# Language Control in Bilingual Children with Low and Typical Language Skills

By

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## Dedication

This dissertation is dedicated in loving memory to my father, Jack Gross, who taught me to be curious and to love words.

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## Abstract

Even as toddlers, bilingual children show a remarkable ability to adjust their language choice to accommodate different conversation partners. This ability to control which language is used for production, known as *language control*, is important for successful communication with a variety of partners in a variety of environments. What factors contribute to a child's ability to exercise language control? One factor is the context of the interaction. A dual-language context, in which children need to switch back and forth between languages to address different speakers, may place higher demands on language control than a single-language context, in which children use each language in separate settings. However, experimental studies documenting costs in dual-language contexts have tended to use single-word paradigms, which do not include the contextual cues available during conversation. This dissertation introduces an interactive scripted-confederate dialogue paradigm to examine the effects of context on language control in 4-6 year-old Spanish/English bilingual children. The results suggest that a dual-language context does not exert the same robust costs on language control at the discourse level that have been documented at the single-word level.

Children's cognitive and linguistic skills may also contribute to language control. Most work in children has focused on linguistic skill as the limiting factor in children's ability to control their language choice. However, models of language control in adults tend to focus on cognitive control. Understanding the skills that contribute to language control is particularly important for considering how language control may be affected in children with atypical development, such as children with specific language impairment (SLI). This dissertation examines the linguistic and cognitive predictors of language control in children with a broad range of language ability, including children with SLI. The results suggest an integrated model of

language control in children in which language ability is the main limiting factor, with cognitive control playing an additional role among children with higher language skills in predicting the ability to adapt to a dual-language context. For children with low language, including those with SLI, their limited language skills may put them at risk for having difficulties with language control.

# Chapter 1: Introduction

## Language Control: Theoretical and Clinical Significance

In order to communicate effectively in a variety of environments and with a variety of conversation partners, bilingual children must develop *language control*, the ability to control which language is used for production and to choose the appropriate language based on the situation. Children exposed to both languages from birth demonstrate an emerging version of this skill, sometimes known as *pragmatic differentiation of language use*, as early as age two, when they have been shown to adjust their language choice depending on the language of their conversation partner (e.g., Genesee, Nicoladis & Paradis, 1995; Genesee, Boivin & Nicoladis, 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Genesee, 1996). Whether children acquire their two languages simultaneously or sequentially, language control becomes a particularly important skill in the preschool years as they enter new language environments and encounter conversation partners with different language knowledge. For example, at school drop-off, children might need to switch between using Spanish to address their parents and English to address their teacher, while they may have bilingual classmates with whom they can use both languages. Choosing the wrong language, or producing a *cross-language intrusion* (e.g., using English with their parents or Spanish with their teacher), would impede communication by disrupting their listener's ability to understand their message.

What skills contribute to the development of language control, and how can cross-language intrusions be explained? This question is of theoretical importance because an understanding of bilingual acquisition must encompass not only the development of skills in each language, but also the developing ability to control the use of each language. Most work on language control in children has focused on the role of linguistic skills (e.g., Lexical Gap

Hypothesis, Nicoladis & Secco, 2000). Cognitive control (a set of higher-level control mechanisms that regulate cognitive processes and behavior, e.g., Miyake & Friedman, 2012, also known as *executive control* or *executive functions*) forms a key component of adult models of language control (e.g., Green, 1998; Green & Abutalebi, 2013; Meuter & Allport, 1999), but this factor has rarely been examined in children. The theoretical contribution of this dissertation will be to test an integrated model of language control that incorporates both linguistic and cognitive factors.

An understanding of the linguistic and cognitive predictors of language control is also of clinical importance when we consider bilingual children who may have difficulties with linguistic and/or cognitive skills. Children with specific language impairment (SLI) exhibit significant difficulties with language that cannot be explained by other conditions such as hearing impairment, neurological impairment, or intellectual disability (Leonard, 2014). However, in addition to these difficulties with language, they have often been suggested to have deficits in cognitive control (e.g., Engel de Abreu, Cruz-Santos, & Puglisi, 2014 [in bilinguals]; Epstein, Shafer, Melara, & Schwartz, 2014; Farrant, Maybery, & Fletcher, 2012; Henry, Messer, & Nash, 2012; Iluz-Cohen & Armon-Lotem, 2013 [in bilinguals]; Kapa & Plante, 2015; Marton, 2008; Pauls & Archibald, 2016; Roello, Ferretti, Colonnello, & Levi, 2015; Sandgren & Holmstrom, 2015 [in bilinguals]; Spaulding, 2010; Vissers, Koolen, Hermans, Scheper, & Knoors, 2015). Given these challenges, children with SLI may be at risk for difficulties with language control, which would impact their ability to be understood by others. The clinical contribution of this dissertation will be to examine linguistic and cognitive predictors of language control in bilingual children with a broad range of language skills, including those with SLI.

Although there is a shifting preference for the term Developmental Language Disorder (DLD, e.g., Bishop, Snowling, Thompson, Greenhalgh, & the CATALISE-2 consortium, 2017), this dissertation was originally conceptualized in terms of SLI and the way it has been defined in the literature, particularly with regard to nonverbal IQ. I will therefore use the term SLI to describe past literature and the children with significant language difficulties included in the current study. However, rather than creating groups with diagnostic labels, this dissertation characterizes overall language ability along a continuum. Especially among bilingual children in whom typical development is still not well understood, it is difficult to draw a strict demarcation between SLI and the lower end of the typical range. For research purposes, a continuum approach may be preferable to examine how language control is affected by low levels of language ability.

## Context Matters: Interactional Contexts and Language Control

The definition of language control and what constitutes a cross-language intrusion depends on the *interactional context* in which bilinguals use their two languages. In their Adaptive Control Hypothesis, Green and Abutalebi (2013) describe three main interactional contexts: single-language, dual-language, and dense code-switching. *Single-language* interactional contexts refer to the use of each language in separate contexts, such as Spanish at home and English at school. In each context, there is a clear target language, and use of the opposite language would constitute a cross-language intrusion and exert an “interactional cost” (Green & Abutalebi, 2013, p. 521) on the bilingual’s ability to be understood by others. A *dual-language* interactional context refers to use of both languages in the same context but with different people. For example, a bilingual who speaks English with one parent and Spanish with the other would have a home environment that is a dual-language interactional context. In this environment, either language could be the target language, depending on whom the bilingual is addressing. Use of the wrong language with the wrong person would constitute a cross-language intrusion and would result in an interactional cost. In both single-language and dual-language contexts, language control requires suppression of the non-target language, but in a dual-language context, the bilingual must also be prepared to activate what used to be the non-target language to address a different interlocutor.

A *dense code-switching* interactional context refers to integrated use of the two languages within the same context, with the same conversation partner, and often within the same sentence, known as *intra-sentential code-switching*. This context occurs when a bilingual is surrounded by other bilinguals who speak the same pair of languages and who frequently integrate both languages within their speech. In this context, there is no single target language, and the concept of cross-language intrusions is not applicable. Language control in a dense code-switching context would refer to following established grammatical and sociolinguistic conventions for integrating the two languages in a way that others who code-switch will understand.

In this dissertation, I focus on single-language and dual-language interactional contexts where there is a clearly defined target language and where use of the non-target language during an exchange with a given conversation partner would constitute a cross-language intrusion and a lapse in language control.

**A note on terminology.** The definition of *language control* in this dissertation resembles Meisel's (1994) definition of *code-switching*: "the ability to select the language according to the interlocutor, the situational context, the topic of conversation, and so forth, and to change languages within an interactional sequence in accordance with sociolinguistic rules and without violating specific grammatical constraints" (p. 414). I view language control and code-switching as overlapping constructs. While the ability to switch back and forth between languages to address different conversation partners is a form of code-switching, the term “code-switching” also evokes the more specific meaning associated with *intra-sentential code-switching*, the practice of integrating elements from both languages within a single sentence. Given the focus of this dissertation on single-language and dual-language interactional contexts where there is a clear target language for any given exchange, instances of intra-sentential code-switching are considered a lapse in language control because they represent a switch into the non-target language that would result in an interactional cost. Therefore, in describing studies that report on the frequency of code-switching in contexts with an established target language, I use the term *cross-language intrusion*, even though the original authors used the term code-switching. I would like to make it clear that I do not view intra-sentential code-switching as a lapse in language control in general, but only in the specific contexts under consideration here.

## The Psycholinguistic Costs of Language Switching: Implications for the Dual-Language Context

In their Adaptive Control Hypothesis, Green and Abutalebi (2013) describe the dual-language interactional context as requiring additional control processes, compared to a single-language context, in order to monitor the need to switch languages and to execute the language switch. Most empirical studies of language control have simulated the dual-language context in laboratory paradigms conducted at the single-word level in which bilinguals are cued to switch back and forth between their languages as they name pictures. These laboratory studies have identified robust costs to the speed and/or accuracy of word retrieval in dual-language contexts. Bilinguals are slower to produce words and more likely to make errors, including producing the word in the wrong language, in a dual-language context than a single-language context (i.e., *mixing costs*; Christoffels, Firk, & Schiller, 2007; Hernandez & Kohnert, 1999; Hernandez & Kohnert, 2015; Jylkkä, Lehtonen, Lindholm, Kuusakoski, & Laine, 2018; Prior & Gollan, 2011, 2013; Weissberger, Wierenga, Bondi & Gollan, 2012). They are also slower and more likely to make errors when they are cued to switch languages compared to when they continue in the same language (i.e., *switching costs*; e.g., Broersma, Carter, & Acheson, 2016; Calabria, Hernandez, Branzi, & Costa, 2011; Christoffels, Firk, & Schiller, 2007; Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006; Declerck, Koch, & Philipp, 2012; Gollan, Kleinman, & Wierenga, 2014; Heikoop, Declerck, Los, & Koch, 2016; Jackson, Swainson, Cunnington, & Jackson, 2001; Jylkkä, Lehtonen, Lindholm, Kuusakoski, & Laine, 2018; Linck, Schwieter, & Sunderman, 2012; Martin et al., 2013; Meuter & Allport, 1999; Olson, 2016; Philipp, Gade, & Koch, 2007; Prior & Gollan, 2011, 2013; Verhoef, Roelofs, & Chwilla, 2009, 2010; Wang, Kuhl, Chen, & Dong, 2009; Wang, Xue, Chen, Xue, & Dong, 2007; Weissberger, Gollan, Bondi, Clark & Wierenga, 2015; Weissberger, Wierenga, Bondi, & Gollan, 2012; Zheng, Roelofs, & Lemhöfer, 2017). A few picture-naming studies have documented similar costs in children as well (e.g., Gross & Kaushanskaya, 2018; Jia, Kohert, Collado & Aquino-Garcia, 2006; Kohnert, 2002; Kohnert, Bates, & Hernandez, 1999).

A key question is whether these costs are an artifact of the artificial nature of laboratory language switching paradigms, or whether they reflect the reality experienced by a bilingual speaker during conversation in a dual-language context. Language switching paradigms that target the sentence level and/or incorporate more social context have been introduced in adults (e.g., Declerck, Lemhöfer, & Grainger, 2017; Festman, 2012; Gambi & Hartsuiker, 2016; Gullifer, Kroll, & Dussias, 2013; Kootstra, van Hell, & Dijkstra, 2010; Liu et al., 2016; Liu et al., 2018; Peeters & Dijkstra, 2017; Tarlowski, Wodniecka, & Marzecová, 2013). However, these more naturalistic paradigms have not necessarily been used to examine language switching costs (e.g., Festman, 2012; Kootstra et al., 2010). Those that did specifically examine costs have yielded mixed results. Some studies still found costs in dual-language contexts at higher linguistic levels (Declerck et al., 2017; Tarlowski et al., 2013) or in more interactive contexts (Gambi & Hartsuiker, 2016; Liu et al., 2016; Liu et al., 2018; Peeters & Dijkstra, 2017). However, there was one study that found no costs (Gullifer et al., 2013). Similar attempts to “scale up” experimental paradigms for examining language control in dual-language contexts have not been conducted in children.

**The Developmental Divide: Different Approaches to Language Control in Adults and Children**

The mixing and switching costs documented in psycholinguistic studies of language switching may reflect the functioning of cognitive control processes recruited to support language control. In adults, models of language control (e.g., Green, 1998; Green & Abutalebi, 2013; see Declerck & Philipp, 2015 for an overview) have highlighted a key role for domain-general cognitive control. For example, the Adaptive Control Hypothesis (Green & Abutalebi, 2013) suggests several cognitive control processes (e.g., goal maintenance, interference control, detection of salient cues, selective response inhibition, task disengagement, and task engagement) that are involved in language control in dual-language interactional contexts. Extensive empirical work has been devoted to examining links between cognitive control and language control through neuroimaging studies (see Abutalebi & Green, 2016 for a recent review) and through behavioral studies that include both measures of cross-language intrusions and cognitive control (e.g., Festman & Münte, 2012; Festman, Rodriguez-Fornells & Münte, 2010; Gollan, Sandoval, & Salmon, 2011; Gollan et al., 2014; Gollan & Goldrick, 2016; Prior &

Gollan, 2013), including some studies that have measured cross-language intrusions at the conversational level (e.g., Festman, 2012; Rodriguez-Fornells, Kramer, Lorenzo-Seva, Festman & Münte, 2012; Soveri, Rodriguez-Fornells & Laine, 2011). Adult models of language control have also considered relative proficiency in terms of the amount of cognitive control required to suppress the non-target language (e.g., Green, 1998), but cognitive control has been identified as the main explanatory factor when adults exhibit cross-language intrusions (e.g., Festman et al., 2010; Festman, 2012; Zheng et al., 2017).

In contrast, most studies of language control in young bilingual children have identified linguistic skills as the limiting factor in children's ability to exercise language control, suggesting that children switch into the non-target language due to limited lexical and/or syntactic knowledge (e.g., Cantone & Muller, 2005; Gawlitzek-Maiwald & Tracy, 1996; Genesee et al., 1995; Genesee et al., 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Secco, 2000; Ribot & Hoff, 2014). However, studies have also documented individual differences in language choice that are not commensurate with children's skills in each language (e.g., Castillo, 2015; Genesee & Nicoladis, 1996; Nicoladis & Genesee, 1996; Paradis & Nicoladis, 2007; Ribot & Hoff, 2014), suggesting that other factors may also contribute to language control. A role for cognitive control has been suggested (e.g., Aguilar-Mediavilla et al., 2015; Jia et al., 2006), but studies of language control in children have rarely measured cognitive control directly.

In our prior work (Gross & Kaushanskaya, 2018), cognitive control was a significant predictor of language control in bilingual children at the single-word level across both single-language and dual-language contexts. However, it is unclear how these findings would generalize to single-language and dual-language contexts at the discourse level. Furthermore, there is a need for an integrated model of language control in children at the discourse level that incorporates both linguistic *and* cognitive factors. It is also important to consider how these factors may interact. For example, it is possible that cognitive control may play a greater role at higher levels of language ability. For children with low language, the ability to maintain the target language may be fully constrained by their limited language skills, such that there is no additional role to be played by cognitive control. Alternatively, given evidence of deficits in inhibition and potentially in shifting among children with SLI (e.g., Engel de Abreu et al., 2014 [in bilinguals]; Epstein et al., 2014; Farrant et al., 2012; Henry et al., 2012; Iluz-Cohen & Armon-Lotem, 2013 [in bilinguals]; Kapa & Plante, 2015; Marton, 2008; Pauls & Archibald, 2016; Roello et al., 2015; Sandgren & Holmstrom, 2015 [in bilinguals]; Spaulding, 2010; Vissers et al., 2015; but see Dibbets, Bakker, & Jolles, 2006; Im-Bolter, Johnson, & Pascual-Leone, 2006; Laloi, 2015 [in bilinguals]), the effects of cognitive control may be intertwined with the effects of low language ability in children at the lower end of the language continuum. Identifying an interaction between cognitive control and language ability would contribute to our understanding of the factors that affect language control in children, including those with SLI.

## Language Control in Children with Specific Language Impairment

It remains unclear whether language control is impaired in children with SLI and how difficulties with language control in this population may relate to low language skills and/or poor cognitive control. Studies comparing the frequency and patterns of language switching in children with typical language and those at risk for SLI have yielded mixed results, with some studies finding differences (e.g., Aguilar-Mediavilla, Buil-Legaz, Pérez-Castelló, López-Penadés, & Androver-Roig, 2015; Greene, Peña, & Bedore, 2013; Iluz-Cohen & Walters, 2012; Silva, 2011) and some not (Greene, Bedore, & Peña, 2014; Gutierrez-Clellen, Simon-Cereijido, & Leone, 2009). These studies differed in sample size, in the contexts in which they elicited language (e.g., conversation, narrative, semantic assessment task), and in the way they measured language switches (e.g., intra-sentential code-switching vs. switches across sentences, inclusion of single-word insertions). Furthermore, these studies have focused on single-language tasks. It remains unknown how the ability to maintain language control in a dual-language context is affected by low language ability.

Most of these studies have taken a group comparison approach, but one study of children with language impairment (Mammolito, 2015) examined overall language ability as a continuous predictor and found a greater tendency to switch into the non-target language during a narrative task among children with more severe impairment. This continuum approach provided more information how language control skills may change with decreasing language ability, even within a group of children that all have language impairment. However, the possible contribution of cognitive control deficits to language control difficulties in children with SLI has not been examined. Group comparisons between children with and without SLI cannot necessarily tease apart the relative contributions of language ability and cognitive control, both of which may be affected in the impaired group. A continuum approach that includes children with SLI at the lower end may shed light on the contribution of cognitive control to language control as language ability drops to impairment levels.

## The Current Dissertation

**Aims.** The current dissertation project was motivated by three major gaps in the literature: a lack of experimental studies of children's language control in dual-language contexts at the discourse level; a focus on linguistic predictors of language control in children without also considering cognitive control; and inconsistent approaches and findings in studies of language control in children with SLI. The central goal of this dissertation was to understand how cognitive and linguistic factors contribute to language control at the discourse level in children with a broad range of language ability. The project had three aims:

1. To examine the effects of a dual-language context on children's language control at the discourse level.
2. To examine the relative contributions of language ability and cognitive control to children's language control overall and specifically to their ability to adapt to a dual-language context.
3. To explore the language control abilities of children with SLI in single-language and dual-language contexts through analyses that take a group comparison approach vs. analyses that treat language ability as a continuum.

**Population.** To address these aims, I recruited a sample of 67 Spanish/English bilingual children (ages 4-6) with a broad spectrum of language ability, ranging from below-average to above-average with over-sampling at the lower end. Included within this sample were 12 children who met my criteria for SLI by demonstrating at least two of the following: Language Index scores of 85 or below on the Bilingual English Spanish Assessment (BESA; Peña, Gutierrez-Clellen, Iglesias, Goldstein, & Bedore, 2014), parent language concerns, and/or an existing diagnosis or history of language services. All children had normal hearing and nonverbal intelligence within normal limits. All children were exposed to Spanish from birth or within their first year of life, but first exposure to English varied from birth to preschool entry. As a result, the sample included both simultaneous and sequential bilinguals. Socio-economic status varied considerably, with maternal education levels ranging from less than high school to a doctoral degree. Therefore, SES was used as a covariate in analyses that included child-level predictors.

A total of 86 Spanish/English bilingual children in the 4-6 age range were initially recruited to participate in the project, but 19 were excluded from the final sample due to failing the hearing screening ($n$ = 3), suspected neurological impairment ($n$ = 1), growing up abroad with more diverse language exposure than the rest of the sample ($n$ = 3), acquiring Spanish after 12 months ($n$ = 1), choosing not to complete the study ($n$ = 8), being unwilling to participate in all conditions of the scripted confederate dialogue task ($n$ = 1), or demonstrating extremely limited English expressive skills compared to the rest of the sample ($n$ = 2). Exclusionary criteria included hearing impairment, frank neurological impairment, genetic syndromes, psychological/ behavioral disorders, other developmental disabilities, and significant current or past exposure to a language other than English or Spanish. ADHD and speech impairments were not considered to be exclusionary criteria. As these conditions often co-occur with SLI, variation in attention and speech skills was permitted in the sample throughout the range of language ability.

**Approach to measuring language control.** A methodological contribution of this dissertation is the development of a computerized scripted confederate dialogue paradigm for studying language control in children at the discourse level while maintaining experimental control. In the scripted confederate technique, participants interact with a partner (the confederate) in an activity that provides motivation to communicate effectively (e.g., taking turns describing and identifying pictures, working together to create a common product). The confederate's utterances are scripted by the experimenter to manipulate their linguistic structure, and the paradigm measures how participants adapt their own productions in response to these manipulations. This approach has been used most often in studies of syntactic priming both within (e.g., Branigan, Pickering & Cleland, 2000 in adults; Branigan, McLean, & Jones, 2005 in children) and across languages (e.g., Hartsuiker, Pickering & Veltkamp, 2004), but Kootstra and colleagues (Kootstra, van Hell, & Dijkstra, 2010) extended it to examine alignment in intra-sentential code-switching behavior.

