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LANGUAGE SWITCHING USING AUGMENTATIVE AND ALTERNATIVE COMMUNICATION: AN INVESTIGATION OF SPANISH-ENGLISH BILINGUAL CHILDREN WITH AND WITHOUT LANGUAGE IMPAIRMENTS

by

MARIKA KING

Under the Direction of MaryAnn Romski, PhD

ABSTRACT

Children with severe speech and language impairments may rely on augmentative and alternative communication (AAC) for a variety of communicative functions. Despite the availability of bilingual AAC devices that allow the user to communicate in more than one language and alternate between languages, little research has addressed assessment and intervention concerns for bilingual children who use AAC. This study investigated the ability of bilingual children with and without language impairments to discriminate between languages using a bilingual AAC app during a cued language switching task.

Participants included 58 English-Spanish bilingual children ages 4;0 – 6;11 (23 with language impairments). Children received standardized language assessments in English and Spanish as well as assessment of nonverbal IQ and processing speed. All participants completed an experimental language switching task in which they were asked to locate images of vocabulary words in Spanish and English using a Spanish and English speech-generating device (SGD). Parents of child participants completed a demographic information form and participated in an interview about their child's language environments.

Results of a series of hierarchical linear regressions indicated that when controlling for age, processing speed significantly predicted children's ability on the experimental language switching task. Nonparametric tests showed no evidence of increased response times on trials where participants were required to switch between languages compared to trials where they did not switch. Further analysis indicated that language dominance, nonverbal IQ, and language abilities were not significant predictors of bilingual language switching ability using AAC.

Results from this study indicated that in addition to age, processing speed ability may be an important predictor of children's ability to language switch using AAC. This study contributes to the understanding of how young bilingual children conceptualize and discriminate between language systems. This research paves the way for further assessment and intervention studies to investigate how best to support bilingual children with language impairments and developmental disabilities who may benefit from AAC.

INDEX WORDS: Augmentative and alternative communication, bilingual language development, language impairment, language switching

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by

MARIKA KING

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

in the College of Arts and Sciences

Georgia State University

2019

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2019

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DEDICATION

This dissertation is dedicated to the children and families who inspired this work.

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1 INTRODUCTION

Bilingual language development is a common experience across the globe. At least half of the world’s population grows up in a bilingual environment (Crystal, 2003) and in the United States, 20% of people over age five speak a language other than English in the home (U.S. Census Bureau, 2013). Researchers have increasingly become interested in understanding the neural and behavioral correlates of bilingual language development in children with typical and atypical development. However, many questions remain about how bilingual language development occurs and how best to support children with cognitive and linguistic impairments who grow up in bilingual environments.

One important aspect of bilingual language development and use is the ability of bilingual individuals to comprehend and use more than one language during a communicative context. Language switching is often regarded as central to the language and culture of bilingual communities and refers to a bilingual mode of speaking in which the speaker alternates between a first language (L1) and a second language (L2) at the word, sentence, or phrase level (Grosjean, 2010, p.50-51). However, switching between languages may incur a cognitive cost because the activation and inhibition of two languages during simultaneous comprehension and production seems to require high levels of cognitive control (Green, 1998). Despite potential cognitive costs, even children as young as two years of age language switch by adjusting their relative use of one language or another based on the language of the interlocutor (e.g., Comeau, Genesee, & Lapaquette, 2003; Genesee, Boivin, & Nicoladis, 1996; Lanza, 1992; Reyes, 2004).

Less is known about language switching when a modality other than spoken communication is used. Bilingual children with speech and language impairments may rely on augmentative and alternative communication (AAC) modalities. AAC involves any type of communication tool (e.g., gestures, picture symbols, manual signs) that supplements or replaces natural speech (American Speech-Language and Hearing Association, n.d.). AAC systems with voice output are referred to as speech-generating devices (SGDs). Like children with typical development, children who use AAC often shift between different language environments at home, school, in therapy, and the community. No known research however, has investigated which cognitive, linguistic, or social factors influence young children's ability to language switch using AAC.

The purpose of this dissertation is to 1) examine predictors including cognitive skills, language skills, and language dominance of bilingual children's performance on a cued language switching task using a graphic symbol-based SGD, 2) investigate group differences across bilingual children with and without language impairments on a cued language switching task, 3) examine whether there are discrete subgroups of participants based on language skills, cognitive skills, socioeconomic status, and language dominance relative to performance on a cued language switching task, and 4) evaluate whether bilingual children exhibit switch costs on a cued language switching task.

In the following literature review, prominent theories of bilingual language development are presented and the literature on bilingual language development in children with typical and atypical language development is discussed. The review then focuses on language switching and its neurobiological correlates, as well as language switching in children with language impairments. Research investigating language switching by individuals who use modalities other than speech to communicate (i.e., signed language) is also considered and the implications for language switching using AAC are discussed.

1.1 Theories of Bilingual Language Development

Early theories of bilingual language development explained the mental representation of bilinguals' language systems either as a single linguistic system or as two separate systems. Volterra and Taeschner (1978) described the bilingual language acquisition of simultaneous bilinguals - that is children exposed to two languages from birth - using the unitary language system hypothesis. In a longitudinal study, the authors documented and examined the language development of two young German-Italian bilingual children using detailed observations and recordings of the children's speech. The authors concluded that bilingual children pass through three distinct stages before they become "truly bilingual" (p. 326). During the first stage, children's language system fuses to form a single lexical system, which contains words from both languages. Children frequently mix languages (i.e., language switch) within a single utterance during this stage. In the second stage, children distinguish between two lexicons but apply the same linguistic rules to both languages and mix languages within an utterance less frequently. Finally, in the third stage, around age three, children clearly distinguish between the vocabulary and grammar of both languages.

An alternative perspective is the dual language system hypothesis proposed by Genesee (1989). This hypothesis assumes that children who are exposed to two languages at birth develop separate systems for each language from the outset of language acquisition and thus, children never go through a stage of language differentiation. Research supporting this hypothesis includes evidence that bilingual children can differentiate between the languages they hear well before they begin producing words (Bosch & Sebastián-Gallés, 2001; De Houwer, Bornstein, & De Coster, 2006; Werker & Byers-Heinlein, 2008). For example, infants establish separate perceptual systems for each language they are exposed to (Burns, Yoshida, Hill, & Werker, 2007; Graf Estes & Hay, 2015). When children begin to produce words, the percentage of translation equivalents (the same words used in both languages) increases with language development (Bilson, Yoshida, Tran, Woods, & Hills, 2015; Nicoladis, 2006; Pearson, 1998). One of Volterra and Taeschner's (1978) arguments for the unitary language system hypothesis was that children demonstrate frequent language mixing of vocabulary and word order rules. Yet, numerous studies demonstrate that simultaneous bilinguals do not frequently demonstrate mixing of word order rules across languages, thus providing support for the dual language hypothesis and indicating that simultaneous bilinguals do have separate morphosyntactic systems (e.g., Meisel, 1994; Paradis, Nicoladis, Crago, & Genesee, 2011; Paradis, Nicoladis, & Genesee, 2002).

At the same time, current research suggests that the language systems of bilingual children and adults are not entirely fused or separate but rather interact via cross-linguistic influences. To investigate how bilingual children develop and differentiate languages, researchers have used adults as a starting point to explore whether adults have separate or interacting language systems (Byers-Heinlein, 2014). Cross-linguistic influences have been demonstrated across language domains in adults including in lexical and sublexical processing (Costa, Roelstraete, & Hartsuiker, 2006) and syntactic processing (Hartsuiker & Pickering, 2008). Costa and colleagues (2006) found support for dual language activation in a SLIP task (Spoonerisms of Laboratory-Induced Predisposition) administered to Spanish-Catalan bilingual adults. Participants were exposed to Spanish biased non-word-pairs, and although Catalan was not involved in the task, the participants appeared to be affected by the Catalan lexicon. The authors posited that Catalan words were activated through the activation of the phonological properties of the target non-words. These findings provide support for the idea that words in L1 can be activated via phonological and lexical properties of L2. Cross-linguistic influences have further been demonstrated in syntactic tasks involving sentence production in adult bilinguals. Hartsuiker and Pickering (2008) investigated the extent to which languages are integrated during sentence production in bilinguals. The authors discussed three different models, all of which postulated that sentence production in bilinguals involves activation of both lexical and syntactic processes and involves cross-linguistic integration.

Ullman (2001, 2016) described yet another model to explain the neural correlates of lexicon and grammar in bilinguals. Ullman presented a domain-general view of language where the neurobiological bases for language rely on other neurobiological systems such as working memory and dorsal and ventral stream processing. Ullman proposed that the mental lexicon and mental grammar of L1 and L2 depend on procedural and declarative memory systems that have been co-opted for language development and use. Declarative memory involves semantic knowledge (i.e., memorized vocabulary and events) and relies on medial temporal lobe regions of the hippocampus and related structures. Procedural memory includes implicit knowledge of grammatical rules (i.e., syntax and morphology), is primarily dependent on left hemisphere structures, and employs frontal/basal-ganglia areas. Under the declarative-procedural (DP) model, the age of exposure to L2 does not affect all language capacities equally. Grammar is influenced by the age of exposure because procedural (or implicit) memory declines with age while declarative memory remains constant. The DP model claims that a shift of dependence from procedural to declarative memory is a function of the age of exposure of L2. In other words, grammatical computation shifts to involve more declarative memory in later L2 acquisition which in turn has implications for a critical or sensitive period in language development. Ullman draws on findings from behavioral, neuroimaging, and event-related potential (ERP) studies to support this hypothesis. For example, imaging studies of adults demonstrated that grammatical processing is less dependent on frontal and basal ganglia structures in L2 than in L1 and the shift from procedural to declarative memory is reflected by increased involvement of the left temporal/temporoparietal structures (Dehaene et al., 1997; Perani et al., 1998). Importantly, this shift from procedural to declarative memory in L2 learners is a function of both the age of exposure to L2 and practice.

Other researchers have questioned Ullman's (2001) hypothesis that L2 acquisition later in life depends on different cognitive mechanisms and cerebral structures than L1 and that grammatical knowledge is declarative rather than procedural during L2 acquisition. Perani and Abutalebi (2005) reviewed studies that demonstrated how the age of acquisition, degree of proficiency, and exposure to L2 affect the neural organization of L2. The authors described studies demonstrating that grammatical processing of L2 is acquired and carried out through the same computational brain devices underlying L1 grammatical processing. Under this model, the same neural system is employed during comprehension and production of both languages despite differences regarding additional resource demands. Perani and Abutalebi argued that language proficiency in L2 mediates access to the meaning of L2 lexical items, but as proficiency increases, this dependency declines. The authors cited evidence from neuroimaging studies showing common activation of regions with comparable proficiencies in both languages.

Additionally, Perani and Abutalebi discussed the important role of language exposure and use of L2 claiming that as L2 proficiency increases, L2 processing converges on the neural representation of L1. The authors described findings demonstrating that neural differences between low and high proficient bilinguals during a word generation task indicated brain plasticity. In contrast to Ullman (2001), Perani and Abutalebi proposed a dynamic view to describe L2 processing in the brain in which L2 is acquired using the same neural devices responsible for L1 processing.

The extant literature described thus far, has predominantly focused on lexical processing in adults which has helped inform many of the current theoretical models. Recently researchers have acknowledged that the available models of lexical processing lack a developmental perspective and that there is a significant gap in the literature from infants to adults (DeAnda, Poulin-Dubois, Zesiger, & Friend, 2016; Grainger, Midgley, & Holcolmb, 2010). A developmental perspective would address whether children's language systems are integrated, separate, or interacting. Furthermore, a developmental model can help untangle the factors that influence bilingual development and address differences in lexical representation and acquisition.

Patricia Kuhl and colleagues have focused on bilingual language development in infants by studying the neural correlates of dual language experience. Kuhl's research highlights the combination of computational, cognitive, and social skills which influence language development in infants. Kuhl (2010) emphasized the role of social experiences as a critical modulator of domain-general cognitive skills, which together determine the neural architecture in infants. Kuhl drew on research evidence of infants' phonetic perception during the first year of life showing that infants possess the perceptual ability to discriminate between phonetic units of all languages very early in development but that this ability declines during the second half of the first year of life. Kuhl et al. (2006) demonstrated that Japanese infants' discrimination of English /r/ - /l/ declined between 8-10 months while at the same time in development, American infants' discrimination of the same sounds increased significantly. Presumably, the Japanese infants' discrimination of English phonemes diminished because they lacked exposure to these sounds.

These findings and others led Kuhl to propose the “Native Language Magnet” theory. Under this theory, Native Language Neural Commitment (NLNC) produces dedicated neural networks that code the patterns of native-language speech while not supporting following phonetic patterns (Kuhl, Conboy, Padden, Nelson, & Pruitt, 2005). Kuhl and colleagues (2005) argued that the NLNC - or this neural commitment to sounds of native languages which is established early on - may have implications for a critical period for language learning.

Recent studies support language interaction models based on emergent accounts of bilingual language acquisition in children. For example, word learning studies in bilingual children show word knowledge in one language facilitates learning in another, suggesting links across lexicons (Bilson et al., 2015; Bosch & Ramon-Casas, 2014). In a study of 435 children ages 6 months to 7 years, Bilson and colleagues found that bilingual children (children who spoke English and one of 8 other languages) overproduced translation equivalents suggesting that labeling a concept in one language, facilitated the learning of a new word for that concept in another language. Furthermore, Bosch and Ramon-Cass found that the acquisition of translation equivalents may vary depending on the phonological similarities between languages. For example, Spanish and Catalan have a high degree of phonological overlap and results indicated that Spanish-Catalan bilingual infants (18 months of age) had many translation equivalents across identical word forms (28%), but few translation equivalents (< 2%) for form similar and form dissimilar words. The authors concluded that phonological form proximity between words across Spanish and Catalan facilitated early lexical acquisition because presumably children had increased exposure to word-concept pairings for highly similar forms. These findings provide support for the emergent theoretical models of bilingual language acquisition that emphasize cross-language influences. However, empirical support for developmental models of dual language acquisition is limited and findings suggest that differences in experience including language distance may impact lexical representation.

Clearly, there is disagreement in the literature regarding the neural representation and interaction between more than one language in bilingual speakers. However, as Byers-Heinlein, (2014) observed, there is a consensus among researchers that bilingual adults can separate their languages functionally. In other words, bilingual adults functionally differentiate languages by treating the sounds, words, and utterances of one language as being different from those of another. This ability allows bilingual adults to shift consciously between language systems during comprehension and production of more than one language. According to Byers-Heinlein, language differentiation is the ability to functionally separate elements of different languages, which is essentially categorization. Byers-Heinlein cited examples from multiple lines of research to support the idea that bilingual adults use language categories in their comprehension and production of language. This hypothesis raises the question of how language categorization develops in children.

To address this issue, Byers-Heinlein discussed the distinction between perceptual and conceptual categorization where perceptual understanding relies on observable features, and conceptual understanding relies on more abstract, non-observable characteristics. Infants have early-emerging perceptual sensitivities that allow for discrimination of the acoustic properties of language (see Kuhl et al.,1 2006). However, they are not yet discriminating languages using conceptual categorization. Byers-Heinlein argued that perceptual biases lay the foundation for later understanding of conceptual language categories. Further, statistical learning mechanisms, which inherently incorporate abstract knowledge, may play a key role in the development of language categorization. Importantly for the current study, language categorization and discrimination in bilinguals may be associated with language switching abilities.

Despite the lack of consensus among researchers regarding the mechanisms and neural representation of bilingual language development, one thing that scholars agree upon is that bilingual language development is a complex, dynamic process that is influenced by various factors including age of exposure and language proficiency. Goldstein (2012) advocated for the premise that in typically developing children, learning two languages is not more difficult than learning one language. Factors that contribute to successful language development in monolingual children (i.e., intact cognition and ability to process language regularities, and a rich and supportive linguistic environment) are the same for children learning more than one language (Goldstein, 2012). There is a high degree of variability in the rate and order of acquisition of linguistic structures by monolingual children. Goldstein argued that in bilingual children, there is even greater individual variability in their developmental trajectories given the influence of additional sociolinguistic factors.

1.2 Bilingual Language Development in Typically Developing Children

The theoretical foundations of bilingual language development are important for understanding the developmental trajectory of bilingual children. If bilingually-exposed children do not initially have a unitary language system followed by a language differentiation stage (see Genesee, 1989), then potentially the cognitive cost of bilingualism is minimized. Alternatively, if bilingual children’s language is dominated by cross-linguistic influences, the cognitive control required to coordinate more than one language may require additional cognitive resources.

Although there is much variability in the language profiles of bilingual children, researchers now generally agree that dual-language learners are not more disadvantaged than their monolingual peers when it comes to cognitive and linguistic development (Genesee, Paradis, & Crago, 2011). Studies comparing the language skills of bilingually exposed children to monolingual children generally demonstrate that bilingual children achieve language milestones within a time frame that is comparable to monolingual children. Oller, Eilers, Urbano, and Cobo-Lewis (1997) evaluated the infraphonological development of bilingually exposed infants during the first year of life and found that the onset of canonical babbling and first words were comparable to monolingual counterparts. Similar findings have been demonstrated for the acquisition of first words (e.g., Pearson, Fernandez, & Oller, 1993; Petitto et al., 2001) and word combinations (Conboy & Thal, 2006; Hoff, Core, Place, Rumiche, Señor, et al., 2012; Petitto et al., 2001). Petitto and colleagues extended these findings across modalities by investigating the language development in children who used a signed language in addition to a spoken language. They found no significant differences in the onset of first words or word combinations when monolingual English-speaking children were compared to children who spoke French sign language in addition to spoken English.

1.2.1 Vocabulary.

Studies comparing the vocabulary size of bilingual children to same-age monolingual peers demonstrate that bilinguals may exhibit smaller vocabularies when only one of their languages is considered. On the other hand, when skills in both languages are measured, vocabulary size is equal or greater to that of monolinguals (Bosch & Ramon-Casas, 2014; Hoff et al., 2012; Pearson, 1998; Pearson, Fernandez, & Oller, 1993). However, in a longitudinal study, Hoff, Rumiche, Burridge, Ribot, and Welsh (2014) presented a more nuanced approach to understanding vocabulary growth in bilingual children. Hoff and colleagues investigated the developmental trajectories of semantic skills in Spanish-English speaking children. Using the

MacArthur-Bates Communication Development Inventories (English and Spanish versions; Fenson et al., 2007), the authors compared the developmental trajectories of expressive language from 22 to 48 months in children from bilingual homes (children with one and children with two native Spanish-speaking parents) and an SES equivalent group of children from monolingual (English) homes. They categorized bilingual children by whether their parents were both native Spanish speakers, or whether one parent was a native English speaker. Results of the study indicated that trajectories of vocabulary development for bilingual and monolingual children were comparable at 48 months, but with differential results depending on bilingual language experience. Children whose parents were both native Spanish speakers demonstrated stronger gains in Spanish vocabulary, while children with one native English-speaking parent had smaller gains in Spanish but stronger gains in English. Regarding total vocabulary, the authors found that children with two Spanish-speaking parents were gaining over the monolingual children in terms of total vocabulary growth, but the children from bilingual homes with only one native Spanish-speaking parent were not. Additionally, English use in the home when parents were not native English speakers did not contribute to English language skills.

In a more recent study, Ribot, Hoff and Burridge (2018) used multi-level modeling to investigate factors that influenced expressive English vocabulary growth in forty-seven 30-month-old Spanish-English bilingual children. The authors divided children into two groups based on parent-report of language patterns: children who spoke English more frequently than they heard English, and children who heard English more frequently than they spoke English. The authors found that beyond age and language input, language use significantly contributed to children’s expressive vocabulary development. Children who spoke English more frequently demonstrated more rapid gains in expressive English vocabulary compared to children who heard English more frequently. These findings support work by Bedore and colleagues (Bedore, Peña, Griffin, & Hixon, 2016; Bedore et al., 2012) which highlight the variations in bilingual experience and underscore the importance of frequency and quality of language input as well as language use in predicting language outcomes for bilingual children.

1.2.2 Grammar.

The literature investigating grammatical development in bilinguals indicates variation in development depending on a variety of factors including: sociocultural linguistic context (Mueller Gathercole, 2007), child-specific language abilities (Marchman, Martínez-Sussmann, & Dale, 2004), bilingual language input (Hoff, Core, Place, Rumiche, Señor, et al., 2012; Nicoladis & Marchak, 2011; Nicoladis, Palmer, & Marentette, 2007; Paradis et al., 2011; Thordardottir, 2015), and bilingual language output or use (e.g., Bedore et al., 2012, 2016; Ribot et al., 2018). Hoff and colleagues (2012) found that young bilinguals may lag in mastering grammar even though the course of development is the same as monolingual children. The authors measured grammatical complexity and mean length of utterance (MLU) in bilingual Spanish-English speaking children. Participants were divided into groups according to language dominance (English-dominant, balanced bilinguals, Spanish-dominant) and were compared to monolingual (English) children. On the English measures of grammatical complexity and MLU, the bilingual children showed approximately a three-month lag. The magnitude of this gap increased with age as the English language skills of the monolingual children developed. However, it is important to note that only English measures of grammatical development were assessed in this study. The authors emphasized the importance of considering children's accomplishments in both languages and the role of language input in influencing language outcomes.

In another study, Davison and Hammer (2012) used spontaneous language samples of English-Spanish bilingual preschoolers to measure acquisition of English grammatical morphemes. The authors compared children who were simultaneous bilinguals (children exposed to L1 and L2 from birth) to sequential bilinguals (children exposed to L2 after age 3) and monolingual English speakers. Results of the study indicated that although simultaneous bilinguals acquired English grammatical morphemes more quickly than sequential bilinguals, within two years the sequential bilinguals had caught up to simultaneous bilinguals. Furthermore, the developmental trajectory of morphological acquisition generally followed English development. The authors concluded that some variations in morpheme development observed across monolinguals and bilinguals might be attributed to language specific features and to overall variation in the bilingual population.

