bilingual children’s performance in math improved when they could answer in Spanish. In addition, Alt et al. (2014) expanded their analysis of ELL math and language skills by comparing their performance with that of children with Specific Language Impairment (SLI). Even though both SLI and ELL children may struggle with English use, children with SLI struggle with language on a deeper level, which prevents them from understanding content. Alt et al. (2014) found that ELL and SLI performance did not differ in terms of language-light tasks (those with visual context and easy linguistic instructions) in math, but the SLI group showed poorer performance with tasks that demanded heavier language instructions or symbolic processing compared to the ELL group. Even though the implications of studies such as Alt et al. 2013 and Alt et al. 2014 are directed to language acquisition rather than acquisition of speech, they have implications for this dissertation as they highlight that educators and clinicians need to be aware of children's linguistic profile in order to accurately assess their school performance. Framed by the socio-demographic and educational situation just described, the present study explores the acquisition of speech in preschoolers attending public schools in Arizona, where English is the language of instruction for all children regardless of the language spoken at home.

2.2. Assessment and Evaluation of Bilingual Children

Over the last three decades, the field of Communication Disorders has noticed an increase in language diversity within the general population. Because of that, the literature on early speech acquisition has begun to pay more attention to multilingual populations in order to meet these children's needs. A handful of standardized tests address bilingual speech such as the subtest from the Bilingual English-Spanish Assessment (BESA, Peña, et al., 2018). The speech subtest comprises a set of target words in both English and Spanish to assess consonant vowel inventories, as well as syllabic position. Even though the BESA subtest may be sufficient for assessing bilingual children with severe speech impairment, it is shorter than the rest of the assessment, and does not include cross-linguistic effects between English and Spanish. Other contributions to the field of early bilingual speech acquisition provide phonological inventories for bilingual Spanish-English preschoolers, including complexity and order of acquisition (Fabiano-Smith & Barlow, 2010), phonetic accuracy (Fabiano-Smith & Goldstein 2010a) and between-language interaction effects based on shared and not-shared sounds that surface in bilingual children's languages, among other features (Fabiano-Smith & Goldstein 2010b). Studies such as those by Fabiano-Smith and Goldstein directly inform scholars to improve current standardized tests, so as to better address the reality of bilingual speech among Latinx children in the US.

In addition to standardized tests aimed at analyzing bilingual speech, criterion-referenced measures are also necessary to provide reference scores for evaluating children's productions regardless of the languages they speak. One of these studies is Fabiano-Smith and Hoffman (2018), who applied traditional evaluation measures to typically-developing English monolingual, Spanish monolingual, as well as bilingual children. The Percentage of Consonants Correct-Revised (PCC-R; Shriberg et al. 1997) was used to analyze the overall speech sound system in monolingual speech. According to this study, the traditional measures of phonological abilities already in place for monolingual speech, such as PCC, provide an accurate diagnosis for bilingual children as well. However, in order to create a stronger foundation for evaluating bilingual speech, and to develop appropriate analysis measures to complement bilingual assessment tools, more methodological studies are necessary. In order to create a stronger analytic foundation for bilingual children, studies are needed to elucidate the pattern of substitution errors and accuracy rates.

Furthermore, cross-linguistic effects in bilingual children also need to be considered. Nicoladis (2016) discusses the relationship between cross-linguistic influence (CLI) and language dominance, suggesting that this relationship poses a methodological challenge if the tools to assess both CLI and language dominance are not independent of each other. In Nicoladis's words, "The greater the bilingual children's proficiency in one language, the more likely they are going to show CLI in their other language" (2016, pp. 227). Signs of a dominant language in some children may be identified as non-typical speech by some clinicians if there are clear cross-linguistic effects between the languages. It is important to incorporate cross-linguistic effects into standardized tests in order to find typicality in children's speech and to avoid misdiagnosis for bilingual children.

Assessing bilingual Spanish-English speaking children is more complicated than assessing monolingual speech, and that is why the body of research discussed in this section is of utmost relevance. Cross-linguistic effects in bilingual speech create a new aspect of early speech acquisition that the current methods for assessing and evaluating multilingual children do not capture; therefore, including cross-linguistic effects and between-language interactions will provide a broader perspective into speech acquisition for multilingual children.

2.3. Early Speech Acquisition: Language Dominance and Socio-Cultural Components

Bilingual speakers, be they children or adults, often have one dominant language (De Houwer 1990, Genesee & Nicoladis, 2007), or multiple dominances across skills in the two languages (Bedore et al., 2011). This dominance, also referred to as language proficiency in early acquisition of speech, can be expressed in many different aspects: greater vocabulary, more advanced knowledge, of the language, more frequent speaking opportunities, and a personal connection to or more input and exposure to the language (Genesee, Nicoladis, & Paradis 1995, Unsworth, 2016, Nicoladis 2016, among others).

By language dominance in this dissertation we refer to the preferred language the children have been exposed at home, as well as the language they use with their siblings and relatives. As stated by Kupisch and Rothman (2016), the environment has much to bear on linguistic development and outcomes. Bilingual children sometimes have less input in the mainstream language than monolingual children. Because there are many variables that cannot be held constant, some studies argue against balanced bilingualism (Baker 2006, pp. 7). Balanced bilingualism assumes that all language components are equal in both languages, but there is considerable evidence that bilingual speakers are not two monolinguals in one (Grosjean, 1982); language exposure for monolingual speakers is constant and does not vary as it does for bilingual speakers. Therefore, it is questionable whether assessment tools that are designed for screening monolingual speech will be of use when evaluating bilingual performance. Children who have been exposed to more than one language display a wide range of language skills that may differ based on experience, exposure to both languages, relationship with the language or other social components (Valdés 1997). Assessing bilingual speech, then, should account for language dominance and a range of skills in each language.

Language dominance is strongly correlated with language use and language choice among interlocutors. Zentella (1994), in her seminal work about *El Bloque* in NYC*,* includes many interactions between bilingual speakers showing how they can alter and adapt to their interlocutors based on their knowledge of how to show respect for social value within the community, the status of the interactants or the symbolic value of the languages (pp.83). This ethnography of US Spanish spoken in New York discusses the influence of community expectations on children's language choice. Children alternated languages every time they addressed elders in Spanish and siblings in English, as a way of adapting to the addressee who may be inclined to use one language versus another.

Along similar lines, Rojas et al. (2016) identified a strong correlation between family members' interaction with bilingual children in the US and the language skills that the children exhibited. This study pointed out that whether children were able to speak in English or Spanish with their older siblings had an effect on their expressive language skills in each language. A factor analysis on narratives from 1363 kindergarteners found that language use with the parents and with the siblings should be analyzed separately. Parents' language use did not affect bilingual children's skills overall, whereas siblings' and peers' language use were influential in shifting children's use from the minority language (Spanish in this particular case) to English. It is crucial, then, to include language dominance and the language network of bilingual children when their language performance is evaluated.

As stated by Hammer and Rodríguez (2012), "to understand bilingual children's language acquisition, one must also understand the social-cultural context in which development takes place." (p.31). Above, we discussed the socio-cultural and linguistic context of the state of Arizona, where educational policies about language impeded the development of Spanish as a minority language. In addition, a considerable amount of literature has been published on the social components that play a role in bilingual language development, such as: (1) the degree of exposure to a particular language and whether or not it is spoken as a first or second language (Ritchie & Bhatia, 1999); (2) home language experiences and use of minority languages by caregivers (Hammer, Davison, Lawrence and Miccio (2009); Guitérrez-Clellen and Kreiter (2003)) and children (Bohman et al. 2010, Rojas et al 2016); (3) the children's age of first exposure to English (Hammer et al. 2008); (4) the level of education of the mother (Brooks-Gunn, Han, and Waldfogel, 2002), and (5) the importance that families place on the use of the minority language at home (Eilers, Zurer Pearson and Cobo-Lewis 2006). Family and language exposure at home, then, are leading factors that affect early speech acquisition. This dissertation aims to contribute to the study of social components that serve as predictors of speech acquisition. Gaps in the literature also exist in the understanding of the role that individual cultural and social differences play in the development of speech sounds for bilingual preschoolers. In sum, there is a pressing need to expand the literature on the role of the individual and cultural contexts in the early acquisition of speech.

2.3.1. Implications for Clinicians Working with Multilingual Children

Speech- language pathologists (SLPs) who are on the front lines of early intervention and preschool-aged services need research to accurately evaluate and diagnose bilingual children. In order to provide evidence-based practice, these providers need to communicate with researchers in the SLP field, as well as to acquire the cultural competence to assess external factors that may influence language performance in minority communities. SLPs should take a holistic multilingual approach when evaluating children exposed to more than one language that includes children’s environmental and personal factors; speech, language, voice and hearing functions; motor skills, and children’s ability to participate in society (McLeod 2016, pp 113). It is best practice for clinicians to assess the two language systems of a bilingual speaker together to make a judgment on their overall language abilities. However, as long as standardized assessment tools for bilingual children are limited, clinicians are likely to continue to assess and evaluate multilingual children's language performance in English only. Other reasons why clinicians may assess bilinguals only in English have to do with the clinicians’ ideologies or other factors such as: assuming that many multilingual children are acculturated to the majority-language-speaking culture (Hammer and Rodriguez, 2012, 40-41); limited knowledge of the other language/s the children speak; or lack of resources, such as test batteries or interpreters, needed to accurately assess the child in their most dominant language.

Cultural awareness is key for clinicians who assess and evaluate the language skills of multilingual children. As of 2018, only 6% of members of the American Speech and Hearing Association (ASHA) felt confident that they could provide bilingual language services (ASHA, 2018). This shortage of bilingual providers could have negative consequences for a correct diagnosis of multilingual children. Clinicians may also lack knowledge or resources to evaluate or assess the minority language. Consequently, they may go to translators and interpreters that speak the minority language of the child in order to properly communicate and to evaluate, holistically, their language and speech abilities. Even though working with support personnel such as interpreters in the speech and language therapy sessions would be ideal, they may not always be available. If the clinician does not have access to a language facilitator at the time of the assessment and does not speak nor understand the minority language of the child, they may screen, evaluate and diagnose only the English of the child (Williams and McLeod, 2011).

Underlying cultural biases may also influence the evaluation of multilingual children (Van Kleeck, 1994; Andrews & Andrews, 1990; Wetsby, 1990). For instance, the implementation of values and beliefs in child-adult conversational interactions that do not represent the family's values and beliefs may be a problem. Van Kleeck (1994), for example, studied cultural biases in early language interventions. These biases are evident in family-centered programs that have been used to retrieve and improve spontaneous conversation of children with their caregivers and to avoid language delays. In such intervention programs, parents are encouraged to engage in practices to improve spontaneous speech from their child, such as: to speak to the child at the same level, be enthusiastic any time they make an effort to communicate and respect the turn-taking dynamics in spontaneous conversation. The results of this study showed that not all cultures engage in adult-children conversations equally; therefore, clinicians need to be aware of the community of speech's beliefs and values when interacting. Van Kleeck (1994) is a powerful example of how cultural awareness in SLPs is of utmost importance. Families' cultural perspectives and individual beliefs and practices vary among different cultures (Rodriguez-Brown, 2009), and they will impact parent-child interactions as well as the role of the child, family, and therapist within SLP services (McLeod 2016; pp. 118). As an example, Latinx children may not interact as much with their caretakers as their mainstream English monolingual peers (Hammer & Rodríguez 2012, p, 40-41), a fact that is directly related to different social classes within this ethnic group; therefore, Latinx bilingual children may receive less input in the minority or majority language at home from their caregivers than children from other cultural backgrounds or monolingual homes. This variable exposure to the language may be impactful in the development of phonological systems, creating a direct link to their acquisition, to their proficiency and, eventually, their identity with their languages.

Due to these factors, multilingual children, specifically Latinx children in the US, maybe placed erroneously into speech and language services that they do not need them simply because they are not at the expected level of language proficiency in English (Yavas and Goldstein, 1998; Morgan et al., 2016). The lack of research in multilingual communities may contribute to this low proportion of bilingual clinicians, resulting in misdiagnoses based on poor cultural competence.

Research should, then, address all these cultural components that affect language acquisition and individual variation within the families. Multilingual children may acquire more than one language before their school years, or they may start at school as monolingual speakers of the minority language and they learn the mainstream language throughout their school years (Hammer and Rodríguez, 2012). Either way, if they are more dominant in the minority language, they usually start school with strong skills in that language, creating a clear division between their language skills in the mainstream language within the academic setting and their first language skills as a language of the house. A Speech-Language Pathologist (SLP) must understand the two language systems of a bilingual speaker to make a judgment on their language abilities as well as to assess their language development. As it was previously stated, optimal assessment tools that accurately describe the skills and abilities of bilingual children in Speech-Language and Hearing Sciences are still scarce (Bedore & Peña 2008, Cruz-Ferreira, 2011), and this gap leads to possible underdiagnosis or overdiagnosis based on the lack of a developmental bilingual baseline. As stated by Dollaghan and Horner (2011), "accurate diagnosis is a prerequisite to ensuring that costly treatment resources are allocated to all and only those likely to benefit" (pp. 1077); therefore, stronger diagnostic accuracy measures for bilingual speech and language are urgently needed.

This dissertation includes socio-cultural factors such as home language use and practice, as well as exposure to the minority language at home. We believe these factors may influence the acquisition of speech in both the minority and majority language. In addition, the current study contributes to our understanding of normative data of bilingual Spanish-English children in Tucson, Arizona, as it describes in detail the substitution patterns of late-developing sounds (rhotics, such as the [r] in *rabbit*, and laterals, such as the [l] in *elephant* in English and Spanish) in both English and Spanish. Depending on the dominant language, children may display different substitution patterns on these late-developing sounds. The present study takes a phonological approach to the study of the substitution pattern of gliding that arises during the earlier years of acquisition of speech and aims to shed light on the substitution patterns, the acquisition of liquids in each language and to provide evidence towards normative data about the interaction of the two phonological systems.

2.4. Early Development of Speech Sounds in Bilingual Children

Children acquire most of their speech sound inventory during the first years of life (Bernthal, et al. 2017, pp. 64). The first stage of early speech acquisition starts with vocalizations. Based on Oller and colleagues' typology of infant phonations, infant vocalization develops from non-speech-like (e.g. burps, hiccups, crying, and other sounds that are not part of speech) to speech-like. This last type of vocalization develops from vowel-like productions to well-formed vowels and canonical syllables, also called babbling (Oller, 2000, in Bernthal, et al 2017, pp. 69). Between one and three years old, they utter their first words and expand their vocabulary to 50 words. It is during this stage that children develop their speech sound inventory and expand their syllable structure. As children grow older, their consonant inventory increases, and with that their syllabic structure becomes more complex. In other words, speech sound inventory transitions from the vowel to the consonant inventory between one and three years of age, developing in a simple-to complex manner.

The syllabic structure of children's first words also evolves from one or two syllables (CV-like, mostly) to more complex structures (Bernthal et al., 2017, pp. 47). How consonants and vowels are organized within a syllable is not arbitrary since this organization depends on the sonority contour. Sonority, as defined by Parker (2011), is "a unique type of relative, non-binary feature-like phonological element that potentially categorizes all speech sounds into a hierarchical scale". Syllables are organized based on this sonority scale. This hierarchical scale creates a relative organization for all sounds in a given language: the more sonorous sounds, such as vowels, are placed in the nucleus of the syllable, while the marginal positions are occupied by less sonorous segments. These universal sonority scales organize and rank segments of speech based on a sonority contour, rising from the onset to the nucleus and then decreasing in sonority towards the coda of the syllable (Clements, 1990). Segments are organized from the less sonorous segment to the most sonorous segment as follows.

Obstruent < Nasals < Liquids < Glides < Vowels.

This phonological concept is of utmost relevance in sequences of two consonants or two vowels, where sonority can determine syllabification.

Sonority, along with other phonological elements, determines the phonological structure of a language in order to form words in the lexicon. Because of that the body of research on phonology and sound development in monolingual infants is extensive. It is important for clinicians to understand sound development for typical-developing children in order to evaluate their phonological skills and their vocabulary attainment. However, the body of research that explores bilingual sound development is still scarce. This section will provide an overview of the state of the field for bilingual speech development and the gaps that still exist.

It is well established that vowels are acquired very early on (Ball and Gibbon 2012, pp. 22), and that is the case for both Spanish and English. Stoel-Gammon and Pollock (2008) offer an overview of how children acquire vocalic sounds and how these acquisitions can parallel the development of vowels for those with speech disorders. Overall, they provide five generalizations for how infants acquire vocalic sounds, illustrating how speech acquisition follows a simple-to-complex behavior mentioned in section 2.4.:

1) “corner” (or high vowels [i u]) tend to be acquired before non-corner vowels,

2) monophthongs tend to be acquired before diphthongs,

3) non-rhotic vowels tend to be acquired before rhotic vowels,

4) vowels in stressed syllables tend to be more accurate than vowels in unstressed syllables, and

5) stressed vs. unstressed syllables is the most difficult contrast to acquire.

In Spanish, the vocalic system presents fewer contrasts than in English: there are five tense vowels that can create diphthongs when they occur next to a glide (refer to section 2.6.2. for more details). Research on cross-linguistic influences in vocalic systems for Spanish-English bilinguals is still scarce. For this dissertation, we will follow the generalizations provided by Stoel-Gammon and Pollock (2008) when analyzing pertinent vocalic sounds.

Research on the first stages of language acquisition shows that infants first acquire “core syllables,” in other words, syllables comprised by voiceless plosives or nasals ([p t m]) followed by a unique vowel (Berthnal et al 2017, pp.71). The analysis of consonant inventories has been the center of speech sound development. Because of that, the baseline for the age of acquisition of consonant inventories has been established for monolingual English (Smit 1990) and monolingual Spanish (Acevedo 1993) speech. Along the same lines, Dinnsen’s (1990, 1992) speech sound typology has been used for evaluating English speech complexity, as he created a complexity measure to apply to the monolingual English phonetic inventory. He observed different inventory levels during early speech development and found that the increase in complexity was dependent on the features of sounds. The typology resulted in five hierarchical levels showing the consonant inventory's development, which falls along a spectrum of simple stops and nasal sounds in the first level to the complete, adult-like consonantal inventory with all the contrasts that it comprises. In addition to bilingual typologies, Goldstein (2001) offered a detailed description of how speech sounds will surface as common segmental characteristics for bilingual children because of the differences between Spanish and English. Specifically, this study explored the common speech sound features that may determine the production of a bilingual child that presents Spanish-influenced-English. For instance, according to this study, children with Spanish-influenced English will be more likely to devoice phonemes such as English /z/ in the word *peas* or English /dʒ/ in the word *gel*, or to include the epenthetic /e/ in onset consonant clusters with /s/ as in *stamp*. Regarding liquids, Goldstein (2001) included the Spanish trill and the tap as possible outcomes for the English rhotic /ɹ/, as in the word *road.* Overall, this study provides a description of speech features that may appear in bilingual Spanish-English children when they are acquiring English with Spanish as their dominant language. The study by Goldstein (2001) is used to determine the dialectal features that are exhibited by Spanish-English preschoolers, in order to accurately classify them as dialectal features rather than phonological errors.

Research focused on consonant production by US bilingual children has grown exponentially in the last decades (Fabiano-Smith and Cuzner, 2017; Fabiano-Smith and Goldstein, 2010a, 2010b; Cataño et al., 2009; Cooperson, Bedore, and Peña, 2013, among others). Specifically, studies such as Fabiano-Smith and Goldstein (2010b) expanded on the area of speech sound inventories by examining consonant accuracy in bilingual Spanish-English preschoolers from North Philadelphia. They provided a detailed analysis of the accuracy of consonantal sounds (by percentage) and contrasted these results with monolingual English and

Spanish productions. Their results showed that bilingual children were less accurate than their monolingual counterparts as far as their phonetic inventory. However, the researchers also found that the sounds that were shared in both phonetic inventories were as accurately produced as those of their monolingual peers, and displayed lower accuracy rates for unshared sounds compared to children with no exposure to Spanish. In other words, Spanish-English bilingual children take as much time as monolingual children when there are shared sounds in both sound inventories. Overall, Fabiano-Smith and Goldstein (2010b) propose a new approach based on Paradis and Genesee's notion of transfer (explained in detail in section 2.8) that is extremely relevant for the present study.

Figures 1 and 2 (borrowed from Fabiano-Smith and Goldstein 2010a) illustrate the accuracy rates of Percentage of Consonants Correct for the production from early- to late-developing sounds in both Spanish and English.

Figure A. Borrowed from Fabiano-Smith and Goldstein (2010a). Early- Middle and Late-developing sounds in English

FIGURE 1. English early-, middle-, and late-developing (EML) categories: monolingual and bilingual children. PCC = percentage of consonants correct.

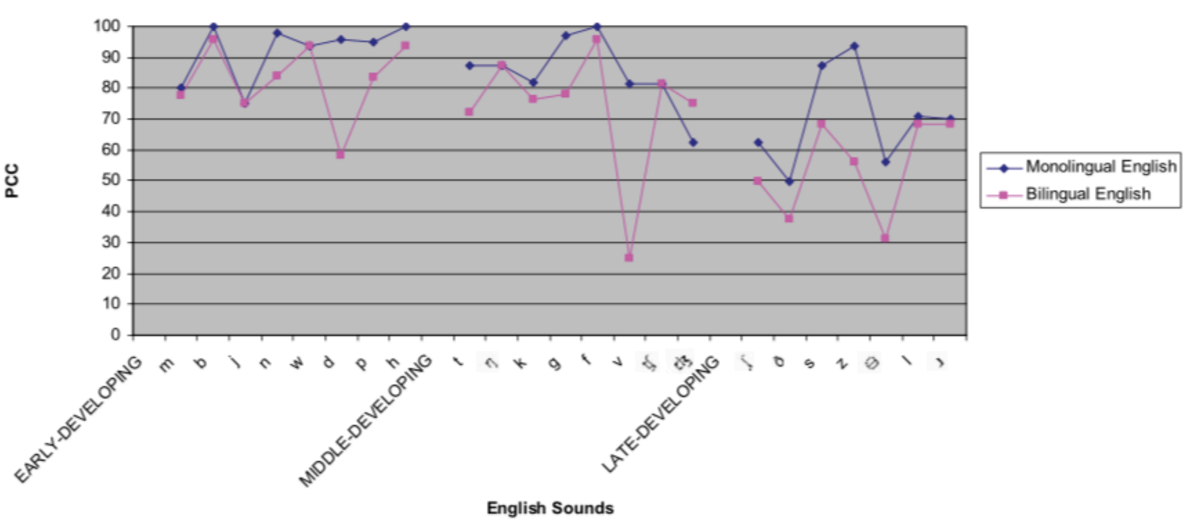
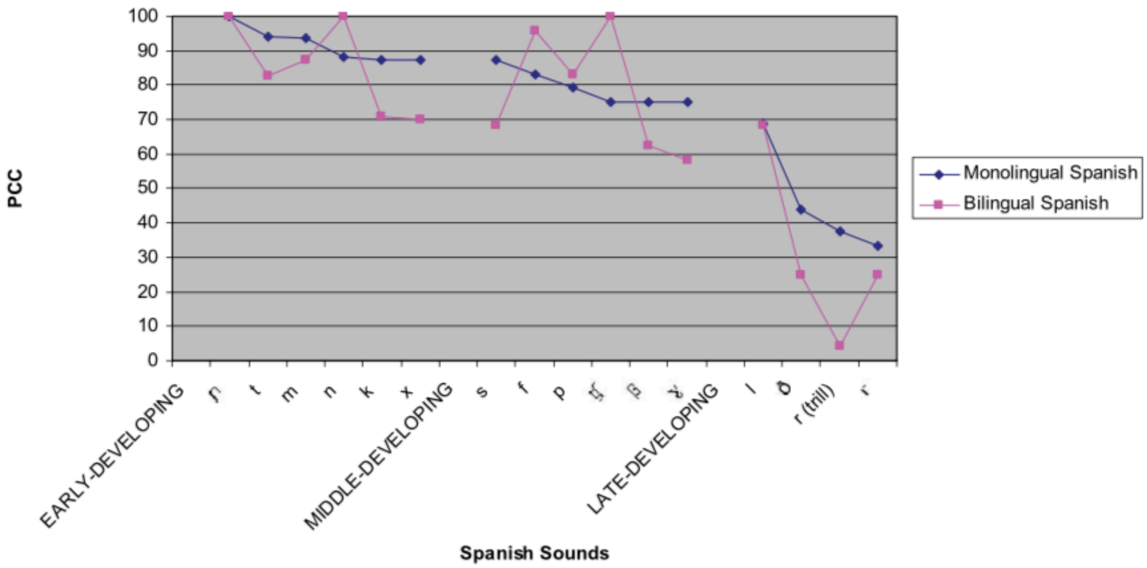


Figure B. Borrowed from Fabiano-Smith and Goldstein (2010a). Early- Middle and Late-developing sounds in Spanish.

