Language Differentiation using Augmentative and Alternative Communication: An Investigation of Spanish-English Bilingual Children with and without Language Impairments

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ABSTRACT

Purpose: Children with severe speech and language impairments growing up in dual-language environments may communicate in more than one language using augmentative and alternative communication (AAC). This study investigated predictors of bilingual children's ability to differentiate between Spanish and English using an AAC iPad app during a cued language switching task and examined whether switching between languages using AAC incurred a cognitive cost.

Method: Participants were 58 Spanish-English bilingual children ages 4;0 – 6;11 (23 with language impairments). Children received standardized language and cognitive assessments and completed an experimental language switching task in which they were asked to differentiate between languages using an AAC iPad app containing English and Spanish vocabulary layouts paired with voice output.

Results: Results of a binary logistic regression indicated that when controlling for age, processing speed significantly predicted whether children were classified as high or low performers on the experimental task. Nonparametric tests indicated that switching between languages did not incur a cognitive cost as evidenced by similar response times on trials where participants were required to switch between languages compared to trials where they did not switch.

Conclusions: This study contributes to the understanding of how young bilingual children with and without language impairments conceptualize and discriminate between languages represented in a visual-graphic modality paired with speech output.

Key words: Augmentative and alternative communication; bilingual language differentiation; language impairments

Language Differentiation using Augmentative and Alternative Communication: An Investigation of Spanish-English Bilingual Children with and without Language Impairments

There is an increasing number of children in the United States (U.S.) with severe speech and language impairments who grow up in dual-language environments where bilingual communication is essential (Soto & Yu, 2014). For these children, augmentative and alternative communication (AAC) provides a critical tool to support language and communication development and to foster successful social and academic outcomes. To date, however, a scant amount of research has investigated bilingual communication using AAC. An early developing skill for bilingual children is the ability to separate, or differentiate, their two linguistic systems (Byers-Heinlein, 2014), yet we know very little about this process in children with language impairments and other disabilities, including children who use AAC. The current study examined how young Spanish-English bilingual children with and without language impairments differentiated between languages using an AAC iPad app with visual-graphic symbols paired with voice-output.

Bilingualism and AAC

Exact estimates of the number of dual-language learners who may benefit from AAC are difficult to obtain. Recently, Andzik et al. (2018) surveyed over 4000 special educators across the 50 United States about the communicative and behavioral characteristics of over 15,000 students in their special education classes. Teachers reported that although most students used natural speech to communicate, 42% were non-proficient oral language communicators. Furthermore, 18.2% of students primarily used AAC (gestures, picture symbols or speech-generating devices) to communicate. Although Andzik and colleagues did not report the number of dual-language learners in their study, national estimates from the 2016 U.S. Census Bureau

American Community Survey, indicated that 22% of children ages 5-17 speak a language other than English at home with state-level estimates increasing to 29% in Arizona and Florida and 44% in California (Kids Count Data Center, 2018). Given this information, we can infer that millions of children in the U.S. have both severe speech and language impairments and are growing up in bilingual environments.

Like bilingual children without disabilities, bilingual children who use AAC often shift between different language environments at home, school, therapy, and in the community. For these children, bilingual communication using AAC is a critical need as the language used at home may not be the same as the language of instruction at school (Kulkarni & Parmar, 2017; Soto & Yu, 2014). In recent years, industry stakeholders have responded to consumer demand for bilingual AAC options by developing AAC software programs and mobile apps that support bilingual communication. These aided AAC technologies have speech-output options in more than one language and several allow the user to toggle between languages within the same app or program. Despite advances in bilingual AAC technologies, research has not kept pace, even in the face of a growing demand for empirical investigations (Bridges, 2004; Kulkarni & Parmar, 2017; Light & McNaughton, 2012; Light et al., 2019; Woll & Barnett, 1998). Currently, there is no empirical research investigating evidenced-based communication interventions for bilingual children who use AAC. Without evidence-based communication interventions to support bilingual language development using AAC, bilingual children who use AAC are at increased risk for poor communication outcomes that can have deleterious effects on social participation and academic performance.

Language Differentiation and Dual Language Development

Successful bilingual communication involves the ability to comprehend and use more than one language during a communicative context. Beginning at birth, young bilingual children show early emerging abilities to differentiate between languages (e.g., English and Spanish) at the phonological, lexical, and syntactic level. Children who receive dual-language exposure during infancy and early childhood are often referred to as simultaneous bilinguals (Genesee et al., 2011). By age 2, simultaneous bilingual children demonstrate pragmatic language differentiation abilities; that is, they are able to adjust their relative use of one language or another to match the language spoken by their communication partner (e.g., Comeau, et al., 2003; Genesee et al., 1995; 1996; Lanza, 1992; Montanari, 2009; Reyes, 2004). There is emerging evidence that pragmatic language differentiation may even be present in children just learning their first words. Kanto et al. (2015) found that as early as 12 months of age, bimodal bilingual infants—that is children learning a spoken language (Finnish) and signed language (Finnish Sign Language)—were able to accommodate their language use depending on the language of their interlocutor.