1.2.3 Bilingual cognitive advantage.

One area of debate that has gained attention in recent years is whether bilingualism affords a cognitive advantage. Because of the requirements of switching between two representational systems (e.g., between L1 and L2), bilingual language comprehension and expression is thought to be inherently more related to the cognitive system than monolingual language. Evidence from neuroimaging and behavioral studies of children and adults indicates neural activation of both languages even in contexts strongly biased towards one (see Bialystok, Craik, Green, & Gollan, 2009). Thus, the assumption is that bilinguals must employ cognitive processes to monitor, activate, and suppress their different languages. The constant need to exercise inhibitory control is hypothesized to lead to increased skill in selective attention and inhibition in nonlinguistic tasks (Bialystok, 2001).

Early work in this area indicated that indeed bilingual children and adults outperformed their monolingual counterparts on various executive control tasks including Simon, Stroop, Flanker, and task-switching tasks (e.g., Bialystok, Craik, & Luk, 2008; Bialystok, Klein, Craik, & Viswanathan, 2004; Carlson & Meltzoff, 2008; Costa, Hernández, & Sebastián-Gallés, 2008). For example, Bialystok (1988) compared bilingual children’s performance on tasks involving selective attention and inhibition to age-matched monolingual children. The bilingual group was sub-divided into groups characterized as “high bilinguals” meaning their exposure and use across two languages was relatively balanced, and “low bilinguals” with unbalanced bilingual exposure and use. Results of this study revealed no significant difference among high and low bilinguals with bilinguals outperforming monolinguals on cognitive tasks. Similar findings have been demonstrated in adolescents (Krizman, Marian, Shook, Skoe, & Kraus, 2012) and adults (e.g., Bialystok et al., 2008, 2004).

More recently, however, findings of a bilingual advantage have been challenged based on methodological concerns (e.g., Morton & Harper, 2007) and possible publication bias where significant results were published more frequently than non-significant results (Hernandez, Greene, Vaughn, Francis, & Grigorenko, 2015). For a response, see (Bialystok, Kroll, Green, MacWhinney, & Craik, 2015). Morton and Harper found that when socioeconomic status was controlled for, the bilingual advantage disappeared. Other studies have failed to find evidence of a bilingual advantage in a variety of cognitive tasks (Antón et al., 2014; Kousaie & Phillips, 2012; Paap, Darrow, Dalibar, & Johnson, 2014; Paap & Greenberg, 2013; Paap & Sawi, 2014). Several meta-analyses have focused on studies examining the bilingual advantage in different components of executive functioning including monitoring inhibitory control, and updating and working memory. Donnelly (2016) conducted a meta-analysis of bilingual advantage studies that considered interference control and task-switching tasks in children, young adults, and older adults. Across both dependent variables, the findings were inconclusive in support of a bilingual advantage at any age group. In another meta-analysis, Lehtonen et al. (2018) analyzed data from 152 published and unpublished studies of adult bilingual and monolingual performance across six executive function domains using 891 effect sizes. Again, the authors found no evidence in support of a bilingual advantage.

The debate surrounding a bilingual cognitive advantage is far from settled. Many authors have pointed out that bilingual research is complex and bilingual speakers are a highly heterogeneous group. Multiple confounding factors can affect an individual's language and cognitive skills, and weaknesses in statistical methods and inconsistencies in measurement methods and tasks are ubiquitous in these studies (Laine & Lehtonen, 2018). Furthermore, other researchers have questioned the construct validity of executive functioning, arguing that many tasks that are commonly used to assess executive functioning may not be tapping into a global measure (Donnelly, 2016). Despite the criticisms of this work, Bialystok et al. (2015) pointed out that the existence of publication bias does not rule out a bilingual advantage and indeed substantial evidence does indicate a bilingual advantage, particularly in specific areas and with highly proficient bilinguals. If bilingual children do demonstrate advantages in cognitive flexibility, this then has direct implications for language switching abilities. Clearly, more systematic and large-scale studies are needed to better understand the specific nature of control processes involved in bilingual language understanding and use.

1.3 Bilingual Language Development in Children with Linguistic and Cognitive Disorders

Evidence from the literature related to bilingual language development in children with typical development points to no substantial negative effects of bilingual language development. However, this raises the question whether the same is true for children with language and cognitive impairments. Afterall, if children with language impairments struggle with learning one language, would learning two languages be even more challenging and possibly confusing? In recent decades, researchers in the fields of speech-language pathology and related disciplines have begun to address this question. Most of the research on bilingual children with developmental disabilities has focused on children with specific language impairment (SLI) which by definition excludes children with concomitant intellectual disability (e.g., Leonard, 2014). Several studies, however, have included children with autism spectrum disorders (ASD) and Down syndrome (DS). Children with ASD present with social communication impairments accompanied by restrictive behaviors. ASD is often but not always, associated with language impairments and intellectual disability (e.g., de Villeirs, Szatmari, & Yang, 2014). Down syndrome is a result of trisomy of the 21st chromosome (Abbeduto, Warren, & Conners, 2007). Children with DS present with secondary cognitive and language impairments and frequently have difficulty with motor skills (Chapman, 1997).

1.3.1 Bilingual language development in children with SLI.

A growing body of evidence is concerned with language development in bilingual children with SLI. Children with SLI demonstrate weaknesses in grammatical skills in addition to vocabulary deficits. When compared to monolingual peers, simultaneous bilinguals with SLI generally demonstrate comparable language skills. Paradis, Crago, Genesee, and Rice (2003) measured English and French verb morphology in school-age children with SLI. The researchers gathered spontaneous language samples from French-English bilinguals with SLI and English monolinguals with SLI. Findings revealed no significant differences across groups on English or French measures of verb-tense use in obligatory contexts.

In another study, Paradis, Crago, and Genesee (2006) investigated the use of direct object pronouns in English and direct object clitics in French by bilingual children with SLI. They compared early school-aged bilingual (French-English) children with SLI to monolingual (English) children with SLI and to bilingual (French-English) three-year-old children with typical development. Again, results from the study revealed no significant differences on language measures in either language. The authors reported that bilingual children with SLI performed similarly to monolingual children with SLI and to younger, bilingual children with typical development.

Gutiérrez-Clellen, Simon-Cereijido, and Wagner (2008) studied the language abilities of bilingual (Spanish-English) and monolingual (English) preschoolers with SLI. They divided participants into four groups: Spanish-English bilingual children with SLI, Spanish-English bilingual children with typical development, monolingual English-speaking children with SLI, and English-speaking monolingual children with typical development. The researchers measured children’s grammatical complexity (e.g., MLU) and subject-verb use in English only. Results revealed a significant effect for SLI with children with SLI performing more poorly on language measures than children with typical development. However, there was no effect for language group with children in the bilingual groups performing on par with children from the monolingual group. Bilingual children in this study were predominantly English dominant and were assessed in their dominant language (English). The authors noted that these findings might be different for children with weaker skills in English.

In addition to difficulties in acquisition of grammatical forms, children with SLI have been found to have deficits in vocabulary. Gibson, Peña, and Bedore (2014) used the weaker links hypothesis to describe vocabulary acquisition in bilingual children with and without SLI. Under the weaker links hypothesis, bilingual children have less exposure to vocabulary in each language than monolingual children. Thus, the phonological-lexical connections among concepts are less developed in each language. Gibson and colleagues identified a receptive-expressive language gap in bilingual children and compared receptive and expressive language skills in typically developing English-Spanish bilingual children to English-Spanish bilingual children with SLI. They found that the magnitude of the receptive-expressive gap in bilingual children with SLI was significantly greater than typically developing bilinguals. These findings indicate that bilingual children with SLI may require additional support to strengthen lexical connections and increase vocabulary skills. However, a weakness of this study was that it did not include control groups of monolinguals with and without SLI.

Kay-Raining Bird, Genesee, and Verhoeven (2016) pointed out important differences in studies examining children with SLI who were simultaneous bilinguals or sequential bilinguals. In a review of studies of bilingual children with SLI, Kay-Raining Bird et al. found that simultaneous bilinguals with SLI demonstrated similar language profiles to monolingual peers when they received intensive and consistent exposure to both languages from birth. In contrast, sequential bilinguals often demonstrated poorer performance on language measures when compared to monolingual peers with SLI. Delayed development in bilingual children with SLI indicates that these children may require even more time to develop language skills than bilingual peers with typical development. Because sequential bilinguals have less practice with a second language than simultaneous bilinguals, trajectories of language development are more variable.

1.3.2 Bilingual language development in children with autism spectrum disorders.

Studies of bilingual children with autism spectrum disorders (ASD) are less common and include participants with a range of characteristics. Similar to simultaneous bilinguals with SLI, the available literature investigating the bilingual language abilities of children with ASD indicates no substantial disadvantage for children who are bilingual. Three different studies found that simultaneous bilinguals with ASD compared with age-matched monolinguals with ASD demonstrated equivalent performance on measures of expressive and receptive language (Ohashi et al., 2012; Petersen, Marinova-Todd, & Mirenda, 2012; Valicenti-McDermott et al., 2012). Hambly and Fombonne (2012) examined the social and language abilities of children with ASD from bilingual (*n* = 45) and monolingual (*n* = 30) environments. Bilingually-exposed children were further sub-grouped based on simultaneous or sequential L2 exposure. Despite significant variability in amounts of bilingual exposure across the sequential and simultaneous bilinguals, the results of the study indicated no significant group differences in language skills. Interestingly, the simultaneous bilingual subgroup demonstrated significantly stronger social interaction scores compared to the sequential bilingual group on the interpersonal subdomain of the *Vineland Adaptive Behavior Scales-II* (Sparrow, Cicchetti, & Balla, 2005). The authors concluded that bilingually-exposed children with ASD do not experience additional delays in language development when compared to monolingually-exposed children with ASD.

In a recent systematic review, Lund, Kohlmeier, and Durán, (2017) reviewed seven studies comparing language abilities of bilingual children with ASD to monolingual peers with

ASD. Most studies showed small, mixed differences in language development when bilingual children with ASD were compared to monolingual children with ASD. Findings from these studies support the hypothesis that bilingual language development does not increase language delays beyond the language impairments associated with ASD.

1.3.3 Bilingual language disorders in children with intellectual and developmental disabilities

Less is known about the bilingual language abilities of children with intellectual and developmental disabilities (IDD), and many practitioners and parents are concerned about the ability of children with low cognitive abilities to learn to speak two languages. These concerns are understandable, given that children with IDD typically have difficulty learning language. One subgroup of children with IDD, is children with Down syndrome (DS), and emerging evidence indicates that bilingually-exposed children with DS, demonstrate similar patterns of bilingual language use when compared with monolingual children with DS (Feltmate & Kay-Raining Bird, 2008; Kay-Raining Bird et al., 2005). Kay-Raining Bird and colleagues compared bilingual (French-English) children with DS to three control groups matched on developmental level: monolingual (English) children with DS, monolingual (English) children with typical development, and bilingual (English-French) children with typical development. Results of the study indicated that bilingual children with DS exhibited language profiles similar to their monolingual counterparts with DS with no significant differences in English language abilities across the two groups with DS. Bilingual and monolingual children did not differ on English language measures of expressive vocabulary, receptive vocabulary, and productive syntax (i.e., MLU). Furthermore, bilingually exposed children with DS demonstrated bilingual language abilities in both languages although there was significant variability across children. These findings indicated no detrimental effect of bilingualism for children with DS. This study, however, was limited by a small sample size (*n* = 22) that was restricted to French and English speakers in Canada and only assessed the English language abilities of the participants.

In another study, Feltmate and Kay-Raining Bird (2008) conducted a detailed analysis of the morphological abilities of bilingual children with DS across both English and French. The authors matched bilingual children with DS in four triads with each triad including a bilingual child with DS, a monolingual child with DS, and a bilingual child who was typically developing, matched on mental age and language experience. Results of the study revealed that overall, bilingual children with DS demonstrated comparable morphological skills to monolingual children with DS and similar patterns of morphological development when compared with typically developing bilinguals.

In a more recent study, Cleave, Kay-Raining Bird, Trudeau, and Sutton (2014) investigated language learning abilities in a group of bilingual (French-English) children with DS using an English language dynamic, syntactic bootstrapping task. The authors investigated whether bilingual and monolingual children with DS were able to learn novel and familiar nouns and verbs when provided with syntactic cues (e.g., the article “a” or participle “-ing”). Overall, children performed better in the familiar than the novel condition and with nouns than verbs. There was no difference in performance across language groups. The authors concluded that using dynamic learning tasks might be a useful tool in assessing language development in bilingual children with DS.

1.3.4 Bilingual AAC use in children with intellectual and developmental disabilities

A subset of individuals with speech and language impairments are not able to use their natural speech to communicate effectively across various settings and environments. These individuals may rely on AAC modalities to communicate. AAC modalities range from low-tech picture boards to high-tech speech generating devices (SGDs) such as tablets or computers with voice output (Beukelman & Mirenda, 2013). Across the globe, many children and youth with IDD may benefit from AAC modalities. Global estimates of the number of bilingual children who may benefit from AAC are difficulty to obtain. The World Health Organization (2011) World Report on Disability estimated that the number of children with disabilities world-wide is between 5% - 11%.

Recently, Andzik, Schaefer, Nichols, and Chung (2018) surveyed over 4000 special educators in the United States about the communicative and behavioral characteristics of students in their classes (*n* =15,634 students across 50 states). Teachers reported that although most students used vocal speech to communicate, 42% of these students were non-proficient oral language communicators. Furthermore, 18.2% of students primarily used gestures, picture symbols or SGD’s to communicate. Findings from this survey indicate that many children with communication impairments are not meeting their communication needs using vocal speech and could benefit from AAC. Given the prevalence of bilingualism across the globe, we can infer that millions of children around the world have both severe speech and language impairments and are growing up in bilingual environments. Bilingual AAC options are imperative.

There is a scarcity of empirical data related to AAC services and supports for children and adults from culturally and linguistically diverse backgrounds. Several studies have investigated culturally and linguistically appropriate symbols and core vocabulary across various languages and cultures (e.g., Andres, 2006; Bornman, Alant, & Du Preez, 2009; Huer, 2004; Robillard, Mayer-Crittenden, Minor-Corriveau, & Bélanger, 2014). Other studies have examined perspectives of AAC through ethnographic interviews and surveys with families and students from culturally and linguistically diverse backgrounds (see Kulkarni & Parmar, 2017 for a recent review).

To date, no published research has investigated ACC assessments or interventions for bilingual children. A recent unpublished master's thesis (Stewart, 2017) described an intervention case study of a bilingual adolescent with Down syndrome who used AAC. The participant communicated in English at school and Spanish at home and findings supported the efficacy of AAC intervention in the home language in improving overall communication outcomes. In a paper discussing general considerations for provision of services to bilingual children who use AAC, Soto and Yu (2014) advocated for a sociocultural approach to AAC service delivery that supports a bilingual child's communication development across both languages. Soto and Yu highlighted the urgent need for more research in this area and acknowledged that due to the lack of empirical research current recommendations are largely speculative.

1.3.5 Summary.

Decades of research in bilingualism have taught us that acquiring two languages is a complex process unique to the individual. Despite disagreement in how bilinguals organize and mentally represent more than one language in the brain, it seems undisputed that bilingual language development is complex and varied and its trajectory and expression is dependent on a multitude of factors including social, linguistic, and cognitive influences.

Behavioral, neuroimaging and electroencephalogram studies demonstrate that the languages bilinguals speak and understand do not function in isolation on a neural level, but rather interact at various levels even when only one language is in use (e.g., Costa, Santesteban, & Ivanova, 2006; Hartsuiker & Pickering, 2008; Perani & Abutalebi, 2005). Furthermore, research to date provides a clear narrative that when individual differences in language experience are accounted for, overall bilingual children do not demonstrate difficulty learning two languages (e.g., Conboy & Thal, 2006; Hoff, Core, Place, Rumiche, Senor, et al., 2012; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson et al., 1993; Pearson, 1998; Petitto et al., 2001). Research investigating the language abilities of bilingual children with language impairments and IDD shows a similar picture demonstrating that these children are not significantly more impaired than monolingual peers with language impairment (e.g., Gutiérrez-Clellen et al., 2008; Kohnert, 2010; Paradis, 2008). Theoretical explanations of the neural and behavioral aspects of bilingual language development are important as we turn our focus to language switching and discuss theoretical models of language switching and factors that influence language switching in children with typical and atypical development.

1.4 Language Switching

A unique feature of bilingual communication is the ability of bilinguals to shift between two linguistic systems and alternate between more than one language during conversation. Within a dual-language context, a bilingual may comprehend language switches (via spoken or written mediums) and may also produce language switches. Switching between languages is common among bilingual children and adults (Poplack, 1980), yet researchers have used a variety of terms to describe this phenomenon (e.g., code switching, code mixing, language switching). The terms code switching and code mixing are sometimes used interchangeably and the terminology used depends on the researcher’s preference and the field of research. Code switching is generally used to describe intentional switching for a specific social purpose, while code mixing is a broader term that refers to language alteration that may not have a deliberate social purpose and may serve to fill lexical gaps in knowledge (Cantone, 2007). Language switching on the other hand, is commonly used in research contexts where switching occurs during non-voluntary tasks or in structured settings. For simplicity and consistency, in this literature review, we use the term language switching to refer to language alteration in social contexts and in structured research contexts and hereby acknowledge that in their work, some authors may have used other terms (e.g., code switching, code mixing).

1.4.1 Types of language switching.

Although virtually all bilingual speakers language switch to some degree, there is great variability in how this language alteration is expressed. Researchers generally agree that language switching is not random but rather patterned and structured. Scholars studying language switching have attempted to describe and categorize types of switching from a linguistic perspective. Linguists, however, have yet to identify and agree upon a systematic explanation of the grammatical constraints on language switching. One prominent explanation of these universal language switching patterns was proposed by Muysken (2000) who outlined a typology which distinguished between three main types of language switching in sentences: insertion, alteration, and congruent lexicalization.

Insertion occurs when words or elements from one language are inserted into an utterance or sentence of another language. Myers-Scotton (1997) described insertion according to the Matrix Language Frame (MLF). From this perspective, there is an asymmetrical relationship between the two languages where the primary language (i.e., Matrix Language) provides the syntactic frame, and the other language (i.e., Embedded Language) is supplementary. Insertion is often labeled as intra-utterance switching or intra-sentential switching. These mixed linguistic constituents can include small linguistic units such as inflectional morphemes and sounds or larger units such as whole words, phrases or clauses (Genesee et al., 2011). An example of insertion (i.e., intra-sentential mixing) is, "I want helado." In this example, the Spanish word "helado" (ice cream) is inserted into the English sentence frame.

Language switching from an alternation perspective occurs when stretches of words in L1 alternate with stretches of words in L2 within a conversational turn. Rather than one language being embedded in the syntactic frame of another, in alteration, both the grammar and lexicon switch completely with each language switch. Alternating between languages across utterances within the same conversation is commonly referred to by scholars as inter-utterance mixing or inter-sentential mixing. For example, "I like chocolate ice-cream! A ti cual te gusta?" In the second sentence in this example, the speaker switches to Spanish to ask, "Which one do you like?"

Congruent lexicalization, or dense language switching, occurs when words and morphemes from different languages are combined to create a shared linguistic structure. According to Muysken (2000), in congruent lexicalization, the grammatical structure of both languages are so similar that they converge to form one language. Lexical items can thus be inserted freely from one language to another. Congruent lexicalization is a less frequent phenomenon requiring high levels of bilingualism as well as structural compatibility across languages.

The degree and frequency with which these types of language switching patterns are used varies greatly across bilingual individuals and contexts. Yet, extensive research on intra-utterance language switching in adults indicates that in most cases, language switched utterances follow the grammatical rules of the respective languages (Genesee et al., 2011). Distinguishing between these types of language switches (i.e., insertion, alteration, congruent lexicalization) may be important to understanding the cognitive control processes in language switching. Green and Wei (2014) suggested that specific cognitive processes mediate different types of language switching such that the degree of neural activation and processing may be different across interactional contexts. These different interactional contexts may establish different habits of language processing control. The cognitive control processes involved in language switching will be discussed in more detail later in this introduction.

1.4.2 Language switching in bilingual adults.

Language switching is integral to the bilingual experience and is ubiquitous across bilingual communities (Ribot & Hoff, 2014). Factors that may affect language switching in adults include the speaker's age, race, role in the conversation, and level of proficiency in both languages (Cheng & Butler, 1989). In particular, the degree of proficiency in both languages can influence the type of mixing or switching that bilingual speakers use. A bilingual speaker who is highly proficient in both languages can shift seamlessly between languages within an utterance without violating grammatical rules. However, speakers who are gaining proficiency in a second language may have difficulty alternating between languages fluidly and may impose the structure of the more proficient language on the mixed segments of another language, resulting in grammatical errors (Genesee et al., 2011).

Bilingual adults language switch for a host of sociolinguistic, sociopragmatic, and cultural reasons. Sociolinguistically, language switching can reflect a bilingual speaker's awareness of the social factors (e.g., setting, topic) and language background of their conversational partners (Neumann, Walters, & Altman, 2016). Sociopragmatic and cultural functions of language switching include expressing bilingual ability to other bilinguals as a mark of identity (Poplack, 1987), and creating intimacy and ethnic solidarity with others of the same language and culture through expression of affect. Furthermore, bilingual speakers might language switch out of respect to others in the conversation who are more proficient in one language or to distinguish themselves from monolingual speakers (Genesee et al., 2011). Language switching also may be used as a linguistic device to narrate episodes that were originally bilingual, to indicate focus, change in topic, or emphasis (Neumann et al., 2016).