FIGURE 2. Spanish EML categories: monolingual and bilingual children.



As seen in Figures 1 and 2, consonant accuracy rates are classified into three categories: early, mid and late developing sounds. The results of this study showed that consonant attainment follows the same order for both English and Spanish monolinguals, and for Spanish-English bilinguals. For early-developing sounds, accuracy rates are at ceiling, and it is during the mid-developing and late developing sounds that the consonant inventories start to differ. Rhotics are the last developing sounds for both Spanish and English. Both [l] and rhotics are at a 70% accuracy rate in Spanish and English, with some instability in Spanish's trill [r], followed by [ð], and the rest of the sibilants in English. Another important component of the organization of late-developing sounds in Fabiano-Smith and Goldstein (2010b) is that some tendencies of phonetic features emerge within each language: in Spanish, all four late-developing sounds [ð l r ɾ] are approximants that share the same place of articulation; in English, the inventory of late-developing sounds includes marked sibilants [ʃ θ s z ð] and liquids (rhotic and lateral approximant). These late-developing sounds will be of utmost relevance for phonological development, mainly because substitutions of these complex sounds occur when this low accuracy percentage is observed.

Other studies have focused on the complexity and order of acquisition of consonant sounds among US bilingual children. For instance, Cataño et al. (2009) explored the complexity of consonant development in US bilingual preschoolers. Their aim was to expand Dinsen's typology proposed for English to bilingual English-Spanish preschoolers in California.

Fabiano-Smith and Barlow (2010) investigated how bilingual Spanish-English preschoolers (aged 3-4) acquire their simple-to-complex consonant inventories in both Spanish and English. Overall, these studies found that the Spanish-English children's phonetic inventories and their complexities were developed at the same pace compared to monolingual norms, with some traces of between-language interaction. Both Cataño et al. (2009) and Fabiano-Smith and Barlow (2010)'s studies added more normative data for bilingual speech acquisition and development in US Spanish.

Lastly, Fabiano-Smith and Goldstein (2010a) included glides in their analysis of consonant accuracy in the sense that glides are part of the early-developing set of sounds in English, but they did not incorporate Spanish glides since they are part of the Spanish vowel inventory. Glides have appeared in studies on consonant cluster reduction (words like *treehouse* pronounced as [t_]*eehouse* or the word *music* pronounced as [m_]*usic*) during early bilingual speech acquisition of English (Cataño, Barlow and Moyna 2009, Barlow 2005, Anderson 2002, Barlow and Dinnsen 1998), thus including them in the English consonant inventory is coherent with the literature. Some studies have also included glides as part of the consonant inventory in their Spanish analysis. However, in the current study, we consider Spanish glides to be part of the vocalic inventory (therefore, not a consonant), as well as vocalic allophones of the high vowels [i] and [u] in agreement with the phonological literature in Spanish (Hualde 1997, Hualde 2005, Colina 2009, among others) (See section 2.6.3. below).

2.5. Phonological "Error" Patterns during Early Speech Acquisition

In their first few years, children produce different versions of the same word as they learn the sound system of their language. Some of the versions they produce may be adult-like, and some may not match the eventual adult form. After learning how to manage their oral motor skills, infants start matching their first 50 concepts with the word sounds. Once they have their first concepts, they continue expanding their vocabulary, together with their language's sound system.

Approximately from ages 2-5, young children produce "errors" at the phonetic, phonologic, and syllabic levels (Bernthal, et al. 2017). It is common for preschoolers to encounter difficulties producing late-developing sounds such as rhotics and laterals. When children are not able to produce marked sounds, they substitute them for an "easier" sound that they have already mastered. Even though the result of these substitutions is speaker-dependent, it is very common to perceive tendencies of sound substitutions in preschoolers. In addition to that, each language substitutes sounds based on its phonotactic patterns. If there are language-specific substitutions, it is probable that languages will interact with each other during bilingual acquisition.

This specific component of early speech acquisition is crucial to linguists as it shows the mapping of sounds at the phonetic level along with their mental representation. The mastery of these "errors" or phonological patterns, from incomprehensible production to the adult target production, changes according to each child. Nevertheless, typical children will master all the phonetic, phonemic, and syllabic inventories by around the age of five.

Phonological error patterns (also known as phonological processes) are defined as the "simplification of the sound class in which target sounds are systematically deleted and/or substituted" (Bankson and Bernthal 1990). These error patterns can affect only one sound resulting in an assimilation to another sound because it appears in the same word; one sound that is systematically replaced by another sound with a different articulation; or one or more sounds that are affected at the syllabic level. Phonological error substitutions commonly involve the whole phonological system, as they take an early-developing sound to replace a more complex sound that the child cannot produce. Interestingly, these phonological error patterns are found in monolingual children speech.

The process of gliding, specifically, is a substitution process in which liquids [l r] are systematically replaced by glides [w j], or by another liquid [l] or [r], in different positions of the word in English. For instance, a child who presents gliding patterns would produce the word *rabbit* as [wabit] (Bernthal et al., 2017, p. 83). Prevocalic liquids or liquids in consonant sequences show specific patterns of substitution: /r/ is usually replaced by [w], but /l/ can be replaced by either [w] or [j]. For some children, the substitution patterns for /l/ are determined by the following vowel, producing [j] before front vowels and [w] elsewhere (Stoel-Gammon and Dunn, 1985, p. 39): *rabbit* [wæbɪt], *look* [wʊk], *leaf* [jif], *balloon* [bəwun], *grass* [gwæs], *blow* [bwo]. Gliding in English can present a fluctuating distribution, declining by 50% or more in children between two and three and then again between four and five (James 2001). Gliding has not yet been explored from a bilingual and cross-linguistic speech sound acquisition approach.

In Spanish, the error pattern of gliding is not as common as in English although it may be present in some children's speech. The substitution error more commonly found in Spanish consists of [l], [d] and [r]/[ɾ] (rather than glides) as substitutes for the liquids, as these three sounds share a common place of articulation (Bosch, 1983). In other words, although the glides [j w] occur in both languages, they surface as an error pattern for English rhotics, although this is not common in Spanish.

The glides [j w] in Spanish can undergo cluster reduction, another type of error pattern present in L1 phonological acquisition (Barlow 2005, Anderson 2002. These studies, however, parse [jw] in a complex onset, thus capable of undergoing any of the error patterns sometimes found in consonant clusters (such as consonant cluster reduction, or any sort of substitution). Yet if glides are not consonants, but a vocalic allophone, as shown below, this pattern of substitution should be nucleus simplification (from complex to simple) rather than cluster simplification, based on the description of glides in Spanish. However, as we will see in 2.6.2, Sonoran Spanish allows glides in the onset (by failing to strengthen them, turning them into obstruents), cluster simplification may be possible and the prediction that the substitution will involve liquids and [d] instead of glides may not be borne out. In other words, gliding could emerge as an error pattern in Sonoran Spanish.

2.6. Phonetics and Phonology of Glides in English and Spanish

Gliding in English is a crucial variable to explore as glides are part of both English and Spanish phonological systems, but their status differs between languages. English glides are part of the consonantal inventory, whereas Spanish glides are allophones of the high vowels. Even though the acoustic features for both English and Spanish glides coincide, the phonological representation of these segments in each language may impact the production of gliding as a phonological substitution pattern. The following section includes a detailed description of English and Spanish glides, and the relevant context where these speech sounds surface and overlap.

2.6.1. Glides in English

Traditionally, sequences with [j] or [w] combined with any other vowel in English (e.g., the [jɛ] in *yellow* or [wa] in *wagon*) are not considered phonemic diphthongs, but a sequence of a onset consonant followed by a nuclear vowel. Thus, the voiced palatal [j] and the voiced labiovelar [w] are mapped as approximant glides in the consonant inventory (Ladefoged and Johnson 2014, p.243). Additionally, when appearing next to another consonant (CGV), the glides [w] and [j], present an asymmetry in terms of their syllabic affiliation. [w] is parsed in the onset as the second member of the consonant cluster in a CGV sequence. However, [j] is assigned to the nucleus (Davis & Hammond 1995). According to Ladefoged and Johnson (2015) [w] in [CwV] is permissible following any obstruent at the left-margin of a syllable (with the exception of /p/ because it shares the labial point of articulation). However, it is not allowed with sonorants such as /n/, /l/, and /r/. Among the vowels, [w] can precede all vowels, except for /ʊ/ and the diphthong /aɪ/. Examples of [CwV] are words such as *queen*, *dwell*, *swing* or *schwa*. [j] can only be followed by the high back vowel [u] (e.g., [Cju]) and can be preceded by any consonant except for coronal sonorants and obstruents: e.g. *music*, *huge* or *beauty*. With the exception of the sequence C[ju], English glides belong to the consonant inventory.

2.6.2. Glides in Spanish

Glides pose a problem for phonology as they display dual behavior (Levi 2004, 2008). As mentioned above, these sounds can be mapped in the consonantic inventory as phonemic units

(Ladefoged and Johnson 2014), as in English, or they can be derived from vowels and, therefore, be allophones of high vowels [i u] (Levi 2011, Hualde 1997), as in Spanish. Another distinction is the syllabic position of these segments, in that English parses glides outside the nucleus of the syllable, while Spanish counts glides as part of the nucleus. In Spanish, glides surface as an allophonic realization of a vowel in a postconsonantal vowel sequence of two vowels, sometimes referred to as diphthong. However, the so-called Spanish diphthongs differ substantially from English diphthongs. As mentioned above, Spanish diphthongs are not phonemic; they are one allophonic realization of two vocalic sounds (which can be realized as V.V in hiatus or as a diphthong VG/GV) and are mapped as complex nuclear segments of the syllable. For instance, the word *miedo* (fear) can alternate in pronunciation between a hiatus and a diphthong without changing the meaning. The word *miedo* pronounced as [mi.e.ðo] (in hiatus) or [mje.ðo] (in a diphthong) only differ in the number of the syllables.

In contrast, in English, diphthongs consist of two vocalic sounds next to each other (VV, rather than GV or VG) that are parsed in the same syllable (for instance, the [aʊ] in the word *house*), or as a hiatus (V.V), if both segments belong to separate syllables (for instance the word *piano*). English diphthongs are classified as part of the vocalic inventory and they are phonemic; they contrast in meaning with the monophthongs (as in the the pair *law* [lɔ:] and *low* [loʊ]). In other words, English diphthongs are one full unit in the phonemic inventory, whereas Spanish diphthongs are combinations of glides and vowels.

The process known as onset strengthening in Spanish demonstrates that glides are not part of the consonant inventory and cannot be a legitimate onset. When glides are forced into the onset position of a word in Spanish because no other consonant is available (and an onset is needed), they are strengthened and they change in quality (e.g., the palatal glide [j] becomes a palatal obstruent [ʝ, ɟ] [ʝe.lo]/ [ɟ e.lo], and the labiovelar [w] surfaces as a velar approximant [ɣ̞], [werta]/ [ɣ̞werta]) (Hualde,1991; 1997, 2005). While this change in quality occurs in the majority of the dialects of Spanish, it does not always occur in Sonoran Spanish, which allows for glides in onset position (Canfield 1981, Alvar 1996), and thus could be considered to have a consonantal glide. An example of this is in the production of the word *hielo* as [je.lo] instead of [ʝe.lo] (Canfield 1981, Alvar 1996). Spanish from Northern Mexico is the closest variety of Spanish spoken in Arizona. This is a factor that must be considered in the interpretation of the findings, as it is possible that some of the children in this study could have consonantal glides in onset position. In that case, gliding could emerge as a substitution pattern in bilingual Spanish and it could be the result of dialectal internal processes (lack of onset strengthening) or cross-linguistic effects. In what follows, we expand on the description of Spanish 'diphthongs' as the contain a nuclear glide which is relevant for this study and contrast them with diphthongs in English, which have a sequence of two full vowels and are phonemic.

2.6.3. Diphthongs in Spanish

Spanish presents five tense vowels [a e i o u] that have a direct correspondence with the graphemes "a e i o u". The vocalic sequences that occur in Spanish are combinations of any of these vowels, and they create either hiatuses or diphthongs. For this language, two adjacent vowels could result in a hiatus (also called heterosyllabic sequence). A hiatus separates the two vowels in different syllables, maintaining their status. Additionally, these vowel sequences can also form a complex syllabic nucleus (a diphthong or tautosyllabic sequence), when the sequence is composed of a combination of unstressed and stressed vocalic sounds. The unstressed high vowels in Spanish, when they are part of the vocalic sequence, surface as glides. In some dialects a mid-unstressed vowel can also become a mid or high glide when there is no high vowel (Hualde 2005, Colina 2009).

This dissertation agrees with the argument that glides in Spanish are allophones of the high vowel phonemes /i/ and /u/ (Hualde, 1991; 1997). Hualde (1997) states that glides are not in the phonemic inventory but are allophones of high vowels in specific phonotactic contexts. Glides show complementary distribution with the allophone [i] postlexically (e.g. *m[i] padre* 'my father' vs. *m[ja]buelo* 'my grandfather'), unless the high vowel is stressed (e.g. *m[i.í]ja*). Hiatuses can surface in slow or careful speech, and also when one of these two "rules" applies: when the high vocoid carries stress (e.g. día), when they are morphologically motivated (e.g. bi.é.njo) or when there is a related word with a stressed high vowel (e.g. [di.úr.no] is related to [dí.a]). In sum, Hualde's work demonstrates that diphthongs in Spanish are not considered one phonemic category (Hualde, 1991; 1997), but rather a glide and a vowel sequence.

However, there are still vocalic sequences that create ambiguous contexts, as it is the case for exceptional hiatuses. These exceptional hiatuses in Spanish follow the structure of diphthongs (unstressed and stressed vocalic sound), but they still create heterosyllabic sequences. Speakers of Spanish usually have intuitions of whether the vocoid's sequence falls into one syllable (a tautosyllabic sequence) or not (Hualde, 1997; 1999). An example can be found in the contrast between words like *diente* 'tooth' and *cliente* 'client' in Spanish. Both lexical items maintain the stress on the same vowel, but the former word contains a tautosyllabic sequence and the latter is labeled as a heterosyllabic one (Hualde, 1991). The difference between these two contexts lies in their allophonic realization, [i.é] for *cliente* and [.jé.] in *diente* (Hualde, 1997). Words like *diente* and *cliente* create a contrast that cannot be explained based on derivational assumptions and must thus be part of the underlying representation. These exceptional hiatuses have been found in Peninsular Spanish, as well as in Mexican and Puerto Rican dialects of Spanish.

As vowel sequences in Spanish are not phonemic but allophonic, they exhibit some variability within each speaker and also across dialects. Some studies have shown that there is a variable pattern towards a conservative hiatus production in Romance languages, e.g. Catalan dialects (Cabré & Prieto, 2004), Peninsular Spanish (Hualde, 1999; Barberia, 2012), Romanian (Chitorian & Hualde, 2003), and Argentinian Spanish in contact with Guaraní (Colantoni and Limanni, 2010). On the other hand, conservative hiatus production is not phonologically productive, and these heterosyllabic vowel sequences tend to be reduced to diphthongs in most varieties of Spanish to eliminate onsetless syllables (Hualde, 2005). This strategy could be manifested as reduction, diphthongization, coalescence, or deletion of vowels. Research on Latin American Spanish dialects has found a different trend on this hiatus resolution mechanism: mid-vowel gliding and coalescence. Mexican City Spanish and Bogotá Spanish present a tendency to reduce the hiatus sequence of /ea/ to [ja]. This phenomenon has been explored in Garrido (2014) who offered some acoustic evidence along with discussion of syllabification intuitions. This study aimed to explore the relevance of proximity of stress, type of vowel sequence and regional variation to diphthongization. The results demonstrated that speakers' syllabic intuitions were variable, but both groups (monolinguals from Bogotá and México City) showed a tendency towards diphthongization sequences of /ea/ as [ia] and /ea/ as [ia] in posttonic position. Garrido (2014) also demonstrated that even though both monolingual groups showed this tendency, participants from México were most likely to reduce the canonical hiatus to a diphthong. This data pattern from Mexican participants is particularly relevant for the present study's focus on Spanish from Northern México.

Another dialect of Spanish to consider is Southwest Spanish, which is in contact with Mexican dialects. Hiatus resolution strategies suggested for this dialect of Spanish are coalescence, gliding, or low-vowel deletion. Overall, various OT accounts of the phenomenon show that Mexican Spanish dialects try to eliminate onsetless syllables while also avoiding the creation of mid glides (Bakovic 1995, 2006; Martínez-Gil 2016; Colina 2009).

Acoustically, Spanish glides [j w] have similar vowel formants as high vowels [i u], but they are shorter in duration and present with steeper formant transitions. Thus, the principal phonetic difference between hiatuses and diphthongs is that diphthongs have shorter static formant structure and steeper transition between vowels, while hiatuses show longer static formant structure and a more gradual transition between vowels.

Aguilar (1998, in Martinez Celdrán and Fernández Planas, 2007, p. 161) studies the acoustic correlates for Spanish diphthongs and hiatuses. She found the mean sequence duration of a diphthong to be 82.26 ms., the transition at 18.58 ms., and the vocalic peak of the syllable at 43.36 ms. Later, Aguilar (1999) measured the difference between hiatuses and diphthongs based on the formant structure for each in terms of the steepness of the transition between F1 and F2. Overall, the curvature in formant tracks results in hiatuses maintaining both formants longer.

Borzone (1978) compared the acoustics of Spanish diphthongs with English diphthongs. Even though some acoustic findings, such as the steady parts of the vowels and the transition between them, paralleled English patterns, Borzone (1978) determined that there are language-specific characteristics in terms of Spanish diphthongs, such as in the steady stages of open vowels [e a o] and the position of the F2 for these vowels as well.

2.6.4. Diphthongs in English

As stated above, diphthongs in American English are phonemic, meaning that the vowel sequences comprise and represent a single unit in the phonological inventory (Ball and Muller, 2005, pp. 507). English diphthongs fall in sonority, from the most sonorous vowel to least sonorous in the vowel sequence, resulting in five falling diphthongs [aɪ aʊ ɔɪ eɪ oʊ]. Whereas the diphthongs /aɪ aʊ ɔɪ/ are truly phonemic diphthongs, [eɪ oʊ] have been considered as allophones of the mid vowels /e/ and /o/, and they surface in complementary distribution.

Diphthongs in American English are part of the vowel inventory and are thus considered phonemic due to contrasts in meaning between words with or without diphthongs (like the contrast between *low* and *law*). This phonological description also aligns with the phonetic features, as the acoustic description of these vocalic sequences shows that diphthongs are one complex unit in English. What characterizes vowels acoustically in any language is their formant structure. Formants of sonorant sounds are created by the airflow bouncing within the vocal track and, based on the position of the articulators, building resonances that constitute the acoustic features associated with each sound. Vowel formants are acoustic representations of two specific vocal tract pitches associated with their overtones: the position of the tongue in the vocal tract and the position of the lower jaw in regard to the roof of the mouth (Ladefoged and Johnson, 2014, p.24). The main difference between a vowel and a phonemic diphthong, then, is the configuration of said formants; a vowel would retain its formant stability, whereas diphthongs would show a transition between one vocalic sound and the next. These transitions, also called “formant movement” or “formant transition,” are static in English, meaning that the production of these complex vowels, both vowel formantic structures and the transition between them, show a unique acoustic configuration.

Formantic structure varies across languages and dialects, but it is the blueprint of the speech sounds that we acquire over time. Some studies discuss the acoustic differences in English between monophthongs and diphthongs. Diphthongs have been described as a double target complex nucleus (Lehiste and Petterson, 1961). However, children, when they are acquiring and creating the phonemic representation of such sounds, may display a different configuration of nucleus targets. Lee et al. (2014) investigate the space between the formantic structure (F1 and F2) of five English diphthongs [eɪ oʊ aʊ aɪ ɔɪ] and compare children's and adult's productions to determine if the phonemic diphthong category is a combination of two monophthongs, and whether diphthongs are mapped at the early stages of language acquisition as a single unit or derived sequences. This study provided acoustic evidence that English diphthongs are one unit instead of a sequence of two monophthongs given that the formantic structure's trajectories contrasted with those of monophthongs, but that children initially exhibited tendencies toward the production of two combined monophthongs since the acoustic evidence showed variability in their diphthong production. These productions gradually shifted to one single unit, diphthongs, in the adult group.

To sum up, diphthongs in English are phonemic and mapped into one single unit both in the acoustic realm and in the phonological representation.

2.7. Processing Rich Information from Multidimensional Interactive Representations' Framework

The analysis of phonological patterns and cross-linguistic influences needs to be framed within a theoretical model of bilingual phonological representation. Acoustic information from the environment contains rich information that applies to multiple domains: the voice of the speaker, their language and dialect, the combination of sounds that represents concepts and meaning, and also the phonetic features that differentiate one sound from another. Regardless of the variability within and between speakers, speech also presents regularities. It is because of the regularities that children who speak any language can create meaning out of speech sounds and replicate these regularities through their own output in the language. The Processing Rich Information from Multidimensional Interactive Representations (PRIMIR; Curtin, et al., 2011) framework reveals how children organize relevant acoustic information as mental representations. PRIMIR is a model that allows for sorting information based on similarity, co-occurrence, and other statistical regularities. That information is assorted into a multidimensional, mental representation space (Werker and Curtin, 2005; Curtin and Werker, 2007). This model also suggests that bilingual speakers, like monolingual ones, can attend to and access acoustic speech cues and encode the language-specific phonetic categories for each language (Curtin, Byers-Heinlein, Werker, 2011).