Evidence of language differentiation in bilingual infants and toddlers has been used to support theoretical explanations of the neural representation of language orgnaization in simultaneous bilingual children. Early theories of bilingual language development explained the mental representation of bilinguals' language systems either as a single linguistic system (unitary language system hypothesis; Volterra & Taeschner, 1978) or as two separate systems (dual language system hypothesis; Genesee, 1989). Evidence of language differentiation in bilingual infants provides strong support for the dual-language system hypothesis proposed by Genesee (1989). Furthermore, it is now well established that in bilingual speakers, lexical representation in both languages is activated regardless of which language is in use during both language comprehension and production (Kroll et al., 2013). Today, most researchers reject the unitary language system hypothesis in favor of models that represent linguistic systems as separate but interacting schemas (Byers-Heinlein, 2014).

Dual Language Representation and AAC

Questions of language representation are important for understanding bilingual communication using AAC. According to the translation hypothesis in AAC (Smith, 1996; Smith & Grove, 2003), individuals who use AAC must map an internal representation of language to an external symbol, most often visual-graphic symbols often paired with digitized or synthesized speech-output. Based on theoretical explanations for dual-language representation in young bilinguals (i.e., the dual-language hypothesis), we would expect that when translated to aided AAC, two or more languages would be organized as separate systems—that is the bilingual child will continue to maintain organizational separation of both languages when mapping an internal representation of a concept to an external symbol. Investigating how young bilingual children map their internal language systems to an external AAC technology represents a first step in understanding bilingual communication using AAC and may guide future intervention research for bilingual children who use AAC.

Kanto et al. (2015) and others suggested that even bilingual children with emerging language skills can differentiate between languages—an ability that appears to be in place before children demonstrate advanced metalinguistic knowledge. While two-year old children are able to pragmatically differentiate between languages and control their language selection, they may not understand on an abstract or conceptual level that they are speaking two different languages (see Byers-Heinlein, 2014 for a discussion). For bilingual children using AAC, differentiating between languages represented on a speech-output device may draw on higher level cognitive and language skills which may be challenging for young children and children with language impairments. In order to measure language differentiation using AAC and to identify potential factors that may influence language differentiation using AAC, the literature on children and adults using spoken and signed languages may provide some information.

Measuring Language Differentiation in Laboratory Settings

Studies of bilingual language differentiation and use in children and adults often use a cued language switching paradigm with the goal of understanding the behavioral and neural correlates of bilingual communication and language representation. Researchers use the term "language switching" to describe language alternation in these structured paradigms. In these studies, participants are cued to name a picture or number in one or another language following a spoken prompt (e.g., "say" in English or "diga" in Spanish) or a visual cue (e.g., country flag or a colored arbitrarily associated with a particular language). The stimuli are presented via a computer and auditory responses are recorded. Although these studies have provided valuable insights into the psycholinguistic aspects of language switching, researchers have raised concerns about the ecological validity of cued language switching tasks, arguing that they do not mirror the everyday experiences of bilinguals (Blanco-Elorrieta & Pylkkänen, 2018) calling for studies that use more naturalistic cues.

Processing Speed and Cognitive Costs

A basic component of cognitive functioning, processing speed, is the rate at which sensory information passes into the nervous system and is operated upon (Jensen, 1998). Researchers often use motor-visual tasks as a measure of general processing speed (Kail & Salthouse, 1994; Leonard et al., 2007). From a general cognitive-linguistic interactive processing framework (Kohnert, 2012), linguistic functions and lexical processing speed are linked at a basic level to general cognitive processes that underlie the speed and efficiency with which language is learned (Leonard et al., 2007). Alternating between languages, especially during cued language switching tasks, is thought to place a greater burden on the cognitive system and incur switch costs, because the activation and inhibition of two languages during simultaneous comprehension and production seems to require high levels of cognitive control (Green, 1998). This cognitive cost may slow processing when compared to single language conditions (e.g., Diamond et al., 2014; Liao & Chan, 2016). Rather than using a standardized measure of processing speed, however, most studies with language switching tasks use reaction time (e.g., the latency between the switch cue and the speaker's response) as a measure of processing speed. These laboratory-based investigations, consistently indicate that switching between languages incurs a cognitive cost. There is strong evidence that in cued switching paradigms, adult and child participants exhibit slower processing speeds. Participants demonstrate increased reaction times, increased errors, or deviant event-related potentials 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 (e.g., Costa & Santesteban, 2004; Gross & Kaushanskaya, 2018; Jia, et al., 2006; Meuter & Allport, 1999; Verhoef et al., 2009).

Language Experience and Language Switching

The bilingual experience is inherently heterogeneous and the trajectory of dual-language development for bilingual children varies greatly based on a host of complex internal and external factors such as age of first exposure to a second language (e.g., Paradis, 2011; Unsworth, 2013), current language exposure and use (e.g., Bedore et al., 2016; Place & Hoff, 2016), and language status in the community (e.g., Hoff, et al., 2018; Poplack, 1987). Often, bilingual children have varied profiles of language dominance; some have equal proficiency in both languages (i.e., balanced bilinguals) while others have relatively stronger skills in another (i.e., unbalanced bilinguals). In cued language switching studies that included preschool-aged children, language dominance influenced performance with increased response times and/or decreased accuracy on trials where the speaker was required to switch from the non-dominant to the dominant language (Gross & Kaushanskaya, 2018; Jia et al., 2006). Children with unequal language profiles may also have more difficulty with language differentiation in conversational settings (Bernardini & Schlyter, 2004; Deuchar & Quay, 2000). Balanced language dominance in bilingual children has been shown to improve task performance when language switching, task shifting, or differentiating between languages (Montanari, 2009; Poarch & van Hell, 2012; Prior & Gollan, 2011). Accounting for the potential effects of language dominance is an important consideration of language switching tasks given the variability in the bilingual experience.