1.4.3 Language switching in bilingual children

Despite the research demonstrating that language switching in bilingual adults serves important social and linguistic functions, parents, educators, and speech-language professionals often perceive language switching by bilingual children as hampering language development and proficiency (Genesee et al., 2011; Grosjean, 1989). Historically, language switching by bilingual children was thought to be evidence of confusion and failure to differentiate between multiple languages. The Unitary Language System Hypothesis (Volterra & Taeschner, 1978) justified this assumption. However, research indicates that as early as age two, children adjust their relative use of one language or another based on the language of the interlocutor (e.g., Comeau et al., 2003; F. Genesee et al., 2011; Lanza, 1992; Reyes, 2004) although they may still make errors in appropriate language selection (Gross & Kaushanskaya, 2015). Today, researchers generally reject the Unitary Language System Hypothesis in favor of models that account for separate linguistic systems with cross linguistic influences on multiple levels.

Just as language development and use across bilingual children are extremely varied, language switching in bilingual children is far from homogenous. The frequency of language switching varies dramatically across bilingual children and the factors that determine this variability are not clearly understood. Seemingly, parental language input, language dominance, language proficiency, and contextual and social factors can affect the degree and rate with which bilingual children language switch. It is important to note however, that none of these factors appear to act in isolation and it is more likely that multiple factors interact to determine a child's language switching behavior.

1.4.3.1 Language input.

Several researchers have argued that parental input plays a key role in determining child language switching. Language switching is a common practice among bilingual parents and children receive varying degrees of language switching input from their parents. Bail, Morini, and Newman (2014) audio recorded interactions between bilingual (Spanish-English) parents with their 18 to 24-month-old children during brief play sessions. Across the 24 child-caregiver dyads included in the study, the authors found that the rate and type of language switching varied greatly across parents (*M* = 15.8%; *SD* = 16.9; range = 0,4 – 58.5%) but that all parents language switched at least once. Surprisingly, even parents who reported that they never language switched with their children did so, with one parent language switching 13 times during a 13-minute observation.

Regarding the frequency of language switching in spontaneous speech among bilingual children, research indicates substantial variability as well. In their research with bilingual French and English children in Montreal, Genesee, Nicoladis, and Paradis (1995) found that in general, children language switched within utterances less than 10% of the time, but with large variation across participants. They also found that children language switched more frequently across utterances than within utterances. However, the authors noted that the type of language switching (e.g., intra-sentential vs. inter-sentential) was also dependent upon language ability since language switching within utterances requires more advanced language skills.

Bail et al., (2014) did not report the rate of child language switching, yet other researchers have sought to determine how parental models of language switching influence the bilingual child's language switching patterns. Research indicates that the children's language mixing is typically proportional to the degree of parental language input (e.g., Comeau et al., 2003; Goodz, 1989). Comeau and colleagues explicitly tested the modeling hypothesis – the prediction that bilingual children's rates of language switching are related to the rate of language switching in the input they receive. The authors audio-recorded the play sessions of six French-English bilingual children (mean age = 2;4) interacting with a bilingual adult. The bilingual adult adjusted her rate of mixing from relatively low (15%) to relatively high (40%), across three different sessions. Results of the study indicated that the children adjusted their rate of mixing according to the adult's rate of mixing and did so by matching their language selection to that of the adult's language choice on a turn-by-turn basis.

In a recent study, Ribot and Hoff (2014) also argued that language switching in young children is dependent on language experience and input. Ribot and Hoff examined patterns of conversational language switching in 115, 2 ½-year-old simultaneous Spanish-English bilingual children. Using a rating scale, parents in the study indicated whether their child language switched from English to Spanish and from Spanish to English when addressed in each language. The authors found asymmetries in conversational language switching across children. Some children language switched in both directions (i.e., to either English or Spanish), others only switched in one direction. However, Spanish elicited more switches with children switching almost twice as frequently to English when addressed in Spanish than to Spanish when addressed in English. The children who demonstrated consistent patterns of language switching did differ in input, with each group receiving more exposure to the language they preferred to use most often. The authors concluded that differences in language switching behavior were associated with differences in language input.

1.4.3.2 Language proficiency.

Language proficiency appears to be related to language switching behavior in both children and adults and filling semantic and syntactic gaps in proficiency is a common hypothesis for bilingual language switching. Young bilinguals often present with varied levels of proficiency in each language. According to the gap-filling hypothesis, when using a less developed language, bilingual children may use words from L1 when speaking in L2 because they lack the vocabulary or syntactic knowledge in L2. This phenomenon is also commonly seen in second language learners (Genesee et al., 2011).

In a study of lexical choice in bilingual preschoolers, Greene, Peña, and Bedore (2012) examined single-word language switching in 606 bilingual preschoolers. The sample included preschoolers with typical development and those identified as at risk for language impairment. The authors evaluated children's lexical choice when presented with Spanish and English items on a semantic screener. The authors evaluated the prevalence of language switching, frequency of language switching, and accuracy of language switched responses on specific test items. They found that nearly half of the participants language switched at least once on either the English or Spanish formal screeners. Given the formalized demands of the assessment task, Green and colleagues concluded that, in general, children language switched by substituting words in one language for words they did not yet know in the other (i.e., filling gaps in lexical knowledge). It is important to note, however, that the authors did not rule out the effects of additional factors such as language input and the social norms of language switching in a community.

Within their sample of bilingual preschool children, Ribot and Hoff (2014) identified distinct subgroups of children with differing profiles of expressive and receptive language skills in English and Spanish. The authors were interested in whether individual patterns of language switching (i.e., language switching asymmetries described above) were related to expressive and receptive language skills across languages. As a whole, the sample of children had higher expressive language scores in English, but equal receptive scores in both languages. However, the authors identified a subgroup of children whose expressive-receptive language profiles were consistent with their language switching patterns. Children who only language switched to English had an exaggerated profile to that found in the larger sample with a greater gap between English and Spanish expressive language scores (greater than 1.5 standard deviations) and with little difference between receptive language scores. However, the subgroup with an opposite asymmetrical language switching pattern (i.e., switching to Spanish when addressed in English) did not demonstrate a complementary language profile. Children in this subgroup had similar expressive language scores in English and Spanish and had higher Spanish receptive language scores. For this subgroup of children, the authors concluded that language choice could not solely be attributed to limited expressive proficiency in one language. The authors concluded that the role of input and expressive/receptive language proficiency in influencing bilingual language switching patterns in children requires further investigation.

1.4.3.3 Language dominance.

Language dominance is closely related to language proficiency. Several studies suggest that language dominance may also influence language switching patterns. In adults, research indicates that during voluntary language switching paradigms, language dominance plays a role in language switching. Gollan and Ferreira (2009) found that English-dominant bilinguals switched more frequently to their non-dominant language to name highly accessible items (i.e., vocabulary items more easily retrieved) but named less accessible items in their dominant language. Furthermore, balanced bilinguals engaged in more voluntary language switching than less balanced bilinguals. In children, multiple studies indicate that a child's language dominance seems to impact lexical selection, particularly during language testing situations. Gross and Kaushanskaya (2015) extended the findings of Gollan and Ferreira and demonstrated that Spanish-English bilingual children also switched to their non-dominant language more frequently on highly accessible items. Several other studies have found Spanish-dominant bilingual children are more likely to switch to English during language testing than switch from English to Spanish (Bedore, Peña, Garcia, & Cortez, 2005; Miccio, Hammer, & Rodriguez, 2009). Importantly, additional factors such as perceived socio-linguistic context (e.g., the language of testing) may play a role in influencing lexical choice.

1.4.3.4 Linguistic context.

As previously noted, language dominance may interact with sociolinguistic context to influence lexical selection in children. Additionally, the rate and type of switching may vary depending on whether language switching is observed in naturalistic, spontaneous contexts or whether it is elicited during formal tasks. Gutiérrez-Clellen, Simon-Cereijido and Erickson Leone (2009) examined language switching in bilingual (Spanish-English) children with and without language impairment during narrative samples and conversational exchanges. In these arguably less structured settings, the authors observed less frequent switching (6.5% of utterances) than in the formal language screening studies (Greene et al., 2012). When they compared the frequency of language switching across conditions, the authors found that bilinguals were more likely to switch during conversational exchanges than during narrative tasks.

1.4.3.5 Pragmatic explanations.

Bilingual children may language switch for a host of pragmatic reasons as well. Particularly in older children, language switching may be used when quoting from another language, narrating an event, or emphasizing a point. Lanvers (2001) conducted a detailed conversation analysis of two German-English bilingual children (ages 1;6 and 2;11) using bimonthly recordings of the children interacting with their parents. The author found that the majority of switches were made for emphasis and appeal and due to vocabulary gaps. Cheng (2003) studied the functions of language switching in a group of 60 Malaysian and Chinese preschool children. These bilingual children used language switching to facilitate a range of discourse strategies. A bilingual child may use different languages depending on the vocabulary available in each language. For example, one language may have more affective vocabulary, and a bilingual child may defer to that language when discussing emotions (Paradis et al., 2011).

1.4.3.6 Social norms.

In addition to familial patterns of language switching, community based-patterns of language switching may also influence the degree and type of language switching that children exhibit. Social norms of language switching within communities and families may dictate the degree and frequency with which a child language switches (Genesee et al., 2011). The variability in the social norms of language switching can be studied both within and between communities (Gardner-Chloros, 2009). Within communities, variation can occur on multiple levels including age, gender, and network. Between bilingual communities, the types of language switching, the frequency of switching, and attitudes toward switching may vary greatly.

In one seminal study, Poplack (1987) compared data collected from bilingual French-English speakers in five neighborhoods within the Ottowa-Hull community in Canada. Importantly for the study, the neighborhoods were divided by a river which acted as a linguistic border where on the Quebec side (Hull) French is the official and majority language and on the Ontario side (Ottowa), French is the minority language and English is spoken more frequently. Differences in language switching were attributed to the language status in the different neighborhoods. The author found that in the Ottowa communities where French was a minority language, language switching was three to four times more frequent than in the Hull neighborhoods where French was the majority language. Furthermore, the same types of language switches were observed in all communities but with differences in the distribution of these types. Genesee and colleagues (2011) pointed out that tolerance and acceptance of language switching varies across communities. Children raised in communities where language switching is regarded as an important aspect of the linguistic culture may learn to language switch more than children raised in communities where language switching is less tolerated.

1.4.3.7 Grammaticality and competence in child bilingual language switching.

We presume that given consistent and quality exposure to two languages, at a certain age, bilingual children acquire the ability to language switch for the full range of functions used by adults. Until they reach this point, their language switching development is related to their linguistic development, social factors, and awareness that two language varieties exist in their environment. From a language development perspective, intra-utterance switching cannot be achieved until the child is combing words in phrases and sentences. Presumably, a child needs to attain an adequate knowledge of the grammars of both languages to comply with language switching grammatical constraints. Thus, children who are not yet combining words to form sentences may demonstrate inter-utterance switches (i.e., alterations) but not intra-utterances switches (i.e., insertions).

Research supports the hypothesis that language switching among bilingual adults is systematic and constrained by grammatical rules of both languages. Although as Gardner-Chloros (2009) observed, these constraints are not categorical but rather reflect tendencies that develop in particular circumstances. Nonetheless, studies across various languages demonstrate that intra-utterance switching by bilingual children is also generally systematic and adheres to the rules of the participating languages (e.g., Lanvers, 2001; Lanza, 1997; Meisel, 1994). Interestingly, Lanza (1997) did not find that the emergence of grammatical categories affected qualitative differences in the language switching patters of young children. However, it is important to note that these studies involved few participants and did not directly compare children's speech with that of adults in their immediate community.

1.4.4 Language switching in children with language impairments.

Still less is known about language switching in bilingual children with language impairments. Greene and colleagues (2012) used a bilingual language screening task to investigate differences in language switching by children at risk for language impairment and children not identified as being at risk. The authors found that language dominance and risk status impacted children's switching patterns. On the English semantic screener, language dominance rather than risk status was associated with the rate of language switches with English-dominant bilinguals switching less than balanced bilinguals and Spanish-dominant bilinguals respectively. On the Spanish screener, however, results indicated that both language dominance and risk status were significantly associated with language switching although there was not a significant interaction. For dominance, a similar pattern as on the English screener was observed with Spanish-dominant bilinguals switching less frequently than balanced bilinguals and English-dominant bilinguals respectively. Furthermore, more children not at risk for language impairment language switched than children at risk for language impairment. Although no children in this study had yet received a clinical diagnosis of language impairment, the findings suggest that risk status may play a role in language switching behavior.

To date, one known study has systematically examined the language switching patterns of children with SLI (see Gutiérrez-Clellen et al., 2009). Children with SLI demonstrate delays in language acquisition with grammatical competence noticeably below that of same-age peers (Leonard, 1988). Thus, it might be expected that given delays in language development overall, children with SLI may demonstrate language switching patterns more similar to younger children or may demonstrate more frequent language switching to compensate for lexical or semantic gaps in their knowledge of one language. Gutiérrez-Clellen and colleagues (2009) examined language switching in spontaneous language samples of 58 Spanish-English bilingual children (ages 5 – 7) with and without SLI. Eighteen of these children had SLI. Language switching was observed during a narrative re-tell task and a conversational sample. When matched for age and language dominance, children with SLI did not language switch more frequently than peers with typical development during either condition. Language switched utterances were then evaluated based on their compliance with the grammatical constraints reported in the adult language switching literature (e.g., Poplack, 1980). No significant differences were found in terms of grammaticality of switched responses and both groups generally adhered to grammatical constraints used by bilingual Spanish-English speaking adults. Furthermore, the majority of language switched responses were intra-sentential and within the noun phrase. However, it is important to note that regardless of the context of elicitation, the proportion of language switched utterances was quite low with only 6.5% of utterances including a language switched response. The authors concluded that like the results of other studies, it appears that language switching varies depending on the linguistic and social environment, rather than differences in language development (Comeau et al., 2003).

In a recent case study, Yu (2016) examined the language switching patterns of a bilingual Mandarin-English speaking preschool child with ASD. The participant, aged five years, ten months, demonstrated qualitative impairments in social interaction, communication, and displayed stereotyped patterns of behavior, interest, and activities. His IQ was within the normal range, and he communicated verbally using full sentences. The author analyzed and coded the language switched instances using conversational analysis and determined that the participant’s language switching was indeed systematic and socially ordered. Through bilingual language switching, the participant demonstrated a range of discourse competencies including clarifying, marking emphasis, ending participation, making an appeal, indicating a change in stance, and commenting on himself. Furthermore, the participant demonstrated deliberate language selection with conversational partners. The author argued that the participant used language switching strategically to meet various participation demands within his family routines and observed that language switching appeared to serve an important role in the child’s ability to participate meaningfully in family interactions. Although the research is limited, the available evidence indicates that language switching among bilingual children with and without language impairments is not detrimental to their language development and is a natural and important phenomenon.

1.4.5 Neural basis for language switching.

Given the importance of language switching in bilingual’s speech, researchers have sought to understand the neural basis for language switching. Studies of bilingual adults consistently demonstrate that lexical representation in both languages is activated regardless of which language is in use during both language comprehension and production (see Kroll, Gullifer, & Rossi, 2013 for a review). These findings suggest that even at high levels of bilingual proficiency, bilingual speakers cannot entirely “switch off” one language while using another. There is cross-language activation for all the known languages when bilingual individuals read, speak, or listen to speech.

Understanding how more than one language is represented on a neural level has been the subject of debate in the literature on language processing. The ability to modulate comprehension and production of two languages is called language control and because bilinguals are often fluently switching between languages they are thought to have a highly developed mechanism for cognitive control (e.g., Abutalebi et al., 2012; Abutalebi & Green, 2007).

Laboratory studies of language switching typically involve artificial paradigms in which participants are cued to name a picture or number in one language or another. Typically, switch trials are presented via a computer and auditory responses are recorded. In cued language switching paradigms participants are prompted to switch by an arbitrary cue (either a color and/or shape prompt) and are asked to associate the specified color or shape with one or the other language. For example, a participant may see a yellow circle flash on a computer screen followed by a picture of a target noun which they are expected to label in the corresponding language. There is strong evidence that in these cued switching paradigms, participants exhibit increased reaction times or deviant event-related potentials (ERPs) on trials where they are required to switch versus trials where they do not switch or in mixed language blocks of items compared to single language blocks (see Bobb & Wodniecka, 2013 for a review of behavioral studies and Van Hell & Witteman, 2009 for a review of neurocognitive studies).

Switch costs in cued language switching studies of children and adults are apparent in language comprehension (e.g., Blanco-Elorrieta & Pylkkänen, 2017; Potter, Fourakis, Morin-Lessard, Byers-Heinlein, & Lew-Williams, 2018; Thomas & Allport, 2000; von Studnitz & Green, 2002) and in language production (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Gollan & Ferreira, 2009; Macnamara, Krauthammer, & Bolgar, 1968; Meuter & Allport, 1999). In comprehension, asymmetrical switch costs are often evident although findings are mixed and asymmetry varies across tasks (e.g., Aparicio & Lavaur, 2014; Declerck & Grainger, 2017; Koch, Gade, Schuch, & Philipp, 2010; Olson, 2016; Philipp & Huestegge, 2015). In word production, switch costs are often asymmetrical with a larger cost incurred for switching to L1 (Guo, Liu, Misra, & Kroll, 2011; Meuter & Allport, 1999). Furthermore, neurobiological investigations demonstrate that language switching in cued paradigms engages executive control regions of the brain, primarily the prefrontal cortex (Branzi, Della Rosa, Canini, Costa, & Abutalebi, 2016). The findings from these studies are used as empirical support for numerous theoretical models of bilingual language switching (e.g., Dijkstra & van Heuven, 2002; Green, 1998; Kroll & Stewart, 1994).

One prominent theory in language switching is Green's (1998) Inhibitory Control model. Green suggested that when using their second language, bilinguals must inhibit the use of the first language to prevent interference. When switching from one language to another, bilinguals must first overcome the inhibition previously placed on the language. The cost, or amount of inhibition required, varies as a function of language dominance with greater inhibition required for the more dominant language. Meuter and Allport (1999) conducted one of the earliest language-switching studies, providing support for Green's Inhibitory Control model. The authors asked bilingual adults to name a series of single digits alternating between their L1 and L2. The language response was cued by color cues (different colors panels presented for L1 and L2), and switches occurred randomly from L1 to L2 or vice versa. Results from this study indicated that naming latencies on the switch trials were slower than the stay trials and switching costs were greater when switching from the weaker language, L2, into the dominant language L1.

Since Meuter and Allport's seminal study, numerous studies have demonstrated that language switching incurs a processing cost which is often asymmetric with greater switch costs into the more dominant language (for another review see Declerck & Philipp, 2015). However, the role of inhibition in switch cost asymmetries is still up for debate. In another extensive review of findings, for example, Koch and colleagues (2010) proposed that switch cost asymmetries in language-switching paradigms may not be due entirely to inhibition. Importantly, task demands can affect observed patterns of asymmetry and studies vary in task difficulty (e.g., length of set size, stimulus timing) and stimuli type (e.g., pictures, numerals). Also, the properties of stimuli (cognates or not) may influence switch costs (Declerck, Koch, & Philipp, 2012). Finally, differences in research design and language proficiency of the participants may affect outcomes.

While the Inhibitory Control model is often used to explain switch costs in production, the Bilingual Interactive Activation Plus model (BIA + model; Dijkstra & van Heuven, 2002) was developed to explain switch costs in comprehension. The BIA+ model of word recognition assumes that the words of two languages are stored in an integrated lexicon. Under the Inhibitory Control model, the language of the target word must be specified at an early stage in lexical selection. However, according to the BIA+ model of perception, parallel activation of both languages is resolved later in the language selection process because the processing is driven by visual/acoustic input. Unlike the inhibitory control model, the BIA+ model predicts switch costs in the dominant to non-dominant direction. Several empirical investigations offer support or partial support for the BIA+ model (Dijkstra, Grainger, & Van Heuven, 1999; Jared & Kroll, 2001; Liao & Chan, 2016). For example, Liao and Chan used ERPs to determine whether switch costs were modulated by the direction of the switch (from dominant to non-dominant or vice versa) in Mandarin-Taiwanese bilinguals as they read sentence stimuli. The authors found that switch costs were greater when participants were cued to switch from the dominant to non-dominant language.

Another area of debate is whether switch costs vary based on the task requirements (e.g., voluntary vs. cued) or with utterance length (word level vs. sentence level). Researchers have rightly raised concerns about the ecological validity of cued language switching tasks, arguing that they do not mirror the everyday experiences of bilinguals. Many bilinguals switch seemingly effortlessly between languages, and the idea of a cognitive cost does not match their everyday experience (Blanco-Elorrieta & Pylkkänen, 2018). Blanco-Elorrieta and Pylkkänen suggested that this disconnect between bilinguals’ experience and the evidence is likely due to the arbitrariness of the relation between the cue and the target language and the forced nature of the switch.

Researchers have recently begun to address this issue by designing studies that use cues that are more naturalistic or by allowing participants to name stimuli in their preferred language (i.e., voluntary switching). More natural cues (such as faces that match those typical of the speaker of a language) have been shown to elicit faster switching times although a cost is still present (Blanco-Elorrieta, Emmorey, & Pylkkänen, 2018; Blanco-Elorrieta & Pylkkänen, 2015; Blanco-Elorrieta & Pylkkänen, 2017; Li, Yang, Suzanne Scherf, & Li, 2013). In the language comprehension research, similar results are evidenced in studies that employ more naturalistic stimuli and context for switching. Several studies have examined lexical selection using inter-sentential (between sentences) language switching. For example, Gullifer, Kroll, and Dussias, (2013) and Ibáñez, Macizo, and Bajo (2010) used inter sentential language switching and did not report a significant switch cost. These findings indicate that information provided by the sentence context in inter-sentential language switching, may help bilinguals overcome the inhibition required during lexical selection.