The acoustic information coming from rich signals is processed and assorted within several spaces. According to the PRIMIR framework of early speech perception and word learning, regularities within a given speech signal are also organized across three multidimensional spaces that overlap in their language systems: a "General Perceptual space" where information such as speakers' voices, indexical features, or each sound's acoustic cues, are stored; a "Word Form space" where the structure of words is extracted; and finally, an emerging "Phonemic space," a final abstract representation of a contrastive sound plane where information gathered in the "General Perceptual Plane" gets merged and generalized. The information stored in each plane will eventually create generalized representations based on repetition: phonetic cues will eventually form clusters, speech sounds will become words with meaning, and generalized speech sounds in a specific context within words will create phonemic categories.

Stored information is dynamically filtered throughout some mechanisms such as biases, task demands, or developmental level (Werker and Curtin, 2005). In addition to these filters, bilingual speakers develop a learning mechanism that aids in comparing and contrasting information for each language and sorts it accordingly (Curtin, Byers-Heinlein, Werker, 2011). Combined with perceptual biases, the learning mechanisms allow bilingual infants to organize their phonological systems as the language regularities start to cluster together. Therefore, in PRIMIR, regularities within each language create two (or more) different domains according to each language in the perception level and extend to the production level. At the same time, these representational spaces "dynamically inform each other to direct processing" (Byers-Heinlein 2014). In other words, PRIMIR accounts for a multidimensional-space representational model of speech acquisition that is created based on co-occurrences for each language the child is exposed to; in the case of bilingual children, these representational spaces coexist and are independent from each other. This framework supports a *dual system model*, where the bilingual infant will make use of both absolute frequencies and distributional frequencies to create two differentiated phonological systems.

Even though PRIMIR accounts for co-occurrences in order to create representational spaces, these repetitions and regularities may also influence how languages communicate with each other in bilingual children. Specific speech segments may occur in multiple phonological inventories, creating spaces that overlap between languages. Based on a *dual system model* approach, the two languages are created and differentiated from one another. Some studies show how languages actually communicate and interact (Paradis & Genesee, 1996). Paradis and

Genesee (1996) expanded on the *dual system* model as they discuss how a series of interdependence hypotheses, *acceleration, deceleration* (Fabiano-Smith and Goldstein 2010b) *and transfer*, will influence the acquisition of speech and language for multilingual children. They compare monolingual acquisition to the multilingual acquisition of speech and language; they also propose that some features experience a faster rate of acquisition --or acceleration--, while others are acquired more slowly -- deceleration--; and that in bilingual acquisition there will be transfer and cross-linguistic influence. Paradis and Genesee's theoretical proposals have been studied cross-linguistically. Fabiano-Smith and Barlow (2010) analyzed the phonetic development of bilingual children as well as the complexity of their phonetic inventories and concluded that bilingual children exhibited deceleration of some sounds compared to their monolingual peers, but maintained inventory complexity at the same developmental milestones. These findings indicate that, if the whole phonetic inventory is analyzed, the speech complexity of bilingual children is similar to the complexity of monolingual children even if the accuracy of phonemic segments occurs at slower rates. Similarly, Fabiano-Smith and Goldstein (2010b) analyzed accuracy rates of shared versus unshared sounds for both English and Spanish following the *Interdependence* hypotheses posed by Paradis and Genesee (1996). Fabiano-Smith and Goldstein's results indicated that the bilingual preschoolers were less accurate, overall, compared to their monolingual peers in each language at the same moment of speech acquisition, providing evidence of deceleration. However, when the phonetic inventory was divided by phonetic similarity, the bilingual group showed a higher rate of accuracy for shared sounds compared to the monolingual group.

In regard to transfer, Fabiano-Smith and Goldstein (2010b) and Fabiano-Smith and Barlow (2010) also found evidence in bilingual preschoolers in both directions: English segments appeared in Spanish inventories as well as Spanish segments were found in English inventories. These studies have shown that, even though the general tendency is that bilingual preschoolers may acquire their phonetic inventory more slowly than their monolingual peers, there were in fact some elements that transferred from one language to the other. Such an overlap between the speech sounds in each inventory will create a bootstrap effect during the acquisition of these shared sounds.

The PRIMIR framework of language processing and acquisition is crucial for this study, as the productions and substitution patterns of children in a bilingual community in a state such as Arizona may inform how the two languages are organized. This dissertation also contributes to the extension of the PRIMIR framework model to the production level. In addition, following the work by Fabiano-Smith and colleagues, the speech sounds for both languages may show some degree of overlap. Previous work by Paradis, Genesee and Fabiano-Smith will complement this framework as it will contribute to the understanding of the interaction between both languages.

2.8. Research Questions (RQ)

Bearing in mind that glides are shared sounds in English and Spanish, that they are consonants in English and vowel allophones in Spanish and that gliding as a substitution pattern (for late-developing sounds) happens only in English, the focus of this study is to provide insight into the following research questions:

RQ1. Does the phonological process of gliding surface in English as the substitution pattern for both bilingual and non-bilingual Spanish-English preschoolers?

RQ2.Are bilingual Spanish-English preschoolers and their non-bilingual counterparts equally accurate in the production of late-developing rhotics and laterals in English?

RQ3. Does syllabic position matter in terms of late-developing rhotics and laterals' substitutions in English and in Spanish for the bilingual preschoolers?

RQ4.Are there any cross-linguistic effects in Spanish based on Spanish dominance?

RQ5. For bilingual children, are there any socio-cultural components that affect substitution patterns, production and accuracy of late-developing sounds (e.g. home language, language exposure and use, birth order, language dominance)?

Overall, we predict that children with exposure to Spanish will present a low accuracy rate in the late-developing sounds [ɹ] and [l] in English, but lower percentage of gliding as a phonological error pattern compared to the non-bilingual counterparts because of the influence of the Spanish sound system. Additionally, it is expected that these late-developing sounds in onset position in English will display gliding (*rocket* as [‘wɑkɪt] or *elephant* as [‘ɛwəfənt] This is considered likely to happen for consonant clusters (*glasses* as [‘gjɑːsɪz] or *green* as [gwiːn]) as well but competing with consonant cluster reduction (*glasses* as [‘g_ɑːsɪz]). The lower percentage of gliding in English for the bilingual preschoolers will support cross-linguistic effects, given the influence of Spanish exposure. Cross-linguistic effects will also surface as the separation of substitution patterns according to each language. In Spanish, gliding is not a recurrent phonological pattern, late-developing rhotics and laterals are replaced by each other; therefore, there may be overlap between phonological processes in English and Spanish for the bilingual children. Regarding the language dominance for the bilingual group, we predict that children will display a wide variety of accuracy rates according to the performance in their dominant language, home language and bilingual network.

Many children in Arizona are educated exclusively through the medium of the L2, with little formal attention paid to their minority language (Genesee, Paradis, Crago 2004, p157). For many of the participants of this study, English will be their non-dominant language, and we predict that there will be between-language interactions in substitution patterns for the late-developing sounds of these particular children in English. For the same reasons we expect more cross-linguistic effects in the Spanish data for bilingual preschoolers.

CHAPTER 3. Methodology

3.1. Participants

The data for this study were selected from the database of an ongoing project (Leah Fabiano-Smith, PI funded by two NIH projects: NICHD: 1R21HDE081382 – 01A1 and NIDCD: 1R01DC016624 – 01A1 and approved by the Institutional Review Board (IRB) at the University of Arizona). This is a database of children's speech collected in the south-central region of the state of Arizona on the US-Mexican border. As mentioned in chapter 2, this region has a population of about one million, of which 35% identifies as Hispanic or Latinx (United States Census Bureau, 2017). The demographics from the school district where this data was collected shows that 83.7% of the children come from Hispanic/Latinx families (Sunnyside Unified School District, 2018). All children from the study attended Title 1 preschools –federally funded and non-profit preschools or Kindergarten programs— in this school district.

This study included sixty-one children ages 3-6, thirty-nine typically developing bilingual Spanish and English speakers (mean age = 5;2; range 3;9 to 6;3) and twenty-two typically developing monolingual English speakers (mean age = 5;00; range 3;4 to 5;9). A Welsh two-way sample t-test found no statistically significant differences in age between the monolingual group and the bilingual group ($t\ (31) = 1.008$, $p = .321$). The majority of the children included in this study come from low socioeconomic status (determined by the caregiver's level of education, or in the absence of such information, eligibility for free or subsidized lunch).

3.1.1. Language

The children included in this study came from heterogeneous language backgrounds. Some of them were growing up in bilingual households, spoke and were exposed to dialectal variants such as Northern Mexican Spanish or Southwestern US Spanish, in addition to Southwestern US English. Some of the children who were not in the bilingual group were not exposed to any Spanish dialect. In order to analyze holistically the speech production of the children of this study, a parent report was given to their caretakers in order to discern their linguistic context. These reports were given to parents to complete in-person or through a phone conversation. Questions about the home language, language use and language concerns, as well as the history of education, speech and language were included in this parent report in order to provide a detailed overview of the child's context (Bedore et al. 2011).

In order to account for the heterogeneity of bilingual speakers' language and speech performance, a dominance continuum was created. This new variable, "language use and practice (LUP)" was assessed on the basis of: the home language the parents reported, whether the child was able to complete the BESA test (explained in section 3.1.4.) in Spanish at the time of the assessment, and the amount of language input (heard) and output (spoken) in Spanish and English as indicated by the parent report. The degree of language exposure (input and output) the children had during a normal day was crucial for assessing the LUP variable. Inspired by the Bilingual Language Profile score (Birdsong, Gertken and Amengual, 2012), this language use continuum was created to capture variation in language preference in the group of bilingual children. The parent report was administered either by a phone interview or an interview after school by a researcher. This report was used to calculate the number of hours a day that the child was exposed to conversation in each language. The report contains one section that asks parents to describe a normal day in terms of language. Questions such as "Who does the child interact with in the morning?" "Who takes care of the child after school?" "What languages do they speak when they are together?" were used to collect language input and output information for their family, followed up with clarification questions such as "So, from the time the child wakes up (6 am) to the time he goes to school (7:30am), he speaks in English, am I correct?". This information was then translated into hours of English and Spanish use (school hours are counted as English, as the children of this study attend Title I schools). The number of hours per language was subsequently converted into a percentage. The final score consists of the percentage of hours the child spoke Spanish minus the hours the children spoke English. As a result, LUP ranged from +100 (only Spanish) to -100 (only English). Monolingualism was represented by a 100% of the time reported being exposed to one language. Based on this information, the LUP places each child on a continuum that measures relative dominance in each language. The closer a score is to positive 100, the more likely the child is to use and be exposed to only Spanish in their everyday life (100 in "Spanish output" - 0 in "English output" = +100). If, on the contrary, the score is close to negative 100, the child is more likely to use only English on a normal day (0 in "Spanish output" - 100 in "English output" = -100).

Let us use an example to show how the information on the parent report was translated into LUP %. A bilingual child (we will refer to him as "Danny") was reported to be awake 14 hours a day. Danny would spend the mornings with his mother and his little brother (age 2.0.), grandpa usually picked him up from school, and he would spend the afternoon in grandpa's house with his cousins until 6pm. His mother would pick him up (6:00pm) for dinner and he would go to bed at 8:00pm. The report asked which language Danny usually speaks during all these time frames, and what language family relatives use with Danny. In Danny's case, his mother reported that he holds a normal conversation in Spanish with her and with his family.

Danny speaks and hears Spanish with his mother and with his grandparents and both Spanish and English with his cousins at his grandparent's house. Therefore, Danny's parent report would look like the following:

- from 6:30am to 8am, Spanish at home (100% Spanish, 2 hours Spanish).
- from 8am to 2pm, English at school (100% English, 6 hours English).
- from 2pm to 6pm, Spanish/English at grandpa's house. The mother reports that Spanish is the dominant language with the relatives, which was translated into 75% Spanish with his grandparents and 25% English with his cousins; 3 hours in Spanish, 1 hour in English).
- from 6pm to bedtime (8:30pm), Spanish is only spoken at home between Danny and his mother (100% Spanish, 2 hours Spanish).

In sum, Danny, who was awake from 6:30 am to 8:30 pm, was exposed 7 hours in Spanish and 7 hours in English during a normal day. His LUP score was 0 (50% Spanish/day, - 50% English/day = 0 LUP).

Because Tucson is a bilingual border community and children are exposed to Spanish by living in this bilingual setting, additional criteria are necessary in order to place each child into the bilingual vs. monolingual group. The Spanish BESA test was given to all children that may speak Spanish at home, that had "Spanish" as a language spoken at home reported by their parents, or if the teacher knew they spoke Spanish. If the child was able to finish the assessment in both languages, Spanish was spoken at home (to any extent) and the caregivers reported that Spanish was also spoken by the child, the child was classified as bilingual. On the contrary, if the child was not able to complete the tasks in Spanish at the time of the recording and Spanish was not spoken at home, the child was classified as monolingual in English. By utilizing a continuum rather than a binary factor for dominance we were able to compare children within each group, as well as perceive tendencies within the bilingual group. Appendix 1 presents the children's socio demographic information.

Appendix 1 describes the background for the children in this dissertation with the information available at the time. As it was mentioned before, classifying the children into the bilingual or monolingual groups was challenging. The most important factor for this categorical classification was whether the child was able to finish the BESA assessment in Spanish. Because we are aware of the factors influencing the children's performance in the minority language, the information from the parent report (whether the minority language was used at home or not, as well as how often they used the minority language at home) was used to create the gradient classification within each group (LUP). Out of the 61 children included in this study, 22 parent reports were not available at the time, therefore the LUP scores were not calculated. The information from Appendix 1 will be of use for the qualitative analysis of the data.

3.1.2. Speech Development

Children were classified as typically developing on the basis of a cognitive development test, a standardized speech development test, and the calculation of the percentage of consonants correct. For children to be considered typically developing, it was required that there were no concerns about the child's speech sound development from the parents, teachers and school speech-language pathologists. None of the participants had neurological, cognitive, sensory, or auditory impairments, and they were considered typically-developing at the time of assessment. In addition, none of the children included in this dissertation were diagnosed with a communication disorder prior to the study.

The Kaufman Assessment Battery for Children (KABC, Litchtenberger et al., 2009) was used to assess cognitive development. This nonverbal test of cognition was used to rule out the influence of cognitive impairment on phonological ability. English, Spanish or both languages were used by the test administrator to provide instructions, based on the child's preference. Only children whose scores were within the average (or above) range were included in the study.

The Bilingual Spanish English Assessment (BESA, Peña et. al 2014) and the Goldman-Fristoe Test of Articulation (GFTA-2, Goldman, R. & Fristoe, M, 2000) were used for assessing speech development and individual speech sound inventories. The phonology subtest for assessment of the speech sound inventory in English and Spanish from BESA was used to assess the bilinguals' phonetic production, as it is designed for children who are exposed to both English and Spanish in early acquisition of speech. GFTA-2 was used for the same purpose with children who were only exposed to English and did not show any sign of growing up in a bilingual setting.

In this dissertation we study children who fall in the typically-developing category in speech and language performance, as we are interested in substitution errors that are common in early development of speech in the preschool years. Describing a typically-developing bilingual child presents challenges. In addition, variation among bilinguals makes it hard to find a baseline for what "typically-developing" means for this population. For these reasons we established criteria for including children with typically-developing speech productions on the basis of the normative sample of the BESA/GFTA-2 with a standard score derived from the tests.

To qualify for this study, children had to score above 90% in either Spanish, had to be typical for their chronological age. In the case of the bilingual group, English scores were calculated first and were followed by the Spanish scores if the English score did not reach the appropriate score for the age of the child. The BESA scores had to fall in the below-average range (a score less than 85) in both languages to be placed in the disorder category. The child's speech was considered typically-developing if at least one of the two languages was above the standardized score. BESA performance was also used to confirm that bilingual children were able to produce speech samples in both languages. If a child was not able to finish the BESA test in Spanish, the child was not given the subsequent tests in Spanish. Both BESA scores and GFTA-2 scores are reported in Appendix 1.

Lastly, it is important to mention that the BESA and GFTA-2 are designed for four to six years old children. All participants were scored following the BESA or GFTA tests except for B27, M02 and M12 who were younger than four and a half years old at the time of the assessment.

3.2. Procedure and Materials

All children were recorded in their preschool, in a soundproof audiology booth. The Assessment of English Phonology (AEP) and the Assessment of Spanish Phonology (ASP) tests (Barlow 2003, 2005), both picture-naming tasks, were used to collect the single-word sample data for this dissertation. These protocols include the type and frequency of phonemes, syllable types and word shapes in English (AEP) and Spanish (ASP). To administer the AEP and ASP, each target word was elicited by asking a question in reference to a photograph. For instance, if the picture displayed an egg carton with six eggs, the SLP asked: “how many eggs do you see?”, expecting to prompt the answer “six”. Some of the pictures contained more than one target word. If the child did not answer the initial prompt spontaneously or produce the target word in the non-target language, children were prompted to produce the word as a delayed imitation (Goldstein, Fabiano & Iglesias, 2004). AEP was used to assess the phonological inventory in English for both groups, and the ASP to assess the one in Spanish for the bilingual group. These assessments served as the sample for the analysis of speech sounds and substitution patterns in both English and Spanish.

AEP and ASP contained familiar vocabulary for children in both languages, and these words were strategically designed so the child could have several opportunities to produce the same sound in different phonemic and syllabic contexts. The initial English assessment contains 81 words, and the Spanish one, 85. For the bilingual group, each session was administered in one language at a time by a trained administrator who shared the language spoken by the child, American English and the regional dialect in Spanish. All assessments were recorded using a *Zoom H4n Handy Recorder*. Appendix 2 displays the target words that were collected from the AEP and Appendix 3 displays the corresponding target words from the ASP.

3.2.1. Items from the ASP and AEP

In order to analyze gliding, words containing late-developing sounds [ɹ] and [l] were selected from the AEP, and words containing [r] [ɾ] and [l] were selected from the ASP. These target items were also organized based according to syllabic position. The syllabic position refers to the place in the syllable where the late-developing sound can surface, either initial or final position or combined with another consonant. Appendix 4 (English) and Appendix 5 (Spanish) display the selected target words organized according to syllabic position.

Appendix 4 includes a total of 26 target words in the AEP with the late developing sounds [ɹ] and [l] (shown in orthographic form). All these target words were candidates for phonological gliding or sound deletion as substitution patterns for these late-developing sounds. There were 26 opportunities for children to glide.

There are contexts in adult English where /l/ and /r/ do not surface as late-developing sounds [ɹ] and [l]. The following contexts and target words are not included in the analysis:

1. The /l/ in final position surfaces as a velarized lateral [ɫ], also known as dark [ɫ], and it parsed in the nucleus as a syllabic consonant. The phonological pattern corresponding to the velarized lateral [ɫ] in English is vocalization: [ɫ] → [oʊ] / __#. (Stoel-Gammond and Dunn 1984, pp. 93). Because of this reason, the words *shovel*, *snail, doll and nail* were excluded from the analysis.
2. In American English, a postvocalic coda rhotic is realized as phonetic component of the vowel, a rhotic or r-colored vowel (Ladefoged & Johnson 2014, pp. 99), and thus it will not be replaced with a glide. Instead, the vowel may lose its rhotic feature (Stoel-Gammon & Dunn 1984, pp93). Thus, the words *feather, mother, father, flowers, hammer, zipper, shower, other,* and *thunder* were excluded from the analysis of gliding.

Appendix 5 includes a total of 57 target words with “r” and “l”s in the orthographic form that contain late-developing rhotics and laterals in the ASP. These could alternate with other late-developing sounds or be deleted. We included the analysis of Spanish late-developing sounds as it could be a possible context for cross-linguistic effects between languages. Additionally, we hypothesized that in the event of between-language interactions, gliding would surface as a substitution pattern for Spanish-English bilinguals.

It is important to mention that late-developing sounds are more frequent in Spanish than in English, therefore the number of items is larger in the ASP in this dissertation. Additionally, liquids in Spanish show a quasi-parallel correspondence between the graphemes “r”, “rr” and “l” to the late-developing sounds [r] [ɾ] and [l]. That was not the case for English, as there are two contexts where graphemes “l” and “r” do not surface as English [l] or [ɹ].

3.3. Analysis

3.3.1. Transcriptions

All the assessments (BESA English/Spanish, GFTA, AEP, and ASP) were phonetically transcribed by Spanish and English speakers trained in narrow transcription using the International Phonetic Alphabet and in acoustic spectrogram imaging. Data transcription of the AEP and ASP were performed using the Logical International Phonetics Program (LIPP) (Oller and Delgado, 2000). LIPP uses the adult target as comparison to the child production and calculates an accuracy score. Sounds accurately produced are those which the child was able to produce in an "adult-like way", matching dialectal features and syllable structure as well. If the child did not attain adult-like production, it was counted as an "error" or an inaccuracy. Transcription reliability was averaged for all samples several times and complemented with PRAAT (Boersma and Weenick, 2019) spectrographic visualizations to create a stronger and more reliable dataset. The overall analysis of the Percentage of Consonants Correct-Revised (PCC-rs) scores in both English and Spanish, as well as the overall percentage of gliding in the dataset was performed using LIPP.

3.3.2. Glides and Dialectal Features in Spanish

The bilingual children in this study were exposed to Northern Mexican and Southwestern US Spanish dialects. US Spanish with Mexican influence and Northern Mexican dialect of Spanish are Spanish varieties that allow glides in onset position (word initial position and between vowels) (Canfield 1981, Alvar 1996). For this reason, the production of the glides in onset position could potentially differ for these participants compared to other Spanish dialects (words like *llueve* could be pronounced with a glide [j] rather than a fricative [ʝ]).

Even though the productions of glides in Spanish were not part of our dependent variables, it was important to consider this dialectal feature in our transcriptions as onset glides suggest the possibility of consonantal glides in this dialect. We considered the productions of words containing glides (or possible strengthening of them) as well as words with *shesheo* (the /tʃ/ sound in the word *chile (*pepper) pronounced as [ʃile], Mendez 2017, Lopez Velarde and Simonet 2019)*,* aiming to accurately represent the dialectal features of the children. A bilingual trained transcriber, a speaker of Northern Mexican dialect born and raised in this border region of US Southwest, served as judge. She classified the bilingual children's productions as either including or not including the dialectal features of *shesheo* and non-consonantized glides in onset position (the word *llama* ([she] calls) pronounced with a rising diphthong in the onset [jama]).

For words with *shesheo*, a second rater collaborated on a selected sample to confirm the dialectal feature productions. Inter-rater agreement for words with /tʃ/ reached 100%. For words with non-consonantized glides in onset position, the ratings from the rater were triangulated with a spectrographic imaging analysis using PRAAT (Boersma et al. 2020), as the rater perceived variability in production of words containing glides in initial position of the syllable. An agreement from the rater and the researcher was used to determine the dialectal features of the children in regard to the glide production in onset position.

An impressionistic acoustic analysis, performed by the researcher, served as a reliability method to transcribe the glides in onset position. The consonantized glides [ʝ] showed a burst vertical bar, high frequency turbulence and a clear transition to the vowel. The non-consonantized glides, on the contrary, did not exhibit turbulence in high frequencies and the formantic structure transitioned as a regular diphthong. The figures below illustrate an example of a consonantized glide [ʝ] in the word *llama* (Figure 3) --where the onset of the word is pronounced with a consonantized glide [ʝ]--, and an example of a syllable-initial non-consonantized glide in the word *castillo* (castle) (Figure 4).