Implications for Children who use AAC

Language impairments and other disabilities are common among children who use AAC (Andzik et al., 2016; Binger & Light, 2006). Minimal research in bilingual language differentiation and switching, however, has included children with disabilities and it is unclear how language impairment might impact bilingual children’s ability to differentiate between languages represented on an AAC system. Processing speed deficits also have been associated with language impairment (e.g., Kail, 1994; Leonard et al., 2007; Miller et al., 2001; 2006) although others debate this premise (Kohnert & Windsor, 2004; Montgomery & Windsor, 2007, 2015; Windsor et al., 2001). Although processing speed may play an important role in language differentiation tasks that involve spoken language, it is unclear whether processing speed is similarly important for language differentiation using AAC. Given that children who use AAC often present with language and other impairments, it is important to understand whether processing speed, and language impairment impact language differentiation using AAC in bilingual children with varying bilingual experience.

Rationale for the Current Study and Research Questions

The diversity in the language experience of bilinguals who belong to an already heterogeneous group of children with language and other disabilities makes research with this population challenging. As bilingualism becomes increasingly common across the globe (Crystal, 2003; Grosjean, 2010), it is critical that research efforts investigate both theoretical and clinical implications of bilingualism in children with language impairments and other disabilities. Just as language differentiation and 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 technologies, little is known about bilingual language use in children who rely on AAC to communicate. The goal of the current study was to examine Spanish-English bilingual children's ability to differentiate between languages represented in a visual-graphic modality paired with voice output, and to investigate the cognitive and linguistic factors associated with this skill. We asked the following research questions:

1. What cognitive and linguistic factors (including processing speed, language impairment, and language experience) influence Spanish-English bilingual children's ability to differentiate between languages in a cued language switching task using AAC? *We hypothesized that bilingual children with poorer performance on measures of processing speed as well as children with language impairments would show decreased accuracy on the task. We predicted that balanced bilinguals (i.e., with relatively equal exposure and use in both languages) would*

demonstrate greater success on the task than unbalanced bilinguals (those with unequal profiles of exposure and use in both languages).

2. Do Spanish-English bilingual children with and without language impairments exhibit switch-costs on a cued language switching task using AAC? *We predicted that switch costs (measured by increased response times) would be evidenced on switch trials compared to stay trials, and that response times would be longer on trials when participants were cued to switch from their non-dominant to their dominant language. We hypothesized that children with language impairments would have longer response times than children without language impairments.*

Method

Participants

Sixty-eight parents and children responded to recruitment efforts for this study. Bilingual Spanish-English speaking children with typical development and language impairments were recruited. Participants were recruited from elementary schools in the metro Atlanta area and flyers advertising the study were sent home with children in preschool, elementary, and first-grade classrooms who were from Spanish-speaking homes. Flyers were also distributed at speech-language pathology clinics and community organizations that served Latinx families. All parent participants in this study provided written informed consent and child participants provided verbal or written assent according to the Georgia State University Institutional Review Board regulations. For their participation in the study, participants received cash compensation.

Data from 58 children (85% of those who consented) were included in analyses. 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 their ability to participate. Child participants were 58

Spanish-English bilingual children ages 4;0 - 6;11 (*M* = 5.34 years, *SD* = .86) who met the following inclusion criteria: (a) were between the ages 4:0 and 6:11, (b) were exposed to Spanish and English (and no other language) on a regular basis as measured by parent report, (c) had adequate fine motor skills to point to 1.75" X 1" picture symbols on a touch-screen as determined by direct observation and (d) passed the familiarization phase of the experimental task of the study. All children either passed a hearing screening at the time of testing (25dB at 1000, 2000, 4000 Hz bilaterally) or had passed a hearing screening within the six months prior to beginning the investigation. According to parent report, children's vision was within normal limits or children used corrective lenses ($n = 8$).

Participants were grouped according to their language impairment status. Twenty children had a prior diagnosis of developmental language disorder as determined by parent report on the demographic survey. Two had a diagnosis of autism spectrum disorder, and one had a repaired cleft palate. For the current study, children were identified with a 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, et al., 2014), (2) had a previous diagnosis of language impairment, or (3) parents reported concern regarding their child's language development on the parent demographic form. Twenty-three children met the criteria for language impairment, and 35 were typically developing. According to parent report, children in the language impairment group primarily communicated using connected speech ($n = 11$) or single words ($n = 7$). Five children primarily used gestures to communicate. No children used an AAC device prior to the study.

Table 1 summarizes group results across standardized measures of language and cognitive abilities. Group differences were significant for age ($t = 2.91$, $p < .05$) and children with language impairments were younger on average (Mean age = 59.52 months) than children without language impairments (Mean age = 67.11) months). Group differences were not significant for demographic variables or for English and Spanish language exposure.