The Adaptive Control Hypothesis, (Green & Abutalebi, 2013) posits that language control may vary depending on the language contexts and communication partners. The authors presented a model that accounted for voluntary language switching in three bilingual language contexts: single language, dual language, and dense language switching. In the single language context, bilinguals use L1 in one environment (e.g., home) and L2 in another environment (e.g., school) and there is no frequent language switching. The single language context is thought to require more global cognitive control. In contrast, in dual language contexts both languages are used in the same settings but with different interlocutors. Language switching occurs frequently but with different speakers and typically not within the same utterance. The dual language context is thought to require high levels of cognitive control due to the constant monitoring that is required when switching between languages and interlocutors. In the dense language switching context, a bilingual is surrounded by other bilinguals who speak the same languages, and language switching happens freely during conversation and within utterances (i.e., intra-sentential language switching). Language switching within this context is argued to require less cognitive control as it does not rely heavily on cognitive processes such as goal maintenance, cue detection and response inhibition. The dual language context is the most similar to cued language switching paradigms, which demand higher levels of cognitive control. The switch costs and mixing costs that are often observed during cued language switching paradigms may be explained by the higher cognitive cost associated with dual-language use and non-voluntary switching tasks.

Gollan, Kleinman, and Wierenga (2014) conducted a series of three studies to investigate cued versus voluntary switching efficiency across different conditions. The authors found similar rates of switching in both cued and voluntary conditions. Furthermore, they found that the switch costs varied depending on the task requirements. For example, they found little difference in response times for voluntary and cued conditions when a large stimulus list was used but a relative advantage for voluntary switching when a shorter list of stimuli was repeatedly presented. The authors concluded that increased lexical accessibility in the task where high-frequency repetitive words were used influenced the voluntary advantage. In a study of children’s voluntary language switching, Gross and Kaushanskaya (2015) investigated language choice during a picture naming task administered to English-Spanish bilingual children. Results indicated that the children exhibited significant switching costs across both languages and asymmetrical mixing costs. Children switched to their non-dominant language most frequently on highly accessible items. Results confirmed findings by Gollan and colleagues suggesting that both accessibility of lexical items and inhibition contributed to children’s language choice.

However, recent studies have found that switch costs were eliminated in voluntary language switching conditions. Kleinman and Gollan (2016) designed a series of experiments to determine whether switch costs are present when a bilingual individual is allowed to switch voluntarily. Participants were instructed to name targets in whichever language was easier and the authors found that switch costs were eliminated in these conditions. Other studies have found that reaction times were quicker for a mixed language condition than a single language condition. For example, de Bruin, Samuel, and Duñabeitia (2018), observed switch costs on both the voluntary and cued language-switching tasks administered to Basque-Spanish bilinguals. Interestingly, the authors found that while cued language use resulted in mixing costs (i.e., increased reaction time during dual language condition compared to single language condition), the voluntary condition showed a mixing benefit. This suggests that using two languages voluntarily may be less costly than having to use only one language. These findings support the hypothesis that voluntary switching is based on availability of lexical items and thus for some situations, it may be easier for bilinguals to switch than to stay in the same language (Poplack, 1980). The authors suggested that findings align with the Adaptive Control Hypothesis (Green & Abutalebi, 2013) because a mixing benefit was observed during the voluntary switch condition which most closely resembles the dense language switching context which is associated with decreased cognitive cost.

1.4.6 Bimodal bilinguals.

Although there is disagreement in the literature surrounding the psycholinguistic theories of language switching, emerging evidence from language switching in bimodal bilinguals may offer novel or clarifying information. Bimodal bilinguals are individuals who speak more than one language across more than one modality. The most commonly used example is individuals who speak a signed language such as American Sign Language as well as a spoken language such as English. Unlike bilinguals who speak two spoken languages, bimodal bilinguals are able to produce both languages simultaneously using separate articulators for each language.

However, as with unimodal bilinguals, bimodal bilinguals must employ cognitive control mechanisms to language switch and demonstrate cross-language activation (e.g., both signed and spoken language) during production and comprehension of a single language (for a recent review see Emmorey, Giezen, & Gollan, 2016).

Simultaneous production of signed and spoken language is referred to as code blending and is common in bimodal communication and typically involves semantically congruent forms (translation equivalents; Emmorey, Borinstein, Thompson, & Gollan, 2008; Lillo-Martin, de Quadros, Chen Pichler, & Fieldsteel, 2014; Petitto et al., 2001). Recent investigations involving both cued and natural code blending found that code blending did not incur a processing cost (e.g., Emmorey, Petrich, & Gollan, 2012). However, language switching from code blend mode into single language mode incurred a processing cost while switching from a single language into a code blend was not costly (Emmorey et al., 2016). The absence of switch costs in bimodal bilinguals indicates that two lexical representations are activated simultaneously, providing support for models such as the BIA+ that propose that language selection occurs in later processing stages rather than in early stages (i.e., Inhibitory Control Model).

Less is known about comprehension of code blends and the associated psycholinguistic processes. In one study, Emmorey and colleagues (2012) found that response times were faster in a code-blend condition than during single language conditions for ASL-English bilinguals in a semantic categorization task. In a follow-up study using fMRI analysis with the same task, the authors found that code blend comprehension did not recruit the anterior cingulate region which is associated with cognitive control and may have even provided a facilitative effect (Weisberg, McCullough, & Emmorey, 2015).

1.4.7 Summary.

It seems certain that fully bilingual adults can functionally separate their languages and consequently switch fluidly. However, in young children the ability to discriminate between languages is a skill that seems to develop in the perceptual realm first with later conceptual discrimination related to the development of categories (see Byers-Heinlein, 2014). Numerous studies indicate that language switching in bilingual children and adults incurs a cognitive cost, specifically during cued language switching paradigms. However, new evidence indicates that in some voluntary switching situations and in more naturalistic contexts, language switch costs may diminish or disappear. Furthermore, bilingual adults seem to switch effortlessly between languages and even young children language switch, although the frequency and motivation for switching vary greatly. Language switching serves important linguistic, pragmatic, and social functions regardless of whether a child has a language impairment or not. Although limited, the available research indicates that in children with communication impairments, language switching is not significantly different in terms of type or frequency of switches when compared to children with typical development.

1.4.8 Language switching among children who use augmentative and alternative communication.

Research investigating production and comprehension of language switching in bimodal bilinguals provides a context in which to consider language switching using AAC. Like signed language, AAC employs a communication modality other than speech. However, unlike sign language, AAC is not a language governed by a distinct set of linguistic rules. When a speaker uses an SGD to communicate, they map a mental representation of a concept onto a visual-graphic symbol (e.g., picture symbols, orthographic symbols, or whole words). When using

AAC, the speaker's communication follows the rules set by the language or languages available on the system (e.g., English, Spanish). There are a number of different visual-graphic symbol systems that are available on AAC devices (e.g., Picture Communication Symbols®, SymbolStix©, Clarity™) and the organization and layout of these symbol systems varies according to the user and the software on the device. Some systems use picture symbols only, others use orthographic symbols or written words in combination with picture symbols, and still other systems use text-to-speech with only orthographic symbols and whole words.

Language switching using an SGD requires the user to shift between systems of visual-graphic symbols and deliberately select one or another language system. In recent years, device manufacturers have developed AAC applications and systems to support dual language use. Systems such as the Proloquo2Go[1], Proloquo4Text[2], TouchChat®[3], UNIDAD[4] and LAMP Words for Life [5] have voice output options in more than one language and allow the user to toggle between languages within the same app. In these systems, the user may have a page-set open in one language (e.g., English) but can switch to a version in another language (e.g., Spanish) by pressing a button. Most of these systems allow for inter-sentential language switching, but do not allow the user to use more than one language within the same message. However, currently the Proloquo2Go and Proloquo4Text have a fully integrated bilingual system

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[1] Proloquo2Go is a product from AssistiveWare and is an AAC software application developed for iPad, iPhone, and iPod touch. See http://www.assistiveware.com/product/proloquo2go for more information.

[2] Proloquo4Text is a product from AssistiveWare and is text-based software application. See https://www.assistiveware.com/products/proloquo4text for more information.

[3] TouchChat® is a language-based SGD available as an app. It is a product of PRC-Saltillo. For more information see https://touchchatapp.com/.

[4] UNIDAD is a product of Prentke Romich Company and is a language-based AAC software application available in English and Spanish. For more information see https://www.prentrom.com/prc_advantage/unidad-espanol-language-system.

[5] LAMP Words for Life is a product of Prentke Romich Company is an AAC software application that uses single-hit communication and allows the user to toggle between English and Spanish layouts. For more information see https://www.prentrom.com/prc_advantage/lamp-words-for-life-spanish-english.

that allows for intra-sentential language switching where the user can create a message that includes words and grammatical features from two languages.

Bilingual individuals who use AAC may be considered bilingual bimodals. These individuals are unique in that they may express more than one spoken language across multiple modalities (e.g., speech approximations, SGD). The speaker may choose to communicate using only the voice output on the SGD or may choose to use speech in combination with the SGD. Thus, the user may be using bimodal communication (e.g., speech and SGD) as well bilingual communication (e.g., English and Spanish). It is encouraging that recent studies indicate that simultaneous language production across more than one modality does not incur an additional cognitive cost in bimodal bilinguals who use sign and speech (e.g., Emmorey et al., 2016). However, a cognitive cost is associated with language switching in cued switching paradigms. Table 1.1 demonstrates that for bilinguals bimodals, there are many contexts in which they may use bimodal communication in dual language environments and the cognitive costs associated with these contexts is unknown. Furthermore, a cognitive load associated with language switching would be added to the cognitive burden of using AAC to communicate. Clearly, many questions remain with respect to language control and lexical access for bilingual bimodals.

Table 1.1 ***Communication contexts across modality and language environment for a bilingual bimodal speaker (Spanish and English used as an example)***

Modality	L1 only	L2 only	Dual Language
Speech	Spanish Speech	English Speech	Spanish, English Speech
AAC	Spanish SGD	English SGD	Spanish SGD English SGD
Bimodal	Spanish speech + Spanish SGD	English speech + English SGD	Spanish Speech + English SGD English Speech + Spanish SGD English, Spanish Speech + English, Spanish SGD English, Spanish Speech + English SGD English, Spanish Speech + Spanish SGD

Note. L1 = first language (e.g., Spanish), L2 = second language (e.g., English); AAC = augmentative and alternative communication; SGD = speech generating device.

1.4.9 Rationale for current study.

Many children grow up in bilingual communities where bilingualism is a necessity rather than a choice, and lack of access to a heritage language may negatively influence a child's connection to their community and culture. Several studies have documented the deleterious effects on family socialization and cohesion when, on the advice of professionals, parents of children with disabilities stop speaking to their child in their native language (Fernandez y Garcia, Breslau, Hansen, & Miller, 2012; Jegatheesan, 2011; Yu, 2013). Furthermore, family members of bilingual children who use AAC have expressed frustration that AAC devices do not include their home language (McCord & Soto, 2004). The diversity in the language experience of bilinguals who belong to an already heterogeneous group of children with intellectual and developmental disabilities makes research with this population challenging. However, as bilingualism across the globe becomes increasingly common, it is critical that research efforts continue to investigate both theoretical and clinical implications of bilingualism. Just as language switching plays an important social and linguistic role for bilingual children who use their natural speech to communicate, we presume that the same holds for children who use AAC modalities.

Despite the increased availability of bilingual AAC applications and systems, little is known about bilingual language development in children who rely on AAC to communicate. No known studies have investigated the cognitive, linguistic, or social factors that influence young children's ability to conceptually discriminate (i.e., language switch) using the graphic-symbol modality. This study aimed to address this gap in the literature by examining predictors of bilingual children's performance on a cued language switching task using a graphic symbol-based bilingual AAC system with voice output (e.g., SGD). The following research questions were addressed.

1.4.9.1 Research question 1.

What factors explain Spanish-English bilingual children's performance on a cued language switching task using graphic symbol-based SGDs?

It was hypothesized that children's nonverbal IQ, processing speed, language skills, and language dominance would significantly predict performance on a cued language switching task using graphic symbol-based SGDs.

1.4.9.2 Research question 2.

What differences in performance are there on a cued language switching task using graphic symbol-based SGDs when English-Spanish bilingual children without language impairments are compared to bilingual children with language impairments?

It was hypothesized that mean differences in performance on the experimental task between bilingual children without language impairments and bilingual children with language impairments would be significant. Bilingual children without language impairments would demonstrate higher levels of performance on the experimental task as evidenced by fewer errors and decreased response times.

1.4.9.3 Research question 3.

How do subgroups of participants vary based on intrinsic and extrinsic variables (e.g., language skills, cognitive skills, language dominance) relative to performance on a cued language switching task using graphic symbol-based SGDs?

It was hypothesized that subgroups of participants would emerge, revealing patterns of language skills, cognitive skills, language dominance and demographic information relative to participants' performance on the cued language switching task.

1.4.9.4 Research question 4.

Do bilingual children exhibit switch-costs on a cued language switching task using graphic symbol-based SGDs?

A three-way interaction between trial type, language dominance, and language impairment status was predicted. Participants would demonstrate slower performance on switch trials compared to stay trials, and slower performance when switching to their dominant language. Furthermore, children with language impairment would demonstrate longer response times than children without language impairments.

2 METHOD

2.1 Study Design

This study employed a non-experimental design to assess factors that influence the abilities of Spanish-English bilingual 4;0 – 6;11-year-old children to language switch using a speech-generating AAC device. Children with typical development and with language impairment were included in this study. Intrinsic and extrinsic variables (e.g., bilingual language abilities, cognitive skills, language environment) were examined and the relationships among these factors relative to children's performance on the experimental language switching task were explored. Child participants completed a series of standardized assessments to measure language skills in English and Spanish (including morphosyntax and semantic abilities), nonverbal IQ, and processing speed abilities. Parents completed a demographic information form and participated in a language environment interview about their child's history of bilingual language exposure and current bilingual input and use. Children participated in an experimental language switching task using picture symbols on Spanish and English SGDs.

2.2 Participants

2.2.1 Inclusionary criteria.

Participants met the following inclusion criteria (a) were between the ages 4:0 and 6:11, (b) were exposed to Spanish and English on a regular basis, (c) had adequate fine motor skills to point to 1.75" X 1" picture symbols on a touch-screen. Participants with a range of language abilities in English and Spanish were recruited. Children were identified with language impairment if they met two out of three of the following criteria: (1) Received scores less than 85

(1 standard deviation from the mean) on the language index on the *Bilingual English-Spanish Assessment* (BESA; Peña, Gutiérrez-Clellen, Iglesias, Goldstein, & Bedore, 2014), (2) had a previous diagnosis of language impairment, (3) parents reported concern regarding their child's language development on the parent demographic form. No children used an SGD prior to the study, however this investigation was a first step toward understanding the cognitive and linguistic processes required to language-switch using AAC.

2.2.2 Exclusionary criteria.

Exclusionary criteria included hearing impairment (>25dB at 1000+ Hz bilaterally), uncorrected vision impairment, serious emotional/psychiatric disturbance (e.g., major depression, psychosis), regular exposure to a third language, or failure to pass the familiarization phase of the experimental task.

2.2.3 Recruitment.

Sixty-eight parents and children responded to recruitment efforts for this study. Two metro Atlanta area school districts granted approval to recruit participants along with one Atlanta area clinic and one community organization that served Latinx families. Flyers advertising the study were emailed to several local clinics and agencies and were placed in community locations. Parents interested in participating in the study completed a consent form that allowed his/her child to participate in the study. Verbal assent was obtained from the child and children were continuously monitored for willingness to participate throughout the entire process. Parents chose their preferred location for participating in study activities: at home, the location where their child was recruited (i.e., school or clinic), or a research laboratory at Georgia State University. Participants were provided with an incentive of $25 for participating in the study and parents were sent a report in English and Spanish summarizing their child's bilingual language and cognitive abilities.

Seven participants were lost to follow up or moved prior to beginning any assessments. Two participants were lost to follow up after partially completing study activities, and one participant withdrew due to parent concerns about his ability to participate. Data from fifty-eight children (85% of those who consented) between the ages of 4;0 and 6;11 (*M* = 5.34 years, *SD* = .86), were included in the analyses, 35 children with typical development, 23 children with language impairment. An a priori power analysis was conducted using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) and confirmed that the proposed number of participants with medium to large effect sizes was sufficient for each of the data analyses.

Parental consent for participation in the study was obtained by distributing flyers and consent forms to 15 pre-kindergarten, kindergarten, and first grade class rooms across eight elementary schools. Twenty-five children across the eight elementary schools returned consent forms to allow for participation in the study. Twenty children were recruited for participation from a metro Atlanta Speech-Language-Pathology clinic. Parents of children who were recruited from school or from the clinic had the option of choosing whether they preferred their child to be seen for the study at school, at home, or at a research lab at Georgia State University. Eight participants were recruited from a local community organization and all participants were seen at the site in a private room. Five of the 58 participants contacted the principal investigator after hearing about the study via word of mouth and were seen at home. Table 2.1 describes the recruitment sources and assessment locations for participants.

Table 2.1 ***Recruitment sources and assessment locations for participants***

Recruitment Source	Assessment location	Number of Participants
School	School	18
	Home	7
Clinic	Clinic	15
	Home	5
Community Organization	Church	8
Word of mouth	Home	5

2.2.4 Family and medical history.

Two of the 58 participants were twins, and seven other participants were siblings. Twenty-three children met criteria for language impairment. Twenty children had a prior diagnosis of developmental language disorder. Two had a diagnosis of Autism Spectrum disorder, and one had a repaired cleft palate. All children either passed a hearing screening at the time of testing or had passed a hearing screening within the six months prior to beginning the investigation. The examiner administered hearing screenings in a quiet room. Pure tones were presented via headphones at 25dB at 1000, 2000, 4000 Hz bilaterally. According to parent report, children's vision was within normal limits or children used corrective lenses (*n* = 8).

2.2.5 Demographic information.

All but one child were Hispanic. Most children (*n* = 48) were born in the continental United States while the rest of the children were born in Puerto Rico (*n* = 1), Venezuela (*n* = 6), Columbia (*n* = 1), or Mexico (*n* = 1). Thirty-eight children were male and 20 were female. Over 60% of children attended kindergarten, preschool, or elementary school, 34% of children attended day-care, and 36% of the children remained at home with a caregiver during the day. Parents were asked to report their own and their child's race on the demographic information form, but most parents (*n* = 38) selected “some other race” for their child or did not report race. Nine children were Caucasian, eight were multiracial, three were American Indian/Alaska Native, and two reported unknown race. According to the United States Census Bureau, many people of Hispanic origin do not identify with the Unites States Government Office of Management and Budget’s official race categories that were used on the demographic information form for this study (US Census Bureau, 2017).

2.2.6 Language background.

Information about children’s language history and dominance was obtained from the *Bilingual Input-Output Survey* (BIOS; Peña, Gutiérrez-Clellen, Iglesias, Goldstein, & Bedore, 2014). The primary author administered the BIOS as a parent interview in the parent’s preferred language either in person or by phone. Parents were asked about the language exposure history of their child including when and in what context each of their child’s two languages was used on a year-to-year basis. Fifty-one children acquired Spanish and English simultaneously before the age of three and seven children learned English at preschool/school entry. Across participants the mean age of first exposure to English was 1.9 years (*SD* = 1.2).

Parents were asked which language their child heard and used during a week day and during a typical weekend day on an hour-by-hour basis. This information provided an estimate of relative language use and exposure during a typical week and yielded an average percent of Spanish input and Spanish output and an average percent of English input and English output. Procedures from Greene et al. (2012) were used to classify child participants by language dominance: English-dominant Bilinguals (EDBs), balanced bilinguals (BBs), and Spanish-dominant Bilinguals (SDBs). EDBs used and heard English more than 60% of the time and Spanish less than 40% of the time (*n* = 28); BBs used and heard English and Spanish between

40% and 60% of the time (*n* = 21); and SDBs used and heard Spanish more than 60% of the time and English less than 40% of the time (*n* = 9). The average percent of English input and output across all participants was 59% (Range = 20% - 87.5%, *SD* = 14.19%). On the demographic questionnaire, 18 parents reported speaking only Spanish to their child, 31 reported speaking mostly Spanish to their child, and nine reported speaking mostly English to their child. Twenty-nine parents reported that they either sometimes or frequently language switched when speaking to their child and 29 parents reported that they rarely or never language switched when speaking to their child. Table 2.2 summarizes group differences in children's language background and characteristics based on parent report.

2.2.7 Group differences.

An independent samples *t*-test revealed a significant difference in age when children without language impairments were compared to children with language impairments (*t* = 2.91, *p*< .05). Children with language impairments were younger on average (Mean age = 59.52 months) than children without language impairment (Mean age = 67.11). Independent samples *t*-tests revealed that mean differences between children without language impairments and children with language impairments were not significantly different on parent-report of languages spoken with their child (*t* = -.05, *p* > .05) or frequency of language switching with their child (*t* = -1.97, *p* > .05). Furthermore, mean differences across groups were not significant for gender (*t* = -.04, *p* > .05, age of first exposure to English (*t* = 1.23, *p* > .05), percent of English input (*t* = -.99, *p* > .05), or percent of English output (*t* = -.1.48, *p* > .05). A one-way ANOVA indicated no significant differences across categories of language dominance (i.e., EDBs, BBs, SDBs) when children without language impairments were compared to children with language impairments (*F* = .624, *p* < .05).