I adapted Kootstra's paradigm to examine language control in single-language and dual-language contexts in a child-friendly interactive picture description game in which I manipulated the language spoken by the confederate (e.g., "My name is Ashley and I only speak English" or "Me llamo María y solo hablo español"). Children were told that they would earn stars when they found the picture described by the confederate and when they helped the confederate find their picture, providing motivation to describe the pictures so that the confederate would understand. For the single-language context, children played with an English-speaking confederate and a Spanish-speaking confederate in separate sessions. For the dual-language context, the children were introduced to two new monolingual confederates, one who spoke English and one who spoke Spanish, and turns alternated pseudo-randomly between the two confederates within a single game. In both contexts, language control was indexed by the production of cross-language intrusions (e.g., using Spanish within picture descriptions addressed to the English-speaking confederate). To increase experimental control, I used pre-recorded videos instead of live confederates. Children were told that they would play a game with someone in another room, and a video of the confederate was presented on a computer screen. Children's behavior (e.g., waving or making unsolicited comments to the partner) suggested that they believed the interaction was occurring in real time. All children heard the same sentences from confederates and described the same pictures that were carefully selected to be easily described in English or Spanish using early-acquired, high-frequency nouns and verbs. Thus, this paradigm provided a controlled way to examine children's language control while addressing speakers of different languages in an interactive context where there was a goal to communicate.

**Overview.** This dissertation consists of two empirical papers (Chapters 2 and 3), an exploratory poster (Appendix), and a General Discussion (Chapter 4). Chapter 2, "Language Control in Bilingual Children: Costs of mixing languages in a scripted confederate dialogue paradigm?" addresses the first aim by examining the effects of a dual-language context on children's language control at the discourse level. This paper focuses on the typically developing children within the larger sample and addresses the question of whether costs identified during mixed-language picture-naming are applicable when children switch languages to address different speakers in a discourse context. It introduces the computerized scripted confederate dialogue paradigm as a method for studying language control in children in a more naturalistic context while maintaining experimental control.

Chapter 3, "Cognitive and Linguistic Predictors of Language Control in Bilingual Children with Low and Typical Language Skills" addresses the second aim by examining the effects of language ability and cognitive control on language control in children. This paper includes the full sample of children and treats language ability (as measured by the Language Index from the Bilingual English Spanish Assessment) as a continuous predictor. It employs a Dimensional Change Card Sort task as a measure of cognitive control in order to examine links between domain-general cognitive control and language control across varying levels of language ability. Building on the previous chapter, this paper examines the overall effects of language ability and cognitive control on language control, as well as their interactions with the effects of context (single-language vs. dual-language).

The Appendix contains an exploratory poster, “Language Control in Bilingual Children with and without Language Impairment,” that focuses on the 12 children that met my criteria for SLI. This poster supplements the findings from Chapter 3 by examining whether the continuous relationship observed between language ability and language control translates into significant language control difficulties among children with SLI compared to a matched group of typically developing peers. The poster also explores different types of language control errors, distinguishing mixed-language responses from responses provided fully in the non-target language.

Chapter 4 contextualizes the findings from the two empirical chapters and the poster in order to draw overarching conclusions, identify broad limitations, and delineate future directions for this work.

# Chapter 2: Language Control in Bilingual Children: Costs of mixing languages in a scripted confederate dialogue paradigm?

Abstract: Do dual-language contexts, in which children use both of their languages in the same setting with different speakers, pose a particular challenge for children's ability to control their language choice? Psycholinguistic language switching studies suggest that there are costs associated with dual-language contexts, but it is unclear whether these costs are applicable at a discourse level. The current study used a scripted confederate dialogue paradigm to examine the ability of 4-6 year old Spanish/English bilingual children to control their language choice when interacting with monolingual speakers of each language in dual-language vs. single-language contexts. The findings revealed an effect of language dominance, but no effect of context. The results suggest that a dual-language context may not exert the same robust costs on language control at the discourse level that have been documented at the single-word level. Possible differences in factors influencing language control at the discourse level are discussed.

Bilingual adults exhibit a remarkable ability to control their language choice, rarely producing words in the non-target language (e.g., Poulisse & Bongaerts, 1994). When interacting with monolingual speakers of different languages, they are able to switch back and forth between their languages to address each person. Bilingual children as young as age two demonstrate an emerging ability to control which language they use for production, exhibiting relative adjustments in their use of one language or the other depending on their conversation partner (e.g., Genesee, Boivin & Nicoladis, 1996; Genesee, Nicoladis & Paradis, 1995; Lanza, 1992; Nicoladis & Genesee, 1996), even when both conversation partners are present at the same time (e.g., Genesee et al., 1995). However, bilingual children (and even occasionally bilingual adults) still produce some words in the non-target language for a given situation or conversation partner, known as *cross-language intrusions* (e.g., Zheng, Roelofs, & Lemhöfer, 2017). Are these difficulties with language control more likely to occur in a *dual-language context* (Abutalebi & Green, 2013), in which bilinguals need to switch back and forth between languages to address different speakers, than in a *single-language context* with only one target language? Are dual-language contexts especially challenging for children, who are still developing their language control skills?

Adult models of language control (e.g., Green & Abutalebi's (2013) Adaptive Control Hypothesis) and psycholinguistic studies of language switching in both adults (e.g., Christoffels, Firk, & Schiller, 2007; Hernandez & Kohnert, 1999; Hernandez & Kohnert, 2015; Jylkkä, Lehtonen, Lindholm, Kuusakoski, & Laine, 2018; Prior & Gollan, 2011, 2013; Weissberger, Wierenga, Bondi & Gollan, 2012) and children (e.g., Gross & Kaushanskaya, 2018; Jia, Kohert, Collado & Aquino-Garcia, 2006; Kohnert, 2002; Kohnert, Bates, & Hernandez, 1999) have suggested that there are costs associated with dual-language contexts. However, these studies were generally conducted at the single-word level, and it is unclear whether these costs also apply to discourse where there is more linguistic and social context to support appropriate language choice. The goal of the current study was to examine the ability of bilingual children to maintain language control in a dual-language vs. a single-language context at the discourse level using a scripted confederate dialogue paradigm.

**Language Switching in Picture-Naming Studies**

The cued-switch picture-naming paradigm is a classic method for studying the control of language choice during language switching while maintaining experimental control. Participants are asked to name a visual stimulus (e.g., picture or digit) in a particular language given a visual cue (e.g., flag or color) or an auditory cue (e.g., "say…", "diga…"). The language cue alternates to create *stay trials*, when participants are cued to use the same language as the previous trial, and *switch trials*, when the cued language changes from the previous trial. Comparing performance on stay trials vs. switch trials yields a measure of *switching costs*. Switching costs in naming speed, where participants name pictures more slowly when they have to switch languages, have been documented in numerous studies of bilingual adults speaking a variety of language pairs and with varying dominance profiles (e.g., Broersma, Carter, & Acheson, 2016; Calabria, Hernandez, Branzi, & Costa, 2011; Christoffels et al., 2007; Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006; Declerck, Koch, & Philipp, 2012; Gollan, Kleinman, & Wierenga, 2014; Heikoop, Declerck, Los, & Koch, 2016; Jackson, Swainson, Cunnington, & Jackson, 2001; Jylkkä et al., 2018; Linck, Schwieter, & Sunderman, 2012; Martin et al., 2013; Meuter & Allport, 1999; Olson, 2016; Philipp, Gade, & Koch, 2007; Prior & Gollan, 2011; Verhoef, Roelofs, & Chwilla, 2009, 2010; Wang, Kuhl, Chen, & Dong, 2009; Wang, Xue, Chen, Xue, & Dong, 2007; Weissberger, Gollan, Bondi, Clark & Wierenga, 2015; Weissberger et al., 2012). These costs are believed to index the increased effort necessary to switch from producing a word in one language to producing a word in another language and to manipulate levels of inhibition and activation to ensure production in the correct language (Green, 1998).

Furthermore, several studies have documented a dominance asymmetry in which costs are greater when bilinguals switch from their non-dominant language to their dominant language than vice versa (e.g., Costa & Santesteban, 2004; Gollan et al., 2014; Jackson et al., 2001; Jylkkä et al., 2018; Linck et al., 2012; Martin et al., 2013; Meuter & Allport, 1999; Philipp et al., 2007; Wang et al., 2009; Wang et al., 2007). This phenomenon can be explained by Green's (1998) Inhibitory Control model, which posits that the amount of inhibition applied to the non-target language depends on its level of activation. When using their weaker language, bilinguals must exert a high level of inhibition on the more active dominant language, and when they need to switch into the dominant language, increased time and effort are required to overcome that inhibition, resulting in a larger switch cost. However, this dominance asymmetry does not always appear when bilinguals switch between languages of unequal dominance (e.g., Calabria et al., 2011; Christoffels et al., 2007; Costa & Santesteban, 2004; Costa et al., 2006; Martin et al., 2013; Olson, 2016; Prior & Gollan, 2011; Verhoef et al., 2009, 2010; Weissberger et al., 2012). In addition , switching costs have been shown to be highly malleable depending on task parameters, stimulus properties, and participant characteristics (e.g., Bobb & Wodniecka, 2013; Calabria et al., 2011; Gollan et al., 2014; Olson, 2016; Runnqvist, Strijkers, & Costa, 2014; Verhoef et al., 2009). More global comparisons between a dual-language context and a single-language context may provide a more robust measure of the increased cost to language control exerted by language switching.

Several language switching studies have also included a single-language block in each language as a source of comparison to the dual-language block in which language switching occurs. This comparison provides a measure of *mixing costs*, which reflect the increased effort necessary to control language choice in a context when the speaker must be prepared to use either language and must monitor cues for language selection. Traditional mixing costs have been documented by comparing performance during the single-language blocks to performance on only the stay trials in the dual-language block (e.g., Christoffels et al., 2007; Jylkkä et al., 2018; Prior & Gollan, 2011). This approach isolates global mixing costs from local switching costs by excluding switch trials in the calculation; it provides a measure of the cost of being prepared to switch even on those trials when a switch does not actually occur. A comparison between overall performance on the single-language and the dual-language blocks (collapsing across stay and switch trials) provides an omnibus measure of the increased demands on language control in a dual-language context (e.g., Hernandez & Kohnert, 1999; Hernandez & Kohnert, 2015). Asymmetries in mixing costs have also been documented, where the dual-language context has a larger effect on performance in the dominant language, sometimes even producing a dominance reversal during the dual-language block (e.g., Christoffels et al., 2007; Jylkkä et al., 2018; Prior & Gollan, 2011; Weissberger et al., 2012). It has been suggested that bilinguals adopt the strategy of globally suppressing their dominant language in a dual-language environment to facilitate access to the non-dominant language (e.g., Christoffels et al., 2007).

In contrast to these measures of switching and mixing costs in naming speed, *cross-language intrusions* (i.e., producing a word in the non-target language) provide a more direct measure of language control. While speed costs reflect a delay of the language control system when it is taxed, cross-language intrusions reflect a direct failure of language control (e.g., Zheng, Roelofs, & Lemhöfer, 2017). Only a small number of studies have investigated cross-language intrusions, in part because they are relatively rare in healthy young adults (e.g., Poulisse & Bongaerts, 1994) and as a result are often combined with other types of errors in any error rate analyses. However, they are produced at a higher frequency under time pressure (Zheng et al., 2017) and in older adults (e.g., Gollan, Sandoval, & Salmon, 2011; Hernandez & Kohnert, 1999).

Studies of cross-language intrusions during language switching have documented similar phenomena to those observed in naming latencies. Bilinguals exhibit *switching costs*, producing more cross-language intrusions when required to switch languages than when staying in the same language (Prior & Gollan, 2013; Zheng et al., 2017). Furthermore, individuals who produce more cross-language intrusions overall during language switching also tend to exhibit larger switching costs in naming speed (Festman, 2012; Hernandez & Kohnert, 1999). *Mixing costs* have been observed in studies that found more cross-language intrusions in a dual-language context than a single-language context (e.g., Hernandez & Kohnert, 1999; Prior & Gollan, 2013). Cross-language intrusions also exhibit *dominance reversals*, such that bilinguals are more likely to substitute a word in their non-dominant language when using their dominant language than vice versa (Zheng et al., 2017). However, it is unclear whether these costs documented using a variety of measures at the single-word level in highly controlled laboratory paradigms reflect the reality of what bilinguals experience when they switch languages during conversation, where there is more linguistic and social context to support appropriate language choice.

**Language Control in More Naturalistic Paradigms**

Attempts to study language control in adults in more naturalistic ways have taken three main approaches: scaling up to a higher linguistic level without introducing an interactive or social component, introducing an interactive or social component but staying at the single word level, and scaling up to a higher linguistic level while also introducing an interactive or social component.

Paradigms that examined language control at a higher linguistic level without manipulating the social context included producing words embedded in a provided sentence context (e.g., Gullifer, Kroll, & Dussias, 2013) and generating sentences in different languages to describe a visual stimulus (e.g., Declerck, Lemhöfer, & Grainger, 2017; Tarlowski, Wodniecka, & Marzecová, 2013). Switching costs were observed in terms of slower production (Tarlowski et al., 2013) or increased cross-language intrusions (Declerck et al., 2017) when participants had to switch languages when producing sentences. Similar to studies at the single-word level, language dominance effects were observed, including a dominance reversal and asymmetrical switching costs in speed (Tarlowski et al., 2013). However, Gullifer and colleagues (2013) found that the speed with which participants read aloud a marked word within a sentence was not affected when the language of the sentence switched from the previous sentence. This result differs from the findings of Declerck and colleagues (2017) and Tarlowski and colleagues (2013), when had to produce the whole sentence themselves. It may be that the reduced costs in Gullifer's study occurred because participants (silently) read words in the target language before having to read aloud the marked word. Taken together, the findings of these studies suggest that language switching at the sentence level still induces costs to language control, except under very specific circumstances.

Instead of scaling up to a higher linguistic level, other studies have introduced a social or interactive component to single-word paradigms by having participants name pictures with a partner (Gambi & Hartsuiker, 2016; Liu et al., 2018) or by eliciting picture naming in one language or the other based on nonverbal cues from avatars presented as monolingual speakers (Peeters & Dijkstra, 2017). In all three studies, switching and/or mixing costs in naming speed were still observed. The presence of costs is particularly striking in the study by Peeters & Dijkstra (2017), given additional research showing that bilinguals can use rapidly formed associations between an individual's face and the language they speak to speed up access to the language associated with that person (Martin, Molnar, & Carreiras, 2016; Woumans et al., 2015). However, single-word picturing naming, even in an interactive paradigm, still lacks the combination of linguistic and social context cues that may aid appropriate language choice during conversation.

Combining the approaches of scaling up to higher linguistic levels and integrating social context, a few studies (Festman, 2012; Kootstra, van Hell, & Dijkstra, 2010; Liu et al., 2016) have examined language control at the discourse level by creating highly structured conversation paradigms. Liu and colleagues (2016) had pairs of Chinese/English bilinguals take turns talking about specified conversational topics. In one condition, they were each told to switch languages after 30 seconds within a one-minute conversation turn. In another condition, they were told to use English throughout the conversation. Although the participants did not produce many cross-language intrusions, they produced more morphosyntactic errors in English after having just switched from Chinese than when they used English throughout the task. The authors attributed these errors to cross-language interference from Chinese and interpreted them as instances of reduced language control. This finding would suggest that there are costs associated with switching languages at a discourse level. However, even though the paradigm involved dialogue, the language switch was still artificially cued in the middle of the participant's response rather than being naturally cued by a change in conversation partner.

Festman (2012) used a conversation paradigm in which Russian/German bilinguals were interviewed by two different experimenters, one who spoke Russian and one who spoke German. The interviewers traded off about every five minutes as they introduced a new topic. Participants were divided into two groups based on their performance on a traditional picture-naming task. The group of participants that produced more cross-language intrusions and higher switching costs during the picture-naming task also produced more cross-language intrusions in both languages during the conversation task. On a self-report measure, they reported more frequent experiences of switching languages without realizing it and indicated that they would be more likely to switch languages with a monolingual communicative partner even though it meant they would not be understood. Although this study did not measure costs of a dual-language context at the discourse level by comparing it to a single-language condition, the associations noted among the picture-naming task, conversation task, and self-report measures provided some evidence that costs observed in picture-naming paradigms may reflect overall difficulties with language control in more naturalistic settings.

Kootstra and colleagues (2010) examined aspects of language control that may be particular to discourse by comparing code-switching patterns during monologue and dialogue tasks. For the dialogue task, they used a scripted confederate dialogue paradigm based on the interactive alignment model of dialogue processing (e.g., Garrod & Pickering, 2004), which posits that individuals have a natural tendency to align various characteristics of their language production (e.g., lexical choice, syntactic structure) to what they have just heard from their conversation partner. Kootstra (2009, 2015) has proposed that this model can be applied to code-switching, arguing that language activation can spread from one conversation partner to another so that they align in when and how they switch languages. In their study, Kootstra and colleagues (2010) had participants take turns describing pictures with a confederate using a sentence completion task. They were instructed on some trials to use at least one word in the opposite language from the sentence starter (i.e., they had to code-switch) and on some trials to use at least one word in the same language as the sentence starter (i.e., they did not have to code-switch, but they could if they wanted to). The sentences produced by the confederate were scripted to manipulate whether or not they code-switched on the trials where code-switching was optional and where in their sentence the code-switch occurred. The study revealed that bilinguals tended to align with the confederate in when they chose to code-switch and in the word order and position of the switches within their sentences.

This study was not specifically designed to measure costs of language switching, but it could be possible to do so by examining errors of language selection in which participants did not produce the cued language. For example, the data tables presented by Kootstra and colleagues (2010) indicated that there were rare occasions when participants were cued to produce at least one word in the opposite language from the sentence starter, but they used only the language of the sentence starter (i.e., failed to switch). These instances appeared to be slightly more frequent (3.67% of trials requiring switches to English, averaged across word order conditions; 9% of trials requiring switches to Dutch) when participants completed the task alone with only the experimental cues than when they completed the task with the confederate (2% of trials requiring switches to English and 5.3% of trials requiring switches to Dutch). Although these data are based on intra-sentential code-switching rather switching languages for different speakers, they reflect the idea that there may be additional alignment forces present during dialogue that assist speakers with the control of language choice in ways that are not observable in traditional language switching cost measures. Based on this approach, the current study employed a scripted confederate dialogue paradigm to measure language control in children at the discourse level.

**Language Control in Children**

The study of language control in children has been more limited than in adults. The preschool and early school-age years are a particularly important period to study language control because children are entering new school and community settings that may place new demands on their developing language control skills. Furthermore, they are still in the process of gaining skills in both languages and may experience shifts in dominance and language preference (e.g., Gibson, Oller, Jarmulowicz, & Ethington, 2012; Hoff & Ribot, 2017) that may exert additional influences on language selection. In the sociolinguistic context of the United States, many children addressed by their parents in the home language will respond in English, a pattern which may have a bi-directional relationship with their developing expressive skills in each language (e.g., Hoff, 2018). It has also been suggested that children may be less sensitive than adults to alignment with the language choice of other family members (Pan, 1995).

Most studies of language control in children have been observational, focused on pragmatic differentiation of language use when bilingual children interact with speakers of different languages (e.g., Castillo, 2015; Genesee et al., 1996; Genesee et al., 1995; Lanza, 1992; Nicoladis & Genesee, 1996). These studies have found that children as young as age two were able to make a relative adjustment in their use of one language or another with different conversation partners, including monolingual adults with whom they had no previous experience (Genesee et al., 1996) and including dual-language settings with parents who speak different languages (Genesee et al., 1995). However, these adjustments tend to be relative rather than absolute, and children do sometimes produce cross-language intrusions in the non-target language. These cross-language intrusions are often attributed to limited skills in the target language (e.g., Nicoladis & Secco, 2000) or "readiness to speak the language" in terms of productivity in the target language (e.g., Cantone & Muller, 2005).

Observational studies of children's language choice during interactions with familiar and unfamiliar interlocutors have yielded valuable information the development of language control, but these studies do have limitations. They often include very small samples, making it difficult to interpret any apparent individual differences or to generalize the findings to a broader population. Naturalistic observations also lack experimental control. For example, Genesee and colleagues (1995) observed children interacting with their English-speaking mothers and French-speaking fathers separately in single-language contexts and together in a dual-language context. However, a comparison of these two scenarios cannot evaluate the presence or absence of language control costs in a dual-language environment because a variety of other factors could have been different as well, such as the topic of conversation and children's familiarity with the relevant vocabulary during each setting.

Experimental studies that have examined language control in children have used the traditional picture-naming paradigm from the adult psycholinguistic literature (Gross & Kaushanskaya, 2018; Jia et al., 2006; Kohnert, 2002; Kohnert et al., 1999). Similar to findings in adults, children were more likely to produce cross-language intrusions when naming pictures in a dual-language context than a single-language context (Gross & Kaushanskaya, 2018; Jia et al., 2006), suggesting that language control is more difficult when children are in a situation in which they have to switch languages. Furthermore, children named pictures more slowly in a dual-language context than in a single-language context (Gross & Kaushanskaya, 2018; Jia et al., 2006; Kohnert et al., 1999; Kohnert, 2002). Within the dual-language context, children also demonstrated switching costs, naming pictures less accurately and more slowly on switch trials than on stay trials (Jia et al., 2006). Jia and colleagues observed dominance asymmetries for switching costs in accuracy, but not in naming speed.

However, as is the case for the adult literature, it is unclear whether these costs reflect a true increase in language control demands in dual-language settings or whether they are an artifact of using decontextualized picture-naming paradigms. When comparing picture-naming and conversation during free-play, Tare and Gelman (2010) found that 2-4 year old Marathi/English bilingual children were more likely to use the non-target language during a picture-naming task than during conversation in a free-play activity. They argued that the reduced context during picture-naming and the need to produce one specific word made it more challenging to control language choice. Although this study only looked at single-language contexts, the findings suggest that demands on language control may differ at the single-word and the discourse level. Therefore, to better understand how language control operates in developing bilinguals, there is a need for work at the discourse level that combines experimental control with the naturalistic conversational context of earlier observational studies.