Parents completed a demographic questionnaire about their child's developmental and medical background. Over 60% of children attended preschool, kindergarten, or elementary school, 3.4% of children attended day-care, and 35% of the children remained at home with a caregiver during the day. Two of the 58 participants were twins, and seven others were siblings. Thirty-eight children were male and 20 were female. All but one child were Hispanic and all children had at least one parent who identified as Hispanic and whose primary language was Spanish. Most children (*n* = 48) were born in the continental U.S. while the remainder of the children were born in Puerto Rico (*n* = 1), Venezuela (*n* = 6), Colombia (*n* = 1), or Mexico (*n* = 1). 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 U.S. and one parent was born in Puerto Rico.

Language Experience

Table 2 summarizes children's language background and language experience based on parent report. For research question 1, we were interested in how children's language experience (based on their current English and Spanish exposure and use) impacted their performance on the language differentiation task. Parents completed the Bilingual Input-Output Survey (BIOS; Peña et al., 2014) in which they were asked which language their child heard (i.e., input) and used (i.e., output) during a week day and during a typical weekend day on an hour-by-hour basis. This information provided an estimate of relative language experience (i.e., average input and output in English and Spanish) during a typical week. Research suggests that compared to bilingual children with balanced language experience, bilingual children with unequal language profiles may have more difficulty with language differentiation in conversational settings (Bernardini & Schlyter, 2004; Deuchar & Quay, 2000) as well as on cued language switching tasks (Jia et al., 2006). On the other hand, balanced language dominance may improve task performance when language switching, task shifting, or differentiating between languages (Montanari, 2009; Poarch & van Hell, 2012; Prior & Gollan, 2011). We predicted that on a continuum of language experience (e.g., low English experience/high Spanish experience to high English experience/low Spanish experience), children at both ends of the distribution would have more difficulty with language differentiation using AAC. Thus, a categorical variable was used to describe language experience based on procedures from Greene et al. (2012). Children's language experience was considered "balanced" if their average English or Spanish input and output (obtained from the BIOS) was between 40% and 60%, and "unbalanced" if their average Spanish or English input and output was greater than 60% or less than 40%.

For research question 2, a binary variable (dominant vs. non-dominant) was used to describe children's language dominance (either in English or Spanish) for each item on the experimental task. Using a binary coding convention for dominance is a well-accepted practice in studies of language switching where participants have unequal language profiles (e.g., Costa & Santesteban, 2004; Meuter & Allport, 1999; Prior & Gollan, 2011). Given that language dominance has been shown to impact switch costs (e.g., Gollan & Ferreira, 2009; Gross & Kaushanskaya, 2018; Liao & Chan, 2016), it is important to evaluate whether asymmetrical switch costs exist at the item level. Language dominance was determined by greater than 50% average input and output in a given language on the BIOS survey (Peña et al., 2014). If a participant's average input/output on the BIOS was 50% in each language, language dominance was determined by the highest language composite on the BESA.

Procedures

The primary investigator, who is fluent in English and Spanish, administered all standardized assessment and experimental procedures. The administration of the language assessment 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.

Standardized Assessments

The morphosyntax and semantics subtests from the *Bilingual English Spanish Assessment* (BESA; Peña et al., 2014) were administered to all participants in English and Spanish. Across both the morphosyntax and semantics subtests, the participants' two highest standard scores (either in English or Spanish) were combined to yield a Bilingual Language Index which accounted for abilities across both languages. Subtests from the *Leiter International Performance Scale, Third Edition* (Leiter-3; Roid, et al., 2013) yielded a composite measure of nonverbal IQ (used for descriptive purposes) and processing speed. The Leiter-3 uses an engaging, nonverbal format and was normed and validated with a diverse group and is appropriate for populations with speech and language disorders and from culturally and linguistically diverse backgrounds.

Experimental Task

The experimental language differentiation task using AAC was developed and pilot tested by the primary investigator and employed a cued language switching paradigm. A pilot study with a single participant was conducted to assess the feasibility of the experimental task and to evaluate the length of time required for the study procedures. The pilot participant was a 5;11-year-old Hispanic, bilingual male with a speech impairment but with language and cognitive abilities within the average range. The pilot participant did not have difficulty understanding the procedures of the experimental task and achieved high levels of accuracy on the task.

Materials. For the experimental task, participants accessed two AAC devices with speech output capabilities—iPads containing the Proloquo2Go[1] AAC application version 5. Synthetic voice output for both iPads was the bilingual child voice (Emilio) from Acapela Group[2] whose accent is described as Bilingual U.S. English/North American Spanish. A customized vocabulary display was created on the iPads using existing color symbols from the Proloquo2Go application. The target vocabulary words used in this study were borrowed from a list of 42 object nouns compiled by Gross and Kaushanskaya (2015) who selected 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. Gross and Kaushanskaya selected and compared English and Spanish vocabulary targets based on the words' frequency of use, age of acquisition ratings, and concreteness ratings. The list of the English and Spanish target vocabulary words included in this study is available as supplemental material.

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

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

words were presented on two iPads: one with English vocabulary and English voice output, one with Spanish vocabulary and Spanish voice output. The iPads were placed six inches from the child and the order of Spanish or English from left to right was randomized across participants as was the order of the picture symbols on the devices. Two separate devices 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 languages represented on the AAC devices. 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). Supplemental materials include screenshots of the AAC device displays containing sample vocabulary layouts in Spanish and English.