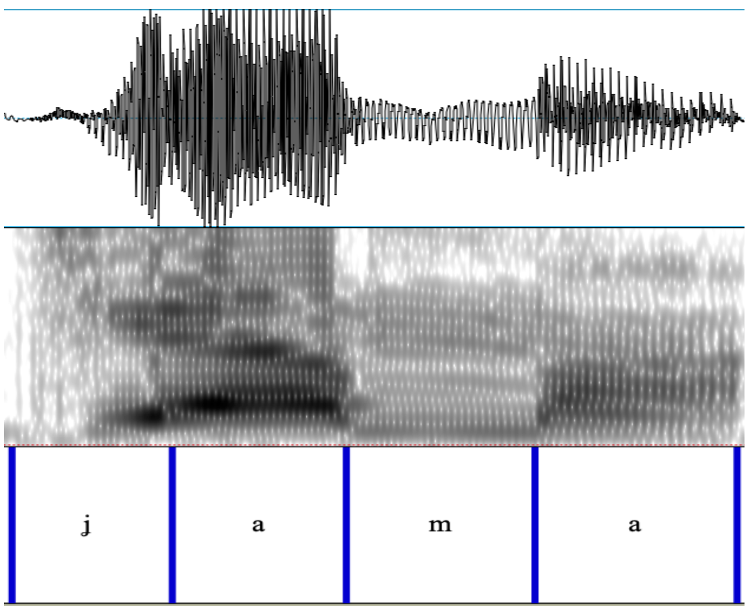


Figure C. Spectrogram and sonogram of the word *llama* produced by B07 with a consonantized glide [ʝ].

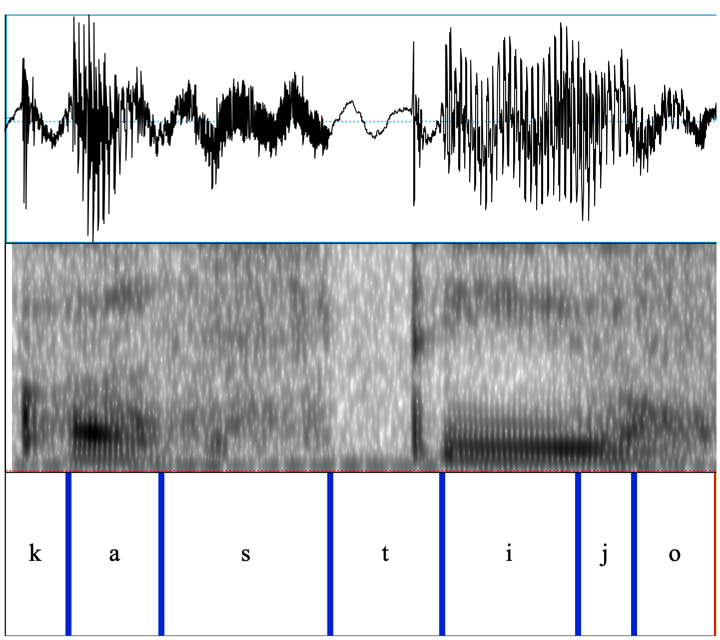


Figure D. Spectrogram and sonogram of the word *castillo* produced by B12 without a consonantized glide [ʝ].

3.3.3. Percentage of Consonants Correct

The Percentage of Consonants Correct-Revised (PCC-R) was used as a dependent measure to judge the overall consonantal accuracy production of each sample. This score was considered reliable for both bilingual and monolingual children (Fabiano-Smith & Hoffman, 2018). PCC-R was calculated based on the production data from the Assessment of English Phonology (AEP) and the Assessment of Spanish Phonology (ASP) productions using LIPP (see Section 3.2). Both the AEP and ASP are designed to evaluate the consonant accuracy of children in English and in Spanish. The PCC-R includes the number of consonants produced correctly divided by the total number of consonants (Bernthal et al. 2017, pp. 80), excluding deletions. It includes how many times the child was able to produce all the sounds of their inventory and how many times these sounds were accurate within the word. In other words, this index provides an analysis of how close to the adult model the consonant inventory of the child is. A PCC-R score above 85% means that the child's consonants are accurate and match the adult target 85% of the time. It is important to mention that the higher the PCC-R score in a speech sample, the closer it is to the adult target production. A child with a 90% in PCC-R will show a phonemic inventory almost identical to that of an adult, whereas a child with a 50% in PCC-R would show a phonemic inventory that is only accurate 50% of the time. A 4-year-old child who scores below 85% in PCC-R was considered as "mildly impaired" if the BESA or GFTA scores were within average range. When the score falls below 80%, GFTA or BESA scores were not within average range, and the child is four years old or older, the child was placed into the disorder category.

For the purpose of this study, we were looking for children who would present gliding. The phonological process of gliding, as well as cluster reduction and segment deletion, are part of the score in the sense that the higher the PCC-R score, the lower probability these phonological processes occur. Because, as we mentioned earlier, we were looking for substitution patterns, we widened the threshold to four-years-old children with PCC-R scores above 80% (who still were classified as typically-developing according to BESA/GFTA-2). Consequently, a total of four children (out of 61) in this study sample could be considered mildly speech impaired (indicated in Appendix 1). Additionally, the sample also included three children who were younger than 4 years old. There are no strict thresholds for this age range, and children younger than four years old are expected to present more errors in their sound system.

Almost all monolingual participants scored a PCC-R of 85% or higher, with the exception of M12 and M02, who were younger than four years old, and M06. Overall, the bilingual group performed higher than the baseline except for B08, B09, B10, B14, B25 and B31. These children with PCC-R scores below 85% may be cases of mild impairment, but they were all within the typical range for the BESA and GFTA scores. The PCC-R scores were used to provide a more detailed description of the children's consonant inventory and overall accuracy rather than for making a specific judgement about their phonological skills.

3.3.4. Statistical Analyses

A non-parametric Mann-Whitney U test was conducted to compare the two groups' means (the English productions of bilingual Spanish-English and monolingual English preschoolers) in terms of the percentage occurrence of gliding. This statistical test was selected as it is a non-parametric test, and it compares two means that do not follow a normal distribution within a small sample size. In addition, due to the small sample size of the gliding occurrences, qualitative analyses were performed as well (see section 3.3.5).

In order to analyze the relationship between the syllabic position of accuracy rates in late-developing sounds by the group of participants, we run a one-way between-subjects Multivariate Analysis of Variance (MANOVA), which investigates the effects of independent variables on a set of continuous outcomes represented by several dependent variables. In this case, the average accuracy in each syllabic position (consonant cluster with late-developing sounds in onset or coda position, the single segment in onset or coda position, or more late-developing sounds within the same target word) was treated as a dependent variable, and the groups (bilingual vs. monolingual) were considered the independent variable. In order to see if this model was a good fit for our data, we tested for multivariate normality and equality of covariance matrices. In order to test the multivariate normality of this data we used the squared Mahalanobis distance, as well as the Mardia's test for skewedness and kurtosis. Box's M was used to test the equality of covariance matrices for the dependent variables. Lastly, the statistical significance and the practical significance were reported for this analysis.

All statistical tests were conducted using R (RStudio Team, 2019).

3.3.5. Qualitative Analyses

In addition to quantitative analyses, we complemented the quantitative analysis with descriptive statistics as well as qualitative analyses. We provided a detailed description on the overall accuracy rates for both English and Spanish late-developing rhotics and laterals, as well as the phonological error patterns that surfaced. This analysis aimed at exploring the syllabic position where the errors were taking place, as well as the phonological substitutions that surfaced in both English and Spanish.

Additionally, phonological error patterns were considered to explore cross-linguistic effects. If children exposed to Spanish transferred sounds between languages, we expected these transfers to surface in the substitution patterns as well. These transfers were analyzed in both English and Spanish data for the bilingual group. Lastly, variables for the language background such as language exposure at home and the language use with the siblings were included in the analysis for the bilingual group.

CHAPTER 4. Results

4.1. Revisiting the Purpose of the Study

This chapter describes the findings for the production of late-developing rhotics and laterals in the English spoken by monolingual preschoolers and in the English and Spanish spoken by bilingual preschoolers in Southern Arizona. Therefore, this chapter compares the data on English production by both participant groups studied, followed by the Spanish productions for the bilingual group. The main purpose of this chapter is three-fold: a) to examine the distribution of late-developing English sounds /ɹ l/ in children who are exposed to only English (the monolingual group) and to Spanish and English (the bilingual group), b) to explore whether exposure to Spanish impacts production of English words with rhotics and laterals as late-developing sounds by bilinguals, and c) to determine if there is any socio-cultural component that may influence the speech development in preschoolers who are exposed to Spanish at home. Specifically, this dissertation analyzes the substitutions for these late-developing sounds, with a specific focus on the phonological process of gliding and possible interactions between languages.

It is important to explain that in this dissertation the word *error* is used to refer to the non-adult like production of a sound and *correct* for the adult-like form. These words are frequently used in the field of Communication Disorders to refer to substitutions. Children at this age are supposed to produce words that deviate from the adult form. *Error* is not used here in its prescriptive sense, rather to mean pronunciation forms that are acceptable among children (regardless of the language they speak) but differ from adult speech.

Section 4.2 reviews accurate and inaccurate (i.e., adult-like or not) production of words with late-developing /ɹ l/ in English. The English Percentage of Consonants Correct (PCC-R) scores are reported first for both the bilingual and the monolingual group. This section includes the results of the subset of children who presents gliding as a phonological pattern (the substitution of the late-developing sounds /ɹ l/ for earlier-developing sounds such as glides [w j], e.g. the word *rabbit* pronounced as [wæbɪt]) in English. The results of this substitution pattern are presented first, followed by a subsection describing the overall accuracy rate of late-developing sounds /ɹ/ and /l/ in English according to language dominance.

Section 4.3 includes the descriptive results in Spanish with overall accuracy of late-developing sounds /r l/, mimicking the same structure of that of the English data. Lastly, Section 4.4 provides the results of the sociolinguistic variables for the bilingual subgroup of children who presented gliding.

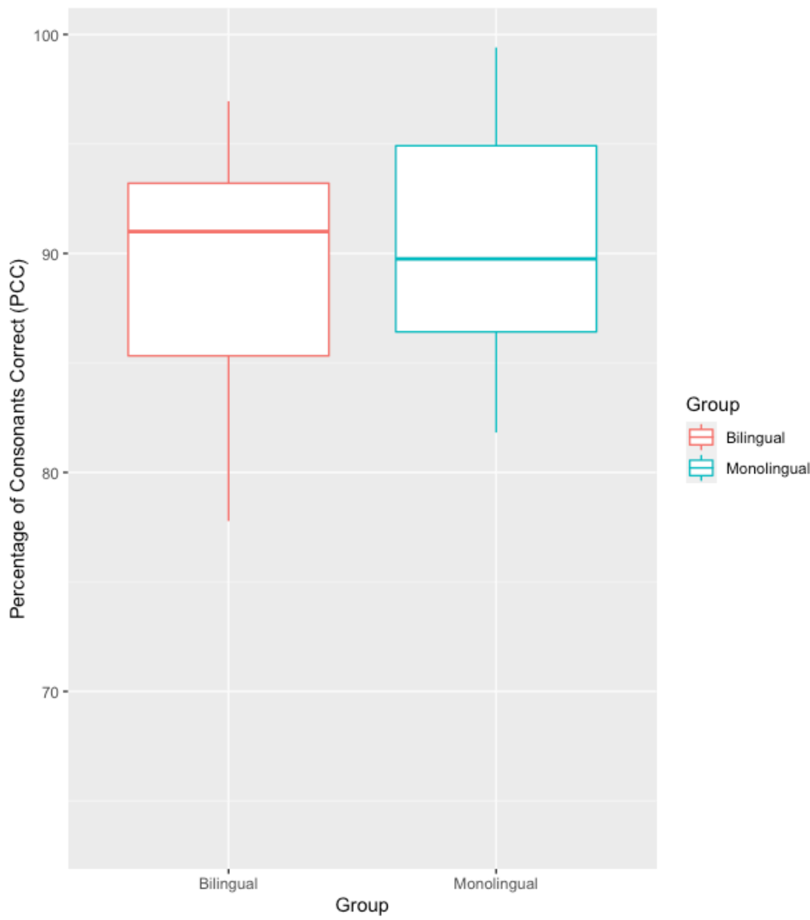
The substitution pattern of gliding is crucial for this study as it is a recurrent pattern in English up to age five (James, 2001), but it does not occur in Spanish early speech acquisition. Gliding can occur in onset position and also in consonant clusters in word-initial or word internal position Words like *rabbit, brush* and *strawberry* may undergo this phonological process, exhibiting the final production of the late-developing sounds of those words as [wɑbɪt], [bwʌʃ] or [stwɔbɛwi]. In Spanish, gliding is not expected because it is not a substitution pattern in that language. Spanish rhotics and laterals sounds are substituted by other sounds that share the same place of articulation: the approximant [ð], the tap rhotic [ɾ] and the lateral [l] are the most common substitution patterns for the trills; when children do not have neither rhotic in their inventory, the resulting substitution pattern is the approximant [ð] and the [l]. As a result, we predicted that bilingual children with early exposure to Spanish would present the substitution processes typical of each language but show lower percentage of gliding than the monolingual counterparts.

4.2. English

4.2.1. Percentage of Consonants Correct (PCC-R) in English

PCC-R was used as a dependent measure to judge the overall consonant accuracy of each child's single word speech sample. As mentioned in Section 3.3.2, the PCC-R includes the number of consonants produced correctly divided by the total number of consonants (Bernthal et al. 2017, pp. 80), excluding deletions. This score aims to complement the analysis of speech disorders as it provides different levels of severity from "mild" to "severe" (Shriberg and Kwiatkowski 1982a, 1982b). Figure 5 displays the PCC-R scores in English for both bilingual (N = 39, mean = 89.35, SD = 5.38) and monolingual (N = 22, mean = 88.82, SD =9.17) children, including the Confidence Intervals for each group. Figure 5 clearly shows that the phonological overall consonant accuracy inventories for both monolingual and bilingual children fell into the typically-developing range for preschoolers.

Figure E PCC-R scores in English



Overall, both groups scored above 85%, therefore both groups were comparable. There is slightly more variability within the monolingual group, but all children were clearly beyond the PCC-R accuracy range expected of typically developing children for their age.

4.2.2. Substitution Pattern of Gliding

We predicted that the bilingual group would show a lower percentage of gliding than the non-bilingual group due to the interaction of Spanish glides with the English phonological inventory. Among the total number of errors in late-developing English sounds, gliding was present in both monolingual and bilingual children. However, the percentage of children who showed signs of gliding was smaller in the bilingual group than in the monolingual one. Gliding was observed in

11 of the 39 bilingual children, and in 11 of 22 monolingual children. Table 1 shows the percentage of children who exhibited gliding in their English productions with the mean and standard deviation of gliding percentage of occurrence. We refer to this subgroup of children with gliding as "gliders", as it is a subset of participants from both the monolingual and the bilingual groups.

Table 1. % of "gliders" with mean and standard deviation of gliding instances per group

Group	Percentage of "gliders" (N= 61)	Mean (SD)
Bilingual	28% (11/39 children)	8.83 (15.09)
Monolingual	50% (11/22 children)	16.26 (15.21)

The percentage of gliding per participant and language group can be found in Tables 2 and 3. The information for the bilingual group can be found in Table 2 and the monolingual information in Table 3 including the child identifier, the total word count for each child, and the percentage of gliding reported in raw scores and percentages.

Even though both groups have the same number of "gliders", there are individual differences that actually make each group distinct. The bilingual group, with the exception of B07, showed a very low percentage of gliding compared to the monolingual group. The percentage of individual gliding is clearly different in each group, as the bilingual group clearly demonstrates fewer instances of this substitution pattern (mean = 8.83) in comparison with the monolingual group (mean = 16.26). Only two out of the 11 children in the bilingual group exceed a percentage of gliding higher than 5%. For the monolingual group, almost half of the group of preschoolers (5/11) had a percentage of gliding higher than 5%.

Table 2. Gliding for the bilingual group

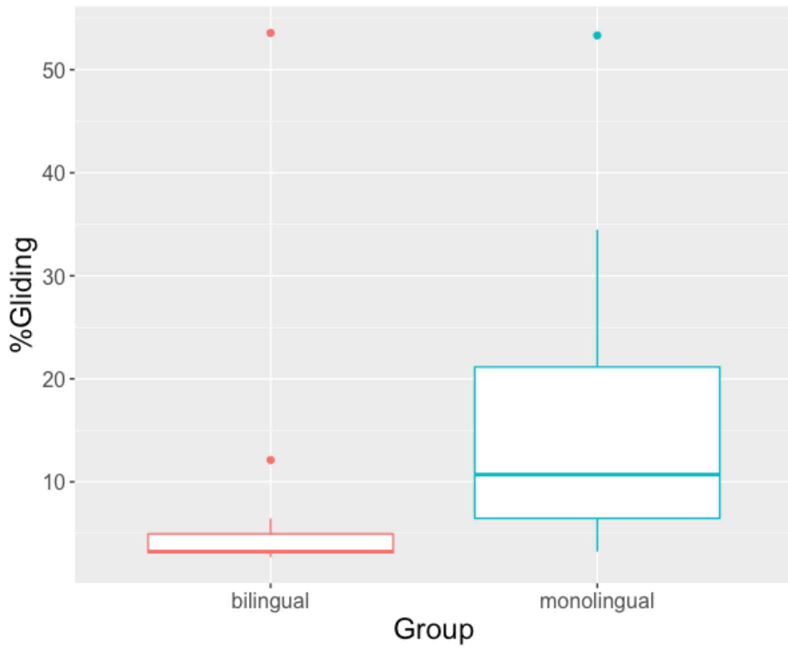
ID	Total words	Total words with gliding	Percentage of gliding
B03	32	1	3.13
B04	32	1	3.13
B07	29	15	53.57
B08	29	1	3.45
B12	32	1	2.94
B14	33	4	12.12
B16	37	1	2.7
B30	32	1	3.13
B31	45	6	6.45
B32	31	1	3.23
B35	30	1	3.33
	Total: 11 out of 39 children		

Table 3. Gliding for the monolingual group

ID	Total words	Total words with gliding	Percentage of gliding
M02	30	16	53.33
M03	28	3	10.71
M04	32	5	15.63
M05	29	3	10.34
M06	29	10	34.48
M11	32	5	15.63
M12	30	2	6.67
M14	31	6	19.35
M17	31	1	3.23
M19	31	1	3.23
M22	32	2	6.25
	Total: 11 out of 22 children		

The first research question of this study was whether the bilingual group would present a proportion of gliding similar to or larger than that of the monolingual group. Figure 6 represents the percentage of gliding exhibited by the bilingual and monolingual groups of children and clearly reveals a different distribution between the accuracy rates of preschoolers exposed to Spanish versus monolingual English preschoolers. The bilingual group's mean percentage of gliding is close to 0, with a narrow range. The monolingual group, however, shows a wider range in terms of percentage of gliding, with a mean close to 10%. In addition, this figure also includes outliers from the center mean for both groups. In the case of the bilingual group, this data point corresponds to the data from B07, a participant who skewed the data distribution drastically as he is the only child who exhibited a percentage of gliding higher than 15%. With the exception of this participant, the mean and median of the percentage of gliding for the bilingual group, as mentioned earlier, stayed closer to zero. In the case of the monolingual group, however, the distribution varied more, except for the outliers M02 and M06, as both of those participants exhibited a gliding percentage higher than 15%.

Figure F. Overall percentage of gliding



In order to further explore the distribution of gliding by groups, a non-parametric Mann-Whitney U test was conducted to compare group productions in terms of their gliding substitution patterns. The results of this comparison test yielded a statistically significant difference (U = 25, *p* = .0212) between the two groups, as the percentage of gliding was higher in the monolingual group (mean = 16.26, SD = 15.21) than in the bilingual group (mean = 8.83, SD= 15.09). This difference can be seen in Figure 6 that displays the mean and standard deviation for the gliding percentage for each group. The effect size was calculated using Vargha and Delaney's A, which showed a strong effect between both groups (A = 0.2066), confirming that there is strong stochastic domination for the monolingual group compared to the bilingual group. This effect size indicates that monolingual preschoolers will be more likely to glide their rhotics and laterals than the bilingual preschooler group 20.6% of the time.

Overall, Figure 6 shows a skewed distribution of the gliding data for the bilingual group, whereas the monolingual group was closer to a normal distribution. The Spanish-English preschoolers clearly showed that their percentage of gliding was skewed towards 0, whereas the percentage of gliding for the monolingual English speakers displayed a larger variance within this group.

Figure 7 shows the overall count of gliding instances according to the sound they were replacing. Both groups exhibited substitution with the labiovelar glide [w]; there were no instances of the palatal glide [j] substituting for late-developing sounds /ɹ/ and /l. Gliding was found in words containing /ɹ/ and /l/ across groups. Both groups exhibited a similar tendency when substituting these late-developing sounds: words with /ɹ/ had higher frequency of gliding than words with /l/. However, children with exposure to Spanish exhibited fewer instances of substitutions compared to the monolingual group overall. In other words, gliding was present in both groups for both contexts, but the frequency of occurrence was higher in the monolingual group.

Figure G. Overall count of gliding in words with [ɹ] and [l] by

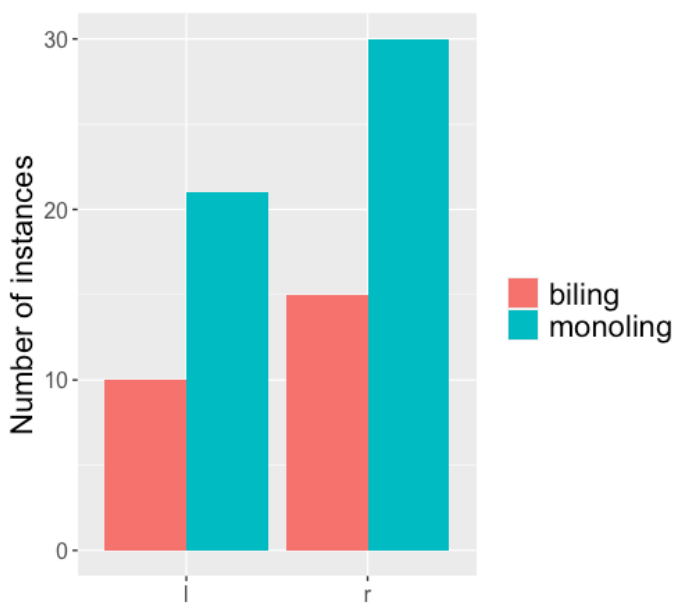
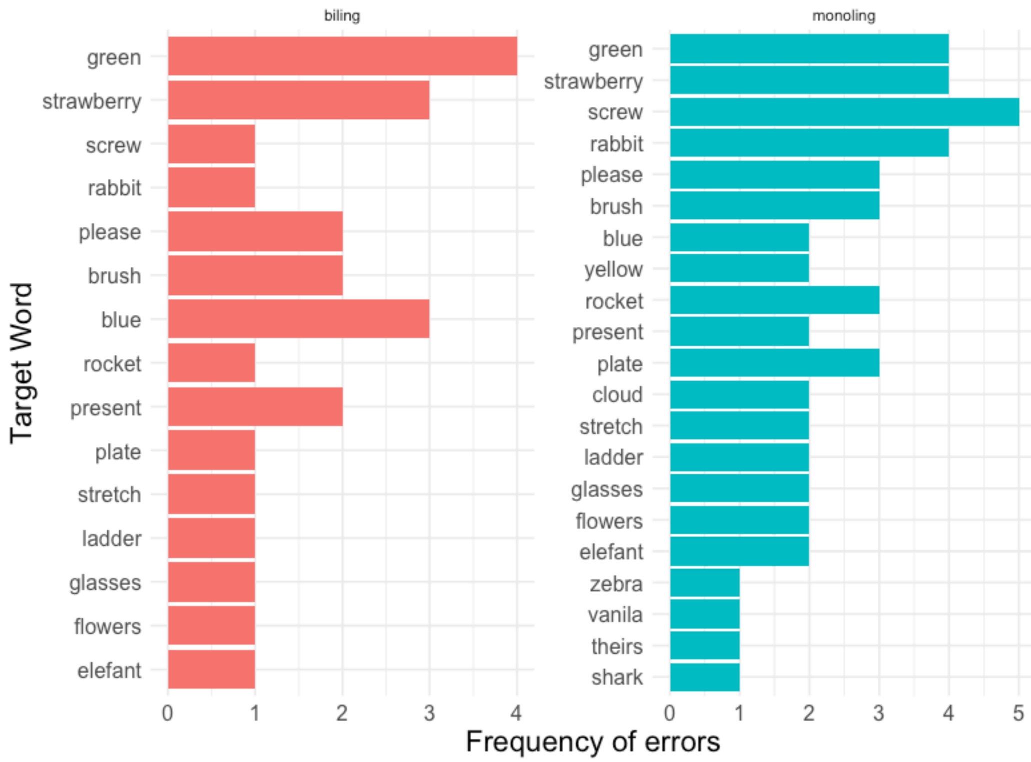


Figure 7 displays the number of gliding instances for the rhotics and laterals produced by each respective group: the coral bars correspond to the bilingual group and the teal bars to the monolingual group. For both groups words with laterals showed a lower gliding occurrence rate than words containing rhotics. However, it is clear that the bilingual group exhibited an overall lower number of substitutions compared to the monolingual group. In other words, substitutions of laterals with the labiovelar approximant [w] were similar to the substitution patterns of rhotics with the labiovelar approximant [w] within the bilingual group but were higher for both late-developing sounds within the monolingual group. The difference, then, lies in the group of children. Both groups presented a similar amount of substitution patterns for words containing laterals and rhotics, but the bilingual Spanish-English group exhibited far fewer instances in both contexts compared to their monolingual counterparts.