In this vein, a recent study by Raichlin, Walters, and Altman (2018) used a story retell task that manipulated the language of the story and the language of the listener to create a challenging context for language control. Russian-Hebrew bilingual children (ages 5-7) were asked to retell a story that they had heard in Hebrew to a monolingual Russian-speaking puppet and to retell a story that they had heard in Russian to a monolingual Hebrew-speaking puppet. Children exhibited more difficulty with language control when speaking Russian, producing more switches into Hebrew (32% of utterances) when re-telling the Hebrew story to the Russian-speaking puppet than into Russian (20% of utterances) when re-telling the Russian story to the Hebrew-speaking puppet. This study demonstrated the effect of the target language on children's ability to maintain language control. Hebrew was the stronger and more preferred language for the majority of children in the sample and also the language of schooling and the broader community. Similar results were obtained in an earlier study (Iluz-Cohen & Walters, 2012) using the same paradigm with English/Hebrew bilinguals, who were more likely to switch from English into Hebrew than vice versa. However, this paradigm did not evaluate costs by comparing children's performance to a single-language condition in which they had to re-tell s story in the same language that they heard it. Furthermore, although children had to shift from listening to a story in one language to retelling it in another, they did not have to switch back and forth between languages to address different speakers as in a truly dual-language environment.

**Current Study**

The goal of the current study was to examine the extent to which Spanish-English bilingual children (ages 4-6) exhibit differences in language control in single-language and dual-language contexts during discourse. To investigate this question, a scripted confederate dialogue paradigm (e.g., Kootstra et al., 2010) was developed to create structured exchanges in which children took turns describing pictures and finding the matching picture with a confederate. Similar to Iluz-Cohen and Walters (2012) and Raichlin and colleagues (2018), the confederates were presented as monolinguals to create an expected target language. In addition to separate interactions with an English-speaking partner and a Spanish-speaking partner, there was dual-language condition in which children played the picture description game with turns alternating pseudo-randomly between two different monolingual partners. This scenario created an expectation that children would need to switch between languages in order to be understood by each partner.

Language control was indexed by whether children produced *cross-language intrusions* during their picture descriptions, defined as inserting one or more words in the language not understood by their conversation partner. If switching between languages at the discourse level is associated with increased language control demands, then children would exhibit more cross-language intrusions in the dual-language condition than in single-language condition. The conclusion would then be that costs identified for switching between languages at the single-word level also apply to more naturalistic conversation settings. However, if children exhibit similar levels of cross-language intrusions in both contexts, the conclusion would be that the costs associated with language switching at the single-word level do not apply to the discourse level. Instead, the increased linguistic and social context may help to support language choice.

# Method

## Participants

Fifty-five Spanish-English bilingual children (20 boys), ages 4-6 ($M_{age}$ = 5.25 years; *SD* = 0.9), with typical language development were drawn from a larger project (F31 DC013920 "Language control in bilingual children with low and typical language skills"). The children in the current study were defined as having typical language development based on obtaining Language Index scores greater than 85 on the *Bilingual English-Spanish Assessment* (BESA; Peña, Gutiérrez-Clellen, Iglesias, Goldstein, & Bedore, 2014) and having no existing diagnosis of language impairment or history of language therapy. Additional exclusionary criteria included hearing impairment, frank neurological impairment, genetic syndromes, psychological/ behavioral disorders, other developmental disabilities, and significant current or past exposure to a language other than English or Spanish. ADHD and speech impairments were not considered to be exclusionary criteria. These conditions often co-occur with language impairment, and thus, in the larger project, attention and speech skills were allowed to vary among participants with typical language as well. As a conservative check, the analyses in the current study were repeated excluding a total of 8 children: one child with an ADHD diagnosis, one child with an IEP for fluency, one child with an IEP for speech, and five children with speech concerns based on the clinical judgment of the first author. The general pattern of findings remained the same.

All children acquired Spanish from birth or within the first year of life and were exposed to English either simultaneously with Spanish within their first year (*n* = 40) or sequentially after 18 months (n = 15). All children passed a pure-tone hearing screening at 20dB at 1000, 2000, and 4000 Hz in each ear and had nonverbal intelligence scores within normal limits. Two children meeting these inclusionary criteria were excluded from the analysis due to extremely limited English expressive skills compared to the rest of the sample (|z|>3.29), such that they were only able to produce 4 or 5 words in English during a vocabulary post-test associated with the main experimental task. One of these children exhibited very limited English input/output (13% of waking hours), but the other child did not (27% of waking hours). Some children receiving limited current exposure to English still obtained high English scores on the BESA (e.g., 17% English input/output, BESA Mosphosyntax 103, Semantics 118). Therefore, although exposure was measured via parent report to characterize children's language environment, a minimum level of exposure was not used to determine eligibility. Socioeconomic status was indexed on a 1-6 Likert scale based on parent report of the highest level of education completed by the child's mother (1 = less than high school, 2 = high school or GED, 3 = two-year degree or some college; 4 = Bachelor's degree, 5 = Master's degree, 6 = Doctoral degree). See Table 1 for participant characteristics.

Table 1. *Language background characteristics for participants (n=55) based on parent report.*

| **Characteristic** | ***Mean*** **(*SD*)** |
|---|---|
| Age of First Spanish Exposure (months) | 0.36 (1.78) [Range: 0-12] |
| Age of First English Exposure (months) | 10.64 (14.32) [Range: 0-48] |
| Current Spanish Input/Output (% of waking hrs) [a] | 53% (16) [Range: 22-83] |
| Language of Instruction at School/Daycare | Spanish: 6, English: 24, Both: 22 |
| | No school/daycare: 3 |
| Maternal Education (1-6 scale) [b] | 3.44 (1.81) [Range: 1-6] |
| Nonverbal Intelligence Std. Score (Leiter-3) | 104.8 (7.05) [Range: 90-123] |
| BESA Spanish Morphosyntax Std. Score | 90.96 (15.94) [Range: 55-123] |
| BESA Spanish Semantics Std. Score | 106.47 (12.59) [Range: 70-130] |
| BESA English Morphosyntax Std. Score | 97.94 (16.40) [Range: 62-118] |
| BESA English Semantics Std. Score | 103.35 (12.40) [Range: 75-123] |
| BESA Language Index [c] | 106.24 (9.65) [Range: 88-126] |

| | |
|---|---|
| Language Index Spanish [d] | 98.4 (12.63) [Range: 66-126] |
| Language Index English [d] | 100.72 (13.29) [Range: 70-117] |

[a] From the Bilingual Input Output Survey (BIOS) in the Bilingual English Spanish Assessment (BESA), completed during the parent interview. Spanish input/output represents an average of the proportion of waking hours during which a child hears Spanish and speaks Spanish. Time periods when both Spanish and English are heard/used are treated as 50% Spanish in the calculation of Spanish input/out, regardless of the actual language breakdown during this time.
[b] Scale: 1 = < HS, 2 = HS/GED, 3 = some college/2-year degree, 4 = BA, 5 = MA, 6 = Doctorate.
[c] The Language Index represents overall language ability and is derived by combining the child's highest Morphosyntax and Semantics scores across languages.
[d] To obtain a measure of language-specific skills and a rough estimate of relative dominance, Language Indices were derived based on morphosyntax and semantics scores within each language separately. A comparison of these two scores was used to assign dominance for coding experimental trials as occurring in the child's "dominant" or "non-dominant" language.

**General Procedure**

The study was completed over three or four 1-1.5 hour individual sessions in a laboratory setting at the Waisman Center. The three versions of the scripted confederate dialogue task (English, Spanish, Dual-Language) were each administered at the beginning of a session. However, for a few children who were hesitant to participate ($n$ = 4), the task was interrupted following the practice or the first few trials. Children were given the opportunity to play or to participate in a nonverbal task (e.g., nonverbal intelligence subtests) to help them feel more comfortable in the setting before resuming the scripted confederate dialogue task. One child who was extremely shy in the first session was unwilling to respond even when the task (dual-language condition, version A) was resumed at the end of the session. In this case, the dual-language condition was repeated in a fourth session, but with version B instead of version A. The standardized assessments of vocabulary, language ability, and nonverbal intelligence were distributed across sessions. At the end of the last session, the children completed the vocabulary post-test in each language to assess their knowledge of the English and Spanish words for the nouns and verbs depicted in the scenes from the scripted confederate dialogue task. The majority of testing was completed by the first author (*n* = 46), who is a certified bilingual speech-language pathologist. When this was not possible due to scheduling conflicts (*n* = 9), some parts of the standardized testing were completed by another certified bilingual speech-language pathologist, a graduate student in speech-language pathology with a high level of Spanish proficiency, or a thoroughly trained undergraduate student who was a native speaker of Spanish. However, the first author still administered the scripted confederate dialogue task for all participants, except for the English condition for one participant (administered by another English-dominant bilingual speech-language pathologist) and half of the Spanish condition for another participant (administered by a native Spanish-speaking bilingual speech-language pathologist).

Children were accompanied by a parent (15 fathers, 40 mothers). Parents were interviewed in their preferred language about their child's development, medical and educational history, language history, and current language use and exposure. Parents also completed the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007) to provide information about their own language background and level of education (as a proxy for socioeconomic status). In addition, parents completed the Bilingual Input Output Survey (BIOS) from the BESA. To determine current exposure, parents are asked to indicate, for each waking hour on a typical weekday and weekend, who their child is with, what language the child is hearing (English, Spanish, or both) and what language the child is speaking (English, Spanish, or both). In the current study, half-hour blocks were used rather than hour blocks to accommodate school start and end times. Parents reported on language exposure and use during school hours to the best of their ability. The formula for calculating the proportion of input and output in English vs. Spanish treats exposure to "both" as 50% Spanish and 50% English, but parents sometimes indicated that periods of dual-language exposure were not necessarily balanced.

## Standardized Assessments

The *Leiter International Performance Scale* (Leiter-3; Roid, Miller, Pomplun & Koch, 2013) was administered to ensure that all participants had nonverbal intelligence within normal limits. It uses a pantomime administration and was developed specifically for special populations, including English language learners. The morphosyntax and semantics subtests from the *Bilingual English-Spanish Assessment* (BESA; Peña et al., 2014) were administered in both English and Spanish to provide a measure of overall language ability, as well as measures of language-specific skills. The Language Index, which combines a child's best morphosyntax and semantics scores across languages, was used to ensure that children in the current study had typical language skills (i.e., Language Index > 85). In addition, we derived English and Spanish Language Indices based on the morphosyntax and semantics scores within each language separately. A comparison of these two indices was used to estimate relative dominance for coding purposes in the scripted confederate dialogue task.

## Scripted Confederate Dialogue Task

**Procedure.** Children participated in a computerized scripted confederate dialogue task to measure language control abilities during discourse. In the current study, the language in which the confederate addressed the child was manipulated to assess the extent to which children aligned their language choice to the language spoken by their partner. Children were told that they would play a game with someone in another room, and a video of the confederate was presented to the child on a computer screen. Videos were pre-recorded to preserve experimental control. Children's behavior (e.g., waving or making unsolicited comments to the partner) suggested that they believed the interaction was occurring in real time.

Children played three versions of the game in three separate sessions, with at least one week between sessions: 1) *single-language* with an English-speaking partner, 2) *single-language* with a Spanish-speaking partner, and 3) *dual-language* with turns alternating pseudo-randomly between a Spanish-speaking partner and an English-speaking partner. All partners were females in their late 30s or early 40s who presented themselves to the children as monolingual speakers (e.g., "My name is Ashley and I only speak English"; "Me llamo Maria y sólo hablo español"). The partners in the dual-language condition were different from the partners in the single-language conditions. Approximately half of the children ($n$ = 26) completed the dual-language version of the task in the first session and the rest ($n$ = 29) completed it in the last session. This was done so that any effect of the dual-language context would not be enhanced or masked by order effects. The order of the single-language versions was determined based on the child's preferred language (as expressed by the parent or the child: 30 English first, 25 Spanish first).

Each version included 20 trials composed of a guessing phase, in which the child had to identify the picture being described by the confederate, and a description phase, in which the child had to describe a picture to the confederate. To provide motivation to complete the task, children were told that they would receive a star each time they found the confederate's picture and each time the confederate successfully found their picture. At the end of the game, they would get to pick one sticker for every 10 stars earned. Every five trials children received a break and saw how many stars they had earned. The number of stars was randomly selected from a few possible options at each break to show progress through the task, but the number was not contingent on actual performance.

The task was presented using E-Prime 2.0 (build 2.0.10.242, Psychology Software Tools, 2012) on a desktop computer with a 23-inch monitor and a resolution of 1920 x 1080. Figure 1 shows the set-up for a sample trial. During the guessing phase, the child saw two pictures and the confederate produced a sentence describing one of them (e.g., “The boy is watching the airplane in the sky. Can you find this picture?”). The child had to push a button on a serial response box to indicate which picture the confederate was describing. The child received encouraging feedback from the confederate (e.g., “Good listening!”) regardless of accuracy. If the child did not push a button during the 20-second time window, the confederate reminded the child that finding the correct picture will earn a star, and the trial proceeded to the description phase. During the description phase, the child saw one picture and was instructed to describe it to the confederate (e.g., “Now it’s your turn. Tell me about your picture and I’ll try to find it.”). If the child produced a description within the 30-second window, the experimenter discretely pushed the space bar to advance the trial and the confederate acknowledged the response (e.g., “Thanks! I’ll try this one”) and pushed a button on her own button box. Videos showing left vs. right responses by the confederate were randomly selected by the experiment presentation software. If the child did not produce a description or indicated “I don’t know,” the confederate reminded the child to try to say something about the picture in order to earn a star, and the experiment proceeded to the next trial. The task was audio recorded, and video recorded if parents granted permission, for later coding. The language of children’s picture descriptions and a rough transcription were also documented on-line by the experimenter when possible.

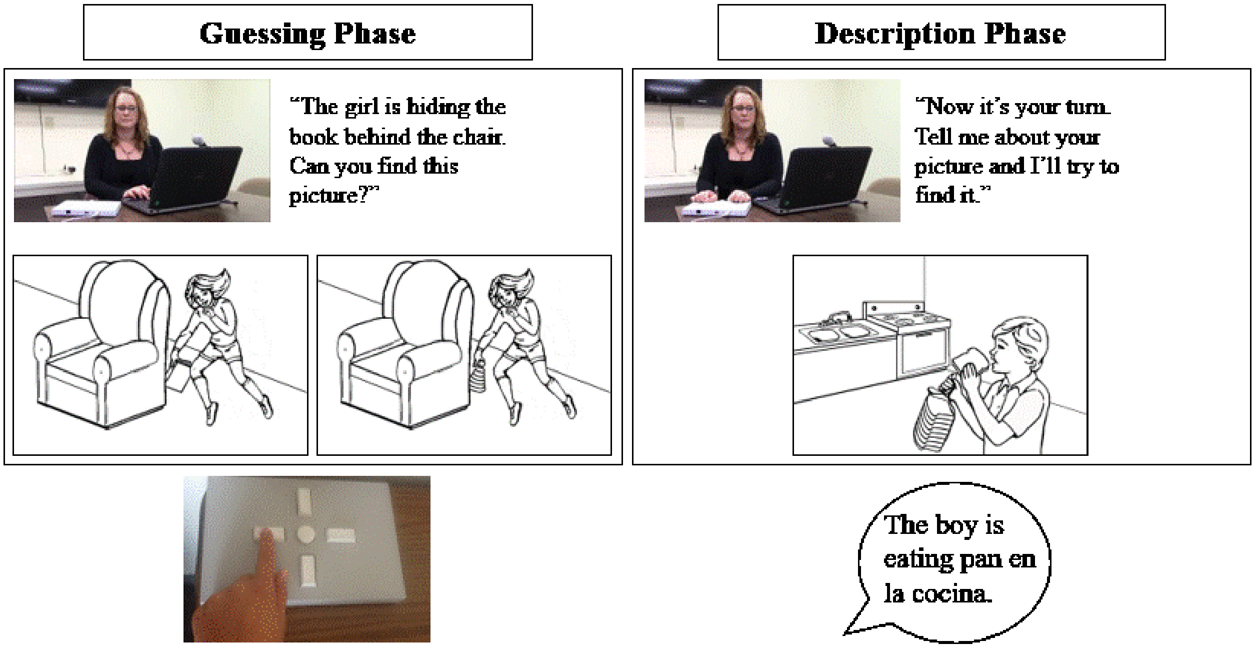


*Figure 1.* Experimental set-up for one trial in the English version of the scripted confederate dialogue task. The boxes show what the child saw on the computer screen. Text is included for demonstration purposes only; the child only saw the scenes and the video of the confederate. Below the boxes are sample responses from the child, pushing the correct button in the guessing phase and producing a description containing cross-language intrusions.

The experimenter provided a brief overview of the game but then indicated that the partner on the computer would explain the game further and that the experimenter was just going to watch. This overview was provided in English for the English version (unless the child specifically requested instructions in Spanish), in Spanish for the Spanish version (unless the child specifically requested instructions in English), and in the child's preferred language for the dual-language version. At the start of the experiment, the confederate introduced herself and demonstrated how to play the game through two practice trials with evaluative feedback. In the dual-language version, the confederate who spoke the child's preferred language introduced the game and presented the first practice trial, and the confederate who spoke the other language presented the second practice trial. If the child did not provide a description during the description phase of the practice trials, the child received one prompt from the confederate to try.

If the child still did not respond, the confederate suggested that the child could say “I don’t know” or “no sé.” At this point, the experimenter reassured the child and provided a sample response in the target language. Beyond the presentation of the confederates as monolingual speakers, children were never explicitly told to speak a certain language. If they asked which language to use, they were encouraged to speak so that their partner would understand. The experimenter spoke as little as possible during the task, prompting the child when necessary to maintain on-task behavior. The experimenter made an effort to use the same language as the current confederate to create a consistent language environment, but the children knew the experimenter was bilingual and sometimes addressed the experimenter and the confederate in different languages. The task was administered by the first author so that any influence of the experimenter’s linguistic background on the language choice of participants would be consistent.

**Materials.** The task included 20 pairs of picture scenes that differed in one element (subject, object, or location) for the guessing phase, as well as 20 scenes for the child to describe back to the confederate in the description phase. The scenes were created in Adobe Photoshop CC 2015 and consisted of object and action images from the International Picture Naming Database (Center for Research in Language; Snodgrass & Vanderwart, 1980; Szekely et al., 2004) and similarly styled clipart or drawings. The sentences produced by the confederate were 8-11 words long and followed the structure NP VP NP PP (e.g., The girl is hiding the book behind the chair). The description scenes were constructed with animate subjects performing an action on an object in a location so that they could be naturally described with this structure as well. The scene elements (subject, verb, object, location) were selected to have English and Spanish labels that were early-acquired and high-frequency nouns and verbs. Age of acquisition information came from the American English and Mexican Spanish versions of the MacArthur

Communicative Development Inventories as reported in the online CLEX database (Center for Child Language; Dale & Fenson, 1996; Jackson-Maldonado et al., 2003). For the scenes children described, the nouns and verbs depicted in the scene had to be produced in both English and Spanish by at least 50% of children between the ages of 24 and 30 months. For the scenes that children had to match to the confederate's sentence, the criteria were less strict (produced by at least 50% of children in one language) because no production was required during the task. In addition, scene elements had lemma frequencies of at least 10 tokens per million in the Corpus of Contemporary American English (Davies, 2008) and the Corpus del Español (Davies, 2002). The sentences produced by the confederate did not contain any cognates, and the description scenes were designed to be unlikely to elicit cognates. The description scenes and guessing scenes were designed to have minimal overlap to reduce lexical priming effects. The only elements that occurred in both sets of scenes were highly common nouns that children would be likely to know in both languages (boy, girl, man, woman, dog, bathroom, kitchen, table, window, tree). The subjects, verbs, objects and location elements included in the scenes to be described by the children are listed in Appendix A. At the end of the final session, children completed a vocabulary post-test to assess their knowledge of the English and Spanish words for these scene elements.

The final set of 20 pairs of scenes to be identified and 20 scenes to be described were selected from a larger set of 28 scene pairs and 33 description scenes following an extensive norming process. Twenty-one English speaking adults and six Spanish speaking adults participated in the first phase of the norming process. For the scene pairs, they rated how easy it was to discriminate between the two scenes and how well each scene matched the sentence used to describe it on a 1-5 scale (1 = best match, easiest to discriminate). Prior to norming, the

Spanish versions of the sentences had been reviewed by two native speakers of Spanish from Mexico for naturalness and well-formedness. Further modifications to the sentences were suggested by the native speakers who participated in the norming process. For the description component, they rated how easy it was to describe the scene on a 1-5 scale (1 = easy to determine what was happening and think of appropriate words in the relevant language). In addition, they rated all scenes for subjective visual complexity on a 1-5 scale (1 = least complex). Based on this information, the scenes were edited to improve clarity, equalize visual complexity, and make the distinctions between guessing scenes more similar across pairs. In addition, children within and slightly beyond the target age range (ages 4-7) performed the guessing and describing tasks in English (n = 11) and in Spanish (n = 5) on the edited stimuli to identify scene pairs that may be too challenging to discriminate (very slow reaction times, incorrect responses) and description scenes that may be too difficult for young children to describe in English and/or Spanish or that may yield too many different interpretations. A set of 23 scene pairs and 23 description scenes was selected from the larger norming set, and the full paradigm with video confederates was piloted with 4 bilingual children (two 4-year olds, one 5-year old, one 6-year old). Piloting revealed that children from the target age range were able to complete the task.