Experimental task procedures. Before beginning the experimental task, participants were required to identify the vocabulary picture symbols in English and Spanish with 100% accuracy. 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 the target vocabulary symbols in both English and Spanish before proceeding with the experimental task.

For the experimental task, 16 vocabulary words were presented in randomized order via a spoken prompt in English or Spanish and participants were asked to select the vocabulary on the corresponding AAC device (either with Spanish or English voice-output). Since the vocabulary items in both English and Spanish were familiar to the children and they were able to correctly associate the picture symbol with the concept, this task required that they differentiate between English and Spanish AAC layouts to select the device with the voice-output that matched the spoken prompt. 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 a script. Three plush dolls were used during the practice trials and the experimental block. The dolls provided a more meaningful and engaging context for the task and were meant to increase the ecological validity of the task. To create a context where the use of the AAC devices for communication was obligatory, the child was asked to help one of the dolls to “talk” using the picture symbols on the iPads. Additional information about the experimental task including the script and example target words and responses is available as supplemental material.

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.

The experimental task was audio recorded using a portable SONY UX530[3] digital recording device with a built-in stereo microphone that was placed directly behind the iPads.

[3] 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 the experimental task, the examiner recorded participants' responses to the prompts on a data sheet and documented whether the child's response was correct. The number of overall correct responses across the 13 trials was recorded. Responses were coded by trial type (stay vs. switch), language dominance, and naming speed. Naming speed—defined as response time (RT) and measured using the audio recordings—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 AAC device. 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 AAC device.

Fidelity

An undergraduate student in communication disorders who was masked to the purposes of the study and not involved in the administration of the experimental task or assessments, completed the coding for fidelity of implementation of the experimental task. The fidelity coder listened to recordings of 20% of randomly selected sessions and used a checklist of 10 pre-established behaviors to mark yes or no to indicate whether the examiner adhered to the experimental task protocol. The fidelity score was 99.36% and was calculated by dividing the number of behaviors adhered to correctly, by the total number of behaviors and multiplying by 100.

Reliability

To evaluate interrater agreement for the scoring of items on the BESA, two additional research assistants who were undergraduate students in communication disorders and psychology, 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. One of the research assistants who was a native Spanish speaker and fluent in Spanish and English, coded the Spanish BESA for agreement. Interrater agreement for the Spanish BESA was 97.23% and interrater agreement for the English BESA was 97.75%.

To establish interrater agreement for the experimental task, three other research assistants who were undergraduate students in communication disorders, listened to the audio recordings of 20% of experimental task sessions and scored participant responses for the target response and for RT. Agreement for the target responses was 98.60%. Agreement for RTs to the nearest tenth of a second was 91.00%. All differences in coding were discussed and resolved.

Results

Figure 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.

Predictors of Performance on the Experimental Task (Question 1)

Research question 1 asked whether language impairment status, processing speed, and language experience predicted children’s performance on the experimental task measuring language differentiation using AAC. The dependent variable, number of correct responses on the experimental task, was not normally distributed and demonstrated a ceiling effect. To remedy this issue, a 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 differentiating between languages on those trials (for example, they may have been using only one AAC device to select all 13 responses so at least 6 would be correct). A total score of 10 indicated that participants better understood the language differentiation task and were accurately discriminating between the English and Spanish AAC devices. On the experimental task, sixty percent of participants (N = 35) were high performers including 28 children without language impairments and seven children with language impairments.

A binomial logistic regression was run using IBM SPSS Version 25.0 (IBM Corp, 2017), to ascertain the effects of age, language impairment, language experience, and processing speed on the likelihood that participants were classified as either high or low performers on the experimental task. Binomial logistic regression aims to predict the probability that a participant falls into one of two categories from the values of several explanatory variables (Tabachnick & Fidell, 2014). Age in months was entered as a covariate. Language impairment (language impairment vs. no language impairment) and language experience (e.g., balanced vs. unbalanced bilingual) were entered as categorical variables. Processing speed was entered as a continuous variable using raw scores obtained from the processing speed subtest of the Leiter-3. Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell procedure (Box & Tidwell, 1962). This procedure transforms the predictors in a regression to linearize the relationship between the dependent variable and the predictor variables. The continuous independent variables were linearly related to the logit of the dependent variable. There was one standardized residual with a value of -2.709 standard deviations, which was kept in the analysis.

Results of the binomial logistic regression are displayed in Table 3. A two-step model was used with age entered in the first block as a covariate. 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, language impairment, bilingual experience, and processing speed were entered in the second block. Model 2 was statistically significant, $\chi^2(4) = 55.06$, $p < .001$ indicating a better fit than Model 1. The explained variance in performance on the experimental task increased to 84.1% (Nagelkerke R^2) in Model 2 and 93% of the cases were correctly classified. Sensitivity increased to 91.4%, specificity was 96.9%, positive predictive value was 94.3% and negative predictive value was 87.5%. Increased age was associated with greater odds of being classified as a high performer on the experimental task. In Model 2, for each 1 month increase in age, the odds of being classified as a high performer increased by 1.37 times. When age was controlled for, processing speed significantly increased the predictive validity of the model. For every unit increase in processing speed, the odds of being classified as a high performer increased by 1.73 times. Language impairment and bilingual experience[4] were not significant predictors of whether children were classified as high or low performers on the experimental task.