Table 2.2 ***Child Language Background and Characteristics based on Parent Report***

	No Language Impairment (*n* = 35)		**Language Impairment (*n* = 23)**	
Characteristic	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**
First exposure to English (years)[a]	2.06(.21)		1.65(.24)	
% English Input[b]	53.49(15.73)		57.43(13.63)	
% English Output[b]	58.31(13.61)		65.04(21.01)	
% Spanish Input[b]	44.80(13.12)		42.57(13.63)	
% Spanish Output[b]	41.69(13.61)		34.96(21.01)	
Typical receptive language				
More English		4(11.4)		6(26.1)
More Spanish		5(14.3)		3(8.6)
About the same in Both		26(65.7)		14(60.9)
Typical expressive language				
More English		5(14.3)		6(26.1)
More Spanish		8(22.9)		4(17.4)
About the same in both		22(54.3)		11(47.8)
Languages spoken to child by parent				
Only English		0		0
Mostly English		3(8.6)		6(26.1)
Only Spanish		12(34.3)		6(26.1)
Mostly Spanish		20(57.1)		11(47.8)
Frequency of parent code switching with child				
Never		11(31.4)		5(21.7)
Rarely		8(22.9)		4(17.4)
Sometimes		13(37.1)		6(26.1)
Frequently		2(5.7)		8(34.8)
Language dominance				
EDBs (>60% English)		16(45.7)		12(52.2)
BBs (40-60% English-Spanish)		14(40.0)		7(30.4)
SDBs (>60% Spanish)		5(14.3)		4(17.4)

note.

[a] Acquisition was indexed by the age in years at which the child was first exposed to English according to parent report.

[b] Percentages of English and Spanish Input and Output determined from *Bilingual Input Output Survey* (BIOS; Peña et al., 2014).

EDBs = English Dominant Bilinguals; BBs = Balanced Bilinguals; SDBs = Spanish Dominant Bilinguals; SD = Standard Deviation

2.2.8 Language and cognitive abilities.

Recruitment targeted children with a range of language and cognitive abilities. Table 2.3 describes children's abilities on standardized tests of language (BESA; Peña et al., 2014) and cognition (*Leiter International Performance Scale*, *Third Edition*; Leiter-3; Roid, Miller, Pomplun, & Koch, 2013). Mean performance across groups on the Bilingual Language Index of the BESA was within the average range for children without language impairments and below average for children with language impairments (*M* = 100, *SD* = 15). Although children with cognitive impairments were not excluded, Nonverbal IQ was within the average range for both groups. However, mean scores for Processing Speed as measured by performance on the Attention Sustained and Nonverbal Stroop subtests of the Leiter-3, were within the average range for children without language impairments, and below the average range for children with language impairments. Independent samples *t*-tests across groups for all subtests and composite scores revealed significant differences between children with and without language impairment on all standardized language measures, and on the Processing Speed composite and associated subtests of the Leiter-3.

2.2.9 Parents.

One parent (*n* = 53) of each child completed a family demographic information form in the parent's preferred language. The family demographic form can be found in Appendix A. The demographic form included information about their child's medical history, race, ethnicity, the parents' language background, and parents' educational achievement and employment to generate information about socioeconomic status (SES). All children had at least one parent who identified as Hispanic and whose primary language was Spanish. The average age of each child's participating parent was 34.55 years (*SD* = 6.37, range = 22 – 47). Forty-seven parents were female, six parents were male. Socio-economic status (SES) was measured by parent educational achievement which ranged from less than high school diploma to a professional degree (e.g., MD, DDS, DVM). Fifty of the 53 parents reported their education level. Twenty percent of parents had less than a high school education, 22.6% had a high school diploma or GED, 24.5% had attended some college but had no degree, 15% had an associate or bachelor's degree, and 13.2% had a graduate or professional degree. Regarding employment, 31 (58.5%) of parents reported that they were homemakers. Most parents were first generation immigrants to the U.S. from Mexico (*n* = 31) followed by Venezuela (*n* = 8), Guatemala (*n* = 3), Columbia (*n* = 2), El Salvador (*n* = 2), Honduras (2) and Peru (1). Four of the 53 parents were born in the continental United States and one parent was born in Puerto Rico.

2.3 Procedures

The primary investigator, who is fluent in English and Spanish, administered all standardized assessment and experimental procedures. The administration of the BESA subtests and the experimental task were audio recorded. A bilingual research assistant who was an undergraduate student in psychology, assisted with collecting parent and child demographic information and with parent interviews for some participants. Children participated in at least two assessment sessions and sometimes a third or fourth session. Assessment sessions ranged from 30 to 90 minutes depending on the child's ability to sustain a meaningful level of attention and engagement with the task. The examiner provided breaks as necessary between tasks and used concrete reinforcements to ensure motivation. The standardized assessments and experimental task included activities that were designed to be fun for young children. If a child was not able to complete all tasks planned for a session, a subsequent visit was scheduled within one month.

2.3.1 Assessment measures.

The *Bilingual English Spanish Assessment* (BESA; Peña et al., 2014) and the *Leiter International Performance Scale, Third Edition* (Leiter-3; Roid et al., 2013) were used to assess English and Spanish language abilities and cognitive skills.

2.3.1.1 Language assessment.

The BESA is a valid and reliable assessment of speech and language ability in English-Spanish bilingual children ages 4:0 – 6:11. Three subtests address the language domains of morphosyntax, semantics, and phonology in English and Spanish. All subtests are norm-referenced and may be combined or used independently. Subtests yield scaled scores, standard scores, percentile ranks, and age equivalents. For this study, the morphosyntax and semantics subtests were administered in English and Spanish.

BESA Morphosyntax Subtest. The morphosyntax subtest provided information about children's grammatical skills in English and Spanish. Test items included fill in the blank or open-ended questions about picture stimuli, and sentence repetition tasks. Grammatical structures tested in English included plural –s, possessive –s, regular past tense, third-person singular, progressives, copulas, auxiliary do + negatives, passives, as well as complex verb forms, conjunctions, and embedded prepositions and noun phrases. Forms tested in Spanish included articles, progressives, clitics, subjunctives, preterit, complex verbs forms, and conjunctions. For each language, the BESA yielded a grammatical cloze subscore, a sentence repetition subscore, and a total morphosyntax score that was a composite of the cloze and sentence repetition subscores. The morphosyntax subtest took 15 – 30 minutes to administer in each language.

Table 2.3 ***Summary of Language and Cognitive Profiles across Children with and without Language Impairments***

	No Language Impairment (n = 35)		**Language Impairment (n =23)**		
Measure	**SS Mean (SD)**	**CI 95%**	**SS Mean (SD)**	**CI 95%**	***t***
BESA Subtests (M = 10, SD = 3)					
English Cloze Sentence	8.51(3.31)	±1.13	3.18(2.22)	±.98	7.28**
English Sentence Repetition	8.97(3.33)	±1.14	4.00(2.53)	±1.12	6.38**
English Expressive Semantics	9.15(2.90)	±1.02	4.82(3.29)	±1.46	4.77**
English Receptive Semantics	9.00(2.82)	±.98	5.68(3.09)	±1.37	4.06**
Spanish Cloze Sentence	7.54(4.03)	±1.38	1.64(2.28)	±1.01	7.14**
Spanish Sentence Repetition	8.51(3.48)	±1.19	3.00(2.56)	±1.14	6.94**
Spanish Expressive Semantics	10.97(2.97)	±1.04	4.09(3.13)	±1.39	8.43**
Spanish Receptive Semantics	9.47(3.24)	±1.13	5.77(2.83)	±1.25	4.57**
BESA Composites (M = 100, SD = 15)					
English Morphosyntax	93.89(16.24)	±5.51	63.55(22.60)	±10.02	5.47**
English Semantics	93.21(17.66)	±6.16	74.05(20.32)	±9.01	3.70**
Spanish Morphosyntax	90.31(17.63)	±6.04	48(31.42)	±13.93	5.86**
Spanish Semantics	101.29(14.22)	±4.96	69.55(23.08)	±10.24	5.08**
Bilingual Language Index	103.71(10.10)	±3.46	75.91(9.40)	±4.06	10.70**
Leiter-3 Subtests (M = 10, SD = 3)					
Figure Ground	9.63(1.97)	±.68	8.91(2.35)	±1.04	1.23
Classification and Analogies	11.23(1.52)	±.52	10.00(3.22)	±1.43	1.74
Form Completion	12.20(1.55)	±.53	12.05(2.38)	±1.06	3.62
Sequential Order	9.77(2.50)	±.86	8.91(1.97)	±.88	1.61
Attention Sustained	10.89(2.63)	±.91	7.50(2.89)	±1.28	4.45**
NV Stroop Incongruent	8.74(2.79)	±.96	6.14(2.21)	±.98	3.91**
NV Stroop Congruent	9.31(2.94)	±1.01	7.59(2.44)	±1.08	2.40*
NV Stroop Effect	9.40(3.36)	±1.16	9.41(2.15)	±.96	-.01
Leiter-3 Composites (M = 100, SD = 15)					
NVIQ	101.89(7.72)	±2.66	96.86(10.99)	±4.87	1.97
Processing Speed	99.29(10.79)	±3.71	83.50(11.93)	±5.29	5.04**

note. BESA = *Bilingual English Spanish Assessment* (Peña et al., 2014); CI = Confidence Interval; SD = Standard Deviation; Lieter-3 = Leiter International Performance Scale, Third Edition (Roid et al., 2013); SS = Standard Score; NV = Nonverbal; NVIQ = Nonverbal IQ**p < .001, *p <. 05, t scores assumed unequal variances

BESA semantics subtest. The semantics subtest provided information about children's vocabulary knowledge and use in English and Spanish. The specific semantic targets included: analogies, characteristic properties, categorization, functions, linguistic concepts, and similarities and differences. The semantics subtest included items that assessed receptive and expressive language skills. Children listened to brief stories about picture stimuli and answered questions related to the stories and pictures either verbally or by pointing. Scoring of the BESA allowed for language switching – giving children credit for a correct response in either language. For each language, the BESA yielded subscores for receptive semantic skills and expressive semantic skills, as well as a total semantics score for each language. The semantics subtest took about 15 - 30 minutes to administer in each language.

2.3.1.2 Cognitive abilities.

The Leiter-3 evaluates nonverbal cognitive, attentional, and neuropsychological abilities in children, adolescents, and adults. It is appropriate for populations with speech and language disorders and from culturally and linguistically diverse backgrounds because it uses an engaging, nonverbal format and was normed and validated with a diverse group. The Leiter-3 provides individual subtest and composite scores that measure intelligence (including four subtests of fluid reasoning) as well as other discrete ability areas (i.e., nonverbal memory, processing speed). For this study, the following four subtests were administered to yield a composite measure of nonverbal fluid intelligence: Sequential Order, Form Completion, Classification and Analogies, and Figure Ground. In addition, the Attention Sustained and Nonverbal Stroop subtests were administered to yield a composite measure of Processing Speed. Administration time for the Leiter-3 tasks was between 30 minutes and 1 hour.

2.3.2 Experimental task.

The experimental task was developed by the primary investigator to measure children's ability to conceptually discriminate (i.e., language switch) between English and Spanish vocabulary displays on a speech-generating AAC device.

2.3.2.1 Pilot study.

Prior to beginning the current study, a pilot study of a single participant was conducted to determine the feasibility of the experimental language switching task and to evaluate the length of time required for the assessments and experimental task. The pilot participant was a 5;11-year-old bilingual male with a speech impairment but with language and cognitive abilities within the average range. The pilot participant was highly cooperative, and testing took approximately 2 hours across 2 sessions. The pilot participant did not have difficulty understanding the procedures of the experimental language switching task and achieved 90% accuracy. Following the pilot study, an additional measure of naming speed (i.e., response time) was included for the larger study to provide a more sensitive measure of performance on the experimental task and to mitigate ceiling effects.

2.3.2.2 Materials.

For the experimental task, participants accessed two SGDs: iPads[6] containing the Proloquo2Go[7] AAC application version 5. Synthetic voice output for both iPads was the bilingual child voice (Emilio) from Acapela Group[8]. A customized vocabulary display was created on the iPads using existing color symbols from the Proloquo2Go application.

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[6] The Apple iPad is a line of tablet computers designed and marketed by Apple Inc. See http://www.apple.com/ipad for more information about the Apple iPad.

[7] Proloquo2go is a product from AssistiveWare and is an AAC software application developed for iPad, iPhone, and iPod touch. See http://www.assistiveware.com/product/proloquo2go for more information.

[8] Acapela Group is a company that develops text-to-speech software and services. More information can be found at http://www.acapela- group.com/.

The target vocabulary words used in this study were borrowed from a list of 42 object nouns compiled by Gross and Kaushanskaya (2015). Gross and Kaushanskaya selected the 42 vocabulary items from a study of picture naming conducted by Bates et al. (2003) in seven languages (including English and Spanish) as part of the International Picture-Naming Project. The 42 vocabulary items were selected if their dominant names in English and Spanish had only one morpheme and had no more than two alternative names in each language according to Bates et al. (2003). Furthermore, vocabulary were comparable in terms of frequency of use (English $M_{\text{log-transformed frequency}} = 3.20$, $SD = 1.46$; Spanish $M_{\text{log-transformed frequency}} = 3.01$, $SD = 1.41$) and age of acquisition in English and Spanish. Frequency information was obtained from the Corpus of Contemporary American English (Davies, 2008) and the Corpus del Español (Davies, 2002). Age of acquisition ratings came from the International Picture-Naming Project database (Center for Research in Language, accessed 2018) and were based on the English and Spanish versions of the MacArthur Communicative Development Inventories. Cognates or translation equivalents that overlapped by more than two phonemes were not included (Gross & Kaushanskaya, 2015). Furthermore, English vocabulary was required to have a concreteness rating of at least 500 on a 700-point scale on the MRC Psycholinguistics Database from the University of Western Australia (Wilson, 1988). Gross and Kaushanskaya did not control for word length because word length is not considered to be a significant predictor of naming speed or accuracy (Snodgrass & Yuditsky, 1996). Table 2.4 includes a list of the English and Spanish target vocabulary words included in this study.

Table 2.4 ***English and Spanish Vocabulary Items used in the Experimental Task***

	English	*Spanish*		*English*	*Spanish*
1.	arm	brazo	22.	hand	mano
2.	axe	hacha	23.	hat	sombrero
3.	backpack	mochilla	24.	heart	corazón
4.	balloon	globo	25.	helmet	casco
5.	bed	cama	26.	horse	caballo
6.	bench	banca	27.	house	casa
7.	bone	hueso	28.	king	rey
8.	book	libro	29.	magnet	imán
9.	bridge	puente	30.	mushroom	hongo
10.	broom	escoba	31.	nail	clavo
11.	butterfly	mariposa	32.	pen	pluma
12.	cheese	queso	33.	pencil	lápiz
13.	church	iglesia	34.	pillow	almohada
14.	clown	payaso	35.	rain	lluvia
15.	couch	sillón	36.	rock	piedra
16.	door	puerta	37.	rocket	cohete
17.	dress	vestido	38.	shovel	pala
18.	drum	tambor	39.	table	mesa
19.	finger	dedo	40.	wheel	rueda
20.	flag	bandera	41.	wig	peluca
21.	frog	rana	42.	witch	bruja

note. Vocabulary items come from Gross andKaushanskaya (2015), obtained from the dataset of Bates et al. (2003), available at: http://crl.ucsd.edu/experiments/ipnp/7lgpno.html.

Prior to the experimental task, parents of child participants indicated which vocabulary words their child was familiar with in both English and Spanish from Gross and Kaushanskaya's (2015) list of 42 words. This information was used to create an individualized display of 16 target vocabulary words in English and Spanish using the Proloquo2Go iPad application. These words were presented on two seperate iPads: one with English vocabulary and English voice output, one with Spanish vocabulary and Spanish voice output. The Spanish and English vocabulary included identical picture symbols and layout on the SGD but with the corresponding speech output in each language. The layout of the symbols on the devices was randomized across participants. Although Proloquo2Go allows for language switching within the application, in this study two separate SGDs were used to eliminate navigation to different language layouts within the app as a confounding variable. The background color for the Spanish display was light blue, and the background color for the English display was yellow. Color coding the background of the displays was the only difference in the layouts and allowed the participants to visually differentiate between the two SGDs. Differentiating between languages using the background color of the stimulus display is a common practice on cued language switching tasks (e.g., Abutalebi et al., 2011; Costa & Santesteban, 2004; Meuter & Allport, 1999). A sample vocabulary layout is included in Appendix B.

2.3.2.3 Training and familiarization.

Before beginning the experimental task, participants were required to identify the symbols for the target spoken words in English and Spanish. The examiner asked the child to select target vocabulary words on the SGD and recorded the child's response. Corrective feedback to facilitate learning was provided if children did not correctly identify a symbol for a vocabulary word. After the participant had identified the vocabulary items in their non-dominant language with 100% accuracy, the procedure was repeated in the other language. If the child was unable to correctly identify vocabulary items in both languages, vocabulary swaps were made from the pool of 42 vocabulary words. All children achieved 100% accuracy for identification of spoken vocabulary items in both English and Spanish before proceeding with the experimental task.

2.3.2.4 Experimental task procedures.

The experimental task used the SGDs with the same 16 target words in English and in Spanish. Vocabulary words were presented in randomized order across trials and participants were asked to use the appropriate SGD to select a target word that was presented in either

English or Spanish. The first three trials were practice trials, and the subsequent 13 trials were the experimental block. If participants erred during the three practice trials, the examiner provided corrective feedback using script for each error type. Cross-language errors occurred when the child's response language using the AAC app did not match the language of the elicitation cue (labeled a Type 1 error). If the child selected the incorrect target concept but in the correct language, this was labeled a Type 2 error. Type 3 errors occurred when the participant selected the incorrect concept in the incorrect language. The error types and corresponding corrective feedback used during the practice trials are presented in Table 2.5. Three plush dolls (Sara, José, and Freddy) were used during the practice trials and the experimental block. The dolls provided a more meaningful and engaging context for the language switching and were meant to increase the ecological validity of the task. To create a context where the use of the SGDs for communication was obligatory, the child was asked to help one of the dolls to "talk" using the picture symbols on the iPads.

Table 2.5 ***Error Types and Examples on the Experimental Task and Corrective Feedback Provided during Practice Trials***

Error Type	**Description**	**Example**	**Corrective Feedback***
1.	Child selects correct concept in nontarget language	Target word = HAND, child selects MANO	You said _(child's response)_ in Spanish but Sara doesn't understand Spanish. You need to tell her _(English target word)_ in English. Dijiste _(child's response)_ en inglés, pero Sara no entiende inglés. Tienes que decir _(Spanish target word)_ en español.
2.	Child selects incorrect concept in non-target language	Target word = HAND, child selects BRAZO	Help Sara say _(English target word)_ on the tablet. You need to tell her in English so she understands. (gesture to both iPads) Ayuda Sara a decir _(Spanish target word)_ en el tablet. Tienes que decirle en español para que entienda (gesture to both iPads)
3.	Child selects incorrect concept in target language	Target word = HAND, child selects ARM	Try again. Help Sara say _(English target word)_ on the tablet. (gesture to iPad) Intenta otravez. Ayuda Sara a decir _(Spanish target word)_ en el tablet. (gesture to iPad)

Note. *Sara used as example "bilingual" doll. Examiner feedback was provided in English or Spanish, depending on the child's language dominance.

The child chose which "bilingual" doll they wanted to help, and this doll was placed next to the child. A script was used to present the dolls and explain the task, as shown in Table 2.6. Depending on the child's language dominance, the examiner used either the English or Spanish script. The examiner explained to the child that the doll they had chosen (i.e., Sara or José) could "talk" in English and Spanish using the pictures on the iPads. The child's task was to help the "bilingual" doll they had chosen to "talk" to the other two dolls, one who "understood" only

English (i.e., Freddy), and the other who “understood” only Spanish (i.e., Sara or José). The two iPads were placed six inches from the child and the order of Spanish or English from left to right was randomized across participants. Depending on the target language of each trial, either the “English understanding” or the “Spanish understanding” doll was placed sitting upright, directly behind and centered between the iPads. While placing the doll behind the iPads, the examiner provided a verbal prompt introducing the communication partner doll and providing the language context and target word (e.g., “*Here comes Freddy. Sara wants to say… HOUSE”*). Table 2.6 includes example prompts used in English and Spanish. Figure 2.1 depicts the set up for the experimental task.

The three practice trials and 13 experimental trials were presented in a mixed block of stay and switch trials. On switch trials, the target word was in a different language than the previous trail. On stay trials, the target word was in the same language as the previous trial. The order of English or Spanish presentation of target words and the order of switch and stay trials was randomized across participants. However, the researcher ensured that in the three practice trials, there was at least one switch and one stay trial. An odd number of total experimental trials was used to ensure an equivalent number of switch and stay trials. During the experimental block, there was a total of six stay trials and six switch trials.

Table 2.6 ***Example Target Words, Set up, Prompts, and Responses for Experimental Task***

Target Word	Set Up	Examiner Spoken Prompt	Child Example Responses using SGD			
			Correct	Type 1 Error	Type 2 Error	Type 3 Error
House	English-understanding doll (Freddy) placed behind iPads. Bilingual doll (José) placed next to child.	"Here comes Freddy, José wants to say…*house*."	HOUSE	CASA	RANA	DRUM
Mano	Spanish-understanding doll (Sara) placed behind iPads. Bilingual doll (José) placed next to child.	"Aquí viene Sara, José quiere decir…*mano."*	MANO	HAND	DOOR	LAPIZ
English Script	*Now we're going to help José to talk using the pictures on the tablets. José speaks both English and Spanish, but his friend Sara (present Sara doll) only understands Spanish. José can talk to Sara in Spanish using this tablet here (point to Spanish SGD). José has another friend called Freddy. Here's Freddy (present Freddy doll). But Freddy only understands English. José can talk to Freddy using this tablet here (point to English SGD). Let's help José talk to his friends!*					

note. Type 1 Error = correct concept, non-target language, Type 2 error = incorrect concept, non-target language, Type 3 Error = incorrect concept, target language.