The final set of 20 scene pairs and 20 description scenes was selected from the reduced pilot set of 23 based on ratings from the norming phase and observations during piloting of children's ability to discriminate the scene pairs and to describe the description scenes with relatively consistent interpretations. The final set of scene pairs had an average discrimination rating of 1.26 (*SD*=0.14; range 1-1.6) on the 1-5 scale. The match between each scene and its sentence description was rated at 1.04 in English (*SD*=0.06; range 1-1.21) and 1.02 in Spanish (*SD*=0.07; range 1-1.25). The mean difference in visual complexity ratings between members of a pair was 0.04 (*SD*=0.08; range 0-0.25). The description scenes had an average rating of ease of describing of 1.66 (*SD*=0.37; range 1-2.11) in English and 1.44 (*SD*=0.27; range 1-1.88) in Spanish. The average visual complexity rating was 2.70 (SD=0.31; range 2.20-3.33).

Each condition (English, Spanish, Dual-Language) included the same set of stimuli but in a different pseudorandomized order. The guessing scene pairs and description scenes were yoked such that a given description scene always followed the same guessing scene pair in each condition. The yoked pairs were carefully selected to ensure no lexical or semantic overlap between the sentence that the child heard and the picture that the child needed to describe. The pseudorandom sequences of trials for each condition were developed by using a random number generator (Research Randomizer, Urbaniak & Plous, 2013 to assign an initial sequence and then making adjustments to ensure that none of the elements (subject, verb, object, location) of a description scene repeated in consecutive trials. The correct response for the guessing phase appeared on the left for half of the trials and on the right for half of the trials in each list.

For the dual-language condition, half of the trials were presented by the English-speaking confederate and half were presented by the Spanish-speaking confederate. The sequence of English and Spanish trials in the mixed list was initially determined with a random number generator and then adjusted to ensure no more than four consecutive trials in a single language and to ensure that half of the trials required a switch in languages from the previous trial (i.e., *switch* trials) and half of the trials continued in the same language as the previous trial (i.e., *stay* trials). The description scenes for the stay and switch trials did not differ significantly in the ease of description ratings from the norming phase in English ($p$ = .97) or in Spanish ($p$ = .30). Two versions of the dual-language block were created such that trials that were presented by the English-speaking confederate in version A were presented by the Spanish-speaking confederate in version B, and vice versa. Thus, a given item occurred in the dual-language condition in only one language for a single participant, but it was presented in both languages across participants. Appendix B shows the yoked pairs of guessing and description scenes in the pseudorandom sequence designed for the dual-language block, version A.

The confederate videos were recorded by four women from the community in their late 30s or early 40s (ages 36-41). The two English speakers reported minimal Spanish experience and spoke with a local mid-Western American accent. The two Spanish speakers were from Mexico, consistent with the background of most child participants. They reported limited English use (occasionally; a couple hours a day) and limited English proficiency (self-rated 2-4 on a 10-point scale). The confederates were instructed to act as if they were speaking to a child. All guessing sentences were recorded, as well as task instructions, prompts, and feedback. Each confederate was recorded individually in a section of a conference room with a slightly different background (two different bookshelves, white board, presentation screen) so that it would be believable to children that the confederate was in another room but it would not be clear exactly where they were. All guessing trials, prompts, and feedback were spliced from the original recording using Adobe Premiere CC 2014 and organized into the experimental paradigm using E-Prime. Feedback contingencies were designed to anticipate possible child responses and to make the interaction seem as real as possible. The four speakers were rotated across the different conditions to create two versions of the English-only block (one with each English speaker), two versions of the Spanish-only block, and eight versions of the dual-language block (one with each possible combination of English and Spanish speakers, for both version A and version B). Each of the eight dual-language versions had an English-dominant presentation where the initial instructions were provided by the English speaker and a Spanish-dominant presentation where the initial instructions were provided by the Spanish speaker. Children were assigned (based on the sequence of their ID number) to a combination of English, Spanish and dual-language versions where the speakers in the dual-language block were distinct from the speakers in the single-language blocks (e.g., English S1, Spanish S2, dual-language with English S2 and Spanish S1).

**Coding.** Children's scene descriptions during each task block were coded for language as English, Spanish, or mixed. The task was audio recorded, as well as video recorded if permitted by the parent, to allow for later coding of responses. The majority of task blocks (77%) were coded on-line by the first author while the child was performing the task, and the language codes were entered into a database by trained research assistants. However, if the experimenter was unsure how to code a particular description or if coding had not been conducted on-line, the video or audio recording was reviewed by the first author or a trained research assistant to determine the language of each description. To assess reliability, a bilingual speech-language pathologist reviewed the audio recordings for 10% of the data and coded the language of the responses. Inter-rater reliability was 96.2%.

To assess the ability of participants to complete the task in both languages, responses on the vocabulary post-test were coded for attempts to name in the target language the nouns and verbs used to make up the description scenes. Even if the response provided by the child was not the anticipated label, the child received credit for retrieving a word in the target language in response to the picture. This coding was completed by the first author and a trained research assistant, and 20% of the data was re-coded by a research assistant who was a native speaker of Spanish. Inter-rater reliability was 96.5%. Based on the distribution of performance on the post-test in English, two children were identified as having expressive English skills significantly lower than the rest of the sample (*z* < -3.29), only producing 4 or 5 English words throughout the 38 items of the post-test. These two participants were excluded from the analysis due to concerns that their English expressive skills were not sufficient to reasonably expect them to respond in English during the scripted confederate dialogue task. The distribution of performance on the post-test in Spanish did not reveal any participants with *z*-scores more extreme than 3.29.

Based on the language of the child's description and the language in which the trial was presented, each description was coded for the presence of cross-language intrusions, defined as producing at least one word in the language not understood by the current confederate for that trial. Scene descriptions containing a cross-language intrusion received a code of "1" and scene descriptions not containing a cross-language intrusions received a code of "0." Trials were excluded from the analysis if the child did not provide a response (*n* = 29 trials), indicated that he or she didn't know what to say (*n* = 109 trials), or provided an entirely unrelated response that was not intended as a scene description (*n* = 4 trials). An additional three trials were excluded due to technical failure or because the child needed to leave the room before one of the scheduled breaks. Overall, these exclusions resulted in the loss of 4.4% of the total trials.

For the analyses, the language of each trial was re-coded from English vs. Spanish to "dominant" vs. "non-dominant" based on each individual child's dominant language. Although dominance is a complex construct and is often mixed depending on the area of language under examination (e.g., Bedore et al., 2012), for the purposes of this study children's relative performance on the English and Spanish subtests of the BESA provided an estimate of dominance. Children whose performance on the Spanish morphosyntax and semantics subtests yielded a higher Language Index than their performance on the English subtests (*n* = 22) were classified as Spanish-dominant. For these children, trials with the Spanish-speaking confederate were coded for language as "dominant" and trials with the English-speaking confederate were coded for language as "non-dominant." Children obtaining a higher Language Index score from the English subtests (*n* = 33) were classified as English-dominant, and trials with the English and Spanish-speaking confederates were coded for language as "dominant" and "non-dominant," respectively. There were no children who obtained equivalent scores in both languages, although there were 12 children with similar scores (within 4 points). This coding convention is commonly used in language switching studies when a sample contains participants with different dominance profiles (e.g., Prior & Gollan, 2011; Weissberger et al., 2012). Dominance asymmetries in mixing and switching costs have been frequently documented in the literature, and therefore it was important to code language in a way that would reveal these asymmetries if they were present.

**Analyses**

To determine whether maintaining and using two languages exerts a cost on language control relative to using only one language, we examined the effect of context on the odds of producing a cross-language intrusion using mixed effects logistic regression models. The outcome variable was the presence or absence of a cross-language intrusion in each scene description trial (coded as "1" and "0", respectively). The independent variables were context (single-language [1] vs. dual-language [-1]), partner language (dominant [-1] vs. non-dominant language [1]), and their interaction. The interaction term tests for a dominance-related asymmetry in the effects of context on language control. Context and partner language were sum coded as -1 and 1, such that the coefficient for one predictor reflects its effect on the dependent variable collapsing across levels of the other predictor. Age, included as a covariate, was both centered and scaled (i.e., standardized) to promote model convergence. Following the "keep it maximal” approach (Barr, Levy, Scheepers, & Tily, 2013), all models included random intercepts for participants and items, as well as random by-participant and by-item slopes for partner language, context, and their interaction. All models were evaluated using the mixed() function from the afex package (Singmann, Bolker, Westfall & Aust, 2018; version 0.20-2) in R version 3.4.4 (R Core Team, 2018). This function uses the package lme4 (Bates, Maechler, Bolker & Walker, 2015; version 1.1-17) to examine the specified model and to create restricted models with each predictor removed. The significance of a given predictor is established through a likelihood ratio chi-square test comparing the full model to the restricted model with the focal predictor removed (Bolker, 2014; Bolker, 2018; Social Science Computing Cooperative, 2016).

First, the effects of counterbalanced manipulations were examined. The order in which children received the dual-language condition (i.e., in the first session vs. in the last session) did not have a significant effect on the production of cross-language errors ($\chi^2(1) = 0.21$, $p = .65$) or moderate the effects of context, partner language, or their interaction (all *p*s > .25). Therefore, order was not considered in further analyses. Children who received version B of the dual-language condition were more likely to produce a cross-language intrusion than children who received version A ($\chi^2(1) = 3.76$, $p = .05$, $b = -1.19$, $SE = 0.64$). Version did not moderate the effects of context, partner language, or their interaction (all *ps* > .68). A comparison of the demographics of children who received each version revealed that children who received version A were significantly older than children who received version B ($M_A = 5.52$, $SD = 0.86$; $M_B = 4.98$, $SD = 0.88$; $t(53) = 2.34$, $p = .023$). When age was included as a covariate in the mixed-effects logistic regression model, the effect of version was no longer significant ($\chi^2(1) = 1.45$, $p = .23$). Given these findings, data from versions A and B were combined in future analyses, but age was included as a covariate.

Next, the target model containing context, partner language, and their interaction tested for the presence of a context cost and any dominance asymmetry. To further evaluate the significance of the effect of context, additional models were conducted removing the interaction between partner language and context and removing partner language altogether. As a source of comparison for the robustness of the context effect, language switching data at the single-word level from a previous study (Gross & Kaushanskaya, 2018) were evaluated using the same analysis approach.

Finally, traditional mixing costs and switching costs were examined by creating two contrasts from a three-level "trial type" variable (e.g., Jylkkä et al., 2018): single-language trials, switch trials from the dual-language block, and stay trials from the dual-language block. The first contrast (1 0 -1) compared stay trials from the dual-language block to single-language trials, evaluating traditional mixing costs. The second contrast (0 1 -1) compared stay trials to switch trials, evaluating traditional switching costs within the dual-language block.

**Results**

The target model for testing the hypothesis that a dual-language context imposes costs on language control is shown in Table 2 and raw data are presented visually in Figure 2. The model revealed a robust effect of partner language ($\chi^2(1) = 22.71$, $p<.001$), such that children were more likely to produce cross-language intrusions when interacting with a partner who spoke their non-dominant language. There was also a significant effect of age ($\chi^2(1) = 6.44$, $p = .01$), reflecting that older children produced fewer cross-language intrusions overall. The effect of context was in the expected direction ($b = -0.86$, $SE = 0.57$), where the odds of producing a cross-language error increased by a factor of 5.57 in the dual-language context compared to the single-language context, but this effect did not reach significance ($\chi^2(1) = 2.38$, $p= .12$). Furthermore, there was no dominance-related asymmetry in the effect of context, as the interaction between context and partner language was not significant ($\chi^2(1) = 0.58$, $p = .45$). Given this non-significant interaction, an additional model was conducted including only the main effects of age, context, and partner language, and the effect of context was still not significant ($\chi^2(1) = 1.77$, $p = .18$). A model including only the effects of age and context (and ignoring the effect of partner language) did yield a significant effect of context ($\chi^2(1) = 4.32$, $p = .04$). However, all other studies of language switching in the literature tend to include both language and context when evaluating language switching costs. Thus, the original model in Table 2 is a closer comparison to previous work.

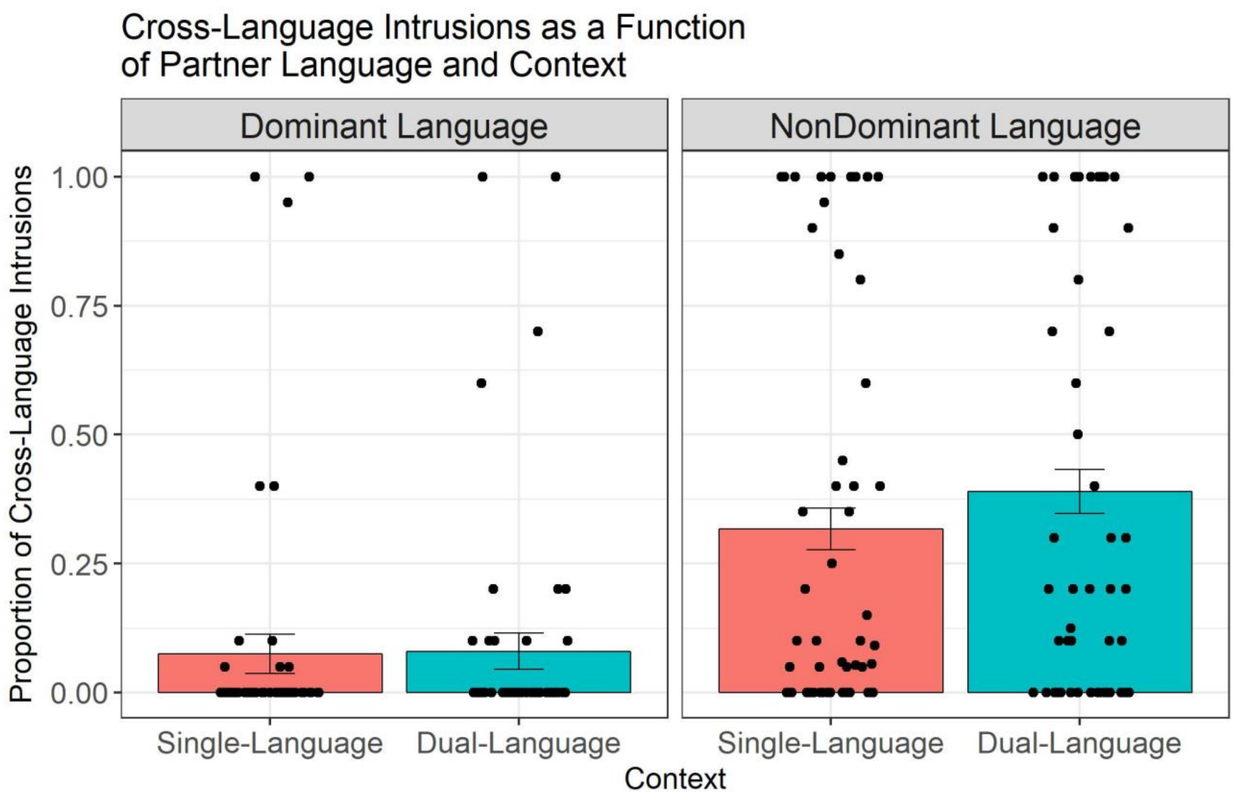


*Figure 2*. Raw data plot of the proportion of cross-language intrusions produced in each language in each context. Data points represent the proportion of cross-language errors produced by individual subjects. Bars represent means averaged over subjects. Error bars represent one standard error, corrected for repeated measures within subjects. Created in R using the ggplot2 package (Wickham, 2009; version 2.2.1).

Table 2. *Mixed-effects logistic regression model for cross-language intrusions*

| Variable | Estimate | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Intercept | -5.58 | 0.86 | | |
| Age (standardized) | -1.32 | 0.55 | 6.44 | .01 |
| Partner Language (dom[-1] vs. non-dom[1]) | 3.86 | 0.91 | 22.71 | <.001 |
| Context (dual-lang[-1] vs. single-lang[1]) | -0.86 | 0.57 | 2.38 | .12 |
| Partner Language X Context | 0.41 | 0.57 | 0.58 | .45 |

Note: Dichotomous variables were automatically sum coded (-1 vs. 1) by the mixed() function used to evaluate the model. Coefficient estimates are in a log-odds scale. To determine the odds ratio for a given predictor (e.g., the odds of producing a cross-language intrusion in the single-language context vs. the dual-language context), the coefficient must be doubled and exponentiated: exp(-0.86*2) = 0.18 odds for single compared to dual; exp(0.86*2)=5.57 odds for dual compared to single.

Given that the central finding of the current analysis is a null effect of context, a similar analysis was conducted on language switching data at the single-word level from a previous study (Gross & Kaushanskaya, 2018) to provide a source of comparison for the robustness of the context effect. This study examined cross-language errors in a cued-switch picture naming paradigm in 5-7 year old Spanish/English bilingual children recruited from the same area as the participants in the current study. This picture naming study had a smaller sample size (43 children), but a larger number of items (42) in each condition. The design was similar to the current study with the same three conditions (single-language naming in the child's dominant and non-dominant language, and dual-language naming with pseudorandom alternation between languages), but children only had to produce picture names instead of providing a full scene description. The effect of context at this single-word level was highly robust ($\chi^2(1) = 23.95$, $p < .001$, $b = -1.55$, $SE = 0.36$), where the odds of producing a cross-language error increased by a factor of 22.17 in the dual-language condition compared to the single-language condition. By comparison, the odds of producing a cross-language error increased by a factor of 9.65 on non-dominant language trials compared to dominant-language trials ($\chi^2(1) = 13.19$, $p < .001$, $b = 1.13$, $SE = 0.36$). Given that context and language variables were sum coded and age was standardized in both sets of analyses, comparing the magnitude of the coefficients should give a sense of relative effect size. Such a comparison suggests that both context and language have an effect on cross-language intrusions at the single-word level, whereas at the discourse level, the tendency to produce a cross-language intrusion is overwhelmingly affected by the language of the trial with only a minimal effect of context, if any.

To ensure that the block-wide comparison between single-language and dual-language conditions was not obscuring more nuanced effects of language switching or language mixing, an additional analysis was conducted in which a 3-level "trial type" variable was coded with stay trials from the dual-language block as the reference level to produce two contrasts: stay trials from the dual-language block vs. single language trials (i.e., mixing costs) and stay trials vs. switch trials from the dual-language block (i.e., switching costs). This model revealed no significant mixing costs ($\chi^2(1) = 2.13$, $p = .14$, $b = -1.06$, $SE = 0.74$), no significant switching costs ($\chi^2(1) = 0.38$, $p = .54$, $b = 0.43$, $SE = 0.66$), and no dominance asymmetries for mixing or switching costs (*p*s > .46).

## Discussion

The goal of the current study was to determine whether a dual-language context exerts costs on the ability of bilingual children to exercise language control at the discourse level. The findings suggest that a dual-language context exerts a minimal cost, if any, on children's language control in comparison to a single-language context. When the effects of partner language were ignored, there was a significant effect of context such that a dual-language context predicted a significant increase in the odds of producing a cross-language intrusion. However, once partner language was included in the model, which is the standard practice in language switching studies, the effect of context was not significant and robust effects of partner language were seen. Thus, it would appear that children's tendency to produce cross-language intrusions at the discourse level is more greatly affected by being expected to use their less dominant language than by being asked to switch back and forth between languages. The absence of any interactions between partner language and context further suggested that an overall effect of context was not being masked by significantly stronger effects of context in one language than another. Furthermore, the effects of partner language were robust regardless of context. When language switching effects were divided into traditional mixing and switching costs, there were no significant costs for either mixing or switching.

These findings stand in contrast to picture-naming studies at the single-word level, where significant mixing costs have been identified in dual-language contexts in both adults (e.g., Christoffels et al., 2007; Hernandez & Kohnert, 1999; Hernandez & Kohnert, 2015; Jylkkä et al., 2018; Prior & Gollan, 2011, 2013; Weissberger et al., 2012) and children (e.g., Gross & Kaushanskaya, 2018; Jia et al., 2006; Kohnert et al., 1999; Kohnert, 2002). In particular, the findings of the current study diverged from our own previous work at the single-word level with a similar sample of bilingual children (Gross & Kaushanskaya, 2018), where robust effects of context were identified that were more similar in magnitude to the effects of language. Based on previous work in children and adults, the current findings raise three main questions: 1) Why were there no costs of language mixing at the discourse level? 2) Why were partner language effects so much stronger than context effects? 3) Why was there no dominance asymmetry or dominance reversal?

**Why were there no costs of language mixing at the discourse level?**

Our findings suggest that costs identified at the single-word level in highly controlled picture-naming studies may not reflect the experience of bilinguals in natural conversation, where they appear to switch between languages with ease. When bilinguals interact with conversation partners, rapidly formed associations between each partner and their language (e.g., Martin et al., 2016; Woumans et al., 2015) may provide a social visual cue that helps to increase the activation of the target language during exchanges with each partner. Although this phenomenon did not help to reduce switching and mixing costs in a single word paradigm in adults (Peeters & Dijkstra, 2017), in the current study there was also increased linguistic context provided by hearing the confederate describe a picture in the target language in the guessing phase and invite the child to describe his or her picture in the description phase (e.g., "Now it's your turn. Tell me about your picture and I'll try to find it."). The concept of interactive alignment in dialogue (Garrod & Pickering, 2004; Kootstra, 2009, 2015) suggests that dialogue partners achieve the goal of mutual understanding by modeling aspects of their own productions (including language choice) on what they have just heard from their partner. Kootstra (2015) argues that "code-switching seems to be best explained by a model in which both intra- and inter-individual forces on language use interact" (p. 52). These alignment forces may be conscious and strategic, but they may also be automatic.