Additionally, gliding was not present in all target words containing late-developing sounds /r/ and /l/. Bilingual children, as we mentioned earlier, substituted late-developing sounds less frequently, therefore gliding was present in fewer target words compared to the monolingual group. Figure 8 illustrates how often each word was affected by gliding for each group (coral color represents the bilingual group sample, and teal color represents the monolingual group sample).

Figure H. Gliding per word per group



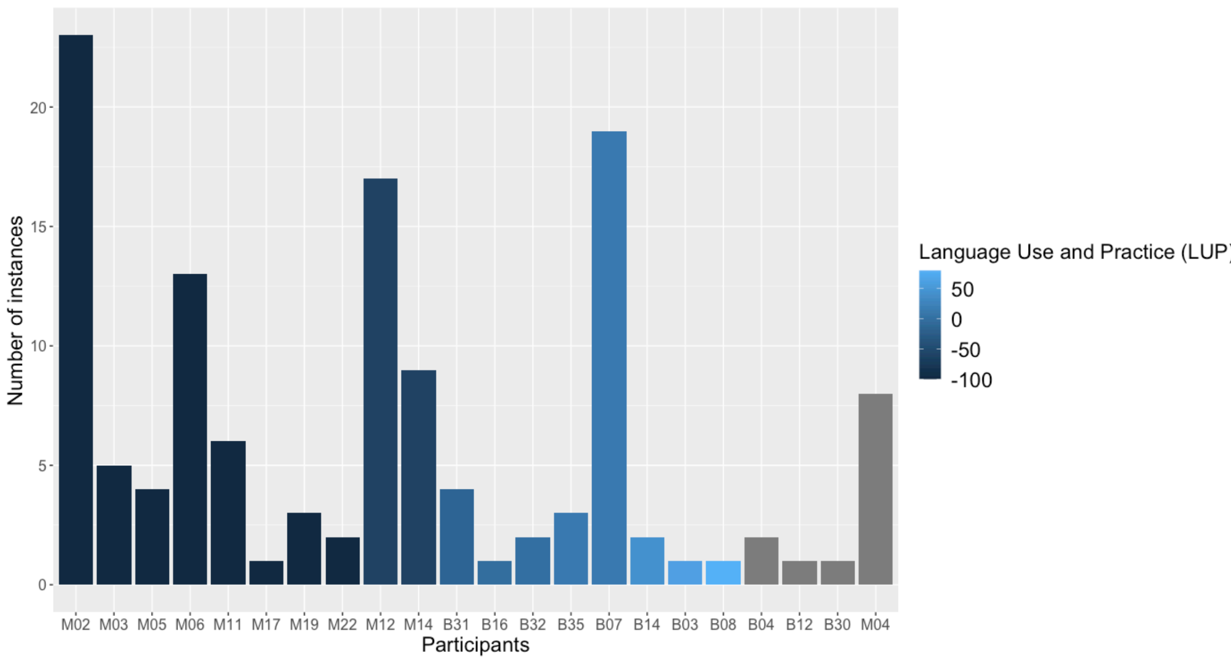
As observed in in Figure 8, there were more target words that triggered gliding in the monolingual group than in the bilingual Spanish-English group. In terms of frequency, it seems that the words containing consonant clusters exhibited more gliding than words with single segments in onset position (with words like *green, strawberry, brush* and *blue* being the most frequent for both monolingual and bilingual groups). The distribution of gliding across the monolingual subgroup indicated that gliding was as frequent in consonant clusters as in single segment substitutions. In other words, gliding patterns occurred in complex onset syllables and in single onset syllables for all "gliders," but the Spanish-English preschoolers showed fewer instances of gliding in single-consonant onsets. Overall, it seemed that the Spanish-English bilingual children mastered the single initial late-developing rhotic and lateral faster than their monolingual peers, and struggled with consonant clusters that involved a higher complexity syllabic structure.

4.2.3. Accuracy of Late-Developing Sounds /ɹ/ and /l/ in the Bilingual Group Who Exhibited Gliding

As we have seen in section, the percentage of gliding for the bilingual group was very low. These results raised the question of whether these children actually were accurate in their production of late-developing sounds, so here we describe the number of "errors" based on the exposure to Spanish at home. Because we wanted to consider all instances of errors in the productions of English liquids, we combined all gliding, consonant cluster reductions, and other substitution patterns and counted how many "errors" were present in the subgroup of preschoolers. Figure 9 shows these error occurrences of the overall target words count in English sorted by the LUP's score for each child. For each participant in this study, a LUP was calculated (see Chapter 3 for a detailed explanation of this analysis), and it was used as a sociolinguistic predictor of the possible correlation between the degree of exposure to Spanish and the accuracy rates for late-developing rhotics and laterals at the individual level. Figure 9 displays this continuum variable using a gradient blue color that goes from darker to lighter. The darker the color, the closer a child's language proficiency is to English monolingual, whereas the lighter the color, the closer a child's language proficiency is to Spanish monolingual. The grey columns indicate that those participants had not completed parent reports at the time of analysis; therefore, there was not enough data to calculate children's LUP and the grey columns display only the total number of "errors" in late-developing sounds.

As seen in Figure 9 the bilingual group showed a lower error rate for late-developing sounds. The darker columns in Figure 9 exhibit more variability than the lighter blue columns. The number of errors drops drastically between M14, the last participant in the monolingual group, and B31, the first participant of the bilingual group (that would correspond to a LUP score of -14). With the exception of B07, the child who presented 53% of gliding in his late-developing sounds /ɹ/ and /l/, the number of errors does not vary much from participant B31 to the end of the continuum.

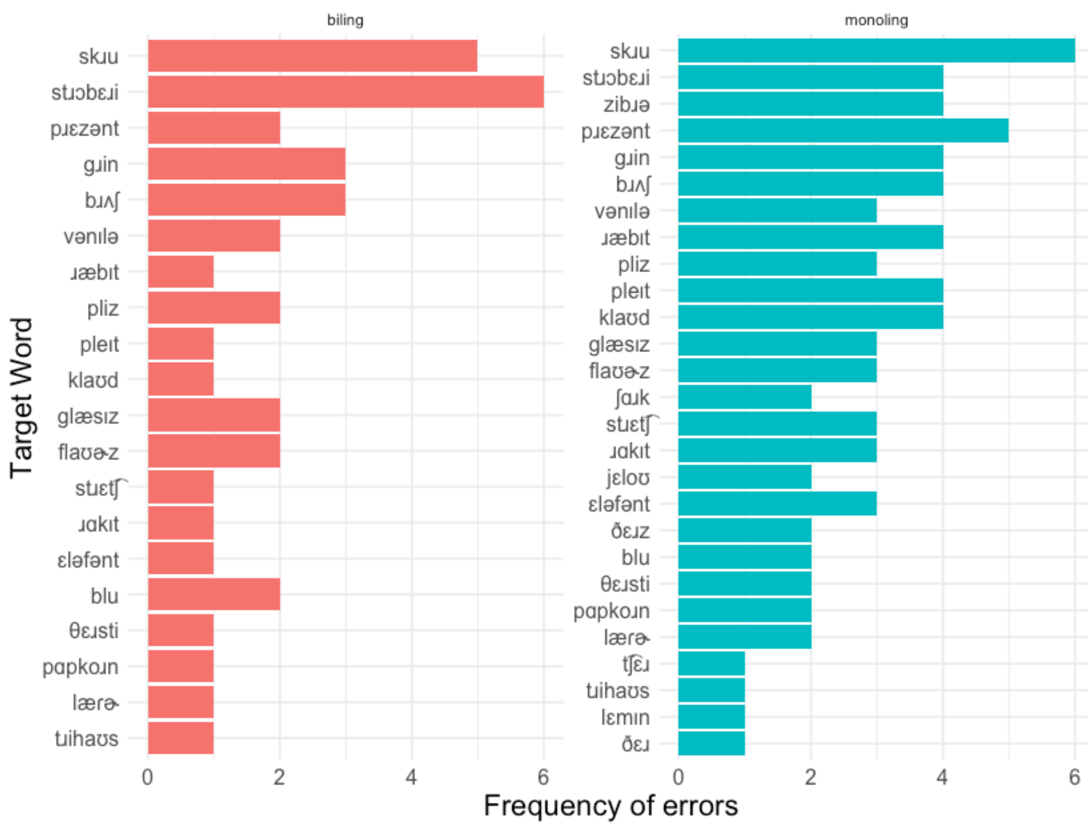
Figure I. Total count of overall "errors" in English sorted by LUP



Overall, we can observe in Figure 9 that both groups differed in terms of accuracy rates, showing higher number of overall instances of non-adult pronunciations in the monolingual group than in the bilingual group.

Figure 10 includes the overall frequency of errors in late-developing rhotics and laterals by word. This figure mirrors the tendencies found in Figure 8, as it shows that words with consonant clusters in the onset and multisyllabic words with more than one rhotic are the most problematic syllabic contexts. Additionally, there were more words with errors in the monolingual group than in the bilingual group. There is a difference in the error frequency rate of the different words as well, as only the words *screw* and *strawberry* were inaccurately produced more than three times. The error frequency in the monolingual group, however, included different consonant clusters with rhotics, as well as onset /ɹ/ and /l/ in monosyllabic and multisyllabic words at a high frequency error rate.

Figure J. Overall frequency of errors by word in English



In sum, we can observe in Figure 10 that, overall, *strawberry* and *screw* were the two most problematic words across the bilingual group, whereas the monolingual group exhibited issues with more words beyond these two.

4.2.4. Other Substitutions

This section explores the remaining English substitution patterns that were present among the subgroup of children who exhibited gliding in this study. As mentioned earlier, gliding was, by far, the most common phonological error pattern in the sample. The following descriptive analysis includes consonant cluster reduction, sound deletion, and other sounds that were produced instead of late-developing sounds. We aim to describe with this analysis the general tendencies that may surface in preschoolers' speech in addition to gliding. Table 4 summarizes preschoolers' late-developing sounds' substitutions (other than gliding).

Table 4. Other substitution patterns in English besides gliding

	Bilingual group (N = 11)	Monolingual group (N= 11)
Rhotic deletion	12	4
Lateral deletion	1	0
Rhotic > lateral	1	0
Lateral > rhotic	0	1
Rhotic > approximant [ð]	1	1
Lateral > approximant [ð]	2	2
Total target words	430	506

It is apparent from Table 4 that not many target words displayed substitution patterns other than gliding. For the monolingual group of “gliders", eight out of 506 instances were other substitutions, accounting for 1.58% of the sample for this group. The bilingual group exhibited a similar tendency except for rhotic deletion. Only 17 out of 430 words were inaccurate, accounting for 3.95% of the group's sample, but 70% of these errors were rhotic deletions. In sum, preschoolers in Southern Arizona did not show any other frequent substitutions patterns besides gliding to replace late-developing sounds, with the exception of the bilingual group who avoided the rhotics by deleting them completely. Words containing complex onsets such as *strawberry*, *treehouse* or *brush* were more likely to be simplified than single onsets.

4.2.5. Overall Accuracy of Late-Developing Sounds /ɹ l/ by Syllabic Positions in English

This study asks whether children exposed to Spanish will be similarly accurate in late-developing sounds /ɹ l/ compared to their monolingual counterparts. We have reported that the percentage of gliding for bilingual preschoolers in Southern Arizona was very low, as it was present only in 22 out of the 61 children included in this dissertation. This low percentage of gliding indicates that in English, late-developing sounds /ɹ l/ were accurately produced. By accurately produced we mean that the child was able to produce them in a given word in an "adult-like way", matching dialectal features and syllable structure as well. If the child did not attain adult-like production, it was counted as an "error" or an inaccuracy. In the bilingual group, the 39 children produced only 93 errors (out of 1,517 English target words), with an error rate of 6.13%. The 22 monolingual children, however, presented a higher error rate in their productions than their bilingual counterparts, with an overall error rate of 11.32% (107 error instances out of 931 target opportunities).

The percentage of error rate includes any target word with a late-developing sound /ɹ l/ in onsets (consonant clusters and single segments), as well as word-middle and word-final consonant clusters. Words containing the rhotic vowel [ɚ] and velarized [ɫ] in coda position are considered in the total number of target words, but they were excluded from the following analysis of gliding and substitution patterns, as the rhotic vowel [ɚ] and the velarized [l] fall into the substitution pattern of vocalization. Tables 5 and 6 display the total number of words with instances of laterals and liquids and rhotic vowels, organized by syllabic position, in addition to the number of items that were not accurately produced. Table 5 shows the distribution of "errors" for the bilingual group, and Table 6 displays the distribution for the monolingual group.

Table 5. Bilingual group: English "errors" and word position of target sound

Sound	**Percentage of "errors"**	**Total number of "errors" by total number of opportunities**
Onset [ɹ]	3.84%	3 /78
Onset [l]	4.40%	7 /159
[ɹ] in onset cluster	9.48%	22 /282
[l] in onset cluster	4.31%	11 /232
Coda [ɹ]	2.70%	3 /111
Coda [ɫ]	18.96%	22 /116
Coda [ɚ]	2.10%	6 /286
[ɹ] in coda cluster	2.86%	4 /140
[ɫ] in coda cluster	2.56%	1 /39
More than one [ɹ] or consonant cluster in onset	30.76%	12 /39
Both [l] and [ɹ] in the same word	5.71%	2 /35
Total	6.13%	93/1517

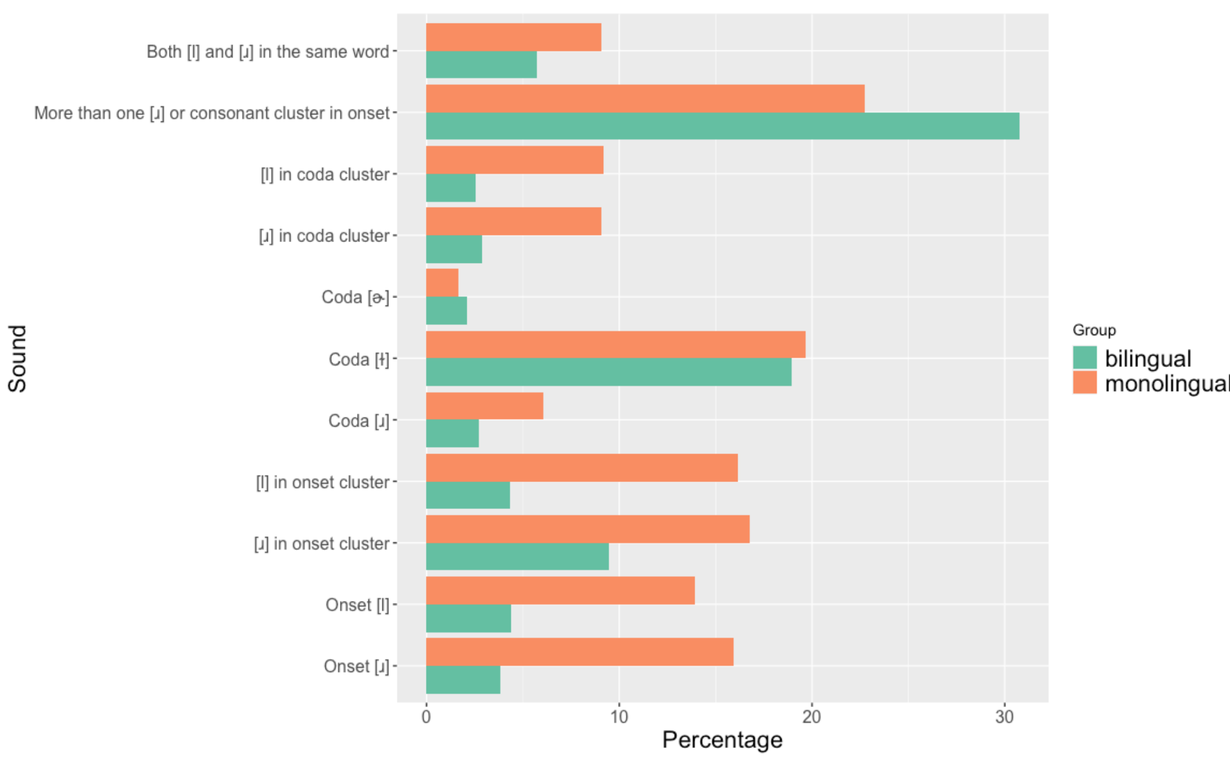
Table 6. Monolingual group: English "errors" and word position of target sound

Sound	**Percentage of "errors"**	**Total errors by total number of opportunities**
Onset [ɹ]	15.91%	7/44
Onset [l]	13.95%	12/86
[ɹ] in onset cluster	16.77%	25/149
[l] in onset cluster	16.15%	21/130
Coda [ɹ]	6.06%	4/66
Coda [ɫ]	19.69%	13/66
Coda [ɚ]	1.68%	4/237

[ɹ] in coda cluster	9.09%	2/22
[ɫ] in coda cluster	9.19%	8/87
More than one [ɹ] or consonant cluster in onset	22.72%	5/22
Both [l] and [ɹ] in the same word	9.09%	2/22
Total	11.38%	103/931

Both groups presented error instances across all syllabic positions, but the frequency differed for each group. Due to the small number of errors, it is not possible to determine whether these results responded to individual or generalized behavior. Figure 11 displays this comparison between the bilingual group and the monolingual group in terms of inaccuracies by syllabic position.

Figure K.Overall "error" count of late-developing sounds in English organized by syllabic position



As seen in Figure 11, the distribution of errors according to syllabic position was similar in the bilingual and the monolingual group. Words containing more than one rhotic (such as *strawberries*) seem to be the most common source of inaccuracies for both bilingual and monolingual children. This context is the one that displays a higher percentage of errors for the bilingual group. The frequency of errors was higher in onset and coda positions for the monolingual group than in the bilingual group. Regarding the bilingual group, Figure 11 also shows that velarized lateral [ɫ] in the coda was less accurate than the productions of rhotacized vowel [ɚ]. Overall, it is important to mention that the percentage of errors in the monolingual group is higher taking into account that the whole sample is smaller by a 5%.

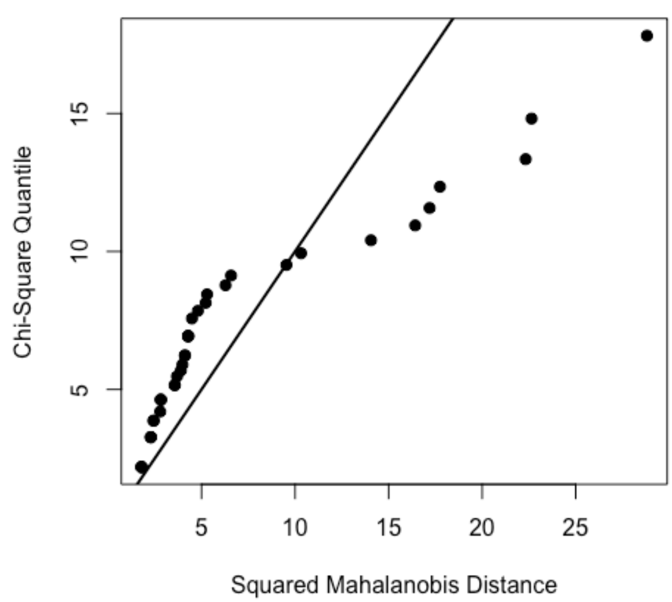
As previously stated, this dissertation examined consonant sound substitutions. Words containing a velarized lateral [ɫ] in the coda position of the syllable (either in a consonant cluster or as a single element) and also a rhotic vowel [ɚ] in the coda position of the syllable in English were not included in this analysis of substitution patterns. The words containing these segments undergo vocalization as a substitution pattern (Stoel-Gammon & Dunn 1985, pp.94), and should be considered syllabic segments rather than consonantal segments, since both the dark [ɫ] and rhotic vowel [ɚ] occur in the nuclear position of the syllable.

4.2.5.1. Multivariate Analysis

Multivariate Analysis of Variance (MANOVA) was used to compare the accuracy rates for both monolingual and bilingual groups of children, as it is a useful tool for comparing a set of dependent variables across multiple groups. The main purpose of this analysis was to observe if syllabic position had an effect on the production of the relevant late-developing sounds based on the language background. The dependent variables for the analysis were the accuracy rates for the syllabic positions previously mentioned, and the participant group (monolingual vs. bilingual) served as the independent variable.

In order to see if this model was a good fit for our data, we tested for multivariate normality and equality of covariance matrices. The Q-Q plot in Figure 12 was used as the first test to compare our sample (points) with a theoretical multivariate normal distribution, also known as sample centroid (line), based on the squared Mahalanobis Distance. The squared Mahalanobis Distance is a multi-dimensional generalization of the data, as it describes how many standard deviations away the data point is from the ideal mean of the theoretical multivariate normal distribution. Each data point in this graph represents the combination of the dependent variables for each child who was not at 100% accuracy rate for late-developing sounds. Figure 12 shows that the data for this study deviated from a normal distribution, as the data points representing each participant are scattered from the sample centroid, compared to how far out they should be in a normal distribution.