2.3.2.5 Coding.

The experimental task was audio recorded using a portable SONY UX530[9] digital recording device with a built-in stereo microphone that was placed directly behind the iPads. During the experimental task the examiner recorded participants' responses to the prompts on a data sheet and documented whether the child's response was correct. Responses were coded by trial type (stay vs. switch) and language dominance (dominant language, non-dominant language). Language dominance information was obtained from the BIOS (Peña et al., 2014) which provided an estimate of the child's Spanish input and output and English input and output

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[9] SONY UX530 Digital Recording Device captures recordings in stereo, stores files via USB memory stick and uses an MP3 music player. This device is manufactured by the SONY Corporation. More information can be found at https://www.sony.com/electronics/voice-recorders/icd-ux530.

during a typical week. However, instead of using three groups for language dominance as described earlier (e.g., EDB, BB ,SDB), for the experimental task, binary language dominance was determined by greater than 50% average input and output in a given language. If a participant's average input/output was 50% in each language, language dominance was determined by the highest language composite on the BESA. Using a binary system of language dominance is a well-accepted practice and has been shown to impact performance on language switching tasks (e.g., Gollan & Ferreira, 2009; Gross & Kaushanskaya, 2016; Liao & Chan, 2016). The number of overall correct responses across the 13 trials was recorded.

In addition, responses were coded for errors and naming speed. Naming speed was defined as response time (RT) and measured using the audio recordings and was computed by measuring the time from the termination of the examiner's spoken prompt to the beginning of the child's output on the SGD. Trained undergraduate research assistants used the Praat speech analysis software version 6.0.43 *(*Boersma & Weenink, 2015) to measure the latency from the termination of the examiner's spoken cue to the onset of the child's response using the SGD.

2.3.3 Reliability and fidelity.

2.3.3.1 Fidelity measures.

Following completion of the experimental task, a trained research assistant determined fidelity for administration of the experimental task by comparing the clinicians' behaviors against pre-established fidelity measures. This assistant was masked to the purposes of the study and was not involved in the administration of any of the assessment or experimental procedures. To ensure that task procedures were followed consistently and correctly, the assistant listened to audio recordings of a randomly selected set of 20% of sessions and judged the examiner's behaviors on adherence to the experimental task administration protocol. Fidelity was calculated by dividing the number of behaviors adhered to correctly from a list of 12 behaviors, by the total number of behaviors and multiplying by 100 (e.g., 12/12 x 100 = 100). The fidelity rating was 99.36% across experimental sessions.

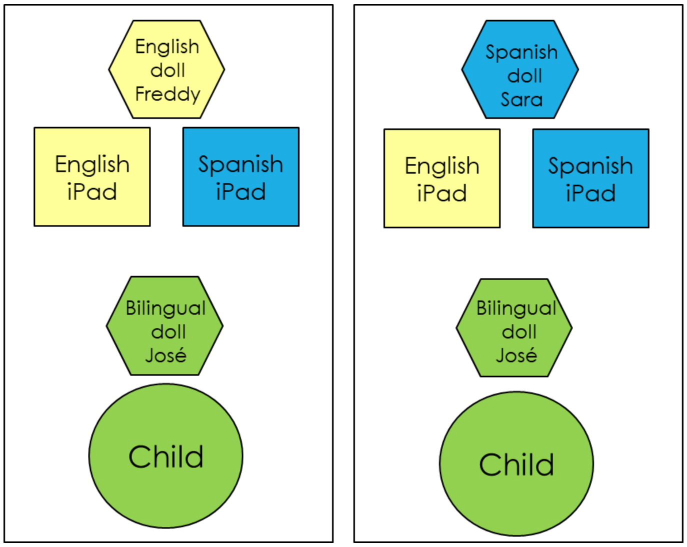

Figure 2.1 *Set up for Experimental Task Paradigm. Child was seated in front of English and Spanish iPads with the "bilingual" doll. Either the "English understanding" or "Spanish understanding" dolls were placed behind the iPads depending on the language*

2.3.3.2 Reliability.

Interrater agreement of the data was established for 20% of sessions. An undergraduate research assistant in communication disorders was trained in the standardized assessment tools and independently scored 20% of the assessments to check for the reliability of raw and standard score calculations. An agreement of 100% was found by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. To establish interrater agreement for items on the BESA, research assistants listened to the audio recordings of 20% of the BESA sessions and documented participant responses on the morphosyntax subtests and expressive items on the semantics subtests. Reliability for the Spanish BESA was conducted by a bilingual research assistant who was a native Spanish speaker. Interrater agreement for the

Spanish BESA was 97.23% and was calculated by dividing the number of agreements by the total number of items. Interrater agreement for the English BESA was 97.75%. For the experimental task, trained research assistants listened to the audio recordings of 20% of experimental task sessions and scored participant responses. Agreement for participant responses was 98.60% and was calculated by dividing the number of agreements by the total number of responses and multiplying by 100. Agreement was calculated for RTs on the experimental task and 20% of sessions were second coded. Agreement for RTs to the nearest tenth of a second was 91.00%. All differences in coding were discussed and resolved.

3 RESULTS

3.1 Performance on the Experimental Task

Figure 3.1 shows the number of correct responses on the experimental task for all participants across the 13 switch and stay trials. All participants correctly selected at least one of the 13 target vocabulary words on the experimental task (*M* = 9.91, *SD* = 3.58, Range = 12) and 40% of the participants (*n* = 23) correctly selected all 13 target vocabulary words. The number of correct responses on the experimental task was higher on average for children without language impairments (*n* = 35, *M* = 11.49, *SD* = 2.43, Range = 8) than children with language impairments (*n* = 23, *M* = 7.52, *SD* = 3.75, Range = 12). When the number of correct responses on only the six switch trials were measured, the average number of correct responses for all participants was 4.38 (*SD* = 1.84, Range = 6). On average participants without language impairments performed better on the switch trials (*M* = 5, *SD* = 1.46, Range = 5) than children with language impairments (*M* = 3.43, *SD* = 2.01, Range = 6).

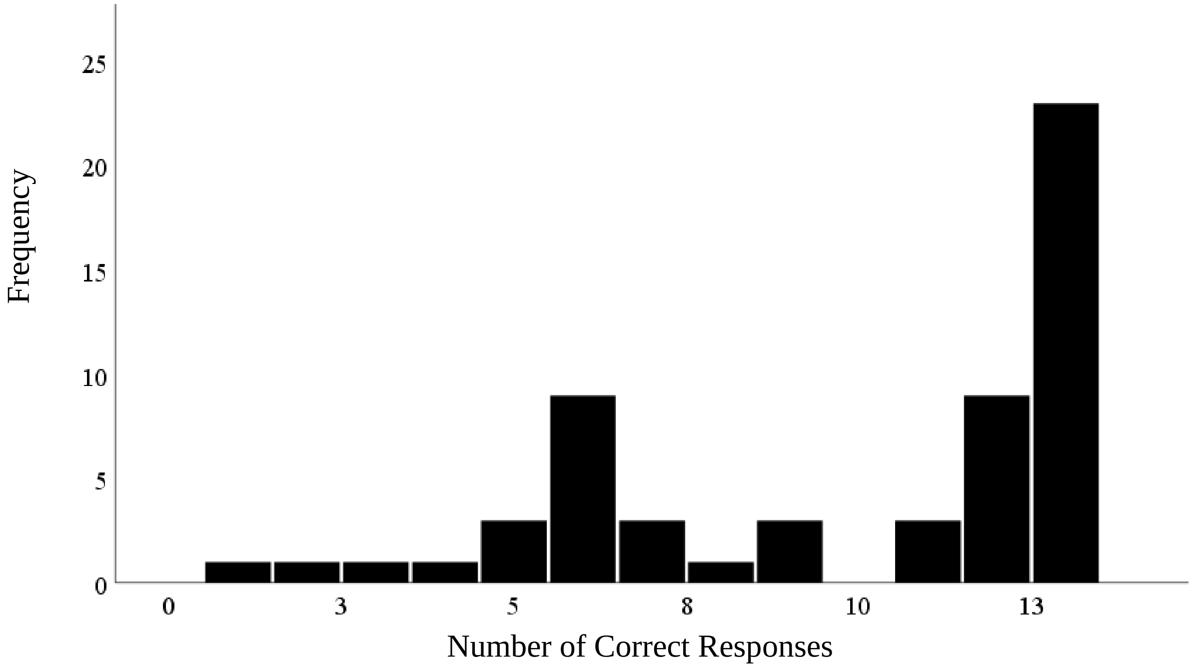

Figure 3.1 *Histogram displaying the frequency of correct responses on the experimental task across all participants (n = 58).*

3.2 Research Question 1

What factors explained Spanish-English bilingual children's performance on a cued language-switching task using graphic symbol-based SGDs?

A series of five hierarchical multiple regressions were run using IBM SPSS Version 25.0 (IBM Corp, 2017), to determine if the addition of processing speed, language ability, nonverbal IQ (NVIQ), and language dominance group improved the prediction of children's performance on the experimental task above age alone. For all regressions, age was entered as a covariate in the first step (Model 1) and in the second step (Model 2), processing speed, language ability, NVIQ, and language dominance were entered. Language ability was derived from a composite standard score on the BESA. The composite score combined performance on the semantics and morphosyntax subtests by using the higher standardized subtest score in English or Spanish. The variables for NVIQ and processing speed were obtained from the Leiter-3 and were standard scores. Initially, language dominance (e.g., EDB, BB, SDB) was entered as a dummy coded variable with balanced bilingual used as the reference group. Dummy coding the language dominance groups decreased the statistical power due to the additional predictors; thus, a comparison regression was run using language dominance as a continuous variable. The dependent variable, number of correct responses on the experimental task, was not normally distributed and demonstrated a ceiling effect. Various regression models were run to determine the best fitting model. In the first regression, language dominance was measured using dummy coded language groups and in the second and all subsequent regressions, language dominance was entered as a continuous variable. In the third regression model, the dependent variable was log-transformed and the fourth and fifth regressions were binomial logistic regressions. Descriptions and results of each regression analysis are below.

3.2.1 Regression 1: Dummy coded language groups.

For the first regression, the variables were untransformed and language dominance groups were dummy coded. Tables 3.1 and 3.2 present the Pearson correlations among variables and the results of the regression model, respectively. A plot of studentized residuals against the predicted values determined that there was linearity. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.813. Visual inspection of a plot of studentized residuals versus unstandardized predicted values revealed an uneven spread of residuals indicating that the assumption of homoscedasticity of residuals may have been violated. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations. Three values for

Cook's distance were just above 1 and three cases had leverage values just above 0.2. All cases were included in the analysis. The assumption of normality was met, as assessed by a Q-Q Plot.

The full model of age, language dominance group, language ability, processing speed, and NVIQ to predict the number of correct responses on the experimental task (Model 2) was statistically significant, $R^2 = .808$, $F(5, 51) = 15.947$, $p < .001$, adjusted $R^2 = .652$. The addition of language dominance group, language ability, processing speed, and NVIQ to the prediction of number of correct responses on the experimental task led to a statistically significant increase in R^2 of .238, $F(5, 51) = 6.994$, $p < .001$. The covariate, age, was statistically significant ($\beta = .152$, $p < .001$). Processing speed was the only other variable that was statistically significant ($\beta = .082$, $p < .05$) indicating that processing speed contributed additional unique variance beyond age.

Table 3.1 ***Summary of Pearson Correlations among Untransformed Variables and with Dummy Coded Language Groups***

Variable (*n* = 58)	1	2	3	4	5	6	7
1. Child Age (months)	1.00						
2. English Dominance	.12	1.00					
3. Spanish Dominance	-.24*	-.41*	1.00				
4. Language Ability	.45**	-.01	-.03	1.00			
5. Processing Speed	.34*	.07	-.08	0.64**	1.00		
6. NVIQ	.12	.20	-.06	.37*	.45*	1.00	
7. Experimental Task	.64**	.09	-.19	.64**	.63**	.40*	1.00

Note. Language dominance determined using Bilingual Input Output Survey (Peña et al., 2014); Bilingual Language Ability determined by Language Index on Bilingual English Spanish Assessment (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on Leiter International Performance Scales (Leiter-3, Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient obtained from Composite score on Lieter-3 (Roid et al., 2013). **p*<.05, ***p* <.001.

Table 3.2 ***Hierarchical Multiple Regression 1 Predicting Number of Correct Responses on the Experimental Task from Age, English Dominance, Spanish Dominance, Language Ability, Processing Speed, and NVIQ***

n = 58	Model 1			Model 2		
Variable	B	SE	β	B	SE	β
Constant	-4.368	2.300		-16.366**	3.642	
Age	.223**	.035	.643	.152**	.033	.440
English Dominance				-.245	.657	-.034
Spanish Dominance				-.638	.911	-.065
Language Ability				.033	.025	.157
Processing Speed				.082*	.030	.308
NVIQ				.065	.037	.168
R^2	.414			.652		
F	39.545**			15.947**		
ΔR^2				.238		
ΔF				6.994**		

Note. Language dominance determined using the BIOS (Peña et al., 2014); Bilingual Language Abilities determined by Language Index on the BESA (Peña et al., 2014); English and Spanish Dominance determined by the BIOS (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on Leiter-3 (Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient determined by composite on Lieter-3. *$p<.01$, **$p<.001$

3.2.2 Regression 2: Language dominance as continuous variable.

In the first regression, when language dominance was entered as a dummy coded variable, it was not a significant predictor of children's performance on the experimental task. The same regression was run again, except with language dominance entered as a continuous variable instead of a group variable. The average English input/output obtained from the BIOS was used as the continuous measure of language dominance where lower values indicated Spanish dominance and higher values indicated English dominance. Age was entered as a covariate in Step 1, and average English input/output and standard scores for language ability, NVIQ, and processing speed, were entered in Step 2. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.850. As in the previous regression, visual inspection of a plot of studentized residuals versus unstandardized predicted values revealed an uneven spread of residuals indicating that the assumption of homoscedasticity of residuals may have been violated. A linear relationship was present between all variables. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations. Three cases had values for Cook's distance above 1 and three cases had leverage values just above 0.2. All cases were left in the analysis. The assumption of normality was met, as assessed by Q-Q Plot.

Tables 3.3 and 3.4 display Pearson correlations among variables and the results of regression 2. Results of regression 2, using language dominance as a continuous variable, were very similar to the previous regression where language dominance was entered as a group variable. In regression 2, language dominance remained a non-significant predictor. The full model of age, English input/output, language ability, processing speed, and NVIQ to predict correct responses on the experimental task (Model 2) was statistically significant, $R^2 = .653$, $F(5, 52) = 19.594$, $p < .001$, adjusted $R^2 = .649$. The addition of English input/output, language ability, processing speed, and NVIQ to the prediction of performance on the experimental task, led to a statistically significant increase in R^2 of .239, $F(4, 52) = 8.975$, $p < .001$. Other than age, processing speed again was the only statistically significant variable, ($\beta = .309$, $p < .01$) indicating that processing speed contributed to additional unique variance. In subsequent regression models, English input/output instead of the group variable for language dominance was used as results of both regressions were similar and statistical power could be preserved by eliminating the additional variable required for dummy coding.

Table 3.3 ***Summary of Pearson Correlations Among Untransformed Variables (Language Dominance = English Input/Output)***

Variable (*n* = 58)	1	2	3	4	5	6
1. Child Age (months)	1.00					
2. English Input/Output	.21	1.00				
3. Language Ability	.45**	-.10	1.00			
4. Processing Speed	.34*	-.04	0.64**	1.00		
5. NVIQ	.12	-.02	.37*	.45*	1.00	
6. Experimental Task	.64**	-.001	.62**	.64**	.40*	1.00

Note. English Input/Output obtained from the BIOS (Peña et al., 2014); Language Ability determined by Language Index on the BESA (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on the Leiter-3 (Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient, obtained from Nonverbal Intelligence Composite score on the Lieter-3. **p*<.05, ***p* <.001.

Table 3.4 ***Hierarchical Multiple Regression 2 Predicting Number of Correct Responses on the Experimental Task from Age, English Input/Output, Bilingual Language Ability, Processing Speed, and NVIQ***

n = 58	**Model 1**			**Model 2**		
Variable	B	SE	β	B	SE	β
Constant	-4.368	2.300		-16.366**	3.642	
Age	.223**	.035	.643	.165**	.033	.475
English Input/Output				-.018	.022	-.069
Language Ability				.029	.025	.135
Processing Speed				.082*	.030	.309
NVIQ				.065	.036	.168
R^2	.414			.653		
F	39.545**			19.594**		
ΔR^2				.239		
ΔF				8.975**		

Note. English Input/Output obtained from the BIOS (Peña et al., 2014); Language Ability determined by Language Index on the BESA (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on Leiter-3 (Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient, obtained from Nonverbal Intelligence Composite score on the Lieter-3. **p*<.05, ***p* <.001.

3.2.3 Regression 3: Log transformed dependent variable.

Assumption testing in regressions 1 and 2 indicated that the dependent variable was not normally distributed and that the data violated the assumption of homoscedasticity of residuals. To address the issue of heteroscedasticity of the dependent variable, the hierarchical multiple linear regression was re-run using the log-transformed dependent variable. See Table 3.5 for full details.

There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.792. However, visual inspection of a plot of studentized residuals versus unstandardized predicted values again revealed uneven spread of residuals indicating that transforming the variables did not resolve the uneven distribution. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations and values for Cook's distance above 1. Two cases had leverage values above .2 (cases 15 and 30). The assumption of normality was met, as assessed by Q-Q Plot.

Table 3.5 ***Hierarchical Multiple Regression 3 Predicting Log Transformed Variable of Number of Correct Responses on the Experimental Task from Age, English Input/Output, Bilingual Language Ability, Processing Speed, and Nonverbal IQ***

n = 58	Model 1			Model 2		
Variable	B	SE	β	B	SE	β
Constant	-2.053**	.272		-3.497**	.453	
Age	.025**	.044	.629	.019**	.004	.462
English Input/Output				-.000	003	-.008
Language Ability				.003	.003	.108
Processing Speed				.009*	004	.173
NVIQ				.008	.004	.173
R^2	.395			.603		
F	36.636**			15.823**		
ΔR^2				.208		
ΔF				6.815**		

Note. English Input/Output obtained from the BIOS (Peña et al., 2014); Language Ability determined by Language Index on the BESA (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on Leiter-3 (Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient, obtained from Nonverbal Intelligence Composite score on the Lieter-3. **p*<.05, ***p* <.001.

Results of the regression with the log-transformed dependent variable were similar to the previous regressions. The full model of age, processing speed, language ability, NVIQ, and English input/output to predict correct responses on the experimental task (Model 2) was statistically significant, $R^2 = .610$, $F(5, 52) = 16.283$, $p < .001$, adjusted $R^2 = .573$. The addition of English input/output, language ability, processing speed, and NVIQ to the prediction of performance on the experimental task using the log transformed dependent variable led to a statistically significant increase in R^2 of .216, $F(4, 52) = 7.217$, $p < .001$. Again, processing speed was the only statistically significant variable, ($\beta = .009$, $p < .05$) when controlling for age.

3.2.4 Regression 4: Binomial logistic regression.

The previous three regression models that included the dependent variable, number of correct responses on the experimental task, violated the assumption of homoscedasticity of residuals and demonstrated a positively skewed distribution even when the data were transformed. To remedy this issue, a fourth binomial logistic regression was run. A new, binary dependent variable was created that classified participants as either high or low performers on the experimental task. Participants who achieved 10 or more correct responses were scored as 1 (i.e., high performers), participants who had fewer than 10 correct responses were scored as 0 (i.e., low performers). The cut-off of 10 responses was used because most participants correctly answered at least 6 responses, but this did not mean they were correctly switching between languages on those trials (for example they may have been using only one SGD to select all 13 responses so at least 6 would be correct). A total score of 10 indicated that participants better understood the language switching task and were accurately discriminating between the English and Spanish SGDs. A binomial logistic regression was performed to ascertain the effects of age, language dominance, language ability, processing speed, and NVIQ, on the likelihood that participants were classified as either high or low performers on the experimental task. On the experimental task, sixty percent of participants ($N = 35$) were high performers including 28 children without language impairment and seven children with language impairments.

Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell (1962) procedure. This procedure transforms the predictors in a regression to linearize the relationship between the dependent variable and the predictor variables. All continuous independent variables were linearly related to the logit of the dependent variable. There was one standardized residual with a value of -2.634 standard deviations, which was kept in the analysis.

Results of the binomial logistic regression are displayed in Table 3.6. A two-step model was used with age entered in the first block as a covariate and English input/output, language ability, processing speed, and NVIQ in the second block. The logistic regression model 1 was statistically significant, $\chi^2(1) = 35.450$ $p < .001$. The model explained 62.9% (Nagelkerke R^2) of the variance in performance on the experimental task and correctly classified 87.7% of cases. Sensitivity was 88.6%, specificity was 86.4%, positive predictive value was 91.2% and negative predictive value was 82.6%. The covariate predictor (age) was statistically significant where increasing age was associated with a greater likelihood of being classified as a high performer on the experimental task.