Models of language processing suggest a tight link between comprehension and production (e.g., Pickering & Garrod, 2013), such that speakers activate production processes while listening as they predict what their partner may say. Evidence for this can even be found in picture-naming paradigms, where participants exhibit switching costs even when they are using a single language, but they hear another participant naming pictures in the opposite language (Gambi & Hartsuiker, 2016). Thus, in the current study, listening to the confederate speak English may activate English production processes sufficiently that, once the child needs to speak, the effects of having switched languages from the previous production trial have already dissipated. This interpretation could also explain why inter-sentential switching still yields costs in sentence-level paradigms where the participant is the only one talking (Tarlowksi et al., 2013; Declerck & Philipp, 2015), but not in a paradigm where the participant has the opportunity to silently read parts of a sentence in the new target language before having to produce one marked word aloud (Gullifer et al., 2013). A related explanation could be that costs were not observed in the current study or by Gullifer and colleagues (2013) because more time elapsed from when participants produced speech in one language to when they had to produce speech in the other language, regardless of whether opportunities for comprehension in the new target language were interspersed between productions. However, studies of preparation time during picture naming have yielded mixing findings, with some evidence that increased preparation time reduces costs (e.g., Costa & Santesteban, 2004; Mosca & Clahsen, 2016) and some evidence that it did not (e.g., Stasenko, Matt, & Gollan, 2017; Verhoef et al., 2009).

The absence of robust context effects in the current study appears to diverge from the predictions of the Adaptive Control Hypothesis (Green & Abutalebi, 2013). The hypothesis suggests that a dual-language context in which bilinguals need to adjust their language choice to accommodate different speakers is the most taxing on language control because it engages more control processes (goal maintenance, interference control, salient cue detection, selective response inhibition, task disengagement, task engagement) than a single-language context, which places increased demands only on goal maintenance and interference control. How to reconcile this account with our findings?

One possibility is that the dual-language context in our study does still place additional demands on language control. However, the observable outcome in terms of cross-language intrusions does not differ from the single-language context because additional processes, such as interactive alignment (e.g., Garrod & Pickering, 2004; Kootstra, 2009, 2015), help the speaker to meet these increased demands. Thus, the mixing and switching costs observed in single-word picture-naming tasks may be representative of increased control demands placed on bilinguals in real conversation, but these decontextualized paradigms do not provide speakers with the conversational forces that help to meet those demands. For example, cue detection would be more challenging in a picture-naming task when the relationship between the cue and the required language is arbitrary, but in a conversational context the social identity and language being used by others provide highly salient cues that may take less effort to detect. Furthermore, if participants are able to disengage from one language and engage the other language while they are listening to their conversation partner, then the time and effort required for these processes may have less of an effect once it is the participant’s turn to speak, compared to when the participant alone must alternate between languages in production.

The increased language control demands in a dual-language context may even have benefits for successful language control, even if it is more effortful. Declerck and colleagues (2017) found that, although bilinguals were more likely to produce cross-language intrusions when they had to switch into a different language to produce a sentence, they were also more likely to go back and correct these cross-language intrusions with the word in the appropriate language. Cross-language intrusions made during non-switch trials, although less frequent, were more likely to be left uncorrected. The authors suggested that monitoring of cross-language intrusions was better when bilinguals were actively switching languages precisely because there was heightened conflict between languages.

Another possibility is that, especially for children, maintaining language control in a single-language setting is already sufficiently taxing that the dual-language context does not add that much more difficulty. This idea finds some support even in the adult literature. Weissberger and colleagues (2015) describe bilinguals as “staying experts” rather than switching experts, arguing that the biggest challenge for language control is staying in the target language, whether that is in a purely single-language context or when maintaining a single-language within a dual-langauge context. Similarly, Festman (2012) noted that more cross-language intrusions and larger switching costs during a picture naming paradigm at the single-word level were associated with difficulties maintaining the target language for a sustained period of time in more naturalistic language use, rather than with failing to switch when necessary. If this is the case, however, our study suggests that the particular difficulty with maintaining the target language is specific to situations when the non-dominant language is being used. As demonstrated in the raw data in Figure 2, cross-language intrusions in the dominant language were extremely rare, whether in the single-language or the dual-language condition. This observation brings our attention to the robust effects of partner language.

**Why were partner language effects so much stronger than context effects?**

The robust effect of partner language reflects that children were far more likely to produce cross-language errors when interacting with the partner who spoke their non-dominant language. Such an effect is to be expected, as children may have more difficulty producing picture descriptions in their non-dominant language, even when they are aware that they should be using this language. Some children adjusted to these limitations by simplifying their picture descriptions in order to avoid producing cross-language intrusions, but other children defaulted to their dominant language. One child said, “I don’t know how to say it in Spanish, so I’m just going to say it in English.” Raichlin and colleagues (2018) describe these as psycholinguistic (as opposed to sociopragmatic) switches. Other children may have made relative adjustments to increase their use of their non-dominant language, but they may not have been able to produce a whole picture description entirely in this language. Such a pattern would be in line with observational studies of children’s ability to accommodate to their parents’ languages. For example, three out of the four children studied by Genesee and colleagues (1996) still used their dominant language more often than their non-dominant language with *both* parents; the accommodation was seen only through greater use of the non-dominant language with the parent who spoke that language than with the other parent. However, in the current study with our all-or-none coding scheme, such relative shifts toward the target language would still be coded as cross-language intrusions.

These difficulties with access to the necessary vocabulary or morphosyntax in the non-dominant language could potentially be expected to be modulated by a single-language vs. a dual-language context. However, if there were floor effects already in the single-language context, especially given our all-or-none coding scheme, then there may not have been much room for additional challenges with language control to be observed in the dual-language context. Even in single-word language switching tasks, effects of context are often seen in the dominant language more so than the non-dominant language. In our study, cross-language intrusions in the dominant language were extremely rare in both conditions. Thus, we may see ceiling effects in the dominant language preventing an effect of context, combined with floor effects in the non-dominant language also preventing an effect of context. The result is an overwhelming effect of language and no effect of context.

In addition, the tendency to produce cross-language intrusions in the non-dominant language may also have come from a general reluctance to use the non-dominant language or a general language preference that operated throughout the task, independent of single-language vs. dual-language context and even independent of partner language. In the current study, children were not explicitly told which language to use. They were expected to align their language choice with their conversation partner to promote mutual understanding, but not all children exhibited attempts to do so. There were some children (n = 3) with relatively unbalanced skills who used their non-dominant language extremely rarely (0-5% of the time) throughout the task, even though they demonstrated expressive skills in that language when directly elicited in the vocabulary post-test and in standardized testing. Even among children with balanced skills, some (n = 5) chose to use predominantly one language (95-100% of the time) throughout all conditions of the task. This strategy would result in nearly 100% alignment with the partner who happened to be speaking the child's chosen language and nearly 100% cross-language intrusions with the other partner, regardless of context. Other studies have noted strong preferences for a single language, resulting in reduced alignment of language choice with others, even when children displayed similar skills in both languages (e.g., Castillo, 2015; Ribot & Hoff, 2014). The setting could also have played a role, as children who normally speak Spanish at home may have been reluctant to do so in a laboratory setting, even though they were interacting with a confederate who was a native Spanish speaker.

**Why was there no dominance asymmetry or dominance reversal?**

Picture-naming studies of language switching have often exhibited counter-intuitive dominance effects, where mixing costs are higher in the dominant language and bilinguals are slower or make more cross-language intrusions in the dominant language in a dual-language context (e.g., Christoffels et al., 2007; Declerck et al., 2017; Jylkkä et al., 2018; Prior & Gollan, 2011; Weissberger et al., 2012; Zheng et al., 2017). These effects have been hypothesized to reflect a strategy of globally suppressing the dominant language in a mixed-language setting in order to improve access to the non-dominant language (e.g., Christoffels et al., 2007; Prior & Gollan, 2011). Dominance reversals have even been observed in adults in sentence-level tasks (e.g., Tarlowski et al., 2013), although not in tasks that incorporated social context as well. In the current study, there were no overall effects of context or traditional mixing costs, and no significant asymmetry. Instead of a dominance reversal, children were far more likely to produce cross-language intrusions in their non-dominant language.

One possibility is that children are not yet able to exercise this language control strategy when faced with a dual-language context. Asymmetrical mixing costs and a dominance leveling have been observed in 5-7 year old children in a *voluntary* language switching task (Gross & Kaushanskaya, 2015), when they could choose when to use their non-dominant language. However, these effects were not observed when children engaged in cued language switching (Gross & Kaushanskaya, 2018). Producing responses in a cued language may still be sufficiently challenging for children, and the difference in accessibility between their dominant and non-dominant language may be too great, such that they would not be able to complete a sentence-level task in a state of global low-level suppression of the dominant language. It would make accessing their dominant language too difficult when required, and it would not be sufficient to facilitate access to their non-dominant language.

In addition to this developmental explanation, it is also possible that this strategy of globally inhibiting the dominant language is not applicable at the conversational level. First, it may not be feasible if participants need to be able to construct an entire sentence in their dominant language to describe a picture, rather than just to access a single lexical item. Second, such a strategy for boosting access to the non-dominant language may not be necessary if activation of the target language and suppression of the non-target language are facilitated by interactive alignment processes as participants listen to their partner using the target language.

**Limitations and Future Directions**

This study was the first to use a scripted confederate dialogue paradigm to examine control of language choice in children. As such, these initial analyses have been fairly broad in order to gain a basic understanding of how the task operates and how it compares to other methods that have been used. More nuanced coding and analysis strategies in future work may provide additional information about how children's language control abilities are modulated by language and context manipulations. For example, the current study considered responses entirely in the non-target language and mixed-language responses both as cross-language intrusions. However, the former reflect no attempt to align with the conversation partner, while the latter reflect a partial attempt to do so that may have been limited by gaps in linguistic knowledge. Analyses distinguishing these two types of deviations from the target language may add additional insights. Furthermore, an analysis of the proportion of words produced in the non-target language as a continuous variable (e.g., Raichlin et al., 2018) may reflect more subtle gradations in language control.

The extreme effects of partner language may have been a product of having fairly lenient inclusion criteria, such that some children in the sample had highly imbalanced language skills, and it may not have been realistic to expect them to describe a picture in their non-dominant language. However, to counter this concern, children with equally low skills in their non-dominant language were observed to use this language during the task to differing degrees. In addition, there were children who chose to complete the entire task in one language, even though it was not their dominant language based on standardized testing and observation. Thus, there appear to be a variety of factors governing children's language choices, and children with limited expressive skills in one language may be part of the natural heterogeneity of bilingual samples.

In addition, unmeasured sociolinguistic variables may have been playing a role. Children may have been sensitive to the fact that, in the United States, Spanish speakers are likely to speak at least some English, while English speakers are less likely to speak Spanish (see Paradis & Nicoladis, 2007 for a similar argument regarding English and French in Canada). There is also a difference in prestige between English and Spanish. For these reasons, even though both confederates presented themselves as monolinguals, children may have exhibited fewer cross-language intrusions with the English-speaking confederate than with the Spanish-speaking confederate, regardless of their own dominance. The coding of partner language in terms of children's dominant and non-dominant language in the current study would have obscured the sociolinguistic effects associated with the contrast between English and Spanish. Other effects on children's language choices may have been difficult to control or measure. Some children may have associated the laboratory environment with school and chosen to use the language that they usually use at school throughout the task. The bilingual status of the examiner may have made children more likely to use both languages, even though the confederates presented themselves as monolingual. Although the examiner tried to remain quiet during the task, children varied in how much prompting they required to stay on task and in how much they initiated interactions with the examiner during the task.

Finally, comparisons between the current study and our previous study at the single-word level (Gross & Kaushanskaya, 2018) are limited by the fact that the two studies were conducted in separate samples with slightly different age ranges (4-6 vs. 5-7). A more stringent test of how costs of a dual-language context measured at the single-word level relate to more naturalistic language use would be to conduct both single-word and discourse-level paradigms in the same sample. Tare and Gelman (2010) took this approach in children and Festman (2012) took this approach in adults, but neither study compared single-language and dual-language contexts at both levels. Furthermore, following Festman's (2012) approach, it would also be important to integrate parent report data about children's language environment. A key component of Abutalebi and Green's (2013) Adaptive Control Hypothesis is that bilinguals adapt their control processes to the contexts in which they most frequently interact. Therefore, the extent to which children show costs in a dual-language context may be influenced by whether they tend to use their two languages in separate contexts or in the same context.

**Conclusion**

The current study presented a new methodology for experimentally measuring language control in bilingual children in a naturalistic discourse context that simulates single-language interactions with one person and dual-language interactions with speakers of different languages. Although dual-language environments have been associated with costs to language control in past work at the single-word level, the results of the current study suggest that costs of a dual-language environment at the discourse level are minimal, and language control is more profoundly influenced by language dominance. Although the current study did not identify overall costs, in future work it will be important to examine child characteristics that may contribute to variability in children's ability to adapt to dual-language environments.

## Appendices

Appendix A. *Elements of description scenes.*

| Subject | | Action | | Object | | Location | |
|---|---|---|---|---|---|---|---|
| **English** | **Spanish** | **English** | **Spanish** | **English** | **Spanish** | **English** | **Spanish** |
| boy | el niño | eat | comer | hand | la mano | head | la cabeza |
| girl | la niña | dar | give | hat | el sombrero (la gorra) | drawer | el cajón |
| man | el señor | put in | poner (guardar) | shoe | el zapato | table | la mesa |
| lady | la señora | wash | lavar/ (bañar limpiar) | glasses | los lentes (anteojos) | bedroom | el cuarto |
| | | sweep | barrer | doll | la muñeca | bathroom | el baño |
| | | close | cerrar | pencil | el lápiz | kitchen | la cocina |
| | | open | abrir | present | el regalo | store | la tienda |
| | | buy | comprar | box | la caja | tree | el árbol |
| | | put on/tie | ponerse (amarrar) | bread | el pan | house | la casa |
| | | | | milk | la leche | | |
| | | | | cheese | el queso | | |
| | | | | orange | la naranja | | |
| | | | | horse | el caballo | | |
| | | | | bunny (rabbit) | el conejo | | |
| | | | | dog | el perro | | |
| | | | | street (road) | la calle | | |
| | | | | window | la ventana | | |
| | | | | door | la puerta | | |
| | | | | cup | la taza | | |
| | | | | floor | el piso | | |

Note: Children’s knowledge of the English and Spanish words for these scene elements was assessed via a vocabulary post-test at the end of the final session.

Appendix B. *Confederate sentences and scenes to be described by participants in the dual-language block (version A) with translations for Spanish sentences provided in italics.*

| **Confederate Sentence for Guessing Phase** | **Scene to be Described by Participant** | **Trial Type** |
|---|---|---|
| El niño está mirando el oso con su hermana.<br>*[The boy is looking at the bear with his sister.]* | a lady washing a dog in the bathroom | Stay |
| La niña está escondiendo el libro detrás de la silla.<br>*[The girl is hiding the book behind the chair.]* | a boy eating bread in the kitchen | Stay |
| The lady is cooking dinner in the kitchen. | a girl sweeping the street in front of a house | Switch |
| The man is drinking water in the kitchen. | a boy putting a bunny in a box | Stay |
| La araña está asustando al niño en el bosque.<br>*[The spider is scaring the boy in the woods.]* | a man opening a door for a woman | Switch |
| The dog is looking at the moon through the clouds. | a girl putting her glasses on a table | Switch |
| The man is looking at the butterfly on the tree. | a lady washing a window in the bedroom | Stay |
| La señora está trayendo los libros a la escuela.<br>*[The lady is bringing books to the school.]* | a man buying milk at the store | Switch |
| El señor está mirando el barco en el agua.<br>*[The man is watching the boat in the wáter.]* | a boy putting a hat on his head | Stay |
| La niña está cocinando pollo en la cocina.<br>*[The girl is cooking chicken in the kitchen.]* | a man washing a horse by a tree | Stay |
| The boy is watching the airplane in the sky. | a girl putting a doll in a box | Switch |
| The man is singing a song at the show. | a boy washing a cup in the kitchen | Stay |
| The spider is scaring the lady in the living room. | a girl sweeping the floor in the kitchen | Stay |
| The boy is looking at the sun through the window. | a lady eating an orange at a table | Stay |
| El niño está cortando las manzanas en la mesa.<br>*[The boy is cutting apples on the table.]* | a man closing a window in the bathroom | Switch |
| The woman is looking at the moon in the sky. | a boy eating cheese in the kitchen | Switch |
| El hombre está mirando sus dientes en el espejo. *[The man is looking at his teeth in the mirror.]* | a woman putting a pencil in a drawer | Switch |
| La niña está leyendo un libro en el sillón.<br>*[The girl is reading a book on the couch.]* | a boy washing his hands in the bathroom | Stay |
| The man is pushing the chair into the living room. | a girl putting on her shoe in the bedroom | Switch |
| La niña está cocinando huevos en la cocina.<br>*[The girl is making eggs in the kitchen.]* | a man giving a present at a party | Switch |

# Chapter 3: Cognitive and Linguistic Predictors of Language Control in Bilingual Children With Low and Typical Language Skills

Abstract: In order to communicate effectively with a variety of conversation partners and in a variety of settings, bilingual children must develop *language control*, the ability to control which language is used for production. Past work has focused on linguistic skills as the limiting factor in children's ability to control their language choice, while cognitive control has been the focus of adult models of language control. An understanding of the cognitive and linguistic factors that contribute to language control is particularly important when considering how language control may be affected in children with low language skills. The current study examined the effects of both language ability and cognitive control on language control in 4-6 year old Spanish/English bilingual children with a broad range of language skills. The findings revealed a robust effect of language ability and a more restricted effect of cognitive control that increased among children with higher language skills. These results may suggest a threshold effect such that a certain level of language ability is necessary before cognitive control skills exert any additional influence on language control in children. For children with low language, their limited language skills may put them at risk for particular difficulties with language control.

Even as toddlers, bilingual children demonstrate an impressive awareness of their two languages and an emerging ability to control which language is used for production, known as *language control.* Evidence of children's emerging language control can be most clearly observed through their ability to adjust their language choice to accommodate conversation partners who speak different languages (e.g., Genesee, Nicoladis & Paradis, 1995; Genesee, Boivin & Nicoladis, 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Genesee, 1996). At this early stage, children show a relative rather than complete adjustment, such as using more English with their English-speaking parent than with their French-speaking parent, but still using some of both languages with both parents. As older children develop more complete language control, they still sometimes exhibit *cross-language intrusions*, when they produce one or more words in the non-target language for a given situation. What factors contribute to the development of language control and explain these lapses? Past work in children has suggested that achieving language control depends on the development of sufficient linguistic skill to express the desired message in the target language (e.g., Cantone & Muller, 2005; Gawlitzek-Maiwald & Tracy, 1996; Genesee et al., 1995; Genesee et al., 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Secco, 2000; Ribot & Hoff, 2014). Pragmatically unsolicited switches to the non-target language are attributed to gaps in linguistic knowledge. This perspective would suggest that bilingual children with specific language impairment (SLI), who exhibit more limited linguistic skills than their peers in *both* languages (e.g., Kohnert, 2010), might have particular difficulty with language control.

However, studies have also documented situations in which children's language choices do not appear to be commensurate with their linguistic skills (e.g., Castillo, 2015; Genesee & Nicoladis, 1996; Nicoladis & Genesee, 1996; Paradis & Nicoladis, 2007; Ribot & Hoff, 2014). Thus, it is important to consider other factors that may also play a role in the ability to control language choice. In mature bilinguals, cognitive control has often been associated with language control, with the argument that the ability to control language choice relies on the same cognitive control skills (e.g., inhibition, shifting) that contribute to other aspects of behavior (e.g., Green, 1998; Green & Abutalebi, 2013; Meuter & Allport, 1999). The role of cognitive control in children's language control has rarely been studied, and only at the single-word level (Gross & Kaushanskaya, 2018). Crucially, linguistic and cognitive factors may interact such that they contribute to language control differently at different levels of ability. For example, in children with under-developed language skills (e.g., those with SLI), their linguistic limitations may fully constrain their ability to maintain use of the target language. Children with more advanced language skills may show more modulation of language control by other factors such as cognitive control. The goal of the current study was to examine an integrated model of language control in children that considers the contributions of both linguistic and cognitive factors.

**The Role of Language Ability in Language Control**

When bilingual children produce words in the language not understood by their conversation partner, this lapse in language control has most often been attributed to limited skills in the target language (e.g., Cantone & Muller, 2005; Gawlitzek-Maiwald & Tracy, 1996; Genesee et al., 1995; Genesee et al., 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Secco, 2000; Ribot & Hoff, 2014). For example, in formulating the Lexical Gap Hypothesis, Nicoladis and Secco (2000) note that very young bilingual children tend to insert words in the non-target language when they do not know the correct word in the target language. With regard to morphosyntax, Gawlitzek-Maiwald and Tracy (1996) suggest a type of "bilingual bootstrapping" through which children use syntactic structures from one language as a placeholder while the analogous syntactic structure in the target language is still developing. Such gaps in lexical and/or syntactic knowledge are a part of typical bilingual acquisition, as bilingual children often show distributed linguistic knowledge across their two languages (e.g., Oller, Pearson, & Cobo-Lewis, 2007; Kohnert, 2010). For example, in toddlers, translation equivalents often make up only about one third of the child's overall vocabulary (e.g., Pearson, Fernandez, & Oller, 1995), which means that the remaining words are known in only one language or the other. Cantone and Muller (2005) suggest a more performance-based metric of "readiness to speak the language" (p. 215), defined as the total number of utterances in a recording in a given language context. They argue that cross-language intrusions reflect low facility with the target language, even if the lexical and morphosyntactic knowledge is technically present. Thus, switching into the non-target language can be seen as a strategic pooling of resources when the desired words in the target language are unknown or not readily accessible (e.g., Genesee et al., 1995).