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[4] We also considered a continuous variable for language experience according to the recommendations of MacCallum et al (2002) and ran an alternative model that included a polynomial term for language experience instead of the categorical variable. We computed a quadratic term for average language input and output from the BIOS and included the new polynomial term and the mean centered variable for average language input and output into step 2 of the model. The conclusions of the binary logistic regression using language experience as a continuous variable did not differ meaningfully from the model that included the categorical specification. That is, language experience was not significantly associated with either the continuous, non-linear specification or the categorical specification.

Switch Costs (Question 2)

Question 2 asked whether bilingual children exhibited switch costs when cued to switch between languages using AAC on the experimental task. Response times (RTs) were measured for all switch and stay trials. A Wilcoxon signed-rank test was conducted to determine whether mean RTs across stay trials and switch trials on the experimental task were significantly different. 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. Because RTs across all trials may have been influenced by errors in the selection of the target response, only correct trials were included in the analyses. The difference scores across switch and stay trials were approximately symmetrically distributed, as assessed by a histogram with a superimposed normal curve. 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. 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 RTs (*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 impairments and children with language impairments. Mann-Whitney U tests were performed on the following dependent variables 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 4 and indicated that RTs for children with language impairments were statistically significantly higher than for children without language impairments 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.

Discussion

This study explored predictors of bilingual children's ability to differentiate between English and Spanish AAC devices and 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. We found that overall, 4 - 6-year-old bilingual children were able to differentiate between languages that were represented visually on two different AAC devices with 60% of the children classified as high performers on the experimental task. When controlling for age, processing speed significantly predicted children's performance 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.

Support for Theoretical Perspectives of Language Differentiation

Findings from this study provide support for the dual language system hypothesis (Genesee, 1989) as well as a large body of research indicating that young bilingual children have differentiated linguistic systems for the languages they are regularly exposed to (Comeau, Genesee, & Lapaquette, 2003; Genesee, Nicoladis, & Paradis, 1995; Genesee, Boivin, & Nicoladis, 1996; Kanto et al., 2015; Köppe, 1996; Tare & Gelman, 2010). However, the current study is novel in that it did not rely on spoken responses to measure language differentiation but instead required children to discriminate between visual representations of the languages paired with voice-output. 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—an ability that presumably requires an abstract understanding of languages as separate systems.

Dual-Language Representation and AAC

The finding that bilingual children were able to differentiate between languages using AAC has important implications for the translation hypothesis in AAC (Smith, 1996; Smith & Grove, 2003; Trudeau, et al.,2007) which states that communication using AAC involves transposition of a mental representation of language to an external modality (i.e., visual-graphic symbol). To our knowledge, however, the application of this theory to bilingual communication using AAC has not been explored. Our findings suggest that bilingual preschool-aged children are able to map their internal representation of two language systems to an external AAC modality where two languages are visually differentiated. This work indicates that bilingual children are not only able to translate a mental representation of a concept (e.g., apple) to a visual-graphic symbol representing that concept, but they are able to determine whether the symbol they select will have corresponding speech output in one language or another. Although most children in this study were able to discriminate between languages using AAC without difficulty (i.e., high performers), not all children were successful on the task (i.e., low performers); thus it is important to understand the predictors of this capacity.

Predictors of Language Differentiation using AAC

The purpose of question 1 was to explore predictors of children's performance on the experimental task measuring language differentiation using AAC. We hypothesized that language impairment status, processing speed, and language experience would significantly predict performance on the task when controlling for age. Our hypothesis was partially supported and we found that only processing speed significantly predicted whether children were classified as high or low performers on the experimental task.

Processing Speed and Language Differentiation

A key finding from the current study was that individual differences on the standardized measure of processing speed were related to performance on the experimental task. This finding supports research suggesting that differentiating and switching between languages draws on higher level cognitive skills (e.g., Green & Wei, 2014; Kroll et al., 2013; Luk et al., 2012). In these studies however, reaction time on switch trials is used as an indicator of processing speed. The current study was unique in that we used a standardized measure of processing speed to investigate the relationship between processing speed and language differentiation. Another possible explanation for this finding is related to the nature of the task. The processing speed measure that we used measured motor-visual processing speed. The experimental task involved processing visual information in the form of picture symbols represented on the English and Spanish AAC devices and selecting the appropriate symbol with a motor response (finger point). Given the motor-visual processing demands of the experimental task, it may not be surprising then that children who performed better on the standardized assessment, also performed better on the experimental task. Furthermore, it should be noted that the processing speed measure used was non-verbal/non-linguistic. Although verbal/linguistic processing as a construct is related to overall processing speed, it has been shown to function as a separable dimension from non-verbal processing (Leonard et al., 2007).