The additional predictor variables, English input/output, language ability, processing speed, and NVIQ were entered in the second block. Model 2 was statistically significant, $\chi^2(5) = 57.33$, $p < .001$. Overall, model 2 showed an increase in explained variance to 86.1% (Nagelkerke R^2) of the variance in performance on the experimental task and classifying 93% of the cases. Sensitivity increased to 90.9%, specificity was 94.3%, positive predictive value was 94.3% and negative predictive value was 90.9%. Findings of the binomial logistic regression indicated that when age was controlled for, the additional predictor variables were not statistically significant, although their inclusion did increase the predictive validity of the model. The significance value for processing speed approached statistical significance ($p = .057$).

Table 3.6 ***Summary of Binary Logistic Regression 4 for Variables Predicting High and Low Performers on the Experimental Task***

n = 57	Model 1				Model 2			
Variable	*B*	SE	Wald	Odds Ratio	*B*	SE	Wald	Odds Ratio
Constant	-16.11**	.44	13.58	.000	-45.52**	15.58	8.65	.00
Age	.27**	.07	13.70	1.31	.35**	.12	8.06	1.42
English Input/Output					-.04	.04	.70	.89
Language Abilities					-.01	.05	.06	.99
Processing Speed					.19	.10	3.61	1.21
NVIQ					.10	.08	1.51	1.11
X^2	34.45				57.33			
Nagelkerke R^2	.64				.86			

Note. English Input/Output obtained from the BIOS (Peña et al., 2014); Language Ability determined by Language Index on the BESA (Peña et al., 2014); Processing Speed determined by Processing Speed Composite score on Leiter-3 (Roid et al., 2013); NVIQ = Nonverbal Intelligence Quotient, obtained from Nonverbal Intelligence Composite score on the Lieter-3. $^*p<.05$, $^{**}p <.001$.

3.2.5 Regression 5: Simplified binomial logistic regression.

Because the predictor variables, English input/output, language abilities, and NVIQ consistently were non-significant across the various regression models, a binomial logistic regression was run that excluded these variables. The goal of this final regression was to find the most parsimonious model. As in the previous binomial logistic regression, the dependent variable was inclusion in the high performers or low performers group on the experimental task. In the first step, age was entered as a covariate, and in the second step both age and processing speed were entered. The logistic regression model was statistically significant, χ^2 (2) = 54.831, $p< .001$. The model explained 83.9% (Nagelkerke R^2) of the variance in performance on the experimental task and correctly classified 94.7% of cases. Sensitivity was 94.3%, specificity was 95.5%, positive predictive value was 97.1% and negative predictive value was 91.3%. After controlling for age, processing speed emerged as a significant predictor, (β = .190, p = .006).

These findings confirmed results of the hierarchical linear regression models indicating that age and processing speed significantly contributed unique variance to language switching ability using bilingual SGDs. Participants who were older and had higher processing speed scores were more likely to be classified as high performers on the language switching task. The current, and fifth regression model was deemed to be the most parsimonious because it correctly classified the most participants based on the fewest predictor variables.

3.3 Research Question 2

What differences in performance are there on a cued language switching task using graphic symbol-based SGDs when English-Spanish bilingual children without language impairments are compared to bilingual children with language impairments?

An ANCOVA was run using IBM SPSS Version 25.0, to determine the effect of language impairment on participants' performance on the experimental task. There was a linear relationship between the log transformed variable of number of correct responses on the experimental task for each group, as assessed by visual inspection of a scatterplot. There was homogeneity of regression slopes as the interaction term was not statistically significant, $F(1, 54) = .136$, $p = .714$. The log-transformed variable was used to mitigate violations of normality, however, the data still failed to meet the assumption of normality of overall model residuals, Shapiro-Wilk's test ($p < .05$).

There was homogeneity of variances, as assessed by Levene's test of homogeneity of variance ($p = .456$). There were no outliers in the data, as assessed by no cases with standardized residuals greater than ±3 standard deviations. Adjusted means are presented, unless otherwise stated. Performance on the experimental task (measured by the log transformed variable of number of correct responses) was greater in children without language impairments ($M = -.319$, *SE* = .053) compared to children with language impairments (*M* = -5.99, SE = .066). After controlling for age, there was a statistically significant difference in performance on the experimental task between children without language impairments and children with language impairments, $F(1, 55) = 10.311$, $p = .000$, partial $\eta^2 = .158$. Post hoc analysis was performed with a Bonferroni adjustment. The number of correct responses on the experimental task was significantly higher for children without language impairments than children with language impairments ($M_{\text{diff}} = .279$, 95% *CI* [.105, .53], $p < .01$). These results must be interpreted with caution because the data violated the assumption of normality.

To address the violation of normality, non-parametric analyses using a Mann-Whitney U test was also run to determine if there were group differences in performance on the experimental task when children without language impairment were compared to children with language impairment. Distributions of the number of correct responses on the experimental task for children across both groups were not similar, as assessed by visual inspection. Performance scores on the experimental task for children without language impairment (mean rank = 36.29) were significantly higher than for children with language impairment (mean rank = 19.17), $U = 165$, $SE = 60.67$, $z = -3.915$, $p < .001$. Although significant, these findings must also be interpreted with caution as this analysis did not control for age as a covariate.

3.4 Research Question 3

How do subgroups of participants vary based on intrinsic and extrinsic variables (e.g., language skills, cognitive skills, language dominance) relative to performance on a cued language switching task using graphic symbol-based SGDs?

A two-step cluster analysis using IBM SPSS Version 25.0 was used as an exploratory analysis to identify if subgroups of participants were present in the data based on a set of preselected input variables. The two-step cluster analysis can handle both continuous and categorical data and is a reliable way to determine the optimal number of clusters. A two-stage algorithm automatically determined the optimal number of clusters based on a set of 10 input variables: Number of correct responses on the experimental task, best morphosyntax standard score, best semantics standard score, processing speed composite, parent frequency of language switching, child age in months, NVIQ, parent education, percent of English input, and percent of English output.

In the first step, original cases were grouped into pre-clusters by constructing a cluster features tree. In the second step, SPSS used the standard hierarchical clustering algorithm to reduce the best number of clusters based on Schwarz's Bayesian Information Criterion (BIC). Both intrinsic and extrinsic variables were included in the model and were selected based on their potential relevance to predicting variance in the model. Results of the two-step cluster analysis revealed separation into two clusters. Table 3.7 lists the predictor variables in order of their importance. The silhouette measure of cohesion and separation of .4 suggested "fair" cluster separation. The ratio of cluster sizes was 1.79 which is considered good. Cluster 1 had 19 participants (35.8%), Cluster 2 had 34 participants (64.2%). Five participants were excluded from the analysis because they were missing data on one of the ten input variables. Cluster membership was most strongly predicted by number of correct responses on the experimental task followed by morphosyntax scores, semantics scores and processing speed. Cluster 1 comprised low performers on the experimental task and Cluster 2 included high performers on the experimental task. Participants who were low performers on the experimental task had lower standard scores in morphosyntax and semantics and lower scores on the processing speed composite. Child age, NVIQ, parent education, and percent English input and output were less important in determining cluster membership than the other input variables. Table 3.7 reports descriptive statistics for each cluster across the 10 input variables. For each continuous variable, *t*-tests were used to confirm cluster differences. Group differences were significant ($p < .05$) for all variables except percent English input and percent English output.

Table 3.7 ***Summary of Two-Step Cluster Analysis and Comparison between Clusters***

Variable *N* = 51	Importance	Cluster 1 Mean/Most Frequent Category	Cluster 2 Mean/Most Frequent Category	*t*
1. Number of Correct Responses on ET	1.00	6.26	12.12	-7.54**
2. Best Morphosyntax SS	.71	74.05	99.44	6.68**
3. Best Semantics SS	.54	84.84	104.24	5.49**
4. Processing Speed Composite	.37	85.26	98.76	4.24**
5. Parent Frequency of language switching	.34	Most Frequent Category = Frequently (47.4%)	Most Frequent Category = Sometimes (44.1%)	--
6. Child Age in months	.31	57.54	67.53	3.77**
7. Nonverbal IQ	.19	96.42	102.85	2.74*
8. Parent Education	.17	Most Frequent Category = Some College, no degree (42.1%)	Most Frequent Category = <High school Diploma (29.4%)	--
9. % English Output	.13	67.84	57.53	-1.90
10. % English Input	.10	60.05	52.85	-1.72

Note. ET = Experimental Task; SS = Standard Score, Best Morphosyntax SS and Best Semantics SS taken from the BESA; Processing Speed Composite and Nonverbal IQ from Leiter-3; % English Output, % English Input from the BIOS. **p* < .05, ***p* < .001.

3.5 Research Question 4

Do bilingual children exhibit switch costs on a cued language switching task using graphic symbol-based SGDs?

To address question 4, response times (RTs) were measured for all switch and stay trials. There was a total of 696 trials. RTs were excluded if the child became distracted and spoke before selecting the target response resulting in 70 trials (10%) that were removed. When only correct responses were included (*n* = 575), 5.9% of trials were excluded. Initially, a 2X2X2 mixed ANOVA was planned. The within-subjects factors were trial type (switch, stay), and language dominance (dominant language, non-dominant language). The between-subjects factor was language group (language impairment, no language impairment). Trials were initially coded by trial type and language dominance resulting in four categories (i.e., switch trials in dominant language, switch trials in non-dominant language, stay trials in dominant language, switch trials in non-dominant language). For each of these four categories, mean response times were calculated for each participant. Mean response times according to trial type, language dominance, and language group are presented in Table 3.8.

The data failed to meet the following assumptions: no significant outliers and normality of residuals. There were four outliers in the group without language impairment and three outliers in the group with language impairments. The data were also strongly positively skewed so a reflect and logarithmic transformation was applied. Even after the data were transformed, the RT data were not normally distributed, as assessed by Shapiro-Wilk's test ($p < .05$). When RTs for only correct trials were included, the data still violated the assumptions of normality even after the data were transformed. Because the RT data failed to meet the assumption of normality despite transformation, non-parametric analyses were the most appropriate statistical option.

Table 3.8 ***Response Times (in Seconds) on the Experimental Task by Trial Type, Language Dominance, and Language Group***

	No Language Impairment		**Language Impairment**	
	Mean (SD)	***N***	**Mean (SD)**	***N***
RTs All Trials				
RT Dominant Switch	2.52(1.06)	34	3.03(1.16)	22
RT Nondominant Switch	2.63(1.18)	34	3.51(1.36)	23
RT All Switch	2.60(1.00)	35	3.31(1.10)	23
RT Dominant Stay	2.40(.85)	30	3.07(1.30)	21
RT Nondominant Stay	2.60(1.36)	34	4.23(4.12)	21
RT All Stay	2.60(1.00)	35	3.31(1.03)	23
RT All	2.60(.95)	35	3.32(.99)	23
RT All Dominant	2.55(.93)	35	2.94(.78)	23
RT All Nondominant	2.73(1.28)	35	3.33(1.16)	23
RTs Correct Trials				
RT Dominant Switch	2.41(1.04)	31	2.86(.96)	17
RT Nondominant Switch	2.88(2.14)	32	3.59(1.71)	21
RT All Switch	2.52(.93)	35	3.14(1.05)	21
RT Dominant Stay	2.45(.88)	29	3.19(1.72)	21
RT Nondominant Stay	2.77(2.14)	32	4.28(3.97)	16
RT All Stay	2.63(1.09)	35	3.53(2.66)	23
RT All	2.58(.96)	35	3.13(.97)	23
RT All Dominant	2.51(.95)	32	3.01(.94)	23
RT All Nondominant	2.55(.94)	32	3.52(1.59)	19

Note. Response Times measured across trials 2 – 13 on the Experimental Task. LI = Language Impairment Group, RT = Response Time in seconds, SD = Standard Deviation. *N* varies because some trials were deemed in valid and were excluded. *N* varies on correct trials because incorrect trials were excluded.

A Wilcoxon signed-rank test was conducted to determine whether mean RTs across the six stay and six switch trials on the experimental task were significantly different. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve. Of the 58 participants recruited to the study, 29 participants showed an increase in RTs on switch trials compared to stay trials, and 29 participants saw a decrease in RTs on switch trials compared to stay trials. There was no statistically significant increase in RT

(*Mdn* = -.0095 seconds) when switch trials (*Mdn* = 2.579 seconds) were compared to stay trials (*Mdn* = 2.707), *z* = .004, *p* = .997.

Because RTs across all trials may have been influenced by errors in the selection of the target response, analyses were also conducted with correct responses only. Two participants did not correctly answer any switch trials and were not included in the analysis (*n* = 56). Results of the Wilcoxon signed-rank test indicated no statistically significant increase in RTs (*Mdn* = -.0037 seconds) when correct switch trials (*Mdn* = 2.447 seconds) were compared to correct stay trials (*Mdn* = 2.527), *z* = .449, *p* = .654.

A Wilcoxon signed-rank test compared RTs on trials where the target word was in the dominant language to trials where the target word was in the child's non-dominant language. Of the 58 participants, 22 participants showed longer RTs on trials in their non-dominant language compared to their dominant language, and 36 participants showed a decrease in RTs on trials in their dominant language compared to their non-dominant language. There was no statistically significant increase in RT (*Mdn* = .1599 seconds) when non-dominant trials (*Mdn* = 2.598 seconds) were compared to dominant trials (*Mdn* = 2.573), *z* = .1.754, *p* = .079. Similar results were found when only correct trials were included in the analysis, however nine cases were excluded from the analysis where participants did not correctly answer any trials in their dominant or non-dominant language (*n* = 49). The Wilcoxon signed-rank test indicated no statistically significant increase in RT (*Mdn* = .1588 seconds) when correct non-dominant trials (*Mdn* = 2.598 seconds) were compared to correct dominant trials (*Mdn* = 2.573), *z* = .1.179, *p* = .238.

To compare group performance, Mann-Whitney U tests were run to determine if there were differences in RTs on the experimental task between children without language impairment and children with language impairment. Mann-Whitney U tests were performed on the following dependent variables for all trials and for correct trials only: Total RT, Stay Trial RT, Switch Trials RT, Dominant Language RT, Non-dominant Language RT. Distributions of RTs for children across both groups were similar across all dependent variables as assessed by visual inspection of histograms. Test statistics from the Mann-Whitney U are presented in Table 3.9 and indicated that RTs for children with language impairment were statistically significantly higher than for children without language impairment across all dependent variables except Stay Trial RT. Although results from the group comparisons were significant, these findings must be interpreted with caution as this non-parametric analysis did not control for age as a covariate.

Table 3.9 ***Group Differences in Response Times by Trial Type and Language Dominance for Participants with and without Language Impairment***

	LI		No LI				
Dependent Variable	*Mdn*	*N*	*Mdn*	*N*	*U*	*z*	*p*
All Trials							
Total RT	3.125	23	2.340	35	592.500	3.020	.003**
Stay Trials RT	3.175	23	2.163	35	572.500	2.70	.007**
Switch Trials RT	3.211	23	2.432	35	575.500	2.750	.0068**
Dominant Language RT	2.802	23	2.252	35	527.500	1.987	.0478*
Non-dominant Language RT	3.077	23	2.264	35	551.000	2.360	.018*
Correct Trials							
Total RT	2.931	23	2.226	35	550.500	2.353	.019*
Stay Trials RT	2.734	23	2.134	35	516.500	1.812	.070
Switch Trials RT	2.759	21	2.318	35	500.500	2.521	.024*
Dominant Language RT	2.765	23	2.216	33	507.000	2.123	.034*
Non-dominant Language RT	2.803	19	2.170	32	419.000	2.240	.025*

Note. Response Times measured across trials 2 – 13 on the Experimental Task. LI = Language Impairment Group, *Mdn* = Median, RT = Response Time in seconds, *U* = Mann-Whitney U statistic. *p < .05, **p < .01.

4 DISCUSSION

This study was the first to investigate language switching using AAC in bilingual children with and without language impairments. It explored the relationships among intrinsic and extrinsic variables that contributed to bilingual children's ability to conceptually discriminate between language layouts (i.e., language switch) across English and Spanish SGDs. Furthermore, this study examined whether children exhibited switch costs (i.e., increased response times) on trials when they were cued to switch between languages compared to trials when they were not. This study was unique because it measured language switching using graphic symbols on an SGD and included bilingual child participants with language impairments.

Overall, this study indicated that bilingual 4 - 6-year-old children were able to switch between languages that were represented visually on two different SGDs. Despite the abstract nature of the task, most children were able to correctly select vocabulary on the English and Spanish SGDs and 60% of the children were classified as high performers on the experimental language switching task. When controlling for age, processing speed significantly predicted children's performance on the experimental task. Other variables including language ability, language dominance, and NVIQ did not significantly predict the number of correct responses on the experimental task. Furthermore, participants did not demonstrate switch costs on the experimental task and mean differences between stay and switch trials were not significant. Participants with language impairments were generally younger and on average had longer RT's than participants without language impairments.

4.1 Support for Language Differentiation in Bilingual Language Development

Given the novel design of the language switching task, the finding that participants were generally able to language switch across Spanish and English SGDs has important theoretical implications related to the development of language differentiation. There is robust evidence that perceptual language differentiation begins early in life with numerous studies demonstrating infants' ability to discriminate between the prosodic and phonetic differences in languages (see Byers-Heinlein, 2014). Research also indicates that young bilingual children who are just beginning to talk can adjust the language they are speaking depending on the language spoken by their communication partner (Cantone, 2004). However, little is known about *when* conceptual language discrimination takes place, that is, when do young children acquire the metalinguistic awareness that they are speaking in more than one language? Byers-Heinlein (2014) suggested that conceptual language discrimination is tied to category development and although compelling, studies of language switching in young children have not explicitly addressed this question.

The current study is novel in that it did not rely on spoken responses to measure language switching but instead required children to discriminate between visual representations of the languages. The use of picture symbols on separate Spanish and English SGDs permitted observation of whether children were able to deliberately discriminate between languages. Children's ability to successfully switch between languages on the Spanish and English SGDs demonstrates that they had the metalinguistic awareness to recognize languages as belonging to separate categories. The distinction that languages were represented visually in the current study is important because children who use bilingual AAC must deliberately switch between language systems represented by visual-graphic symbols on an AAC system. Presumably, switching between languages represented by visual-graphic symbols requires conceptual understanding of languages as belonging to separate categories.

4.2 Intrinsic and Extrinsic Factors that Effect Children's Language Switching Ability

In the current study, the first research question investigated the effects of age, language dominance, language ability and cognitive skills on children's ability to language switch using bilingual SGDs. The hypothesis was partially supported in that age and processing speed significantly predicted children's language switching ability using bilingual SGDs. Across all regression models, age consistently emerged as a significant predictor of performance on the task with older children performing better than younger children. When age was controlled for, processing speed significantly predicted variance in the model with higher processing speed scores associated with better performance on the experimental task.

4.2.1 Age and language switching ability.

Although studies of language switching in children are limited, prior research supports the findings of the current study indicating that control of language choice may increase with age (Muller & Cantone, 2009) but that there is variability in when children show adult-like language switching (Nicoladis & Genesee, 1997; Vihman, 1985). In cued language switching paradigms such as the one used in the current study, age appears to be an important factor in determining language switching ability. Kohnert, Bates, and Hernandez (1999) and Kohnert (2002) found that children's accuracy and reaction time increased with age on a cued language switching task involving picture naming of nouns. Similarly, Jia, Kohnert, Collado, and Aquino-Garcia (2006) found that in a verb naming task involving single language and mixed language conditions, naming speed and accuracy among English-Spanish bilinguals improved with age.

The finding that increased age was associated with better performance on the experimental task suggests that language differentiation is tied to development and may be explained by the notion that conceptual language discrimination is related to category development. Older children with more advanced category knowledge may be better able to functionally differentiate between languages. In the current study, high performers were generally older, thus according to the category development theory, it can be assumed that they conceptualized Spanish and English as belonging to separate categories and were able to demonstrate this awareness when the languages were represented visually (i.e., on separate SGDs). Likewise, low performers, who were on average younger, may not yet have developed the metalinguistic skills required to conceptually discriminate between languages represented visually.

The findings from the current study support and build on prior work indicating that age influences language switching abilities on cued-language switching tasks. However, other studies suggest that factors that predict language switching ability may vary depending on the type of language switching (e.g., cued vs. voluntary). Research examining language choice in children's voluntary switching found that linguistic competency and environmental and social factors determined switching behavior beyond age (e.g., Kanto, Laakso, & Huttunen, 2017; Yow, Patrycia, & Flynn, 2016). Voluntary and cued language switching are thought to employ different cognitive mechanisms (Blanco-Elorrieta & Pylkkänen, 2017), thus the effect of age on language switching ability may vary based on the language switching task.

4.2.2 Processing speed and language switching ability.

In the current study, processing speed significantly predicted children's performance on the experimental task. Processing speed is a basic component of cognitive functioning and is defined as the rate at which sensory information passes into the nervous system and is operated upon (Jensen, 1998). Although related to other executive functioning processes such as memory and inhibition, processing speed is considered a functionally distinct ability that improves with development and declines with aging (Albinet, Boucard, Bouquet, & Audiffren, 2012; Kail & Salthouse, 1994; McAuley & White, 2011). Faster processing speed is associated with decreased reaction times and suggests that more information can be processed. Consequently, deficits in processing speed likely limit the amount of information an individual can process in a given time.

Switching between languages, especially during cued language switching tasks is thought to place a greater burden on the cognitive system and slow processing when compared to single language conditions (e.g., Liao & Chan, 2016). Diamond, Shreve, Golden and Duran-Narucki (2014) found that in adult bilinguals, processing speed was significantly slower during language switching tasks than on nonlinguistic switch tasks during a cued switching paradigm. The authors concluded that language switching tasks that required activation and inhibition across two languages resulted in an overall slowing of the cognitive system. In another study, Blumenfeld, Schroeder, Bobb, Freeman, and Marian (2016) used response time on word recognition and Stroop tasks to index processing speed in older and younger adult bilinguals. The authors found that performance was influenced by individual differences in processing speed with older bilinguals demonstrating increased reaction time.