Researchers have tended to focus on the role of language-specific knowledge, but several recent studies have considered the role of overall language ability by examining language switching patterns in 5-6 year old bilingual children at risk for SLI. While typically developing bilingual children show distributed linguistic knowledge that may result in language-specific gaps, children with language impairment are further challenged by more fundamental difficulties with language learning, processing, and use (e.g., Leonard, 2014) that could make it particularly difficult to exercise language control. However, studies have yielded conflicting results as to whether bilingual children at risk for SLI differ from their typically developing peers in their language switching patterns and frequency of their switches into the non-target language.

There are a few studies that did not identify differences between children with language impairment and their typically developing peers. In a study by Gutierrez-Clellen, Simon-Cereijido, and Leone (2009), Spanish/English bilingual children with SLI did not differ from their typically developing peers in how often they switched into the non-target language within a sentence or in the grammaticality/typicality of their switches during narrative and conversation tasks. However, this study only examined intra-sentential switches and used more restrictive definitions with regard to single-word insertions than some other studies. Greene, Bedore, and Peña (2014) did not find any differences between low and high language groups in the rate of switches into Spanish in a study of lexical strategies used to ameliorate lexical gaps when telling narratives in English. These studies would suggest similar language control abilities in children with differing levels of underlying language ability.

Other studies have yielded more mixed findings. Greene, Peña, and Bedore (2013) found that Spanish/English bilingual children with a high risk for language impairment did not switch languages more frequently overall during an assessment of semantic skills than their low-risk peers, but they did show differences in the direction and success of their switches. Children with low language were more likely to switch into Spanish during the English assessment, while children with higher language were more likely to switch into English during the Spanish assessment. The latter pattern is more common among bilinguals in the United States and may reveal more sensitivity to sociolinguistic norms. Furthermore, children with low language were more likely to still produce a semantically incorrect response when they switched languages, while children with higher language skills more successfully used a switch into the non-target language to improve their response. Silva (2011) also found that children at risk for language impairment were similar to their typically developing peers in how often they switched from Spanish to English during a narrative task, but they exhibited more frequent switches from English to Spanish. However, most of these switches were "syntactical," where all of the words were still in English but the word order reflected interference from Spanish syntax.

This difference in switching direction has been duplicated in other studies that also found overall differences in the amount of language switching by bilingual children with SLI. Iluz-Cohen and Walters (2012) found that English/Hebrew bilinguals with SLI exhibited more language switching overall, both when narrating a familiar story from a book and when re-telling a story to a puppet who was introduced as monolingual. The retell task was particularly taxing on language control, as children needed to retell a school story that they had heard in Hebrew to an English-speaking puppet and a home story that they had heard in English to a Hebrew-speaking puppet. Typically developing children were more likely to switch into Hebrew (the community language) when re-telling the school story in English, while children with SLI were more likely to switch into English (their home language) when re-telling the home story in Hebrew, and their switches during the school story occurred in both directions. Similar to Greene and colleagues

(2013), the authors suggest that children with SLI may be less sensitive to the sociolinguistic context. The types of switches also differed. Although both groups made more single-word insertions than switches on extended segments, children with SLI exhibited more extended switches than their typically developing peers, suggesting that their switches were not only filling single lexical gaps. In a study of older Spanish/Catalan bilinguals, Aguilar-Mediavilla and colleagues (Aguilar-Mediavilla, Buil-Legaz, Pérez-Castelló, López-Penadés, & Androver-Roig, 2015) found more language mixing during a narrative task in children with language impairment than in age-matched controls at age 8, but not at age 12.

The studies discussed thus far have focused on group comparisons between children with and without SLI. In a study that only included children with SLI (ages 5-11), Mammolito (2015) found that the tendency to switch into the non-target language during a narrative sample was correlated with overall language ability. Children with more severe impairment (i.e., lower core language skills in both languages) were more likely to switch languages when telling a narrative in Spanish. Although the younger children showed the pattern observed by other studies in which children with SLI switched more frequently from English to Spanish than vice versa, the older children with SLI in Mammolito's sample showed very little switching from English to Spanish and were more likely to switch from Spanish to English.

Although both language-specific knowledge and overall language ability have been associated, to at least some extent, with the ability to maintain language control, there are studies that have identified difficulties with language control that cannot fully be explained by language skills. For example, in their study examining children's ability to adjust their language choice with monolingual strangers, Genesee and Nicoladis (1996) found one child who did not make this adjustment, but this child was not the least proficient of the group in the stranger's language.

Nicoladis and Genesee (1996) examined concepts for which children knew the translation equivalents in both languages and found that even after they started to demonstrate the ability to adjust their language choice, there were still situations (albeit far less than previously) when children used the French word for the concept with an English speaker and the English word with a French speaker. These cross-language intrusions cannot be explained by lexical gaps, as children demonstrated knowledge of the word in both languages. However, even when children know the word in both languages, they may not always be able to access this knowledge in the moment (e.g., Heredia & Altarriba, 2001; Lanvers, 2001). This issue of accessibility raises the possibility that processes involved in regulating the degree of inhibition and activation of each language may also play a role in language control.

## The Role of Cognitive Control in Language Control: Language Switching Studies

In addition to expressing the desired message in the appropriate language, to achieve language control bilinguals also need to monitor the environment for cues, select the appropriate language and inhibit the non-target language, and shift between languages as necessary. These skills (monitoring, inhibiting, shifting) conceptually overlap with *executive functions*, higher-level control processes involved in regulating a variety of behavior (e.g., Miyake et al., 2000; Miyake & Friedman, 2012). Several theoretical models (see Derclerck & Philipp, 2015 for a review) suggest a role for domain-general cognitive control skills in language control, including the Inhibitory Control Model (Green, 1998), the Adaptive Control Hypothesis (Green & Abutalebi, 2013), and the Control Processes Model of Code-switching (Green & Wei, 2014). These models include a language schema level (e.g., “speak in English”; “speak in Spanish”) based on the concept of “task sets” from the general task-shifting literature (e.g., Monsell, 2003). While language schemas exert an influence *on* the language system to help coordinate the processes required for production in the target language, they are believed to be governed *outside* the language system by the same domain-general processes that coordinate any kind of task-shifting.

The relationship between cognitive control and language control has been examined extensively in the adult psycholinguistic and neurolinguistic literature. Neuroimaging studies have found brain regions and networks associated with cognitive control to be active when bilinguals exercise language control during language switching or tasks that increase interference from the non-target language (e.g., Abutalebi, Della Rosa, Ding, Weekes, Costa & Green, 2013; Branzi, Della Rosa, Canini, Costa & Abutalebi, 2015; De Baene et al., 2015; de Bruin, Roelofs, Dijkstra & Fitzpatrick, 2014; Guo, Liu, Misra & Kroll, 2011; Luk, Green, Abutalebi & Grady, 2012; Wang, Kuhl, Chen & Dong, 2009; Wang, Xue, Chen, Xue & Dong, 2007; Weissberger, Gollan, Bondi, Clark & Wierenga, 2015; see Abutalebi & Green, 2016 for a recent review;).

Behavioral studies have examined this relationship by testing for associations between measures of language control and measures of cognitive control in the same participants. Several studies have documented a relationship between cross-language intrusions and measures of inhibition and shifting (e.g., Festman & Münte, 2012; Festman, Rodriguez-Fornells & Münte, 2010; Gollan, Sandoval, & Salmon, 2011; Gollan, Kleinman, and Wierenga, 2014; Gollan & Goldrick, 2016; Prior & Gollan, 2013). For example, bilinguals who more frequently produced words in the wrong language on a cued language switching task were also more likely to perform the wrong task when they were cued to switch between non-linguistic tasks (Gollan et al., 2014; Prior & Gollan, 2013), to make more perseveration errors on the Wisconsin Card Sorting Task (Festman & Münte, 2012), and to take more time on the alternating condition of a Trail-Making task (Gollan & Goldrick, 2016). This relationship between non-linguistic task-shifting and the control of language selection during language switching aligns with the models of language control that include a language schema level governed by domain-general processes.

Other behavioral studies have measured language control by deriving cost measures from naming latencies in picture-naming paradigms. These cost measures reflect how much longer it takes to name a picture in the appropriate language in a dual-language block vs. a single-language block (i.e., *mixing costs*) and how much longer it takes to name a picture when switching languages than when continuing in the same language (i.e., *switching costs*). Larger costs are believed to reflect less efficient language control (e.g., Christoffels, Firk & Schiller, 2007). Significant associations between language mixing or switching costs and parallel cost measures from cognitive control tasks have been documented in some studies (e.g., de Bruin et al., 2014; Klecha, 2013; Linck, Schwieter & Sunderman, 2012; Prior & Gollan, 2011, 2013; Stasenko, Matt & Gollan, 2017; Woumans, Ceuleers, Van der Linden, Szmalec & Duyck, 2015). In addition, Liu and colleagues found that providing training on a Simon switch task that involved both inhibition and shifting changed the language control strategy (as indexed by switch-cost patterns) used by bilinguals when switching between their first and second language (Liu, Liang, Dunlap, Fan, & Chen, 2016) and when switching between their native language and a newly acquired third language (Liu, Dunlap, Liang, & Chen, 2017). However, other studies have identified dissociations between language switching or mixing costs and measures of cognitive control (e.g., Branzi, Calabria, Boscarino & Costa, 2016; Calabria, Branzi, Marne, Hernández & Costa, 2015; Calabria, Hernández, Branzi & Costa, 2011; Gollan et al., 2014; Jylkkä, Lehtonen, Lindholm, Kuusakoski, & Laine, 2018; Magezi, Khateb, Mouthon, Spierer & Annoni, 2012; Weissberger, Wierenga, Bondi & Gollan, 2012).

These discrepant findings for cross-language intrusions vs. speed cost measures may relate to differences in how these measures index language control. Cross-language intrusions reflect a failure in language control, while mixing and switching costs in naming latency reflect a less efficient process that was still ultimately successful (e.g., Zheng, Roelofs, & Lemhöfer, 2017). Furthermore, naming latencies incorporate not only selection of the correct language, but also lexical selection of the specific lexical item to be produced. The lexical selection process involves modulating activation levels of within-language and across-language lexical items competing for selection, and it remains unclear whether it recruits domain-general cognitive control or is accomplished through control processes specific to the linguistic system (e.g., Christoffels et al., 2007; Gollan, Kleinman & Wierenga, 2014; Green, 1998). For these reasons, cross-language intrusions, which index a failure of language control at the stage of language selection, may have a more robust association with cognitive control. However, this association has been demonstrated mostly through highly constrained laboratory paradigms, such as picture naming tasks. Paradigms such as these afford more experimental control, but they are very different from the conditions under which bilinguals exercise language control in everyday language use.

**The Role of Cognitive Control in Language Control: Discourse Level**

The focus of the current study is on children's ability to exercise language control at the discourse level by adjusting their language choice for different conversation partners. There are several key differences between laboratory paradigms and conversational speech that might affect the extent to which cognitive control is recruited for language control. For example, picture-naming paradigms use rather decontextualized cues (a color or a flag) to indicate when speakers should switch languages. In conversational speech, there are a variety of social and linguistic cues to indicate when a language switch may be necessary, including the topic or setting, prior knowledge about the other person's language background, and hearing the language being spoken by the other person. In his Interactive Alignment Model of code-switching, Kootstra (2009, 2015) suggests that language activation levels spread from one conversation partner to another so that they align with each other in their language choice. This alignment can be automatic and driven by priming, where listening to a partner speaking one language primes an individual to then use that same language for production. The alignment can also be conscious and strategic based on factors such as prior information about the interlocutor's language knowledge or preferences. What is unclear in this description of automatic vs. strategic alignment is the extent to which domain-general cognitive control processes may be involved in achieving either type of alignment.

The role of domain-general cognitive control processes in language control at the conversational level has been formalized in Green and Abutalebi's (2013) Adaptive Control Hypothesis. This model of language control still includes a language schema level, as in Green's (1998) Inhibitory Control Model, but the way the language schemas are regulated by the domain-general cognitive control system differs depending on the interactional context. When bilinguals operate in single-language contexts, such as using one language at school and another language at home, the language schema for the target language in a given context is activated and the other language schema is inhibited. When bilinguals use both of their languages in the same context, but with different speakers (i.e., a dual-language context), a similar competitive relationship between the language schemas exists, but there are additional control demands imposed by the need to be prepared to switch which language schema is active and which language schema is inhibited when addressing speakers of different languages. In contrast, when bilinguals use both of their languages in a dense code-switching context with other bilingual speakers who tend to use both languages within a single sentence, the language task schemas are in a cooperative relationship to allow the integration of elements from both languages. The Adaptive Control Hypothesis posits that a bilingual's cognitive control processes become tuned to achieving language control in the interactive context in which they find themselves most frequently. The current study examined children's ability to adjust their language choice to accommodate different conversation partners. Therefore, the dual-language interactional context is most relevant. According to the Adaptive Control Hypothesis, this context also places the most complex demands on cognitive control processes.

The Adaptive Control Hypothesis posits that exercising language control in the dual-language context requires *goal maintenance* to determine the target language (e.g., English), *interference control* to inhibit the non-target language (e.g., Spanish), *detection of salient cues* to determine when a language switch may be necessary (e.g., the arrival of a Spanish-speaking conversation partner), *selective response inhibition* to stop speaking English, *task disengagement* to disengage from the task set for "speak in English", and *task engagement* to shift to the task set for "speak in Spanish." Although Green and Abutalebi note that there are a variety of multi-model cues to help with some of these processes, such as using the voice or face of the addressee to establish the target language, they note that there may be other cues in the environment that would be distracting (such as hearing someone else speaking a different language), and thus cognitive control processes are still necessary to coordinate how these bottom-up cues are used.

There are a few studies that have linked cognitive control skills to measures of language control (in terms of cross-language intrusions) in more naturalistic settings. For example, higher self-ratings on questions measuring unintentional language switching in daily life on the

Bilingual Switching Questionnaire were associated with poorer inhibitory control, as measured in the lab by a Flanker task (Soveri, Rodriguez-Fornells & Laine, 2011) or a Stop-signal task (Rodriguez-Fornells, Kramer, Lorenzo-Seva, Festman & Münte, 2012). Combing self-report with laboratory measures, Festman (2012) noted that the same bilinguals who demonstrated a relationship between poorer cognitive control (as measured by the Flanker and Wisconsin Card Sorting Task) and increased cross-language intrusions during picture-naming in the lab also provided higher self-report ratings of unintentional switching in daily life. Furthermore, these same individuals produced more cross-language intrusions during a conversation sample in which two interviewers (one who spoke German and one who spoke Russian) alternated about every five minutes when introducing a new topic. Liu and colleagues (2016) used a similar approach by asking pairs of Chinese/English bilingual participants to take turns talking about conversational topics, either using English (their weaker second language) throughout the task or switching between languages half-way through a one-minute turn. Although they observed few cross-language intrusions, they noted an increase in morphosyntactic errors in English when speakers switched from Chinese into English compared to when they completed the whole task in English. The authors suggested that these errors reflected a reduced ability to inhibit interference from Chinese morphosyntax, which does not include inflections or subject-verb agreement. In support of this assertion, the effect of language switching on morphosyntactic errors was modulated by inhibitory control (as measured by a modified Simon switch task) but not by English proficiency. These studies suggest that cognitive control may play a role in language control even as it is exercised in more conversational paradigms or in daily life.

**The Role of Cognitive Control in Language Control in Children**

In contrast to the extensive literature on the relationship between cognitive control and language control in adults, very little work has examined the role of cognitive control in the ability of children to exercise language control, even at the single word level. The role of cognitive control is of particular interest in preschool-age children, as this is a period of rapid development in cognitive control (e.g., Best & Miller, 2010; Davidson, Amso, Anderson & Diamond, 2006; Garon, Bryson, & Smith, 2008; Huizinga, Dolan & van der Molen, 2006) and a period of adjustment to new language environments outside the home. On the one hand, the increased variability in cognitive control skills in young children may provide more opportunities to observe a relationship between language control and cognitive control. A similar argument has been made for older adults who also exhibit increased variability as they begin to experience cognitive decline. For example, Gollan and colleagues (2011) observed a relationship between cross-language intrusions and Flanker errors in older adults but not in younger adults. On the other hand, studies of language control in older adults have also identified dissociations such that language control skills appeared to be relatively preserved compared to cognitive control (e.g., Calabria et al., 2015; Gollan et al., 2011). At the other end of the age spectrum, it is possible that language control could develop more quickly than cognitive control. For example, children begin to demonstrate the ability to shift from one language to the other based on conversation partner as early as age two (e.g., Nicoladis & Genesee, 1996), while the ability to shift from sorting by color to sorting by shape does not emerge on tasks like the Dimensional Change Card Sort (DCCS) until age 4 or 5 (e.g., Zelazo, 2006). However, as mentioned previously, this early language control involves only relative adjustments in language choice, and it is possible that children's developing cognitive control plays a role, along with their developing linguistic skills, in helping them to achieve more complete language control.

Providing direct evidence of a relationship between cognitive control and language control in children, our previous work (Gross & Kaushanskaya, 2018) identified cognitive control (as measured by the DCCS) as a significant predictor of cross-language intrusions during picture-naming by 5-7 year old Spanish/English bilingual children. The effect of cognitive control did not interact with the effect of context, indicating that children did not appear to be recruiting cognitive control more when switching between languages in a dual-language context than when using only one language in a single-language context. Young children who are still developing language control may recruit cognitive control skills to a similar extent to inhibit the non-target language even in a single-language context where no switching is required (see Davidson et al., 2006 for a similar phenomenon in cognitive control tasks). However, the relationship between cognitive control and language control in young bilinguals has not been examined at higher linguistic levels in paradigms that more closely resemble a dialogue context.

**Integrating Cognitive and Linguistic Predictors of Language Control**

While the Adaptive Control Hypothesis focuses on the role of cognitive control, this model is not necessarily intended as a developmental model and in fact presupposes a high level of proficiency in each language (Green & Abutalebi, 2013). The authors acknowledge that proficiency in each language, as well as variability in cognitive control capacities, may constrain the extent to which individuals are able to adapt their control processes to match the interactional context. Some work in adults suggests that effects of cognitive control on language control are independent of language ability. Festman and colleagues (Festman et al., 2010; Festman, 2012) found that bilinguals who produced more cross-language intrusions differed from their fellow participants on measures of cognitive control (e.g., Flanker, Wisconsin Card Sort), but they did not differ on various measures of proficiency in either language (correct responses on verbal fluency tasks, self ratings of spoken language, quality of language samples). However, these bilinguals were highly proficient in both languages. Even among bilinguals with less proficiency in their second language, there is some evidence that having better cognitive control skills makes their language control resemble that of more balanced bilinguals (Liu, Fan, Rossi, Yao, & Chen, 2015; Liu, Rossi, Zhou, & Chen, 2014; Liu et al., 2017).

In children, however, it is unclear how linguistic and cognitive factors may interact in contributing to language control. In children with lower levels of language ability, including those with SLI, their limited language ability may constrain language control such that cognitive control does not exert any additional influence, suggesting a type of threshold effect. In addition, children with low language may also tend to have lower cognitive control skills. Deficits in inhibition and/or shifting, which are the components of cognitive control most associated with language control, have been demonstrated in both monolingual children with SLI (e.g., Epstein et al., 2014; Farrant et al., 2012; Henry, Messer, & Nash, 2012; Kapa & Plante, 2015; Marton, 2008; Pauls & Archibald, 2016; Roello et al., 2015; Spaulding, 2010; Vissers et al., 2015) and bilingual children with low language or a diagnosis of SLI (e.g., Engel de Abreu et al., 2014; Iluz-Cohen & Armon-Lotem, 2013; Sandgren & Holmstrom, 2015), although findings have been somewhat mixed with regard to shifting (e.g., Dibbets, Bakker, & Jolles, 2006; Im-Bolter, Johnson, & Pascual-Leone, 2006; Laloi, 2015). Therefore, it is possible that cognitive control could also have a negative effect on language control in children with low language, but these effects may be difficult to separate from the effects of limited language ability. In children with higher levels of language ability, based on what has been observed in adults, cognitive control and language ability may have more independent effects on language control. An examination of the contributions of both cognitive control and language ability in children across a broad spectrum of ability is necessary to understand how both cognitive and linguistic factors may contribute to language control.