Language Impairment and Language Differentiation

Our hypothesis that children with language impairments would have more difficulty on the experimental task was not supported. Instead, we found that language impairment was not a significant predictor of whether children were classified as high or low performers on the task. One possible explanation for this finding is that the task requirements were not demanding enough to differentiate children with language impairments from those with typical development. On the experimental task, children were cued to select items with which they were already familiar in English and Spanish. Seven of the twenty-three children in the language impairment group (16%) were classified as high performers on the experimental task. Closer inspection of these participants may provide useful information in understanding the performance of children with language impairments on the task. Children with language impairments who were also high performers 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 on the BESA 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 differentiation abilities using AAC than language impairment.

Given the range in language ability of the participants with language impairments, further inspection of those with more severe impairments may provide additional information. Post-hoc analyses revealed that 12 children (92%) with severe language impairments (i.e., language index scores below 77.5 on the BESA), were classified as low performers on the experimental task. Although as a categorical variable language impairment status did not significantly predict performance on the experimental task, these findings indicate that the severity of language impairment may influence language differentiation abilities using AAC.

Bilingual Experience and Language Differentiation

We hypothesized that participants with relatively balanced experience in English and Spanish would perform better on the experimental task than those with unequal profiles. However our hypothesis was not supported and instead we found that more exposure to and use of both languages did not equate to increased ability to differentiate between the languages using AAC. This finding may be explained by the nature of the task which required participants to identify vocabulary that they already understood in both languages. Although the literature frequently indicates that language experience predicts performance on language switching tasks, it is possible that on the current task, even low experience in one language was sufficient for successful language differentiation. This interpretation is supported by research from Kanto et al. (2015) who showed that in bimodal infants learning a spoken and a signed language, language experience was not related to their language differentiation ability. The authors concluded that as soon as children have some level of competence in language they are able to pragmatically differentiate between languages.

Switch Costs

The second research question asked whether children exhibited switch costs on the experimental task 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. 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; Mueter & Alport, 1999). However, 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, 2015; 2017; Li, et al., 2013) and disappear when switching is voluntary (e.g., de Bruin et al., 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 AAC. Switch cost asymmetry has been found to disappear when longer preparation time is given even in unbalanced bilinguals (Verhoef et al., 2009) and when there is time between trials for decay of activation (Declerck et al., 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.

Language Dominance, Language Impairment, 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. Although asymmetrical switch costs have been documented frequently in the language switching literature (e.g., Guo et al., 2011; Meuter & Allport, 1999), other studies indicate, that for highly proficient or balanced bilinguals, asymmetrical switch costs disappear (Costa & Santesteban, 2004). In the current study, many participants were balanced bilinguals and did not show clear dominance in either Spanish or English. An analysis 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 impairments. Results of a series of Mann Whitney U tests indicated that participants with language impairments demonstrated increased RTs compared to participants without language impairments regardless of trial type or language dominance. However, any analyses that did not account for age are difficult to interpret and we cannot conclusively determine whether language impairment group influenced participants' response times on the language switching task.

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 explained over 80 percent of the variance in the logistic regression model, providing confidence in the results. It is possible, however, that the experimental task may not have been sufficiently complex to detect effects of the predictors of interest or to elicit differences between switch and stay trials. The number of children with language impairments was also small, which limits the broader generalizability of the findings. It also is important to note that this study did not include participants who used AAC as their primary means of communication prior to the study. However, this investigation was a first step toward understanding the cognitive and linguistic processes required to differentiate languages using AAC.

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 AAC devices instead of a single system limits the generalizability and ecological validity of these findings. This study also did not account for dialect and it is possible that the dialect of the experimenter and/or the dialect of the synthetic voice used on the AAC devices may have interfered with children's performance on the tasks.

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, the language cue was a sentence level prompt 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 AAC device than to differences in trial type.

Future Directions and Clinical Implications

Findings of the current study provided preliminary evidence that 4 to 6-year-old bilingual children were able to differentiation between languages without significant cognitive costs on a task that employed on single word identification (of known nouns represented with picture symbols) given a simple, sentence level prompt. Children's processing speed (measured using non-verbal, motor-visual processing tasks) was significantly related to performance on the task. These findings must be replicated with a larger sample and additional research is needed to investigate whether switch costs are present if the complexity of the task increases and the context for switching is more naturalistic than the current setting. 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 differentiation abilities. Questions remain, however, about which developmental skills are associated with language differentiation. The development of metalinguistic skills including category knowledge is thought to influence children's ability to conceptually discriminate between languages (see Byers-Heinlein, 2014) although this idea has not been empirically tested. Because metalinguistic knowledge may affect language differentiation using visual-graphic symbols, future studies should explore the role of individual semantic and metalinguistic skills in children's ability to differentiate languages 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 differentiation across subsets of these populations (including children with more severe language impairments) and to increase the generalizability of the findings. Furthermore, it is unknown whether non-verbal IQ influences language differentiation ability and if there is a lower age limit of language differentiation using bilingual AAC.

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

Conclusions

This study represents an important first step in understanding young children's ability to differentiate bilingual language layouts using AAC. Results demonstrated that age and processing speed played a significant role in children's ability to differentiate between languages on a cued language differentiation task using Spanish and English AAC devices. Furthermore, most children in this study, including some children with language impairments, were able to discriminate between languages using AAC. These findings are encouraging as they suggest that communication using bilingual AAC may be achievable for young children. This study paves the way for future research that investigates how best to support communication development in bilingual children who use AAC.