Figure L. Q-Q Plot comparing our data to the sample centroid of a normal distribution



Two follow-up tests checking for multivariate normality were also conducted: Mardia's tests for multivariate skewness and kurtosis. Skewness (χ^2 (39) = 295.417, p< .001) and kurtosis (z (39) = 7.77, p < .001) results from Mardia's tests corroborated that the sample significantly deviated from a multivariate normal distribution. Based on the results of these assumptions we affirm that the distribution of the syllabic context sample was not multivariate normal. These assumptions indicate that there is intervariability within the data points, therefore the sample is not balanced in terms of representation of all possibilities (it does not follow a "multivariate bell shape" form sample). Considering that the number of instances with non-adult like productions was very low and almost non-existent for most of the children in some of the contexts, these assumptions represents the reality of our sample.

Box's *M* was used to test for equality of covariance matrices in each group for the independent variable. The results were in line with previous tests as they did not yield statistically significant results (χ^2 (28) = 102.72, p < .001), therefore the groups on the language background of the sample had unequal covariance matrices. The results from Mardia's tests and Box's *M* are crucial for the interpretation of the MANOVA analysis, as the power of the MANOVA statistical test is low. Having a non-normal multivariate distribution and unequal covariance matrices indicates that the MANOVA does not have sufficient power to predict any major effect between the group of participants.

As expected, the factorial between-subjects' MANOVA did not exhibit any main effect of the group (F(31, 7) = 1.97, p = 0.09), meaning that both groups showed similar inaccuracy rates regardless of their language background. Because of the nature of our data set, we report the Pillai's Trace due to the fact that the group covariance matrices are unequal. Pillai's Trace indicated that the language background's predictor explained 30.8 % of the generalized nonredundant variance in the set of syllabic position for late-developing sounds, indicating that there is a large effect of language exposure on the syllabic positions where the errors appeared. Based on the MANOVA results, it seems that all preschoolers produced errors across syllabic positions similarly regardless of their language background.

We followed up by checking for practical significance. The practical significance indicates the effect size for this sample. Because the Eta-sq and partial Eta-sq were equivalent given the variables of this sample, we report partial Eta-sq ($\eta^2 = .308$). Even though the MANOVA tests did not yield any statistically significant *p* values, the effect size from eta-sq showed a large percentage of generalized non-redundant variance explained by the main effect. Taking into consideration that the sample was not multivariate normal and the covariance within the groups for the predictor "Group (language background)" was not equal, we rely on the practical significance as it showed that 30% of the generalized nonredundant variance within the syllabic contexts was explained by the different groups' language exposure.

Overall, the practical significance of the MANOVA analysis hinted that the syllabic context where late-developing sounds were inaccurately produced seemed to be different in each group, as the language background of the children could explain 30% of the variance of errors in all the rhotics and laterals' syllabic positions.

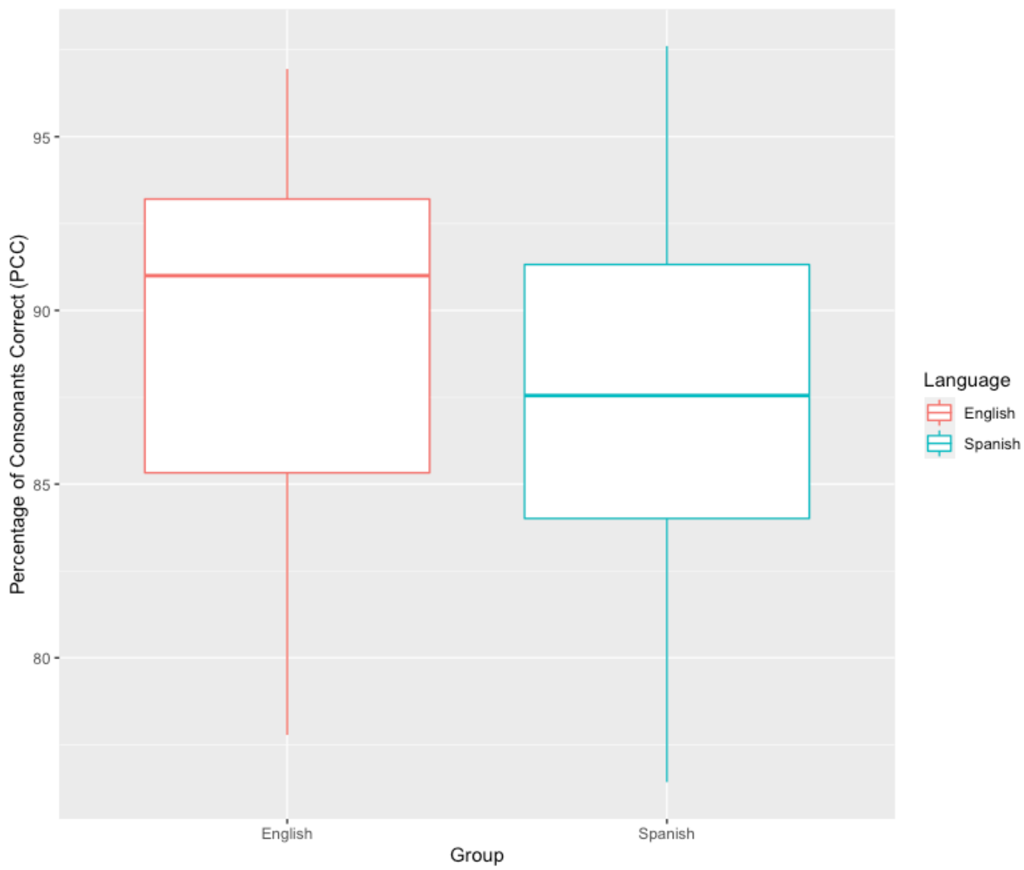
4.3. Spanish

4.3.1. Percentage of Consonants Correct (PCC-R) in Spanish

Figure 13 includes the PCC-R scores in Spanish (mean = 87.92, SD = 5.53) and in English (mean = 87.35, SD =5.38) among the bilingual group, including the Confidence Intervals for each group. The English PCC-R scores are repeated in this section for comparison purposes, as Figure 13 represents the overall accuracy rate for the bilingual group's languages. As seen in

Figure 13, Spanish productions overall were less accurate, with a median at 85% and variance within this variable.

Figure M.PCC-R scores for the bilingual participants in Spanish and English tasks



This figure illustrates that the Spanish productions were not as accurate as the English ones in terms of PCC-R. Although the Spanish productions showed more variability than the English productions, the PCC-R scores were still above 85% for most of the bilingual participants.

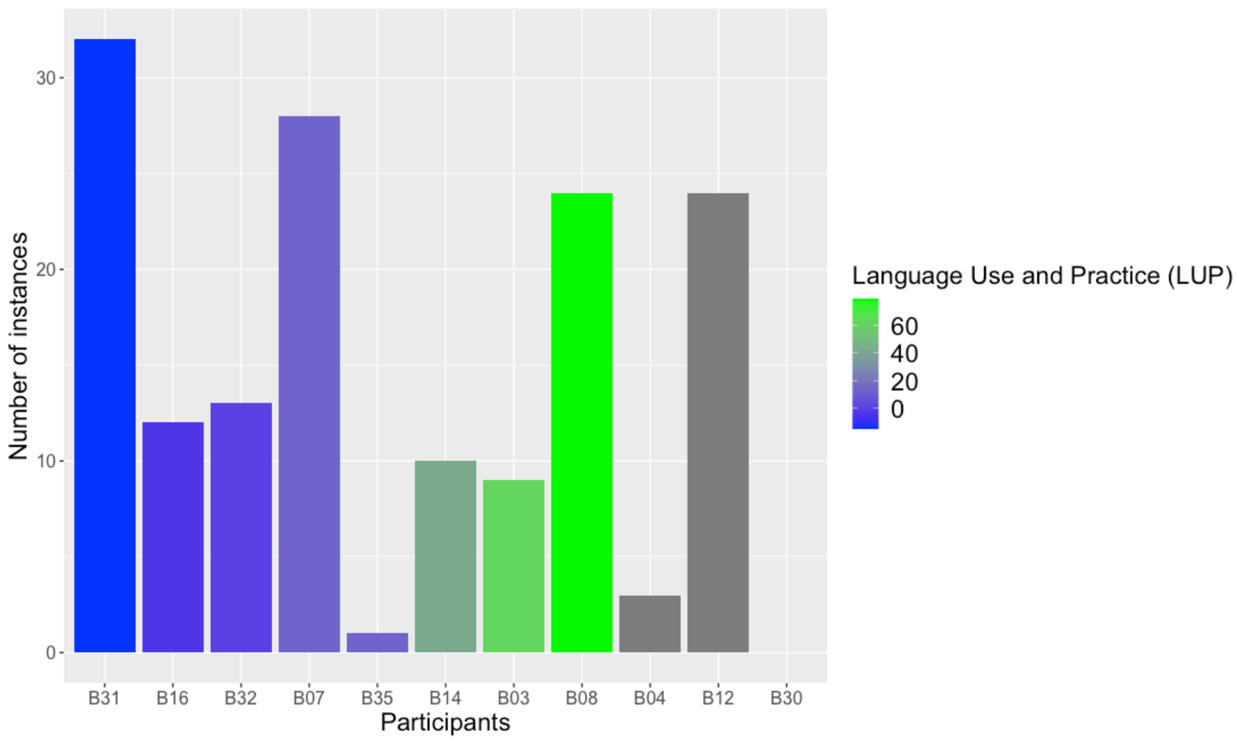
4.3.2. Onset Glides in Spanish

The group of bilingual children in this study presented variation in regard to the strengthening of glides in onset position. Appendix 6 and 7 (in Appendix) display the percentage of consonantized glides for these children. As shown in Appendixes 6 and 7, the production of non-consonantized glides was found in all children but alternated with the consonantized glide for some of them. Despite this variation (between strengthened consonantal realizations of the glide and non-strengthened ones), most children did not present gliding as a substitution pattern, with a couple of exceptions (B07 and B31, cf. section 5.3).

4.3.3. Substitution Patterns for "Gliders" in Spanish

As this dissertation aimed to explore the substitution pattern of gliding, we further explored the Spanish productions of the bilingual children who showed gliding in English. Taking the subset of the bilingual participants who presented gliding (N = 11), this group accounted for 34.06% of the total number of errors, and these errors were spread across all syllabic positions in Spanish. Figure 14 shows the number of errors for each bilingual child. The dominance score was used to compare the accuracy rates of children within the bilingual group, in order to see if exposure to Spanish, as well as the amount of exposure and use, had an effect on the accuracy of late-developing sounds /r/ and /l/ in Spanish. The color of the bar gives the relative dominance score of this group: the darkest colors represent these children who were more dominant in English, and the lighter colors, those who were more dominant in Spanish. The three grey columns represent the children with no dominance score as the parent's report was unavailable at the time of the analysis.

Figure N. "Error" count in Spanish rhotics and laterals



As seen in Figure 14, the frequency of errors was variable within the subgroup of bilingual children. B31 and B07 exhibited the highest number of errors, followed by B8. It is important to note that all these three children (B31, B07, and B08) had comparable scores among them, and still displayed an error rate higher than 25 instances. Overall, Spanish rhotics and laterals were less accurate than English rhotics and laterals for this subgroup of bilingual preschoolers.

In regard to substitution patterns in Spanish, the fourth research question asked whether the bilingual group of preschoolers would exhibit any cross-linguistic effects in rhotics and lateral's phonological error patterns. The substitution patterns corresponding to the Spanish productions of the group of "gliders" can be found in Table 7. Overall, we can see that the bilingual group behave as expected in Spanish, as their substitution patterns were coherent with what have been found in Spanish early acquisition of speech. The subgroup of bilingual children examined in this section displays substitution patterns that correspond to Spanish language acquisition, such as laterals replaced with Spanish taps, trills produced with taps; rhotics and laterals produced as [ð], and sound deletion. The percentage of substitutions of rhotics seems to be higher than those of laterals. Moreover, gliding was found as a substitution pattern for Spanish late-developing sounds /r l/. Interestingly, the labiovelar glide as well as the palatal glide were equally present as instances of gliding in Spanish. Apart from gliding, crosslinguistic effects were also found in other substitution patterns in Spanish, such as the English rhotic for the Spanish rhotic.

Table 7. Spanish substitution patterns

Substitution pattern	Percentage of substitutions	Total substitutions by total amount of opportunities
Rhotic for [ð] *perro* > [péðo]	10.90%	35/313 words
Rhotic for [l] *mariposa* > [malipósa]	4.67%	15/313 words
Trill [r] for tap [ɾ] *perro* > [péɾo]	20%	13/65 words
Lateral for [ð] *cumpleaños* > [kumpðjáɲos]	0.88%	2/225 words
Lateral for rhotic *cumpleaños* > [kumpɾjáɲos]	2.12%	5/225 words
Sound deleted	*8.34%*	45/539 words
Rhotic for [w] in Spanish *fresa* > [fwésa]	1.59%	5/313 words
Rhotic for [j] in Spanish *reloj* > [jelóx]	1.89%	5/313 words

Lateral for [j] in Spanish *delfín* > [tɾejfín]	2.65%	6/226 words
English rhotic in Spanish *estrella* > *[*estɹéja]	7.66%	24/313 words
Total	28.94%	156/539 words

4.3.4. Overall Accuracy for Late-Developing Sounds by Syllabic Position in Spanish

In Spanish, the production accuracy of rhotics and laterals varied among all the bilingual children of this sample. Overall, 23.91% of the Spanish sample presented errors (458 errors out of 1926 words). All bilingual children clearly showed they were navigating late-developing laterals and rhotics at this stage of early acquisition of speech, not only the group of “gliders”. Specifically, bilingual children exhibited a higher number of errors in the production of trills and taps in Spanish, as expected for this age. Regarding syllabic positions, late-developing /r l/ in coda positions presented some errors as well as multisyllabic words with more than one /r l/. The error rate of both rhotics in the onset combined was also high. 8 displays the raw numbers and error rates in Spanish for this group.

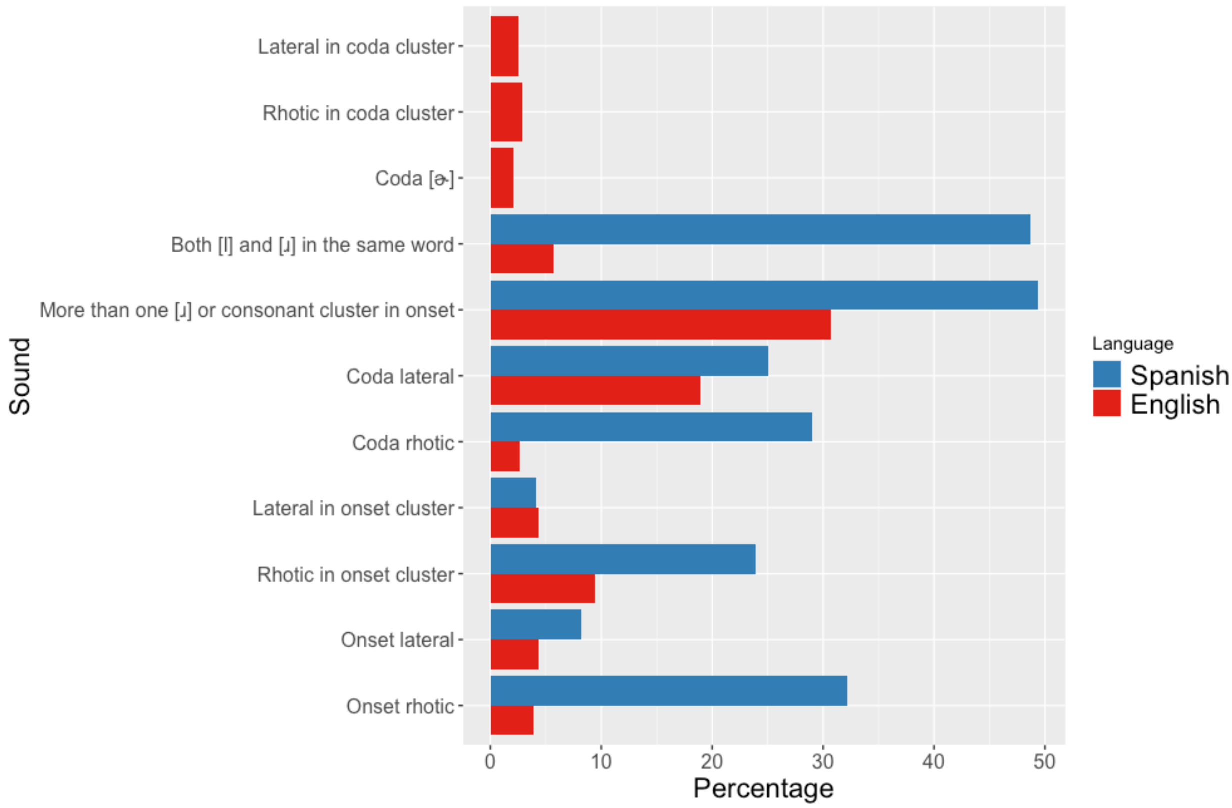
Table 8. Bilingual group. Spanish errors

Sound	**Percentage of errors**	**Number of “errors” by total amount of opportunities**
Onset [r]	32.15%	100/311
Onset [ɾ]	15.51%	74/477
Onset [l]	8.19%	24/293
[ɾ] in onset cluster	23.95%	91 /380

[l] in onset cluster	4.16%	13/312
Coda [ɾ]	28.97%	51/176
Coda [l]	25%	29/116
Both [l] and [ɾ] in the same word	48.71%	38/78
More than one [ɾ] or consonant cluster in onset position	49.35%	38/77
Total	23.91%	458/1926

Figure 15 illustrates the percentage of errors across languages for this group. Words containing Spanish rhotics and multisyllabic words with more than one /r l/ sound are the type of words with less accuracy, as the percentage of errors is higher for these two contexts. Additionally, bilingual preschoolers struggled with rhotics and laterals sounds in coda position in Spanish. Figure 15 compares the Spanish error rates with their productions in English based on the syllabic contexts. In Figure 15, we combined both percentages of trills and taps in the onset to capture the percentage of errors in this syllabic context rather than separate the two sounds. In addition, the figure includes the three phonotactic contexts that only apply to English (vocalic [ɚ] in coda position, rhotics in coda clusters and laterals in coda clusters). The results of this analysis showed that /r, l/ in Spanish presented more errors than English /ɹ l/ for Spanish-English bilingual children across all syllabic positions.

Figure O. Overall "error" count of rhotics and laterals in Spanish and English organized by syllabic position



The syllabic position accuracy was analyzed in terms of word items, in order to explore if the error productions from the bilingual children were dependent on specific words or specific late-developing sound, rather than on syllabic position. Figure 16 displays the overall error productions of words containing rhotics, and Figure 17 corresponds to the overall error productions of words containing laterals. Words containing trills were the most difficult to produce, leading the overall error rate when they appeared between vowels (as in *perro* (dog) or *burro* (donkey)). The word *verde* (green), and the word *delfin* (dolphin) were also difficult to pronounce, counting with more than 15 errors, with the tap or the lateral in coda position in middle position of the word. Additionally, there were more words with onset clusters presenting errors than single consonants in other positions of the words.

Figure P. "Error" frequency of target words with Spanish rhotics

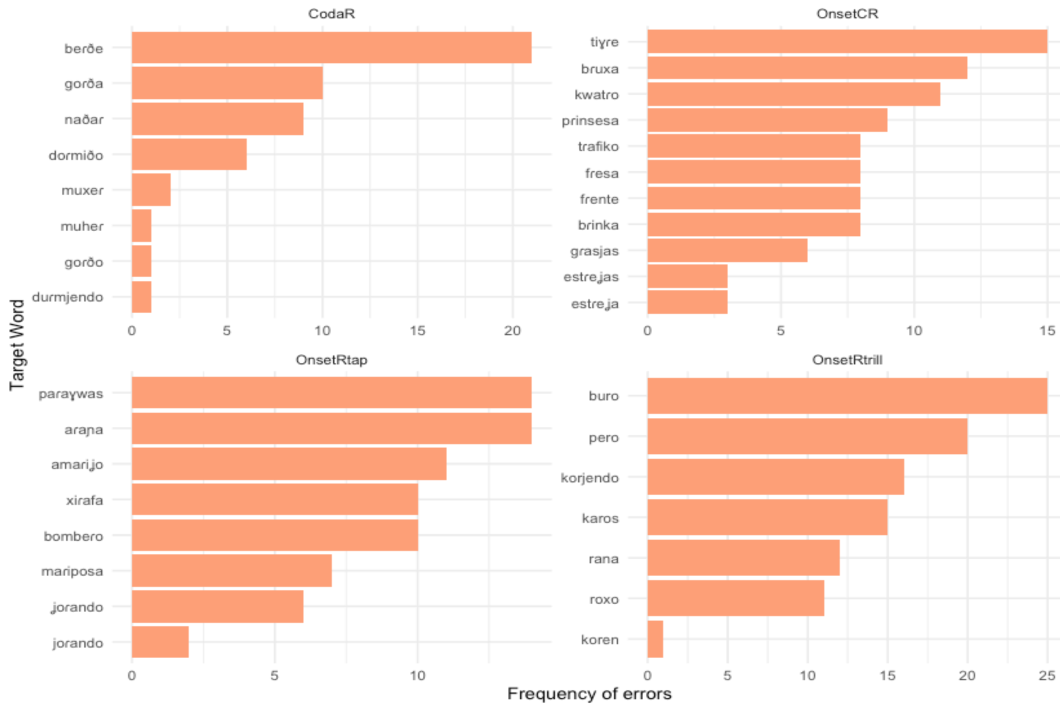
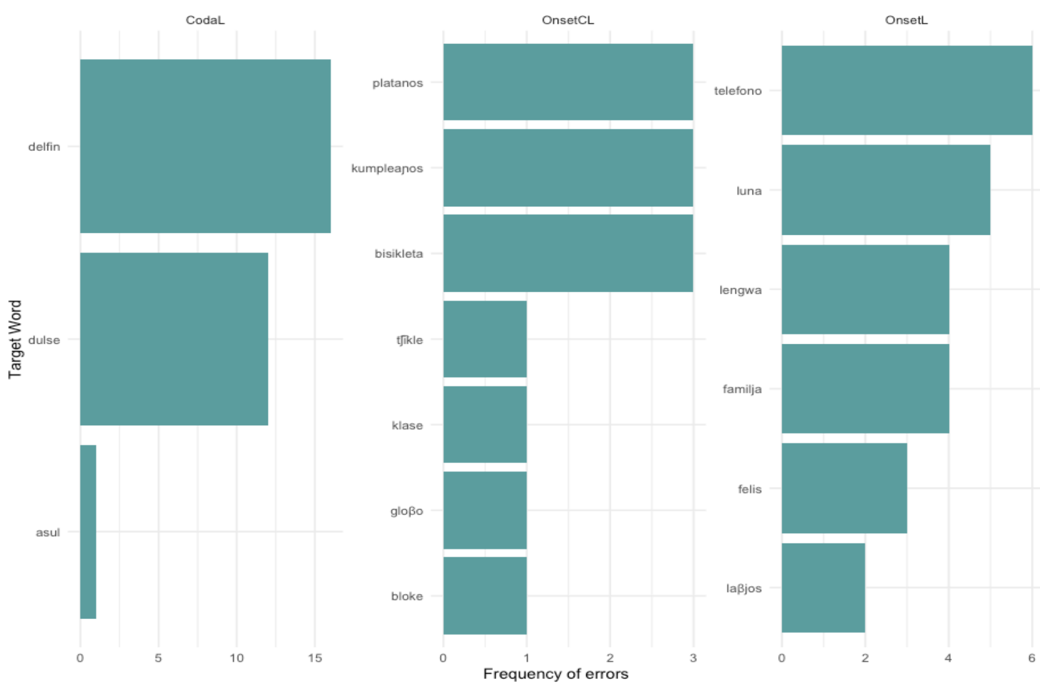


Figure Q. "Error frequency of target words in Spanish laterals



4.3.5. Socio-Cultural Components for Preschoolers with Exposure to Spanish

To understand between-language interaction and if there is a correlation between home language use (Spanish or English, or both) and the late-developing /r l/ accuracy, we further explored the socio-cultural context of the bilingual preschoolers. Table 9 includes the language context of the subgroup of children who exhibited gliding in English. The language context in this section is assessed by a) the dominance score (their LUP score that ranges from -100 as a monolingual English speaker to +100 as a monolingual Spanish speaker) corresponding to each child, b) the home language the family reported as the primary language, and whether one or both languages where used at home; and c) the number and age of the siblings in the household, as well as the language they used at home to interact with the participant.