**Current Study**

The goal of the current study was to test an integrated theoretical framework for language control in bilingual children that considers both linguistic and cognitive factors. Most studies of language control in children have focused on the role of linguistic skills, either in terms of language-specific knowledge or in terms of overall language ability. Cognitive control has been an important component of models of language control in adults and has been associated with language control in empirical studies in single-word laboratory paradigms, as well as in some studies of conversational language use. However, these models of language control have not been extended to children, and cognitive control has rarely been examined in empirical studies of language control in children. Our prior work (Gross & Kaushanskaya, 2018) identified a role for cognitive control in predicting language control in children at the single word level, but we did not also consider the contributions of language ability. Furthermore, findings at the single-word level may not necessarily generalize to the discourse level, where there are more contextual cues to support language control. The current study examined the effects of language ability and cognitive control on language control at the discourse level in young Spanish/English bilinguals (ages 4-6) across a broad range of language ability, including those with low language. We sought to answer the following research questions:

1. How does overall language ability affect language control?
2. How does cognitive control affect language control?

3. Do language ability and cognitive control interact in their effects on language control?

To examine language control at the discourse level, we designed a computerized scripted confederate dialogue paradigm. The scripted confederate technique has been used in previous studies of linguistic alignment of syntactic choices in monolingual children (Branigan, McLean, & Jones, 2005) and in monolingual and bilingual adults (e.g., Branigan, Pickering, & Cleland, 2000; Hartsuiker, Pickring, & Veltkamp, 2004), including in a study of code-switching behavior (Kootstra, van Hell & Dijkstra, 2010). The basic approach is that the participant takes turns identifying pictures described by a partner (the confederate) and describing pictures to the confederate. In the current study, we introduced children to multiple confederates. Some confederates presented themselves as monolingual speakers of English and used English throughout the task, and others presented themselves as monolingual speakers of Spanish and used Spanish throughout the task. Our measure of interest was the extent to which children aligned their language choice to the language spoken by the confederate when they interacted with confederates separately in single-language games and when they interacted with two confederates in a dual-language game. This dual-language game represents the dual-language interactional context that the Adaptive Control Hypothesis (Green & Abutalebi, 2013) describes as recruiting the most cognitive control processes to achieve language control. The current study examined whether children's overall language ability and cognitive control skills predicted their ability to exercise language control during the scripted confederate dialogue task overall, and whether these skills interacted with children's ability to adapt to the dual-language context.

Overall language ability was indexed by the Language Index score from the Bilingual English Spanish Assessment (BESA; Peña, Gutierrez-Clellen, Iglesias, Goldstein, & Bedore, 2014), which combines children's best performance across languages on measures of morphosyntax and semantics. Our sample included children with an official diagnosis of language impairment or who may be at risk for language impairment due to low performance in both languages and parent language concerns. However, we chose to analyze language ability as a continuum rather than as a categorical comparison between children with and without SLI. From a practical diagnostic perspective, it can be difficult to draw a strict demarcation between SLI and the lower end of the typical range, particularly in bilingual children in whom typical development is still not well understood. Furthermore, even among monolingual children, researchers question whether children with language impairment constitute a discrete category of learners or whether they fall along a continuum of language ability from below-average to superior (e.g., Dollaghan, 2011; Leonard, 2014). Although there may be clinical utility to comparisons of language control in children with and without SLI, the goal of the current study was to understand the effect of language ability on language control, as well as its potential interactions with cognitive control, throughout the continuum of language ability.

We measured cognitive control using a version of the Dimensional Change Card Sort (DCCS) adapted from work by Bialystok and Martin (2004) and Zelazo (Zelazo, 2006; Zelazo et al., 2013). The DCCS is a complex cognitive control task that requires children to shift from sorting colored shapes by one dimension (e.g., color) to sorting the same stimuli by a different dimension (e.g., shape). This task requires both the ability to *shift* mental sets and the ability to *inhibit* information from the currently irrelevant dimension. In this way, the DCCS taps the same cognitive control skills that may be involved in shifting between languages and inhibiting the non-target language, but in a task that we specifically designed to be as non-linguistic as possible. We use the general term “cognitive control,” rather than specifying specific constructs such as shifting and inhibition, because the goal of the current project was to examine the role of domain-general cognitive control and not necessarily to pinpoint the specific processes involved. In addition, the relationship between shifting and inhibition may be complex, especially in young children (e.g., Best & Miller, 2010; Garon, 2008).

Based on past work on language control in children, we expected that the ability to exercise language control during our task would be predicted by overall language ability, such that children with stronger language skills overall would be more successful in controlling their language choice. It was difficult to predict the role of cognitive control given the paucity of research on cognitive control and language control in children. Based on our past work at the single word level (Gross & Kaushanskaya, 2018), we would expect cognitive control to have an overall effect on language control. If the Adaptive Control Hypothesis can be applied to children, then we would expect an interaction with context such that cognitive control would be especially associated with language control in a dual-language context. Finally, we expected an interaction between the effects of language ability and cognitive control such that cognitive control would make a more independent contribution to language control in children with higher levels of language ability.

## Method

### Participants

The current study included sixty-seven[1] Spanish-English bilingual children (28 boys), ages 4-6 ($M_{age}$ = 5.31 years; *SD* = 0.91). These children were participating in a larger project (F31 DC013920 “Language control in bilingual children with low and typical language skills”). Another study from this project, which examined language switching costs at the discourse level in children with typical language (Gross & Kaushanskaya, in preparation [this dissertation, Chapter 2]), included 55 of these children who did not exhibit signs of SLI. The current study included the full sample of 67 children with a broad range of language ability (*M* = 102.16, *SD* = 12.77, *range* = 71 - 126), as measured by the Language Index score from the *Bilingual English-Spanish Assessment* (BESA; Peña et al., 2014). Red flags for SLI included Language Index scores of 85 or below (*n* =8), parent language concerns (*n* = 33), and/or an existing diagnosis or history of language services (*n* = 8). A total of 12 children met at least two out of these three criteria, which was our operational definition for SLI. The larger proportion of children at risk for SLI in the current study (18%) compared to the estimated prevalence in the general population (7%, Tomblin et al., 1997), reflects our over-sampling efforts at the lower end of the continuum of language ability.

All children acquired Spanish from birth or within the first year of life and were exposed to English either simultaneously with Spanish within their first year (*n* = 47) or sequentially after 18 months (n = 20). All children passed a pure-tone hearing screening at 20dB at 1000, 2000, and 4000 Hz in each ear and had nonverbal intelligence scores within normal limits. Exclusionary criteria included hearing impairment, frank neurological impairment, genetic syndromes, psychological/ behavioral disorders, other developmental disabilities, and significant current or past exposure to a language other than English or Spanish. ADHD and speech impairments were not considered to be exclusionary criteria. As these conditions often co-occur with SLI, variation in attention and speech skills was permitted throughout the range of language ability. The sample included one child with a diagnosis of ADHD who had typical language, six children receiving speech services (two with typical language, four also receiving language services), and five children with typical language suspected of having speech impairments based on the clinical judgement of the first author. Two children who initially met all criteria were excluded due to extremely limited English expressive skills compared to the rest of the sample

(|$z$|>3.29), such that they were only able to produce 4 or 5 words in English during a vocabulary post-test associated with the main experimental task.

Table 1 presents participant characteristics. Language exposure was measured via parent report to characterize children's language environment, but a minimum level of exposure in each language was not used to determine eligibility. Socioeconomic status was indexed on a 1-6 Likert scale based on parent report of the highest level of education completed by the child's mother (1 = less than high school, 2 = high school or GED, 3 = two-year degree or some college; 4 = Bachelor's degree, 5 = Master's degree, 6 = Doctoral degree).

Table 1**.** *Language background characteristics for participants (n=67) based on parent report.*

| **Characteristic** | ***Mean* (*SD*)** |
|---|---|
| Age of First Spanish Exposure (months) | 0.30 (1.61) [Range: 0-12] |
| Age of First English Exposure (months) | 11.42 (15.06) [Range: 0-48] |
| Current Spanish Input/Output (% of waking hrs) [a] | 54% (16) [Range: 22-84] |
| Language of Instruction at School/Daycare | Spanish: 6, English: 29, Both: 29 |
| | No school/daycare: 3 |
| Maternal Education (1-6 scale) [b] | 3.19 (1.77) [Range: 1-6] |
| Nonverbal Intelligence Std. Score (Leiter-3) | 104.12 (7.25) [Range: 87-123] |
| BESA Spanish Morphosyntax Std. Score | 86.70 (17.48) [Range: 55-123] |
| BESA Spanish Semantics Std. Score | 103.75 (13.43) [Range: 70-130] |
| BESA English Morphosyntax Std. Score | 93.86 (17.77) [Range: 62-118] |
| BESA English Semantics Std. Score | 100.21 (14.14) [Range: 65-123] |
| BESA Language Index [c] | 102.16 (12.77) [Range: 71-126] |

[a] From the Bilingual Input Output Survey (BIOS) in the Bilingual English Spanish Assessment (BESA), completed during the parent interview. Spanish input/output represents an average of the proportion of waking hours during which a child hears Spanish and speaks Spanish. Time periods when both Spanish and English are heard/used are treated as 50% Spanish in the calculation of Spanish input/out, regardless of the actual language breakdown during this time.
[b] Scale: 1 = < HS, 2 = HS/GED, 3 = some college/2-year degree, 4 = BA, 5 = MA, 6 = Doctorate
[c] The Language Index represents overall language ability and is derived by combining the child's highest Morphosyntax score (English or Spanish) and highest Semantics score (English or Spanish). For a child with mixed dominance, the Language Index could combine, for example, morphosyntax in English and semantics in Spanish.

## General Procedure

The study was completed over three or four 1-1.5 hour individual sessions in a laboratory setting at the Waisman Center. The three versions of the scripted confederate dialogue task (English, Spanish, Dual-Language) were each administered at the beginning of a session. However, for a few children who were hesitant to participate after the practice or the first few trials ($n$ = 5), the task was resumed later in the session once the child felt more comfortable. In one exceptional case, a child continued to provide null responses on the dual-language condition during the first session even during this second attempt, and the task was re-administered in a fourth session using version B instead of version A to reduce practice effects. The standardized assessments of vocabulary, language ability, and nonverbal intelligence were distributed across sessions. The cognitive control measure, a computerized Dimensional Change Card Sort, could be administered in any session, as long as it occurred after the children had completed the dual-language version of the scripted confederate dialogue task. At the end of the last session, the children completed a vocabulary post-test in each language to assess their knowledge of the English and Spanish words for the nouns and verbs depicted in the scenes from the scripted confederate dialogue task.

The majority of testing was completed by the first author (*n* = 55), who is a certified bilingual speech-language pathologist. When this was not possible due to scheduling conflicts (*n* = 12), some parts of the standardized testing were completed by another certified bilingual speech-language pathologist, a graduate student in speech-language pathology with a high level of Spanish proficiency, or a thoroughly trained undergraduate student who was a native speaker of Spanish. The first author administered the scripted confederate dialogue task to all children but two. For one child, the English condition was administered to one child by a different English-dominant speech-language pathologist, and for another child, the second half of the Spanish condition (after the first author had conducted the practice portion and the first two blocks) was administered by a native Spanish-speaking speech-language pathologist.

Parents (17 fathers, 50 mothers) were interviewed in their preferred language about their child's development, medical and educational history, language history, and current language use and exposure. They also completed the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007) to provide information about their own language background and level of education (as a proxy for socioeconomic status). The Inventory to Assess Language Knowledge (ITALK) from the Bilingual English Spanish Assessment (BESA, Peña et al, 2014) was administered to obtain parent ratings of their child's language skills, as well as a measure of parent language concerns. Parents rated their child's abilities in English and Spanish on a 1-5 scale for vocabulary, speech, sentence production, grammar, and comprehension and indicated whether they were concerned about how their child talks. Average ratings below 4.2 in both languages are considered an indicator for further assessment. Sixteen parents provided average ratings below 4.2 in both languages and/or indicated that they had concerns, but only 10 of these parents also shared concerns during the general parent interview and only five of the children exhibited additional red flags, including low BESA scores and/or a history of language services. There were 17 parents who shared concerns during the general interview but not on the ITALK and seven children who obtained low scores or presented with a history of language services that were not flagged for concern by the ITALK. These inconsistencies underscore the difficulty of identifying SLI in bilingual children and lend support to the continuum approach used in this study. The ITALK was used as one possible measure of parent concern but the ratings were not used in any analyses.

Parents also completed the Bilingual Input Output Survey (BIOS) from the BESA. The BIOS provides information about both cumulative and current language exposure. The current study focused on the measure of current exposure, in which parents indicated, for each half hour that their child is awake on a typical weekday and weekend, who their child is with, what language the child hears (English, Spanish, or both) and what language the child speaks (English, Spanish, or both). Parents reported on language exposure and use during school hours to the best of their ability. The formula for calculating the proportion of input and output in Spanish vs. English treats exposure to “both” as 50% Spanish and 50% English, but parents sometimes indicated that periods of dual-language exposure were not necessarily balanced. Spanish input and output proportions were averaged together to obtain Spanish input/output values as described in the BESA manual (Peña et al., 2014).

**Standardized Assessments**

The *Leiter International Performance Scale* (Leiter-3; Roid, Miller, Pomplun & Koch, 2013) was administered to ensure that all participants had nonverbal intelligence within normal limits (i.e., > 85). The Leiter was developed specifically for special populations, including

English language learners and children with communication impairments, and uses a fully nonverbal pantomime administration.

To measure language ability, children completed the English and Spanish morphosyntax and semantics subtests from the *Bilingual English-Spanish Assessment* (BESA; Peña et al., 2014). The higher morphosyntax score (whether in English or Spanish) was combined with the higher semantics score to obtain a Language Index score. For a child with mixed dominance, the Language Index could reflect, for example, a combination of morphosyntax skills in English and semantics skills in Spanish. Children are also permitted to code-switch during the assessment, such that they can receive credit for English responses on the Spanish semantics subtest, as long as the answer demonstrates understanding of the question. The Language Index has good sensitivity (88.9-96.0, depending on age group) and specificity (84.9-92.4, depending on age group) for detecting language impairment in 4-6 year old Spanish/English bilingual children (Peña et al., 2014). In the current study, the Language Index was used as a continuous variable to index overall language ability.

## Scripted Confederate Dialogue Task

Children participated in a computerized scripted confederate dialogue task to assess their language control abilities. Full details about the development and norming of the paradigm and stimuli are presented in another study examining costs of language switching at the discourse level (Gross & Kaushanskaya, in preparation [this dissertation, Chapter 2]). Here we focus on the task details most relevant to the current study.

**Procedure.** Children were told that they would play a game with someone in another room, and a video of the confederate was presented to the child on a computer screen. All confederates presented themselves to the children as monolingual speakers of English or Spanish (e.g., “My name is Ashley and I only speak English”; “Me llamo Maria y sólo hablo español”). The confederate videos were pre-recorded to preserve experimental control, but feedback contingencies were programmed into the experiment so that the interaction would seem as natural as possible. Children played three games in three separate sessions, with at least one week between sessions: 1) *single-language* with an English-speaking partner, 2) *single-language* with a Spanish-speaking partner, and 3) *dual-language* with turns alternating pseudo-randomly between a new Spanish-speaking partner and a new English-speaking partner. To avoid confounding the effects of dual-language context with order effects, the dual-language game was presented in the first session for approximately half of the children ($n$ = 31) and in the last session for the rest ($n$ = 36). The order of the single-language games was determined based on the child’s preferred language (as expressed by the parent or the child: 36 English first, 31 Spanish first).

The task was presented using E-Prime 2.0 (build 2.0.10.242, Psychology Software Tools, 2012) on a desktop computer with a 23-inch monitor and a resolution of 1920 x 1080. Each game included 20 trials composed of a guessing phase and a description phase. During the guessing phase, the child saw two pictures and the confederate produced a sentence describing one of them (e.g., “The boy is watching the airplane in the sky. Can you find this picture?”). The child had 20 seconds to push a button on a serial response box to indicate which picture the confederate was describing. During the description phase, the child saw one picture and was instructed to describe it to the confederate (e.g., “Now it’s your turn. Tell me about your picture and I’ll try to find it.”). If the child produced a description within the 30-second window, the experimenter discretely pushed the space bar to advance the trial and the confederate acknowledged the response (e.g., “Thanks! I’ll try this one”) and pushed a button on her own button box. If the child did not produce a description or indicated "I don't know," the confederate reminded the child to try to say something about the pictures, and the experiment proceeded to the next trial. When possible, the experimenter noted a rough transcription and the language used by the child on each trial. Audio and/or video recordings (depending on parent permission) were made for later coding. To provide motivation, children were told they would earn a star each time they found the confederate's picture and each time the confederate found their picture. Every five trials children received a break and saw how many stars they had earned (randomly generated to show progress, but not contingent on actual accuracy), and at the end of the game they got to pick one sticker for every ten stars earned.

The experimenter provided a brief overview of the game in the language of the task for the single-language games (unless the child specifically requested otherwise) and in the child's preferred language for the dual-language game. Then the video confederate introduced herself and demonstrated how to play the game through two practice trials. In the dual-language version, the confederate who spoke the child's preferred language introduced the game and presented the first practice trial, and the confederate who spoke the other language presented the second practice trial. Beyond the presentation of the confederates as monolingual speakers, children were never explicitly told to speak a certain language. If they asked which language to use, they were encouraged to speak so that their partner would understand. The experimenter spoke as little as possible during the task, prompting the child when necessary to maintain on-task behavior. To create a consistent language environment, the experimenter generally used the same language as the current confederate, but the children knew the experimenter was bilingual and sometimes addressed the experimenter and the confederate in different languages. The task was administered by the first author so that any influence of the experimenter's linguistic background on the language choice of participants would be consistent.

**Materials.** The task included 20 pairs of picture scenes that differed in one element (subject, object, or location) for the guessing phase, as well as 20 scenes for the child to describe back to the confederate in the description phase. The scenes were created in Adobe Photoshop CC 2015 and consisted of object and action images from the International Picture Naming Database (Center for Research in Language, accessed 2014; Snodgrass & Vanderwart, 1980; Szekely et al., 2004) and similarly styled clipart or manual drawings. The sentences produced by the confederate were 8-11 words long and followed the structure NP VP NP PP (e.g., The girl is hiding the book behind the chair). The description scenes were constructed with animate subjects performing an action on an object in a location so that they could be naturally described with this structure as well. The description scenes and guessing scenes were designed to have minimal overlap to reduce lexical priming effects. The scene elements (subject, verb, object, location) were selected to have English and Spanish labels that were non-cognates, early-acquired (CLEX database for acquisition norms from the American English and Mexican Spanish versions of the MacArthur Communicative Development Inventories, Center for Child Language; Dale & Fenson, 1996; Jackson-Maldonado et al., 2003) and high-frequency (at least 10 tokens per million in the Corpus of Contemporary American English [Davies, 2008] and the Corpus del Español [Davies, 2002]). At the end of the final session, children completed a vocabulary post-test to assess their knowledge of the English and Spanish words for these scene elements.

Each condition (English, Spanish, Dual-Language) included the same set of stimuli but in a different pseudorandomized order (Research Randomizer, Urbaniak & Plous, 2013) in which none of the elements (subject, verb, object, location) of a description scene repeated in consecutive trials. The guessing scene pairs and description scenes were yoked such that a given description scene always followed the same guessing scene pair in each condition. The yoked pairs were carefully selected to ensure no lexical or semantic overlap between the sentence that the child heard and the picture that the child needed to describe. For the dual-language condition, half of the trials were presented by the English-speaking confederate and half were presented by the Spanish-speaking confederate. The sequence of English and Spanish trials in the mixed list was pseudo-randomized to ensure no more than four consecutive trials in a single language and to ensure that half of the trials required a switch in languages from the previous trial. Two versions of the dual-language block were created such that trials presented by the English-speaking confederate in version A were presented by the Spanish-speaking confederate in version B, and vice versa. Thus, a given item occurred in the dual-language condition in only one language for a single participant, but it was presented in both languages across participants (34 children received version A, 33 received version B).

Four adult female confederates (two functionally monolingual English speakers and two functionally monolingual Spanish speakers) were rotated across the different conditions to create two versions of the English-only block (one with each English speaker), two versions of the Spanish-only block, and eight versions of the dual-language block (one with each possible combination of English and Spanish speakers, for both version A and version B). Children were assigned (based on the sequence of their ID number) to a combination of English, Spanish and Dual-Language versions where the speakers in the dual-language block were distinct from the speakers in the single-language blocks (e.g., English S1, Spanish S2, Dual-Language with English S2 and Spanish S1).

**Coding.** Each picture description provided by the child was coded as "English," "Spanish," or "Mixed." The task was audio recorded, as well as video recorded if permitted by the parent, to allow for later coding of responses. The majority of task blocks (75%) were coded on-line by the first author while the child was performing the task, and the codes for each picture description were entered into a database by trained research assistants. However, if the experimenter was unsure how to code a particular description or if coding had not been conducted on-line, the video or audio recording was reviewed by the first author or a trained research assistant to code the language of each description. To assess reliability, a bilingual speech-language pathologist reviewed the audio recordings for 10% of the data and coded the language of the responses. Inter-rater reliability was 96.9%.

Based on these language codes, scene descriptions were then coded for the presence of cross-language intrusions, defined as producing at least one word in the language not understood by the current confederate for that trial (i.e., descriptions coded as "Mixed" or "Spanish" addressed to the English-speaking confederate). Scene descriptions containing a cross-language intrusion received a code of "1" and scene descriptions not containing a cross-language intrusions received a code of "0." Trials were excluded from the analysis if the child did not provide a response ($n$ = 33 trials), indicated that he or she didn't know what to say ($n$ = 118 trials), provided a response that was too unintelligible to identify cross-language intrusions ($n$ = 1 trial), or provided an entirely unrelated response that was not an attempt to describe the picture ($n$ = 15 trials). An additional four trials were excluded due to technical failure or because the child needed to leave the room before one of the scheduled breaks. Overall, these exclusions resulted in the loss of 4.25% of the total trials.