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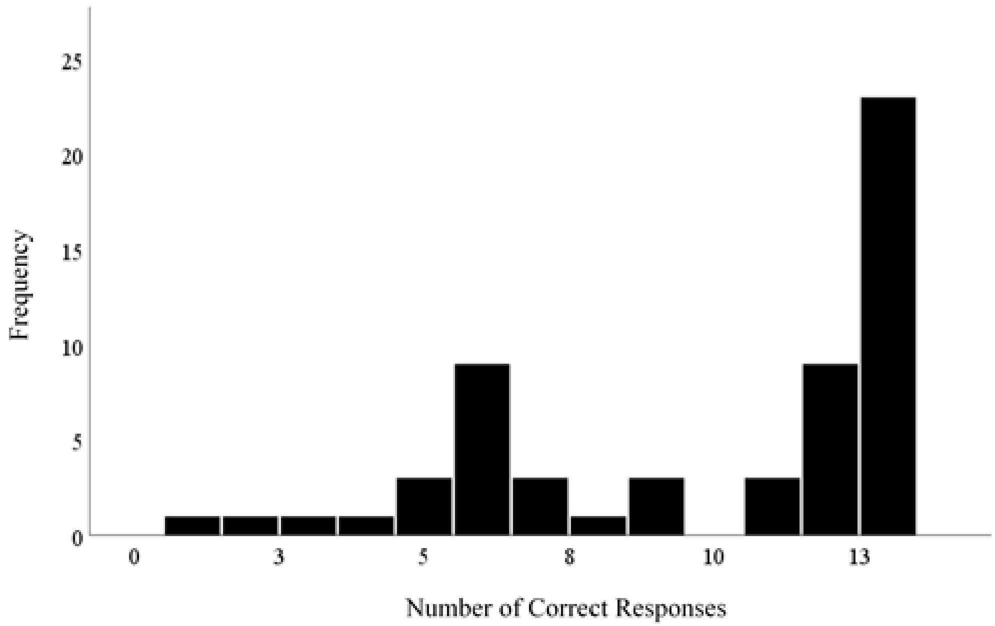
Figure 1. Histogram displaying the frequency of correct responses on the experimental task across all participants (n = 58).



Supplementary Material Descriptions

Supplementary Material 1. Supplementary Material 1 includes a table of the English and Spanish vocabulary items used in the experimental task.

Supplementary Material 2. Supplementary Material 3 includes two screenshots of the AAC device displays containing sample vocabulary layouts in Spanish and English.

Supplementary Material 3. Supplementary Material 2 includes a table with the script used to administer the experimental task as well as example target words and responses.

Table 1. *Summary of Language and Cognitive Profiles across Children with and without Language Impairments (Mean = 100, SD = 15)*

	No Language Impairment (*n* = 35)		**Language Impairment (*n* =23)**		
Measure	**SS Mean (SD)**	**CI 95%**	**SS Mean (SD)**	**CI 95%**	***t***
BESA Composites					
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 Composites					
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; NVIQ = Nonverbal IQ**p < .001, *p <. 05, *t* scores assumed unequal variances

Table 2. *Child Language Background and Dominance base on Parent Report*

	No Language Impairment (*n* = 35)		**Language Impairment (*n* = 23)**	
Characteristic	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**
First exposure to English (years)	2.06(.21)		1.65(.24)	
% Current English Input	53.49(15.73)		57.43(13.63)	
% Current English Output	58.31(13.61)		65.04(21.01)	
% Current Spanish Input	44.80(13.12)		42.57(13.63)	
% Current Spanish Output	41.69(13.61)		34.96(21.01)	
BBs (40-60% English-Spanish)		14(40.0)		7(30.4)
UBs (>60% English or Spanish)		21(60.0)		16(69.6)
EDBs (>60% English)		16(45.7)		12(52.2)
SDBs (>60% Spanish)		5(14.3)		4(17.4)

Note. Percentages of current English and Spanish Input and Output determined from *Bilingual Input Output Survey* (BIOS; Peña et al., 2014). BBs = Balanced Bilinguals; UBs = Unbalanced Bilinguals, EDBs = English Dominant Bilinguals; SDBs = Spanish Dominant Bilinguals; SD = Standard Deviation

Table 3. *Summary of Binary Logistic Regression 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 in months	.27**	.07	13.70	1.31	.32*	.12	8.06	1.42
Processing Speed					.55*	.23	5.93	1.73
Language Experience					.40	1.37	.09	1.50
Language Impairment					.59	1.43	.17	1.80
X^2	35.45				55.06			
Nagelkerke R^2	.63				.84			

Note. Language experience indicated whether or not participants were balanced bilinguals (e.g., used and heard Spanish and English between 40% - 60% of waking hours). Language Impairment determined using 2 out of 3 criteria including standardized scores on bilingual language test, parent concern, and prior diagnosis of language impairment. Processing Speed was raw scores obtained from the Leiter-3 (Roid et al., 2013); *$p < .05$, **$p < .001$.

Table 4. *Group Differences in Response Times by Trial Type and Language Dominance for Participants with and without Language Impairment*

Dependent Variable	LI		No LI		*U*	*z*	*p*
	Mdn	*N*	*Mdn*	*N*			
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. *$p < .05$, **$p < .01$.