Table 9. Home language use for the bilingual "gliders" group

ID	LUP	Percentage of English gliding	Home language	Number of siblings	Ages of siblings	Siblings' language with child
B16	+2.72	2.7%	Spanish	1 brother	7	both
B12	NA	2.94%	NA	NA	NA	NA
B03	-62	3.13%	Both	2 cousins	13, 15	English
B04	NA	3.13%	NA	NA	NA	NA
B30	NA	3.13%	NA	NA	NA	NA
B32	0	3.23%	Both, mostly English	no	na	NA
B35	+13	3.33%	Spanish	1 sister	0;8	NA
B08	-62.5	3.45%	Both	cousin (not at home)	na	NA
B31	-14.8	6.45%	Both, mostly English	1 sister	2	NA
B14	+45	12.12%	Spanish	4 brothers and	2,2,8,9	both

				sisters		
B07	+14	53.57%	Spanish	no	na	na

The children with negative bilingualism scores used English as well as Spanish at home. B03 and B08 presented the highest scores towards English dominance (-62, -62.5 respectively), and both children reported interacting often with their cousins in English. We cannot draw any conclusion for B08 as the ages of their cousins were not reported, but B03 showed a clear preference for English with their older cousins. In contrast, when Spanish is used at home with siblings, the child's bilingualism scores range towards the Spanish-dominant side of the continuum. That is the case for B14 and B16, as Spanish is reported as their home language, as well as one of the languages the child uses to interact with their siblings. B07, B31, B35, and B32 showed balanced use of English and Spanish as their LUP's scores fell in the center of the continuum. It is important to mention that these children did not speak with their siblings either because they did not have siblings (as it was the case for B07 and B32), or their siblings were babies at the time (B31 and B35's case). Overall, there seems to be a correlation between the language used at home with siblings and young relatives in the family and the LUP: if the preschoolers had opportunities to talk with their siblings and cousins in Spanish, their bilingualism scores show dominance towards Spanish; if the child only spoke English with their siblings/young relatives, bilingualism scores fell into the English dominance range. When children were unable to speak with young siblings at home, their bilingualism scores stayed balanced in both English and Spanish.

If we take the percentage of gliding in English into account, the bilingual children with the highest percentages of gliding were B07, B14 and B31. According to the LUP's score displayed in Table 9, we can see that B07 and B14 show a stronger dominance towards Spanish than B31. These two children seemed to have issues with both languages in similar error rates. Spanish as a home language seems to prevail for these three children, specifically in the case of B14 as he uses Spanish with their parents as well as their brothers and sisters. However, neither B07 nor B31 had siblings at the time of the assessment.

Table 10 includes a more detailed look at the results for children who exhibited cross-linguistic effects in their productions of late-developing rhotics and laterals Spanish, as well as their corresponding substitution patterns. Interestingly, bilingual children showed two clear cross-linguistic patterns: either they exhibited gliding in Spanish or they transferred the English rhotics to the Spanish words. Moreover, how the cross-linguistic effects surfaced was also very specific to each child, as each of them showed a slightly different pattern of transfer. For instance, B07 accepted gliding in onset with palatal [j], whereas B31 accepted consonant cluster gliding with [w]. B07 and B31 were the only children who exhibited gliding in Spanish, the rest of the cross-linguistic effects were in regard to the English rhotic into the Spanish productions. B16 transferred their English rhotics to the Spanish words, but only substituting the tap and one instance of [l] in coda position. B30 and B12 also transferred their English rhotic into their Spanish productions for both consonant clusters and trill in onset position. Unfortunately, we cannot draw any conclusion regarding their cross-linguistic effects as LUP was not available. Lastly, B14 only exhibited one instance of English rhotic in the word *corriendo* (to run[ning]). It is important to mention that all these six children showed a high percentage of errors in Spanish with late-developing /r l/ independently of their LUP score. More data is needed to draw any conclusion in relation to the correlation between language dominance and cross-linguistic effects as this sample is not large, but we can see a tendency between language exposure and error rates in both English and Spanish. All children with cross-linguistic effects have a higher error rate in

Spanish than in English. B07 and B14, both preschoolers with a positive LUP score, seemed to struggle the most with late-developing rhotics and laterals in both languages, as the percentage of errors was almost balanced in both languages. For B07, half of the English and half of the Spanish sample presented errors in words with /ɹ l/, and B14 followed this tendency in a lower scale, as his percentage of gliding was at 12.12% (4 instances of gliding in total) and his Spanish error rate at 21.27% (10 instances). For B31, the only child with a negative LUP score that exhibited cross-linguistic effects, the percentage of gliding was low (6.45%, two instances), but the error rate in Spanish was even higher than B07, with 66% of the sample with errors in the late-developing sounds (23 instances). B16 followed the same tendency of B14, with 2.7% of gliding (one instance) and a Spanish percentage of errors of 24% (12 instances), and he presented a positive LUP score close to 0. We are unable to discuss the tendencies for B30 and B12, as they did not have a LUP score available for the analysis.

For the two children with gliding in English who fell right in the middle of the continuum of the LUP (B07 and B31), it seems that navigating the late-developing rhotics in English and Spanish created interference in the direction to Spanish, as gliding was found in English and Spanish. This might indicate that these children are having more trouble separating both language phonological errors while acquiring their phonological systems. For the rest of the children, English rhotic in Spanish words with rhotics was frequent, rather than gliding in Spanish. These children seemed to prefer replacing one sound from the other language that "fits" into the same context than to recur to a phonological process, which would interact with the whole phonological system.

Table 10. Cross-linguistic effects in the Spanish productions within the "gliders" group

ID	LUP's score	Percentage of Gliding in English	Percentage of late-developing /r l/ sounds's errors in Spanish	Gliding in Spanish	English rhotic in Spanish
B07	+ 14	53.57%	58.33%	3 instances [majposa] [jeɣalo] [jelox]	0 instances
B14	+45	12.12%	21.27%	0 instances	1 instance [koɹjendo]
B31	-14	6.45%	66.66%	4 instances [fwente] [fwesa] [pwinsesa] [sombweðo]	0 instances
B30	NA	3.13%	29.79%	0 instances	4 instances [fɹesa] [gɹasjas] [ɹana] [ɹoxo]
B12	NA	2.97%	50%	0 instances	13 instances [bɹuxa] [buɹo] [estɹeʝas] [fɹente] [fɹesa] [kaɹos] [kwatɹo] [lagɹima] [peɹo] [ɹana] [ɹoxo] [tiɣɹe] [tɹafiko]
B16	+ 2.72	2.7%	24%	0 instances	5 instances [beɹðe] [bɹuxa] [taɣɹima] [muxeɹ] [paɹaɣwas]

					[dɚ fin]

CHAPTER 5. Discussion

5.1 Introduction

The present study was undertaken to examine the overall description of the gliding substitution pattern for late-developing sounds /ɹ l/ by bilingual preschoolers in Southern Arizona. The main aim was to compare the substitution patterns based on language background and exposure to Spanish. Additionally, the present study also contributes to the existing literature on English-Spanish interactions for bilingual children in the early stages of speech acquisition. Specifically, this dissertation intended to answer the following questions:

RQ1: Does the phonological process of gliding surface in English as the substitution pattern for both bilingual and non-bilingual Spanish-English preschoolers?

RQ2: Are bilingual Spanish-English preschoolers and their non-bilingual counterparts equally accurate in the production of late-developing rhotics and laterals in English?

RQ3: Does syllabic position matter in terms of late-developing rhotics and laterals' substitutions?

RQ4: Are there any cross-linguistic effects based on the degree of bilingualism?

RQ5: For bilingual children, are any of the socio-cultural components that affect substitution patterns and/or production of late-developing sounds (e.g. home language, language exposure and use, birth order) relevant in terms of late-developing sound accuracy?

RQ5: For bilingual children, are there any socio-cultural components that affect substitution patterns, production and accuracy of late-developing sounds (e.g. home language, language exposure and use, birth order, language dominance)?

We predicted that children with exposure to Spanish would exhibit low percentage of gliding in their English productions (RQ1) but would demonstrate an equally low accuracy rate for late-developing sounds as their monolingual counterparts (RQ2). Regarding syllabic position, we predicted that the late-developing rhotics and laterals would present more instances of gliding in onset positions for both groups (RQ3). In addition, we expected that both phonologies for the bilingual Spanish-English group of children would show that they are developing individually, but with some interactions, and this between-language interaction would surface differently based on the LUP (RQ4). Lastly, the late-developing rhotics and laterals would be expected to differ among the bilingual group based on language exposure of Spanish at home, as well as the language they would use with their siblings (RQ5). The research questions were examined by semi-spontaneous, single-word production data for 61 children growing up in Southern Arizona. Twenty-two of these children were monolingual speakers of English and 39 were bilingual Spanish-English children. All the monolingual children participated in a word-elicitation task containing late-developing English sounds, and all bilingual Spanish-English children participated in the same word-elicitation task both in English and in Spanish.

5.2. Substitution “Error” Patterns for Late-Developing Sounds /ɹ l/

This section discusses the main findings by providing the results for English productions, Spanish productions, and the interactions between English and Spanish. The first two research questions (RQ1-RQ2) asked whether bilingual children would exhibit the phonological error pattern of gliding, and whether their accuracy rate would mirror that of their English-speaker counterparts. Sixty-one children were included in the analysis of this dissertation (39 bilingual and 22 monolingual preschoolers) but only 22 of them produced instances of gliding in their English productions. Out of the 39 bilingual Spanish-English children, only 11 exhibited gliding in English. The analysis of the overall error frequency of late developing rhotics and laterals indicated that the group of children with exposure to Spanish presented fewer gliding instances than their monolingual counterparts. Apart from participant B07 who presented a percentage of gliding of 53% over the whole assessment, the bilingual group's mean percentage of gliding was below 10% (mean of the percentage of gliding at 8.83%) and their late-developing sounds /ɹ l/ in English were not accurately produced 6.13% of the time. For children with no exposure to Spanish, half of the group presented instances of gliding, their percentage of gliding was higher (mean of the percentage of gliding at 16.26%) and, overall, the group's late-developing sounds /ɹ l/ in English were not accurately produced 16% of the time. Apart from gliding, sound deletion was the most common phonological error pattern, with 17 instances in the English of the bilingual preschoolers, and only four times in the monolingual group. Overall, gliding was the most common phonological error pattern for both all children in the dissertation, but the accuracy rate was significantly lower for the monolingual group of children. Interestingly, both groups exhibited some instances of sound deletion, but the proportion was higher in the bilingual group compared to the monolingual group.

Previous studies have found that gliding is a recurring pattern in English until the age of five (Bernthal, et al. 2017, James 2001, Stoel-Gammon and Dunn, 1985). Overall, our findings fall in line with what has been documented previously in monolingual English preschoolers, as gliding was present in 50% of the monolingual preschoolers. This was not the case for children with exposure to Spanish, as it was present in only 28% of the group, and instances were sporadic among this group. The difference between these groups of children in terms of their percentage of gliding was found statistically significant. Our study validates previous work examining the phonological error pattern of gliding for monolingual English speakers but adds to the description of gliding for typically developing English-Spanish bilingual children in Southwestern US. Additionally, the fact that the bilingual group exhibited more sound deletion instances in relation to the monolingual counterparts may be associated to gliding as well, rather than higher accuracy of rhotics and laterals. In other words, if bilingual children were not able to produce these late-developing sounds, they may delete the sound completely rather than substituted it by a glide.

In terms of syllabic context (RQ3), the results of this study were in line with the syllabic markedness for each language. Errors were slightly more frequent in consonant clusters than in single onset elements, and the error rate for rhotics and laterals in the coda was lower than in the onset. All children exhibited a low accuracy rate in words like *strawberry*, the most marked syllabic context. A combination of flap and consonant cluster with /ɹ/ creates a highly complex context; therefore, this low accuracy rate was expected. Aside from this highly marked context, the errors were distributed across the rest of the syllabic context. The results of the MANOVA yield practical significance in terms of error rate between both groups across the syllabic context. Children with exposure to Spanish showed equal frequency of errors in rhotics and laterals in the onset, with a slightly higher error rate in onset clusters in English (e.g. words such as *screw*). For the monolingual group, onset /ɹ l/ exhibited slightly more errors than /ɹ l/ in the coda. Even though more data would be necessary to argue that the syllabic context might have a strong effect for these children, these results may be interpreted in regards to saliency for each language. Spanish does not contain three-sound consonant clusters; therefore, it requires more effort for a child with exposure to Spanish to create this syllabic boundary. Additionally, the fact that rhotics and laterals in coda position exhibited less errors in English may have to do with their syllabic status, which excluded them from this phonological process.

In Spanish, highly marked multisyllabic words such as *sombrero* (hat) or *lágrima* (tear) exhibited the largest number of errors. Rhotics were more difficult to pronounce in onset position than laterals in Spanish, but both segments were equally problematic in coda position. Additionally, the error rate for consonant clusters with rhotics in the onset was large, while the consonant clusters with laterals was not. Overall, this small sample of phonological errors showed that, in English and in Spanish there was not a specific syllabic context that was significantly more difficult than others as long as the word was not a multisyllabic highly marked word. If the word was multisyllabic and included more than one late-developing rhotic or lateral, then the probability of errors in that words was high.

The phonetic context played a more important role in terms of gliding and substitution patterns than the syllabic position as there were some tendencies in line with the language's saliencies. For the subgroup of children who exhibited gliding, the more frequent words for each group were *strawberry* and *screw*. The rest of target words with onset clusters that presented more errors were *present, green* and *brush*. Except *strawberry*, that contains a [stɹ] cluster, the rest of the consonant clusters included either a bilabial or a velar sound, therefore the coarticulation towards [w] was not surprising. Additionally, it is important to mention that gliding was not the only phonological error that we found. Bilingual preschoolers also exhibited consonant cluster reductions, indicating that when they struggled with that syllabic context, they were likely to delete the sound completely.

In Spanish, errors in words with rhotics in onset clusters were also frequent, as in *tigre* (tiger), *bruja* (witch), *cuatro* (four) and *princesa* (princess). However, the target words with the highest error rate were *burro* (donkey) and *perro* (dog), followed by the words *verde* (green) and *dulce* (dessert). Taking all these examples into account, we can suggest that, overall, rhotics were more problematic than laterals, and that trills were more difficult for preschoolers to produce than taps. These tendencies were also in line with previous studies that have explored consonant accuracy in English and Spanish (Fabiano-Smith and Goldstein 2010a).

The fact that the bilingual group exhibited a lower error rate of late-developing /ɹ l/ in English compared to the monolingual group seems to indicate that children with exposure to Spanish did not struggle with these late-developing sounds in English as much as their monolingual counterparts. When analyzing the Spanish productions of this subgroup of bilinguals, the accuracy rate of rhotics and laterals was at 71.09%. Fabiano-Smith and Goldstein (2010a) found that, for 3;0-4;0 preschoolers, English rhotics and laterals were at 70% accuracy for both monolingual and bilingual children, the Spanish lateral was also 70% accurately produced, and accuracy of rhotics fell below 50% for both groups. Taking Fabiano-Smith and Goldstein (2010a) into account, the results of this dissertation suggest that, Spanish-English bilingual preschoolers in Arizona were organizing their phonological representation of late-developing rhotics and laterals according to each language, but in a slightly different order of acquisition as compared to monolinguals. These findings can be interpreted as a case of acceleration (Paradis and Genesee 1996) in English, as children whose Spanish speech development competes with their English at the early stages of phonological acquisition may create a mechanism of distributing the articulation of both consonant inventories.

Interestingly, the fact that English rhotics were accurately produced before the Spanish rhotics for the bilingual group, even though these findings are in alignment with previous work, might indicate that the bilingual phonological systems may be creating a new order of acquisition of these sounds that does not correspond to the monolingual norm. These findings in terms of accuracy of rhotics and laterals may suggest that, for bilingual children, the broader inventory might align with the phonology of each individual language (Curtin et al., 2011), but the individual speech sound categories might develop using cross-linguistic information. Children receive input in both languages at these early stages of acquisition, and they need to sort the sound system to their corresponding language. Their phonological system might develop in a way that does not parallel the monolingual system of either of their languages.

5.3. Theoretical Implications

The findings of this dissertation also yield some cross-linguistic effects (RQ4). A possible interpretation of this asymmetrical error rate in English between monolingual and bilingual children could be that there is an interaction between Spanish and English glides. The PRIMIR framework predicts that children sort acoustic information based on similarity, co-occurrence, and regularities from a given speech signal (Werker and Curtin, 2005), and then encode the language-specific phonetic category representation for each language (Curtin, Byers-Heinlein, Werker, 2011). The fact that glides are acoustically shared sounds in both English and Spanish creates a high-frequency co-occurrence for bilingual Spanish-English children. Nevertheless, the information that is sorted in their phonetic category representation may fit into each corresponding language's syllabic structure, creating between-language interactions or differentiating each language's context (Curtin, et al., 2011). If we assume, even in the Sonoran dialect that allows Spanish glides in the onset, that Spanish glides are allophones of high vowels that surface as non-syllabic and non-consonant in specific phonotactic contexts (Hualde 1997), and that they are not considered a phonemic category (Hualde 1991, 1997), then English gliding as a substitution pattern for English laterals and rhotics may not be as coherent in English for bilingual children as it is for their monolingual counterparts.

Another interesting aspect of these findings is that preschoolers showed a similar error rate for gliding in words with laterals and words with rhotics regardless of their language background. Words containing rhotics were produced with slightly less accuracy than words containing laterals, but, overall, substitutions from liquids to the labiovelar approximant glide [w] were equally balanced within each group. Additionally, the labiovelar glide was also found as the only substitution pattern for consonant clusters in words with /l/ and with /ɹ/, supporting the asymmetry of the syllabic affiliation of C[w]V to the onset --whereas the glide in C[j]V would be mapped to the nucleus of the syllable-- (Davis and Hammond, 1995). That gliding surfaced as labiovelar glide instead of the palatal glide suggests that children were substituting a consonant for another consonant in onset position. [w] was also found in the gliding instances in the Spanish productions of B31. This bilingual child was the only one who exhibited gliding in consonant clusters in Spanish (e.g. *princesa* (princess) pronounced as [pwinsesa]). B07, who also had gliding in Spanish, produced with the palatal glide [j] in onset position (as the word *regalo* (present) pronounced as [jeɣalo]), unlike B31. This difference between the realizations of gliding in B31 and B07 in Spanish could also be a reflection of cross-linguistic effects and the differences in the phonological status of glides in Spanish and English. Allowing the labiovelar [w] as a substitution for the late-developing /ɹ/ and /l/ in consonant clusters suggested that B31's phonological system accepted an English-like substitution pattern in Spanish. B07 presented gliding with [j] in onset position, a phonotactic context that is allowed in some varieties of Spanish (without consonantization/strengthening) and in English (see section 2.6.2 on onset glides in Sonoran Spanish)

If we take a closer look at the results for B07 and B31 we can observe how language use and dominance play an important role in the substitution process of gliding in English and

Spanish. These two bilingual preschoolers had several elements in common: they were both equally exposed to Spanish and English as their LUP score was close to zero (B31 = -14.8; B07 = +14); they matched in age (B31 = 4;6, B07 = 4;7); neither of them had siblings at home, and they both exhibited gliding in English (B31 = 6.47%, B07 = 53.57%).

We argue that the slight preference towards one language or the other was crucial for these two children, as illustrated in the direction of the cross-linguistic effect. In the case of B07, who is exposed only to Spanish at home, rhotics were not produced on target for either language, as he presented an error rate of 58.33% in Spanish and 53.57% of gliding in English. As previously stated, gliding was found in his Spanish productions, leaning towards a more Spanish-like production of [j] in the onset ([jeɣalo] for the word *regalo* (present), and [jelox] for the word *reloj* (watch)) and one instance of gliding in coda position ([majposa] for the word *mariposa* (butterfly)). It is important to mention that B07 strengthened the onset glides 80% of the times in the Spanish sample, but it seemed that gliding was permeable enough to transfer to his Spanish to some extent. We cannot determine whether the production of *mariposa* surfaced as a falling diphthong because the rhotic was deleted or substituted. However, in the other two examples gliding occurs in the onset, as the rhotic was replaced by the palatal glide [j]. Onset [j] was not strengthened ([ʝelox] or [ʝeɣalo]). The findings on gliding in Spanish for this child indicated that gliding as a phonological error pattern was allowed within the Sonoran Spanish dialect's saliency. This dialect of Spanish allows glides in the onset, therefore the gliding instances that we observed in B07 could be the result of transfer of this phonological pattern from the English sound system and/or the phonetic context that allows Spanish glides in onset position, which could have had a facilitative effect.

B31, however, showed an error rate in Spanish of 44% and his percentage of gliding was at 6.45% in English. This bilingual child was raised in a mostly English dominant home. This child showed a slight preference towards English throughout the assessment, as he usually initiated spontaneous responses in English first and was asked to switch back to Spanish in the ASP. The gliding instances that were found in his Spanish productions were only in consonant clusters (the word *frente* (forehead) as [fwente], the word *fresa* (strawberry) as [fwesa], the word *princesa* (princess) as [pwinsesa], and the word *sombrero* (hat) as [sombweðo]).

These two case studies illustrate that, even with similar exposure to both languages, children may still show tendencies that agree with the language they have greater exposure to and that they show a preference for. Another detail that may be relevant for these two children is the fact that neither of them has siblings at home to interact with. B07 lived with his Spanish-speaking grandmother, whereas B31 was close to his Spanish speaking grandfather.

Even though more information is needed to conclude why these two children were performing differently, the findings on these two case studies indicate that we should include socio-cultural components as home language (Hammer et al., 2009; Gutiérrez-Clellen and Kreiter 2003) and linguistic network (Bohman et al., 2010; Rojas et al. 2016) to understand the bilingual children's language performance rather than consider all bilingual children as a monolith. If we can account for the heterogeneity of the input and use of the minority and majority languages, and comprehend the relationship between bilingual input and the phonological processes that children exhibit, we may be able to establish a solid foundation of bilingual acquisition of speech. This baseline will contribute to a more accurate diagnosis of Latinx children, as it will allow us to compare bilingual acquisition with bilingual speech normative data, rather than comparing bilingual output with monolingual output.