In the current study, children with language impairments had more difficulty switching languages and had longer RTs on the experimental task when compared to children without language impairments. Processing speed deficits are thought to be associated with language impairment (e.g., Kail, 1994; Leonard et al., 2007; Miller et al., 2006; Miller, Kail, Leonard, &

Tomblin, 2001). Kail (1994) proposed that limitations in processing speed may account for language difficulties in children with SLI and argued for the general slowing hypothesis in which processing speed reflects general cognitive processing abilities rather than a specific skill. Kail cited evidence from several studies of children with SLI who exhibited slower performance on linguistic and non-linguistic tasks when compared to age-matched typically developing peers.

Some studies have found that children with SLI do not significantly differ from children with typical development on some simple speeded tasks (Kohnert & Windsor, 2004; Montgomery & Windsor, 2007, 2015) and the degree of slowing may vary across types of tasks (Miller et al., 2006). Kohnert, Windsor and Ebert (2009) found that children with language impairment demonstrated slower reaction time on processing speed tasks when compared to bilingual and monolingual children but these results were not statistically significant. There was also no significant difference in performance when bilingual children were compared to monolingual children without language impairments.

Other perspectives of processing speed in children with language impairment suggest that rather than general slowing, processing speed abilities may vary depending on the complexity of tasks (Montgomery & Windsor, 2015) or the type of information that is processed and nature of the task (Windsor, Milbrath, Carney, & Rakowski, 2001). Under this notion, not all tasks are slowed by the same amount and more complex tasks will incur more processing requirements regardless of the type of information to be processed (e.g., phonological, grammatical, lexical, spatial, visual). Windsor et al. (2001) questioned the validity of the general slowing hypothesis by demonstrating that HLM analysis across 25 studies of processing speed did not yield sufficient support for the general slowing hypothesis but rather study-specific characteristics contributed to differences in processing speed between LI groups and age-matched controls.

Clearly, many questions remain regarding the relationship between processing speed, language switching and language impairment. Future research should continue to explore how processing speed and language impairment influence language switching in both cued and voluntary paradigms.

4.2.3 Language impairment and language switching ability.

Children with language impairments performed significantly more poorly than children without language impairments. These results must be interpreted with caution. Because the dependent variable, number of correct responses on the experimental task, was not normally distributed, nonparametric analyses were used. Age was not controlled for, however, and *t*-tests between groups indicated that children with language impairment were significantly younger than children without language impairment. Seven of the twenty-three children in the language impairment group (16%) were classified as high performers on the experimental task. Closer inspection indicated that these seven participants generally had semantic abilities at or near the average range in at least one language although their morphosyntactic abilities may have been below average and their overall bilingual language index was below average. These seven participants generally had processing speed abilities within the average range. These findings suggest that individual differences in semantic skills and processing speed may be more important in determining language switching abilities than language impairment.

4.2.4 Participant clusters around intrinsic and extrinsic variables.

The third question in this study further examined participant characteristics to see whether participants clustered around various intrinsic and extrinsic factors. In general, findings from the exploratory cluster analysis confirmed results from the regression and group comparisons. Participants formed two clusters, most strongly determined by their performance on the experimental language switching task. For the most part, high performers had better language skills in English and Spanish and better processing speed abilities than low performers. Morphosyntax and semantics scores were entered separately, rather than using the overall language index. Morphosyntax was a stronger indicator of cluster membership than semantic abilities and processing speed.

Parent report of language switching was less important in predicting cluster membership than performance on the experimental task, language abilities, and processing speed. Participants whose parents reported low rates of language switching with their child were more likely to be in the cluster associated with higher performance on the language switching task. This finding is not intuitive, however, recent work indicates that exposure to language switching may influence children's language outcomes differentially and may be moderated by working memory (Kaushanskaya & Crespo, 2019). Also of note, children's age, NVIQ, parent education, and the percent of English output and percent of English input were not as important in determining cluster membership as performance as other variables. The finding that NVIQ, and language dominance (measured as percent of English input and output) contributed minimally to cluster membership, confirmed findings from the linear regression models indicating that NVIQ and language dominance were not significant predictors of language switching ability. Because in the cluster analysis performance on the experimental task was a swamping variable, meaning that 100% of participants were classified based on this variable, the relative importance of the additional variables must be interpreted with caution.

4.2.5 NVIQ and language switching abilities.

The relationship between NVIQ and performance on the experimental task was not significant as measured by Pearson's correlation, as well as in the various regression models and in the cluster analysis. This finding is not surprising given that children's NVIQ did not represent a range of performance and most children, including those with language impairments, had NVIQs within the average range. It is unclear whether NVIQ may influence language switching abilities as most prior studies of language switching in bilingual children did not measure NVIQ. However, in one study of Spanish-English bilinguals (ages 5 – 7), Gross and Kaushanskaya (2016) found that when controlling for NVIQ, nonlinguistic task-shifting ability significantly predicted cross-language errors on a cued language switching task. Children who were better at nonlinguistic task switching produced fewer cross-language errors when asked to name words in single language and mixed language conditions.

4.2.6 Language dominance and language switching abilities.

Findings from the study indicated that language dominance did not significantly predict language switching ability overall. This finding is not surprising given the nature of the task which required participants to identify vocabulary that they already understood in both languages. Previous work suggests that in children's voluntary switching, language dominance may play a greater role in predicting the frequency of switching. For example, children who are considered imbalanced bilinguals may be less likely to switch within sentences compared to fluent bilinguals (Meisel, 1994; Vihman, 1998). Furthermore, language switching may vary based on the language as well as dominance. Gutiérrez-Clellen, Simon-Cereijido and Erickson Leone (2009) found that the English-dominant children language switched more when tested in their non-dominant language (Spanish) compared to the Spanish-dominant children tested in their weaker language (English). Gross and Kaushanskaya (2015) found that on a cued language switching task, Spanish-English speaking 5 – 7-year-old children were more likely to produce cross-language errors in their non-dominant language and took longer to name items in their non-dominant language than in their dominant language. The mixed findings of the effects of language dominance on language switching warrant further exploration.

4.3 Switch Costs

The final question in this study, asked whether children exhibited switch costs on the cued language switching activity by comparing RTs based on trial type (i.e., switch trial versus stay trial), language dominance (dominant vs. non-dominant language), and language impairment group. Across all participants, response times on switch trials were not significantly different from stay trials. This finding held true even when only correct responses were included in the analysis.

The finding that participants did not take longer to respond on switch trials compared to stay trials contradicts research indicating that switching between languages incurs a cognitive cost (e.g., Green, 1998). Switch costs appear to be influenced by task-related factors (see Bobb & Wodniecka 2013 for a review). Several studies, for example, indicate that switch costs diminish when switching is performed in more naturalistic contexts (e.g., Blanco-Elorrieta et al., 2018; Blanco-Elorrieta & Pylkkänen, 2015; Blanco-Elorrieta & Pylkkänen, 2017; Li et al., 2013) and disappear when switching is voluntary (e.g., de Bruin, Samuel, & Duñabeitia, 2018; Kleinman & Gollan, 2016). Although the current study was a cued switching paradigm, the use of dolls as communication partners and the sentence level elicitation cues were designed to create a more naturalistic switching context. Providing a sentence level prompt to switch between languages may have masked the ability to detect switch costs as participants had several seconds to process the language of the prompt and to respond using the SGD. Switch cost asymmetry has been found to disappear when longer preparation time is given even in unbalanced bilinguals (Verhoef, Roelofs, & Chwilla, 2009) and when there is time between trials for decay of activation (Declerck, Koch, & Philipp, 2012). The current study does not rule out switch costs but rather indicates that in a mixed language context, alternating languages did not impose detectable switch costs when response time was measured in seconds.

4.3.1 Language dominance and response time.

Findings from the non-parametric analyses also indicated that there was no significant difference in RTs when trials presented in a participant's dominant language were compared to trials presented in their non-dominant language. Guo et al. (2011) and Meuter and Allport (1999) observed asymmetrical switch costs on cued language switching tasks, where RTs in the dominant language were greater than in the non-dominant language. Although paradoxical, the increase in RT on dominant trials aligns with Green's inhibitory control hypothesis because greater inhibition of the dominant language requires more cognitive effort to overcome when a bilingual speaker switches from the non-dominant language to the dominant language. An alternative view suggests that asymmetrical switch costs are not caused by inhibition but rather due to prolonged activation of the non-dominant language which increases competition between languages (see Declerck & Philipp, 2015). Studies indicate, however, that for highly proficient or balanced bilinguals, asymmetrical switch costs disappear (Costa & Santesteban, 2004). This finding also supports the Inhibitory Control theory, which predicts that switch costs would be reduced if the amount of inhibition applied to both languages is approximately equal. This model is supported by results of the current study as many participants were balanced bilinguals and did not show clear dominance in either Spanish or English. However, the analyses compared response times according to language dominance on all trials and did not look at differences according to stay trials vs. switch trials, which limits the ability to interpret these findings.

4.3.2 Response times across language impairment groups.

Question four also compared RTs on switch and stay trials according to language impairment group and language dominance. The non-parametric analyses, however, did not allow for age to be controlled for and prior *t*-tests revealed that children with language impairments were significantly younger than children without language impairment. Thus, the findings must be interpreted with caution. When total RTs were analyzed, results of a series of Mann Whitney U tests were significant for language impairment group, indicating that participants with language impairments demonstrated increased RTs compared to participants without language impairments regardless of trial type or language dominance. When only correct trials were included, participants with language impairments demonstrated increased RTs on switch trials but not on stay trials. RTs were also significantly longer for children with language impairments compared to those without language impairments on trials in their dominant and non-dominant language. The finding that participants with language impairments demonstrated increased RTs, corroborates the result that processing speed is an important factor in predicting language switching abilities and supports research that children with language impairments may demonstrate delays in processing speed. Because age was not controlled for, it is likely that the differences observed here between the groups of children with and without language impairment were influenced by age. Language ability was not a significant predictor of performance on the experimental task in the regression models and age consistently emerged as a significant predictor. Thus, any analyses that do not account for age are difficult to interpret and we cannot conclusively determine whether language impairment group played a role in determining children’s ability to language switch using SGDs.

4.4 Limitations

A number of limitations are important to note regarding the current study. The sample size of this study was modest and a larger sample size would increase the power to detect significant effects. Despite the small sample size, results from the regression analysis consistently explained at least 60 percent of the variance across the regression models, providing confidence in the results. The number of children with language impairments was also small, which limits the broader generalizability of the findings. Also, it is important to note that this study did not include participants who used SGDs as their primary means of communication prior to the study.

The ability to make group comparisons was also limited in two main ways. First, participants were not age-matched across groups and children with language impairments were on average younger than those without language impairments. Groups of language dominance (e.g., EDB, BB, SDB) were also not matched in terms of number of participants or by age. Because most participants attended school and were educated in English, EDBs were the largest group, followed by balanced bilinguals. Only nine participants were SDBs. To mitigate this issue, language dominance was measured as a continuous variable as well (e.g., percent of English Input/Output).

This study involved a cued language switching paradigm. As described in the introduction, cued language switching tasks have limited ecological validity and may employ different cognitive mechanisms than voluntary switching. To increase the ecological validity of the task and to make use of the SGDs more meaningful, we used dolls as communication partners and as an additional cue for the target language. Typically, cued language switching studies use arbitrary signals (e.g., color or shape) to cue language selection. In the current study we created a language switching scenario where the child was “helping” a “bilingual speaking” doll to talk to a “Spanish understanding” doll and an “English understanding” doll. This novel approach allowed us to measure language switching in a controlled environment that was also meaningful and engaging.

The vocabulary symbols used in this study included only concrete nouns that were easily depicted. Furthermore, two separate iPads were used so that participants would not have to navigate between language layouts. Children may have performed differently, however, had the vocabulary been more representative of a typical AAC system (e.g., an array of symbols representing various parts of speech) and the use of two separate SGDs instead of a single system limits the generalizability of these findings.

Another limitation of the current study was in the measurement of RT. Typically in RT studies, the target stimulus is presented using an automated computer-based prompt and the timing of the stimulus does not vary between trials. In the current study, however, the examiner verbally presented the stimulus. Although efforts were made to ensure consistency across trials and participants, because the administration of stimuli was not computerized, there was likely variability in the way that the verbal prompts were presented (e.g., rate of speech, prosody). Furthermore, RTs across stay and switch trials may not have captured switch costs because of the nature of the task. The language cue was a sentence level prompt (e.g., “Here comes Freddy, José wants to say, *house.”*) and thus children had likely already processed the language switch by the time they were ready to select the target word. Hence, any costs were not detectable using behavioral analysis. Within-participant variability in RT may have been more likely due to searching for the correct target symbol on the SGD than to differences in trial type.

4.5 Future Research Directions

One goal of this study was to contribute to the literature on bilingual language switching in children. Findings provided preliminary evidence that 4 to 6-year-old children were able to switch between language layouts on an SGD and that switching between languages did not incur significant cognitive costs. These findings must be replicated with a larger sample and more research is needed to investigate whether switch costs are present if task requirements are changed and during voluntary language switching. Furthermore, future research may need to employ EEG or imaging to capture time-sensitive neurological changes during language switching using AAC.

This study also confirmed that age played a significant role in determining children's language switching abilities. However, questions remain about which developmental skills are associated with children's language switching abilities. The development of metalinguistic skills including category knowledge is thought to influence children's ability to conceptually discriminate between languages (see Byers-Heinlein, 2014). This idea, however, has not been empirically tested. Because metalinguistic knowledge is integral to language switching using visual-graphic symbols, future studies should explore the role of category knowledge and metalinguistic skills in children's language switching ability using bilingual AAC.

It is important that future work in this area include bilingual children with limited speech who use bilingual AAC though they may be a challenging group to recruit. Because children with language impairments and children who grow up in bilingual environments represent heterogeneous groups, additional research is needed to explore language switching across subsets of these populations and to increase the generalizability of the findings. Furthermore, it is unknown whether NVIQ influences language switching ability and if there is a lower age limit of language switching using bilingual AAC.

Finally, it is critical that this work advance clinical applications for bilingual children who may benefit from AAC. Preliminary evidence from this study suggested that 4-6-year-old children were able to language switch using bilingual AAC on a cued language switching task, many without difficulty. However, for young children and for some children with language impairments discriminating between language layouts on an SGD may be challenging. Future research should investigate whether young bilingual children and bilingual children with language impairments can be taught to language switch using AAC so that they are able to communicate effectively across language environments and with different communication partners. Clearly more research is necessary to investigate language switching in bilingual children who use AAC to advance the broader understanding of bilingual language development and to study and evaluate clinical applications.

4.6 Conclusions

This study represents an important first step in understanding young children's ability to language switch using AAC. It advances both basic understanding of language switching ability as well as applied research in AAC. Results demonstrated that age and processing speed played a significant role in children's ability to discriminate and switch between languages on bilingual SGDs. Furthermore, most children in this study, including some children with language impairments, were able to switch between languages using the AAC devices. Children's success on the language switching task indicated that they were able to deliberately control their language selection and understood that two different languages were represented by the graphic symbol layouts on Spanish and English SGDs. These findings are encouraging as they suggest that communication using bilingual AAC is achievable for young children. This study paves the way for future research that investigates how best to support communication development in bilingual children with limited speech who use AAC.

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APPENDICES

Appendix A: Family Demographic Information Form

General Information

Participant Number: ___________________ Date: _____________

Child's date of birth: ___________________ Age: _______

Gender: ☐ Male ☐ Female

☐ Yes ☐ No Does your child regularly hear or speak a third language (other than English or Spanish)?

CHILD

Ethnic Background: ☐ Hispanic ☐ Non-Hispanic
(Hispanic or Latino: A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.)

Race: *Please check all that apply:*

☐ American Indian/Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian/Pacific Islander
☐ White
☐ Multiracial
☐ Other:_________
☐ Unknown

Child's country of birth_______________

Health/Development History

Were any of the following conditions present near or after your child's birth?

☐ Stayed in hospital after mother
☐ Was in an incubator or isolette
☐ Prematurity
☐ Birth weight less than 5 lbs
☐ Infection at birth
☐ High fever
☐ Difficulty breathing
☐ Jaundice
☐ Physical deformity/Syndrome
☐ Other

☐ Yes ☐ No Does your child have any serious psychiatric or emotional problems?

Was your child delayed in any of the following? ☐ babbling ☐ talking ☐ sitting ☐ walking

☐ Yes ☐ No Do you have concerns about your child's physical or mental development?
Explain: ____

Communication

☐ Yes ☐ No Does your child have a diagnosed language impairment?
If yes, list diagnosis____

☐ Yes ☐ No Do you have any concerns about your child's language development?

Which of the following is most typical of your child's ability to understand speech?
☐ Understands clearly what is said
☐ Understands familiar statements or questions
☐ Understands what is said when the speaker gestures
☐ Understands very little of what is said
☐ Does not understand what is said

Which of the following is the most typical of your child's ability to express himself?
☐ Speech is clearly understandable
☐ Speech is understood by family but not by others
☐ Uses speech, primarily single words
☐ Uses gestures or motions but no speech
☐ Does not use gestures or speech to communicate
☐ Uses an AAC system (picture symbols or a computer tablet) to communicate.

My child ***understands*** more ☐ English ☐ Spanish ☐ about the same in both languages
My child ***speaks*** more ☐ English ☐ Spanish ☐ about the same in both languages

Hearing

☐ Yes ☐ No Does your child have hearing impairment?
When was your child's hearing last tested? __________________
Where was your child's hearing last tested? __________________
Does your child have frequent ear infections? _________________

Vision

☐ Yes ☐ No Does your child have visual impairments?
When was your child's vision last tested? __________________
Where was your child's vision last tested? __________________
☐ Yes ☐ No Does your child wear glasses or contacts?

Social History

Who are the adults and children in your child's home (parents, grandparents, siblings)? (please

list)
____

Where does your child spend a typical weekday?
☐ Stays home with parent/caregiver
☐ Daycare
☐ Preschool
☐ Kindergarten
☐ Elementary School
☐ Home-school

PARENT 1 (Parent filling out this survey)

Title (e.g. mother/father): ________________

Age _____   Occupation _________________

Parent's Ethnicity: ☐ Hispanic   ☐ Non-Hispanic
(Hispanic or Latino: A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.)

Parent's Race: *Please check all that apply:*
☐ American Indian/Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian/Pacific Islander
☐ White
☐ Multiracial
☐ Other:_________
☐ Unknown

What is the highest degree or level of school this parent has completed? (If currently enrolled in school, please indicate the highest degree *received*.)
☐ Less than a high school diploma
☐ High school degree or equivalent (e.g. GED)
☐ Some college, no degree
☐ Associate degree (e.g. AA, AS)
☐ Bachelor's degree (e.g. BA, BS)
☐ Master's degree (e.g. MA, MS, Med)
☐ Professional degree (e.g. MD, DDS, DVM)
☐ Doctorate (e.g. PhD, EdD)

Parents country of birth _______________
Have you ever had a ☐ vision problem, ☐ hearing impairment, ☐ language disability, or ☐ learning disability? (Check all applicable).

If yes, please explain (including any corrections):
____

Please list all the languages you know **in order of dominance:**

1.	**2.**	**3.**	**4.**	**5.**

Please list all the languages you know **in order of acquisition (your native language first)**

1.	**2.**	**3.**	**4.**	**5.**

In what languages do you typically speak to your child?
☐ Only English
☐ Only Spanish
☐ Mostly English (Some Spanish)
☐ Mostly Spanish (Some English)

☐ Yes ☐ No Do you code-switch when speaking with your child? (Use English and Spanish in the same sentence or conversation)

How frequently do you code-switch when speaking to your child?
☐ never
☐ rarely
☐ sometimes
☐ frequently

PARENT 2

Title (e.g. mother/father): _________________

Age _____ Occupation __________________

Parent's Ethnicity: ☐ Hispanic ☐ Non-Hispanic
(Hispanic or Latino: A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.)

Parent's Race: *Please check all that apply:*
☐ American Indian/Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian/Pacific Islander
☐ White
☐ Multiracial
☐ Other:_________
☐ Unknown

What is the highest degree or level of school this parent has completed? (If currently enrolled in school, please indicate the highest degree *received*.)
☐ Less than a high school diploma
☐ High school degree or equivalent (e.g. GED)
☐ Some college, no degree
☐ Associate degree (e.g. AA, AS)
☐ Bachelor's degree (e.g. BA, BS)
☐ Master's degree (e.g. MA, MS, Med)
☐ Professional degree (e.g. MD, DDS, DVM)
☐ Doctorate (e.g. PhD, EdD)

Parents country of birth _______________

Date of immigration to the USA, if applicable _____________

Has this parent experienced any of the following? ☐ vision problem, ☐ hearing impairment,
☐ language disability, or ☐ learning disability? (Check all applicable).
If yes, please explain (including any corrections):
____

Please list all the languages this parent knows **in order of dominance**:

1.	**2.**	**3.**	**4.**	**5.**

Please list all the languages this parent knows **in order of acquisition (native language first)**

1.	**2.**	**3.**	**4.**	**5.**

In what languages does this parent typically speak to your child?
☐ Only English
☐ Only Spanish
☐ Mostly English (Some Spanish)
☐ Mostly Spanish (Some English)

☐ Yes ☐ No Does this parent code-switch when speaking with your child? (Use English and Spanish in the same sentence or conversation)

How frequently does this parent code-switch when speaking to your child?
☐ never
☐ rarely
☐ sometimes
☐ frequently

Appendix B: Sample Vocabulary Layout for Experimental Task