5.4. Socio-Cultural Components and Late-Developing Rhotics and Laterals for Bilingual Children

RQ5 asked whether there were any socio-cultural components, such as home language exposure and use, birth order, or language preference, affecting the accuracy of late-developing sounds. Overall, we predicted that the sociolinguistic background would have an effect in terms of error rate, and we found a tendency in the small group of children with gliding in English. Specifically, we noticed that there was a correlation between language use at home with siblings and young relatives in the family and the degree of bilingualism of these children. These findings aligned with Rojas et al. (2016), as we also found that siblings' language use was influential in determining the language preference and dominance. Additionally, the correlation with language exposure to the minority language seemed to have an effect on the accuracy of late-developing sounds /ɹ l/, as children with more exposure to Spanish either had issues with late-developing sounds /ɹ l/ in both languages (the case for B07 and B14) or only with Spanish late-developing rhotics and laterals (the rest of the group of bilingual children with gliding).

Besides this effect on sibling's language use, we also found that, for the three bilingual children who presented the highest percentages of gliding, there may be a relationship between the percentage of gliding and the LUP scores (i.e. dominance in Spanish was associated with less gliding in English). As predicted by the PRIMIR framework, the more exposure the children had to co-occurring sounds, the more likely the phonological system would create clusters of phonetic representations and form their phonological categories. Glides are high-frequency sounds in English and Spanish. If we assume Spanish glides are allophonic variations of the high-vowels /i u/, bilingual children would map Spanish glides to the vocalic inventory and English glides to the consonant inventory. If, however, late-developing sounds involve glides as their substitute, when this substitution is not recurrent in Spanish, Spanish-English bilinguals.

Unexpectedly, B14 and B07, the two children among the bilingual group with the highest percentages of gliding in English, had a positive LUP score towards Spanish dominance (+14 and +45 respectively). B31, on the contrary, had a negative LUP score (-14) and the lowest percentage of gliding of the three (6.46%) in English. What is important to notice between these three children is that, as mentioned in section 5.3., B07 and B31 transferred their gliding pattern into Spanish, and both children were close to the 0, therefore they were truly “balanced” bilinguals as they were almost equally exposed to both languages. On the contrary B14 did not exhibit any instance of gliding in Spanish. Specifically, B14 presented a 21.27% of errors in Spanish, and only the word *corriendo* displayed some traces of the English phonology, as he produced the word as [koɹjendo], changing the Spanish trill for the English rhotic. His LUP score was +45, and the rest of the phonological error patterns in his Spanish were in line with the Spanish substitution patterns (examples of this participant's errors were words like *burro* produced as [buɾo], as well as the alternation between laterals and rhotics as the word *regalo* pronounced as [legaɾo]). What seems to be different between B07, B31, and B14 in terms of the socio-cultural background is that B14 spoke Spanish at home and used both English and Spanish with his siblings, whereas B31 and B07 did not have children to communicate with at home as they did not have siblings at the time.

As it can be noticed, bilingual children in this study had different degrees of language exposure in the minority language at home while all were learning English at school. These findings suggest that language exposure at home and interaction with siblings might have an effect on the early acquisition of speech as well as the phonological error patterns. Children with a balanced exposure to both languages at home seemed to exhibit language interaction in both phonological representations and phonological errors. Although we cannot draw any conclusion towards the possible correlation between language at home and phonological representation, this dissertation has contributed methodologically to account for the heterogeneity of the bilingual group of children and to compare bilingual speech to bilingual speech within this small data set. Future studies should examine a larger number of bilingual children with gliding to observe socio-cultural components more closely, as well as between-language interaction between both languages, strengthening our understanding of typical bilingual phonological representations.

5.5. Clinical Implications

This study provides a framework for analyzing phonological error patterns that bilingual children may exhibit in their early stages of speech acquisition. The findings clearly showed different phonological error patterns between the monolingual and the bilingual preschoolers, as well as differences within the bilingual groups based on language exposure and LUP. These linguistic and socio-cultural components need to be included in any bilingual assessment of speech that aims to assess language diversity within the general population. This study also reinforces the importance of including parent reports in a child's language profile to understand the speech of each specific child. As shown here, bilingual speech varies, and this variation is correlated to the input the children are receiving in each language. Yet, bilingual speech variation can only be explained if the sociocultural context of acquisition is available.

Even though preschoolers in Southern Arizona are attending English-only education, being exposed to Spanish at home may be "bootstrapping" their proficiency of the English rhotics. Interestingly, only children who were exposed to both English and Spanish equally exhibited a higher percentage of gliding, and even for these children they still showed tendencies towards one language or the other. It is important to remember that the phonological error of gliding is expected until the age of 5;0. Bilingual preschoolers are outperforming their monolingual peers in the production of English rhotics at this early stage of speech acquisition. While still exhibiting phonological errors that might raise concerns in the acquisition of English, the mastery of English rhotics indicates that bilingual children cannot be assessed based on monolingual norms. Children with exposure to minority languages at home exhibit their own process of speech sound acquisition, therefore they need to be assessed accordingly. Some studies have supported including language exposure in the analysis arguing for a "gaining traction" effect (Bohman et al. 2010) in both languages (de Houwer, 2007; Gathercole & Thomas, 2009). Specifically, the study by Bohman et al. (2010) examines the effects of input and year of exposure in bilingual speech acquisition and argues that both are crucial measures for the analysis of bilingual speech. This study was in line with previous studies arguing for the importance of input and output as children progress in their acquisition of language domains, such as semantics and syntax, in both Spanish and English (Pascual y Cabo and Rothman 2012; Prada Pérez and Pascual y Cabo, 2011; Bohman et al., 2010; among others).

There is an extensive body of research that assesses the language and speech abilities of bilingual children according to the concept of "incomplete acquisition" (Montrul 2008). This approach to understanding language and speech acquisition leads to the belief that bilingual children are not acquiring language adequately when compared to their monolingual peers (Kupisch & Rothman, 2016; Putnam & Sanchez, 2013; Pascual y Cabo & Rothman, 2012; de Prada Pérez & Pascual y Cabo, 2011). Even though the purpose of this dissertation was not to question the concept of incomplete acquisition, our study aligns with previous studies that have argued against the notion of "incompleteness", as we agree that the goal should be to describe the typical bilingual speech acquisition rather than expect it to become the monolingual norm. . The bilingual speech acquisition system will depend mostly on the input the children are receiving during their first years, and because the language exposure is different, the output may be different as well. More studies that examine how the bilingual phonological systems developed are needed to eventually create a normative baseline for bilingual acquisition of speech and phonological patterns without recurring to comparisons with monolingual communities, accounting for the heterogeneity of the bilingual community

5.6. Limitations and Future Directions

This dissertation presents several limitations that do not allow us to make generalizations to all bilingual children acquiring Spanish and English in the US. Even though the initial sample of preschoolers was large, the group of children with gliding was small. Additionally, the gliding sample did not exhibit a normal distribution, as it was skewed, presenting difficulties to properly conduct the statistical analysis of this data. This specific limitation is implicit in naturalistic data collection, as it is not possible to control the phonological error patterns that would surface in preschoolers' productions. Yet, naturalistic data has the advantage of allowing for the analysis of spontaneous speech samples. Children exhibit different phonological substitution patterns that may not surface if the assessment had an experimental design. Collecting data with children presents challenges in regard to attention to the task, especially when the time is very limited. Therefore, collecting this data in a naturalistic context allows us to get the best of children's sample in a short window of time.

Further work in this area is necessary in order to fully understand the relationship between initial traction in two languages and later attainments in bilingual speech acquisition. This dissertation provides a strong methodology that can be replicated in other groups of preschoolers, as well as other dialects in contact within the US, in order to find more cross-linguistic patterns between phonological acquisition in multilingual communities such as this of Southern Arizona.

5.7 Concluding Remarks

The present dissertation investigated the phonological substitution pattern of gliding in Spanish-English bilingual and English monolingual preschoolers in Southern Arizona. Specifically, it provided a description of the accuracy rates for late-developing rhotics and laterals in English, sounds that are commonly mispronounced by preschoolers. The descriptive accounts and the statistical analysis allowed to confirm that bilingual Spanish-English preschoolers present lower percentages of gliding than the children without exposure to Spanish at home, leading to a new finding that has not been discussed before. More importantly, the findings of this analysis shed light on the accuracy rates of late-developing rhotics. Gliding is not a recurrent phonological pattern in English for bilingual preschoolers, and the English rhotic seems to be acquired earlier than their monolingual counterparts. The results of this study may be interpreted within the PRIMIR framework, that accounts for the separation of phonological representations given the input for each language, and within the Paradis and Genesee (1996) model, as it also showed some traces of acceleration in the direction of English rhotics.

For the bilingual Spanish-English preschoolers, cross-linguistic effects were found in their Spanish productions. Specifically, the LUP provided a scope for the interpretation of language dominance in regards to phonological error patterns, as the children with more “balanced” proficiency skills in both English and Spanish and with higher percentages of gliding exhibited gliding in Spanish as well, but children with stronger dominances towards English or Spanish did not.

To sum up, this study has offered a mixed-methods' analysis to the acquisition of bilingual speech, providing with a new methodological assessment comparing bilingual children to bilingual children, and analyzing the differences between English monolingual children and Spanish-English bilingual children in terms of their phonological system. Lastly, the theoretical contributions of this study fit into the communication disorders' field as it provides new data for the acquisition of late-developing sounds. Gliding may be a very common phonological error in English for monolingual preschoolers, but Spanish-English bilinguals definitely do not exhibit it as often. These findings also have clinical implications, as they illustrate that for bilingual Spanish-English bilingual children, this "expected" phonological error is not frequent. Lastly, the accuracy of late-developing rhotics and laterals in English is high. An interpretation for these finding could be that the bilingual Spanish-English children are in an advantage if we compare them with the monolingual group. However, we are inclined to believe that these results represent the differences in development of the Spanish-English bilingual phonological system based on their exposure to the languages and their correspondent dialects.

Appendices

Appendix A. Children's socio demographic information, BESA/GFTA Scores and PCC-R scores in English (and Spanish for the bilingual group)

ID	Chronological Age in Years and (months)	Sex	Home Language	Siblings	Birth Order	GFTA Score	BESA Score English	BESA Score Spanish	PCC English	PCC Spanish	%bilingualism
B01	5;5 (65)	Male	N/A**	N/A	N/A		115	100	94.33	90.7	N/A
B02	6;3 (75)	Female	both, mostly Spanish	yes (5)	youngest		100	95	91	94.84	-42.9
B03	5;5 (65)	Female	Both	yes (2)	youngest		115	85	94.44	86.45	-62
B04	6;1 (73)	Female	N/A	N/A	N/A		90	100	88.5	95.85	N/A
B05	5;5 (65)	Male	Both	yes (2)	youngest		110	105	85.96	81.82	-100
B06	5;0 (60)	Female	N/A	N/A	N/A		110	95	87.02	92.86	N/A
B07	4;7 (55)	Male	Spanish	no	no		90	80	77.78	87.34	-14
B08	5;0 (60)	Female	Both	no	no		105	80	84.69	84.23	-62.5
B09	4;8 (56)	Female	Both	yes (1)	oldest		100	100	84.62	84.25	0
B10	5;1 (61)	Female	Spanish	yes (2)	youngest		90	65	79.6	76.42	4
B11	5;5 (65)	Male	Spanish	yes (2)	middle		110	79	91.63	80.92	-50
B12	5;4 (64)	Female	N/A	N/A	N/A		115	65	92.46	86.53	N/A
B13	5;5 (65)	Male	Both	yes (3)	middle		100	80	90.82	92.4	0
B14	5;6 (66)	Male	Spanish	yes (4)	middle		100	95	78	83.79	45%
B15	5;6	Female	Spanish	yes (3)	youngest		105	70	91.92	87.55	-18

	(66)										
B16	5;7 (67)	Male	Spanish	yes (1)	youngest		110	85	96.04	91.7	2.72
B17	5;6 (66)	Female	N/A	N/A	N/A		110	90	92	95.6	N/A
B18	5;7 (67)	Male	Both	yes (3)	youngest		115	80	94	90.94	20
B19	4;10 (58)	Female	Both	yes (1)	oldest		115	80	94.55	86.18	-33.34
B20	4;11 (59)	Female	N/A	N/A	N/A		115	100	94.44	88.72	N/A
B21	4;8 (56)	Female	N/A	N/A	N/A		100	105	84.54	90.74	N/A
B22	4;7 (55)	Female	N/A	N/A	N/A		95	85	88.54	90.16	N/A
B23	4;9 (57)	Female	N/A	N/A	N/A		115	110	92.54	90.8	N/A
B24	4;8 (56)	Male	N/A	N/A	N/A		80	100	93.03	97.61	N/A
B25	4;8 (56)	Male	N/A	N/A	N/A		85	95	80.81	79.6	N/A
B26	5;3 (63)	Female	N/A	N/A	N/A		105	95	93.03	90.53	N/A
B27	3;5 (47)	Female	N/A	N/A	N/A		N/A	NA	88.78	88.26	N/A
B28	4;11 (59)	Female	N/A	N/A	N/A		115	100	90.86	82.79	N/A
B29	4;11 (59)	Male	N/A	N/A	N/A		125	95	96.95	85.26	N/A
B30	4;8 (56)	Male	N/A	N/A	N/A		100	90	91.5	82.81	N/A
B31	4;6 (54)	Male	Both, mostly English	yes (1)	oldest		90	75	81.15	78.84	40.7
B32	5;1 (61)	Male	Both, mostly English	no	no		95	90	93.91	83.33	0
B33	5;8 (68)	Male	Mostly Spanish, some English	yes (2)	youngest		90	85	84.13	87.64	-43.4
B34	5;7	Male	Both	yes (1)	oldest		120	NA*	96.92	87.19	-30.8

	(67)										
B35	5;7 (67)	Female	Spanish	yes (1)	oldest		100	105	80.67	97.28	13
B36	5;4 (64)	Male	Both, mostly Spanish	yes (2)	middle		100	80	88.21	78.55	-42.9
B37	6;2 (71)	Female	Both	yes (2)	middle		110	70	88.89	87.55	-50
B38	5;8 (68)	Female	N/A	N/A	N/A		115	95	93.16	96.06	N/A
B39	5;9 (69)	Female	both	yes (3)	youngest		115	90	93.25	94.92	-4
M01	4;11 (55)	Male	N/A	N/A	N/A	113			95		N/A
M02	3;9 (45)	Female	English	no	no	NA			65.41		-100
M03	3;7 (43)	Male	English	no	no	117			88.29		-100
M04	5;8 (68)	Female	N/A	N/A	N/A	104			89		-100
M05	4;11 (59)	Female	English	no	no	110			84.69		-100
M06	5;0 (60)	Male	English	yes (1)	oldest	97			81.82		-100
M07	4;6 (54)	Female	N/A	N/A	N/A	115			84.83		N/A
M08	4;9 (57)	Female	N/A	N/A	N/A	117			86.26		-100
M09	5;6 (66)	Male	N/A	N/A	N/A	103			90.05		-100
M10	5;4 (64)	Female	English	yes (3)	middle	99			93.53		-20
M11	5;7 (67)	Female	English	yes (1)	oldest	110			93.97		-100
M12	3;4 (40)	Female	N/A	N/A	N/A	NA			63.68		-100
M13	4;6 (54)	Male	English	no	no	112			96.53		-100
M14	4;7 (55)	Male	English	no	no	103			89.45		-63
M15	5;8	Female	Mostly	yes (2)	youngest	111			99.41		-100

	(68)		English								
M16	5;8 (69)	Female	English	yes (1)	oldest	109			96.39		-100
M17	5;7 (67)	Male	English	yes (2)	middle	113			94.92		-100
M18	5;2 (62)	Female	English	yes (1)	youngest	107			98.48		-100
M19	5;11 (71)	Male	English	yes (1)	oldest	103			89.18		-100
M20	5;8 (68)	Female	N/A	N/A	N/A	102			91.37		-100
M21	5;10 (70)	Female	Both, mostly Spanish	yes (2)	youngest	105			86.89		-57.7
M22	5;2 (62)	Male	English	yes (1)	oldest	113			94.92		-100

** Parent reports were not always available at the time of the analysis, as some parents or guardians were not able to be reached.

* The Spanish BESA scores are unavailable because there were audio issues associated with the microphone at the time of data collection. This child was still classified as typical as he performed in the typical range in English.

Appendix B. Assessment of English Phonology (Barlow 2003)

Item	Target word	Item	Target word	Item	Target word	Item	Target word
1	glasses	19	this	37	chicken	55	space
2	ghost	20	yoyo	38	cloud	56	ocean
3	six	21	guitar	39	flower	57	teacher
4	vacuum	22	lemon	40	vase	58	finger
5	elephant	23	yellow	41	music	59	wagon
6	zebra	24	stretch	42	sock	60	chair
7	zoo	25	popcorn	43	jeep	61	thirsty
8	brush	26	father	44	doll	62	queen
9	blue	27	mother	45	game	63	twins
10	plate	28	yes	46	hammer	64	them
11	knife	29	you	47	nail	65	zipper
12	shark	30	behind	48	hanger	66	pig
13	teeth	31	present	49	nothing	67	screw
14	feather	32	thank you	50	ladder	69	shower
15	green	33	please	51	magician	70	theirs
16	vanilla	34	strawberry	52	rabbit	71	thunder
17	shovel	35	snail	53	other	72	vest
18	there	36	beehive	54	rocket	73	treehouse

Appendix C. Assessment of Spanish Phonology (Barlow 2005)

Item	Target word	Item	Target word	Item	Target word	Item	Target word
1	teléfono	22	bruja	43	frente	64	jirafa
2	vaca	23	escoba	44	lengua	65	bloque
3	leche	24	jugo	45	llorando	66	verde
4	brinca	25	fantasma	46	boca	67	chicle
5	niño	26	blanco	47	lágrima	69	rana
6	niña	27	regalo	48	huevos	70	carros
7	globos	28	feliz	49	sombrero	71	tráfico
8	rojo	29	cumpleaños	50	estrella	72	chile
9	azul	30	gracias	51	luna	73	queso
10	amarillo	31	llama	52	dormido	74	yoyo
11	cuatro	32	fresa	53	cama	75	cadena
12	dedo	33	plátanos	54	nadar	76	llaves
13	mano	34	gente	55	bicicleta	77	reloj
14	perro	35	corriendo	56	gallo	78	princesa
15	hueso	36	delfín	57	campana	79	castillo
16	sopa	37	agua	58	clases	80	dulce
17	tigre	38	paraguas	59	cachetes	81	nieve
18	fuego	39	llueve	60	gato	82	fuente
19	humo	40	ojo	61	moño	83	familia
20	bombero	41	labios	62	mariposa	84	araña
21	foca	42	mujer	63	burro	85	gordo

Appendix D. Target words from the AEP classified by context

Sound and Syllabic position	**Words**	**Adult target**	**Count**
[l]			
In onset cluster	Glasses blue plate please cloud	[glæsɪz] [blu] [pleɪt] [pliz] [klaʊd]	5
syllable initial	Elephant vanilla lemon yellow ladder	[ɛləfənt] [vənɪlə] [lɛmɪn] [jɛloʊ] [læɾɚ]	5
		total	10
[ɹ]			
in onset cluster	Zebra brush green stretch screw strawberry treehouse	[zibɹə] [bɹʌʃ] [gɹin] [stɹɛt͡ʃ] [skɹu] [stɹɔbɛɹi] [tɹihaʊs]	7
Word-final consonant cluster	Shark popcorn theirs	[ʃɑɹk] [pɑpkoɹn] [ðɛɹz]	3
Syllable initial	Strawberry rabbit rocket	[stɹɔbɛɹi] [ɹæbɪt] [ɹɑkɪt]	3
Syllable final	Guitar there chair	[gɪtɑɹ] [ðɛɹ] [t͡ʃɛɹ]	3
		total	15

Appendix E. Target items from the ASP classified by context

Sound	**Word/s**	**Adult target**	**Count**
[l]			
Syllable initial consonant cluster	Globos blanco cumpleaños plátanos bicicleta bloque chicle	[gloβos] [blanko] [kumpljaɲos][1] [platanos] [bisikleta] [bloke] [t͡ʃikle]	7
Syllable initial	Teléfono leche regalo feliz labios lengua lágrima luna chile reloj	[telefono] [let͡ʃe] [reɣalo] [felis] [laβjos] [leŋgwa] [laɣɾima] [luna] [t͡ʃile] [relox]	10
Syllable final	Delfin dulce	[delfin] [dulse]	2
		total	19
[ɾ]			
syllable initial consonant cluster	Brinca cuatro bruja gracias fresa frente lágrima estrella	[bɾinka] [kwatɾo] [bɾuxa] [gɾasjas] [fɾesa] [fɾente] [laɣɾima] [estɾeʝa]	11

[1] For this word we accepted both production with hiatus [kumpleaɲos] and diphthong [kumpljaɲos]

	sombrero tráfico princesa	[sombɾeɾo] [tɾafiko] [pɾinsesa]	
Syllable initial	Amarillo bombero paraguas llorando sombrero mariposa jirafa	[amaɾiʝo] [bombeɾo] [paɾaɣwas] [ʝoɾando] [sombɾeɾo] [maɾiposa] [xiɾafa]	7
		total	18
[r]			
Syllable initial	Rojo regalo rana carros reloj burro	[roxo] [reɣalo] [rana] [karos] [relox] [buro]	6
Syllable final [r] ([ɾ] also possible)	mujer dormido nadar verde	[muxeɾ] [doɾmiðo] [naðaɾ] [beɾðe]	4
		Total	10

Appendix F. Consonantized glides in onset position for bilingual Spanish-English children. Raw count and percentage of consonantized glides are reported by participant.

Participant	Instances of consonantized glide	Percentage of consonantized glides
B01	9/14	64.28%
B02	7/14	50%
B03	9/13	69.23%
B04	8/13	61.54%
B05	9/12	75%
B06	14/14	100%
B07	10/12	83.33%
B08	12/14	85.71%
B09	9/13	69.23%
B10	9/12	75%
B11	6/12	50%
B12	8/12	66.67%
B13	11/13	78.57%
B14	8/14	57.14%
B15	11/14	78.57%
B16	8/14	57.14%
B17	9/14	64.28%
B18	10/13	90.90%
B19	2/14	14.28%
B20	10/14	71.42%
B21	7/14	50%
B22	6/13	46.15%
B23	8/14	57.14%
B24	9/13	69.23%
B25	7/10	70%
B26	12/14	85.71%
B27	9/13	69.23%
B28	3/11	23.07%
B29	9/13	69.23%
B30	12/14	85.71%
B31	9/14	64.28%
B32	9/14	64.28%
B33	9/13	69.23%
B34	12/14	85.71%
B25	10/14	71.42%
B36	6/12	50%
B37	4/14	33.33%
B38	5/14	35.71%
B39	9/14	64.28%

Appendix G. Consonantized glides in onset position for bilingual Spanish-English children. Raw count and percentage of consonantized glides are reported by word.

Word	Instances of consonatized glide	Percentage of consonantized glides
Amarillo	8/39	20.51%
Llama	20/37	55.55%
Agua	28/38	73.68%
Paraguas	35/37	81.08%
Llueve	25/33	75.75%
Lengua	36/36	100%
Llorando	24/34	70.59%
Huevos	38/39	97.43%
Estrella	9/36	25%
Gallo	12/37	32.43%
Yoyo	31/37	83.78%
Llaves	29/39	74.36%
Castillo	7/37	18.92%
Hueso	32/37	86.49%

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