To assess the ability of participants to complete the task in both languages, responses on the vocabulary post-test were coded for attempts to name the nouns and verbs used to make up the description scenes in each language. Even if the response provided by the child was not the anticipated label, the child received credit for retrieving a word in the target language in response to the picture. This coding was completed by the first author and a trained research assistant, and 20% of the data was re-coded by a research assistant who was a native speaker of Spanish. Inter-rater reliability was 96.5%. Two children who produced only 4 or 5 English words throughout the 38 items of the English post-test were excluded from the analysis for having expressive English skills significantly lower than the rest of the sample ($z < -3.29$) such that one could not reasonably expect them to respond in English during the scripted confederate dialogue task. The post-test in Spanish did not reveal any participants with *z*-scores more extreme than 3.29.

**Dimensional Change Card Sort (DCCS)**

As a measure of cognitive control, children completed a version of the Dimensional Change Card Sort (DCCS) that integrated components of the color-shape game used by Bialystok & Martin (2004) and the DCCS task created for the NIH toolbox (Zelazo et al., 2013). This version of the DCCS was initially designed for a project examining language and executive function in older children (ages 8-11) with typical language, specific language impairment, and autism spectrum disorder (e.g., Kaushanskaya, Park, Gangopadhyay, Davidson, & Ellis Weismer, 2017), but versions of the DCCS have often been used with 4-6 year old children (e.g., Bialystok & Martin, 2004; DiFrye, Zelazo, & Palfai, 1995; Zelazo, 2006; Zelazo et al., 2013). Our version was designed to reduce linguistic demands by using simple red circles and blue squares as stimuli, pairing initial verbal instructions (in the child's preferred language) with photographs that illustrated what to do, and using non-linguistic sorting cues (a row of amorphous color patches for sorting by color and a row of grey circles and squares for shorting by shape). The cues remained throughout the trial to reduce working memory demands.

The DCCS was presented using E-Prime 2.0 on a desktop computer with a 23-inch monitor. For each trial, the sorting cue appeared at the top of the screen, and, after 500 ms, the stimulus (a red square or blue circle) appeared in the center of the screen while the cue remained at the top. Throughout the task, grey response buckets marked with a red square and a blue circle were present at the left and right bottom corners of the screen. Children were instructed to sort the stimulus into one of the buckets by pressing the left or right button on a serial response box. Following the child's response, or at the end of the 10-second response window, the next trial began after an inter-trial interval of 800 ms.

The task included three phases: pre-switch, post-switch, and mixed. During the *pre-switch* phase, the children were introduced to the "color game" by showing them how to sort the blue square into the bucket marked with the blue circle and the red circle into the bucket marked with the red square by pushing the corresponding buttons. To ensure that children understood the basic idea of pushing a button to sort the stimuli, they completed four practice trials with feedback, and the instructions and practice were repeated if children made more than one mistake. Then the child completed the 5 pre-switch trials with no feedback. In the *post-switch* phase, children had to shift from sorting by color to sorting the same stimuli by shape. To respond correctly, children had to *shift* mental sets to the new dimension and *inhibit* their attention to color and the prepotent response to sort by color. For example, in the post-switch phase they needed to put the blue square in the bucket marked with the red square, even though in the pre-switch phase it would have gone in the opposite bucket (Figure 1). Children were introduced to this new "shape game" with an example of how to sort each stimulus, but they completed the 5 post-switch trials with no practice to avoid diluting the effect of the shift in sorting rules. All children advanced from the pre-switch to the post-switch phase, regardless of performance on the pre-switch phase.

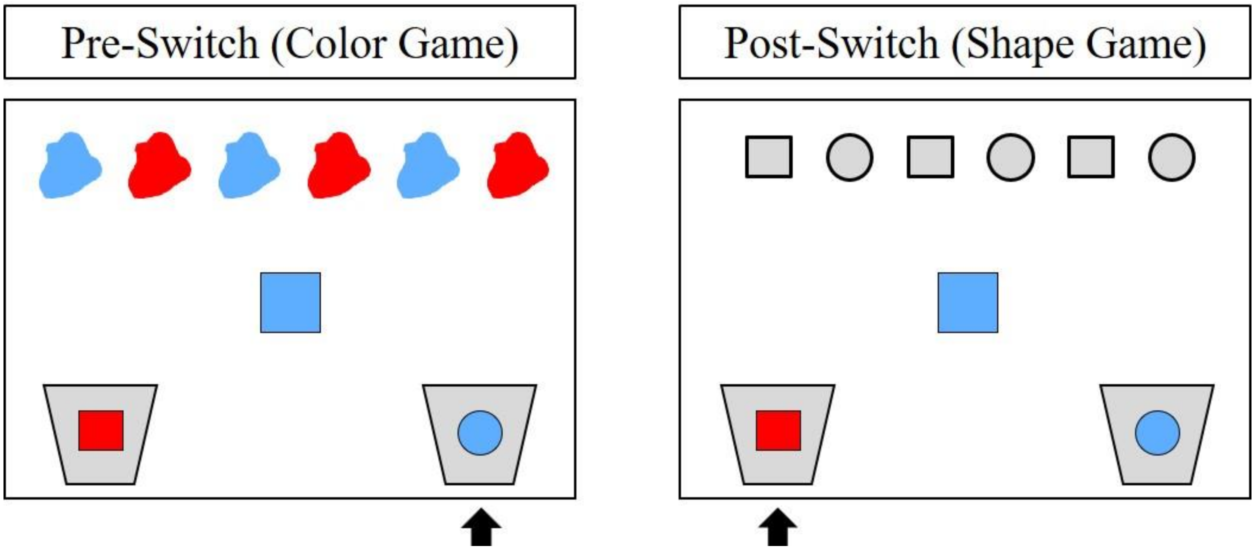


*Figure 1*. Schematic of Dimensional Change Card Sort (DCCS) task, depicting the shift from the pre-switch phase (left) in which children sort the stimuli by color, to the post-switch phase (right) in which child must shift to sorting the same stimuli by shape.

Finally, the children were told they would play both games together in the *mixed* phase (30 trials) and were instructed to look at the cues at the top of the screen each time to see which game to play. The mixed phase followed the design of the NIH toolbox version of the DCCS (Zelazo et al., 2013) such that there were more shape trials (n=23) than color trials (n=7) in order to create a bias toward sorting by shape; this made the switches to color more unexpected and more challenging. The trials were presented in a fixed pseudorandomized sequence in which there were 2-5 shape trials between each color trial and color trials never repeated consecutively. This resulted in 13 *switch* trials when the sorting rule changed from the previous trial and 17 *stay* trials when the sorting rule was the same as the previous trial. Unlike the NIH toolbox version, all chidlren advanced to the mixed phase regardless of performance on the post-switch phase. Accuracy on the mixed phase has been a useful index of cognitive control in our previous work with 5-7 year-old children using a slightly different version of the DCCS with an equal number of shape and color trials (Gross & Kaushanskaya, 2018). Although the age range in the current study is slightly younger, and young children have generally not been very successful in the mixed version (e.g., Zelazo, 2006; Zelazo et al, 2013), we wanted to have the option of using the mixed phase as our index of cognitive control. This phase indexes the ability to maintain both sorting rules in mind, to *monitor* cues on each trial, and to *switch* back and forth between sorting rules, rather than just making a single shift to a new rule as in the post-switch phase.

Accuracy and reaction time data were collected for each trial. However, we did not analyze the reaction time data in the current study. Prior work on cognitive control in young children has suggested that accuracy may better index performance than reaction time (e.g., Davidson et al., 2006; Diamond & Kirkham, 2005). Reaction times are only analyzed for correct trials, and young children who make many errors will therefore have few data points in an analysis of reaction time; instead, errors may be capturing the relevant patterns of performance.

Table 2 displays the average accuracy for each condition (pre-switch, post-switch, mixed), as well as stay vs. switch trials within the mixed phase. Overall accuracy was quite low in the mixed phase (58%), with little difference between stay (60%) and switch (55%) trials, suggesting that this phase may have been too challenging for the age range in the current study. There were several children who sorted by only one dimension on at least 29 out of the 30 trials ($n$ = 5 for shape, $n$ = 6 for color). Because of the imbalance in color and shape trials, children who played the shape game on almost every trial would still achieve over 70% accuracy, while children who played the color game on almost every trial would achieve less than 30% accuracy, even though neither group of children was engaging in switching as instructed. For all these reasons, we decided not to use the mixed phase as our index of cognitive control in the current study. Instead, we focused on the shift from the pre-switch phase to the post-switch phase, which is often the focus of studies using the DCCS in preschoolers (e.g., Bialystok & Martin, 2004; Diamond, Carlson, & Beck, 2005; Rennie, Bull, & Diamond, 2004).

We scored the post-switch phase on a pass/fail basis, in keeping with the approach of previous work (e.g., Diamond et al., 2005; Rennie et al., 2004; Zelazo, 2006). Children who responded correctly on 4/5 trials were considered to pass, and all other children were considered to fail. Children who passed the DCCS were significantly older ($n$ = 42, $M$ = 5.50, $SD$ = 0.88) than children who failed ($n$ = 25, $M$ = 4.98, $SD$ = 0.89), $t(65) = 2.34$, $p = .02$. They did not differ on other variables, including SES, nonverbal IQ, language ability, English age of acquisition, or current language exposure (all $p$s > .30).

In addition, we also calculated *shifting costs* as a more nuanced measure of cognitive control. As opposed to a binary pass/fail measure based only on post-switch performance, shifting costs subtract post-switch accuracy from baseline accuracy on the pre-switch condition. These costs provide similar information to the pass/fail scoring but provide a more graded distinction among those who did not shift sorting dimensions at all ($n$ = 9, cost = 1.0), those who shifted initially and then forgot or who took a few trials to switch ($n$ = 14, costs 0.4 - 0.8), those who shifted almost perfectly ($n$ = 9, cost = 0.2), and those who shifted perfectly ($n$ = 27, cost = 0). Negative values represent better performance in the post-switch condition than the pre-switch condition. Slight negative costs (e.g., -0.2) occurred for three children who missed one item during the pre-switch phase as they were adjusting to the task but obtained perfect scores on the post-switch phase; these were not considered to be unusual. However, five children obtained negative shift costs more extreme than -0.2 due to uncharacteristically low performance on the pre-switch phase (0.6 or less) and perfect accuracy on the post-switch phase. Because highly negative shifting costs are difficult to interpret, these children were removed from analyses involving shifting costs. One child with a low score of 0.6 on the pre-switch phase was still retained because he also had difficulty with the post-switch phase, and thus the low score on the pre-switch phase appeared representative. An analysis with the full sample of children still yielded the same pattern of results, but in this paper we present the analysis without the five children exhibiting extreme negative shifting costs. These five children had typical language ability and did not differ systematically from the rest of the sample in terms of age, SES, nonverbal IQ, language scores, or Spanish exposure. Table 2 also includes a summary of DCCS performance for the subset of 62.

Table 2. *Proportion correct for conditions of the Dimensional Change Card Sort (DCCS).*

| | Full Sample (*n* = 67) | | Subset[a] (*n* = 62) | |
|---|---|---|---|---|
| Condition | Mean (SD) | Range | Mean (SD) | Range |
| PreSwitch (Color Game) | .91 (.16) | .20 - 1.0 | .95 (.10) | .60 - 1.0 |
| PostSwitch (Shape Game) | .66 (.40) | 0 - 1.0 | .64 (.40) | 0 - 1.0 |
| Shifting Cost (Pre-Post) | .25 (.43) | -.60 - 1.0 | .31 (.40) | -.20 - 1.0 |
| Mixed Phase Overall | .58 (.20) | .20 - .83 | .57 (.20) | .20 - .83 |
| Mixed Phase Stay Trials | .60 (.33) | 0 - 1.0 | .59 (.34) | 0 - 1.0 |
| Mixed Phase Switch Trials | .55 (.12) | .38 - .92 | .55 (.12) | .38 - .92 |

[a] Five children were observed to have highly negative shifting costs due to uncharacteristically low performance on the pre-switch phase relative to the rest of the task. These children were removed from the analysis in which shifting costs were used to index cognitive control.

**Analyses**

To address the current study's research questions about linguistic and cognitive predictors of language control, mixed effects logistic regression models were conducted to examine the effects of overall language ability and cognitive control on the odds of producing a cross-language intrusion (coded as "1" vs. "0"). In addition to examining the main effects of language ability and cognitive control, we were also interested in whether these skills would modulate children's ability to maintain language control in a dual-language context. Thus, our models included context (single-language [-1] vs. dual-language [1]) and its interaction with language ability and/or cognitive control. Context was sum coded as -1 and 1, such that the coefficients for language ability and cognitive control would reflect the effects of these predictors on the dependent variable, collapsing across contexts. Any other dichotomous variables included as covariates or predictors of interest were also sum-coded, and the codes assigned are indicated in the text and tables to facilitate interpretation of the coefficients reported. Continuous variables were both centered and scaled (i.e., standardized) to promote model convergence. Following the "keep it maximal" approach (Barr, Levy, Scheepers, & Tily, 2013), all models included random intercepts for participants and items, random by-participant and by-item slopes for context, and random by-item slopes for language ability, cognitive control, and their interactions with context. All models were evaluated using the mixed() function from the afex package (Singmann, Bolker, Westfall & Aust, 2018; version 0.20-2) in R version 3.4.4 (R Core Team, 2018). This function uses the package lme4 (Bates, Maechler, Bolker & Walker, 2015; version 1.1-17) to examine the specified model and to create restricted models with each predictor removed. The significance of a given predictor is established through a likelihood ratio chi-square test comparing the full model to the restricted model with the focal predictor removed (Bolker, 2014; Bolker, 2018; Social Science Computing Cooperative, 2016).

Partner language (i.e., the language used by the confederate to address the child on each trial) was not included as a predictor in the current study for the following reasons. First, we are examining the effects of cognitive control and overall language ability (not language-specific skills) on language control as a whole, regardless of which language the child was expected to use on a given trial. Second, it is difficult to determine the most appropriate way to code partner language in the current sample. As in our previous work using this paradigm (Gross & Kaushanskaya, in preparation [this dissertation, Chapter 2]), some children exhibited stronger skills in English ($n$ = 39) and some children exhibited stronger skills in Spanish ($n$ = 28) during the BESA. Therefore, coding partner language as English vs. Spanish would not consistently align with language dominance in the sample. However, in the current study there were more children who obtained very similar scores in the two languages ($n$ = 18), including 6 children who obtained low scores below 85 in both languages. Coding partner language as "dominant" vs. "non-dominant" based on BESA performance may not be fully representative for these children. Third, we are already interested in a three-way interaction among context, language ability, and cognitive control; a four-way interaction also including partner language would be too difficult to interpret. A preliminary examination of models including partner language did not yield any significant interactions with context, whether language was coded as English/Spanish ($\chi^2(1)$ = 1.19, $p$ = .27) or dominant/non-dominant ($\chi^2(1)$ = 0.46, $p$ = .50). Given our theoretical and practical motivation, and the empirical evidence that the effect of context did not vary across languages, we felt comfortable focusing on the effects of context without including partner language.

Before constructing models to test our research questions, we examined potential covariates that may also explain variation in language control. Based on our previous work (Gross & Kaushanskaya, in preparation [this dissertation, Chapter 2]), we included age, and we also examined the potential contribution of socioeconomic status, which varied widely within our sample. Socioeconomic status was indexed by the highest level of education completed by the child's mother, on a 1-6 Likert scale. However, based on visual inspection of a scatterplot and because the intervals between points on the Likert scale are not necessarily equal, we also tested SES as a categorical variable, contrasting maternal education levels less than a Bachelor's degree (i.e., levels 1-3, $n$ = 35, "low SES") with maternal education levels of a Bachelor's degree, Master's degree, or Doctoral degree (i.e., levels 4-6, $n$ = 32, "high SES"). Next, we tested for any significant effects of counterbalanced manipulations, including the version of the dual-language condition (A vs. B) and the order in which the dual-language condition was administered (in the first session vs. the last session). We followed up any significant effects with demographic comparisons to determine whether the effect was truly an effect of version or order, in which case the variable would be retained in subsequent models, or whether it was driven by a child characteristic that should be included as an additional covariate.

To address our first research question about the role of overall language ability, we included the BESA Language Index score and its interaction with context in a model containing our control variables. To address our second research question about the role of cognitive control, we included performance on the Dimensional Change Card Sort (DCCS) and its interaction with context in a model containing our control variables. We operationalized performance on the DCCS as a dichotomous pass/fail variable. To address our third research question about the relationship between language ability and cognitive control in their effects on language control, we included both the BESA Language Index score and DCCS performance in a model containing our control variables, as well as their interactions with each other and with context. In addition, we constructed another model using shifting costs as a more nuanced measure of performance on the DCCS.

## Results

### Assessing Control Variables

Age had a significant effect on language control ($\chi^2(1) = 4.88$, $p = .03$, $b = -0.53$, $SE = 0.23$), with older children less likely to produce cross-language intrusions. When the 1-6 Likert scale values for socioeconomic status were treated as a continuous variable in a model also containing age, SES had a significant effect on language control ($\chi^2(1) = 7.46$, $p = .006$, $b = -0.59$, $SE = 0.21$), such that children with higher levels of maternal education were less likely to produce cross-language intrusions. When SES was treated as a categorical variable, children with low SES (levels 1-3, less than Bachelor's degree) were significantly more likely to produce cross-language intrusions than children with high SES (levels 4-6, Bachelor's degree and above), $\chi^2(1) = 12.28$, $p < .001$, $b = 0.75$, $SE = 0.21$. The AIC, BIC, and deviance values suggested that the model containing this categorical variable was a better fit to the data than the model with the Likert scale treated as a continuous variable. Thus, SES was included as a categorical variable (High [-1] vs. Low [1]) in all subsequent models, such that a positive coefficient would reflect more cross-language intrusions in children with lower SES. Neither SES ($\chi^2(1) = 0.02$, $p = .89$), nor age ($\chi^2(1) = 0.78$, $p = .38$) interacted with the effect of context.

In a model controlling for the effects of age and SES, children who received version B of the dual-language condition performed equivalently to children who received version A ($\chi^2(1) = 0.27$, $p = .60$), and there was no interaction between version and context ($\chi^2(1) = 0.12$, $p = .73$).

Therefore, version was not included in any subsequent models. With regard to order, children who received the dual-language condition in the first session tended to produce more cross-language intrusions than children who received the dual-language condition in the last session (*b* = 0.36, *SE* = 0.20), although this effect did not reach statistical significance ($\chi^2(1) = 3.12$, *p* = .08). Although order was intended to be assigned randomly, an examination of demographic characteristics revealed that children who received the dual-language condition last had significantly higher Spanish exposure as indexed by the input/output measure from the BIOS (*M* = .57, *SD* = 0.16) than children who received the dual-language condition first (*M* = .49, *SD* = 0.16), *t*(65) = 2.07, *p* = .04. Once Spanish input/output was included in the model, any potential effect of order was no longer present ($\chi^2(1) = 1.30$, *p* = .25, *b* = 0.24, *SE* = 0.20). Further examination of the effects of Spanish input/output in a model containing the previously identified covariates of age and SES revealed both a significant main effect ($\chi^2(1) = 7.32$, *p* = .007, *b* = -0.55, *SE* = 0.20) and a significant interaction with context ($\chi^2(1) = 6.64$, *p* = .01, *b* = 0.19, *SE* = 0.07), such that children with greater Spanish exposure exhibited fewer overall cross-language errors but a larger context effect. Given these findings, subsequent models included age, SES, and Spanish exposure, along with its interaction with context, to control for the effects of these demographic variables on language control prior to testing our effects of interest: language ability and cognitive control. A model with finalized control variables is presented in Table 3.

Table 3. *Mixed-effects logistic regression model of the odds of producing a cross-language intrusion, containing control predictors.*

| Variable | Estimate | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Intercept | -2.04 | 0.21 | | |
| Age (standardized) | -0.69 | 0.21 | 9.78 | .002 |
| SES (High[-1] vs. Low[1]) | 0.81 | 0.20 | 14.96 | <.001 |
| Spanish Input/Output (standardized) | -0.55 | 0.20 | 7.32 | .007 |
| Context (single[-1] vs. dual[1]) | 0.25 | 0.08 | 7.81 | .005 |
| Spanish Input/Output X Context | 0.19 | 0.07 | 6.64 | .01 |

Note: Dichotomous variables were automatically sum coded (-1 vs. 1) by the mixed() function used to evaluate the model. Coefficient estimates are in a log-odds scale. To determine the odds ratio for a dichotomous predictor (e.g., the odds of producing a cross-language intrusion for children with high vs. low SES), the coefficient must be doubled and exponentiated: exp(0.81*2) = increase by a factor of 2.25 in the odds of producing a cross-language intrusion for children with low SES compared to children with high SES. For scaled continuous variables, exponentiating the coefficient yields the factor by which the odds of producing a cross-language intrusion increase (or decrease, if negative) with a one standard deviation increase in the predictor. For example, a 1-SD increase in age is associated with a decrease in the odds of producing a cross-language intrusion by a factor of exp(-0.69) = 0.50.

**The Effect of Language Ability on Language Control**

Controlling for the effects of age, SES, and Spanish exposure, language ability had a significant main effect on language control ($\chi^2(1) = 6.67$, $p = .01$, $b = -0.65$, $SE = 0.25$). For an increase of one standard deviation above the average BESA Language Index score, the odds of producing a cross-language intrusion decreased by a factor of 0.52. Or, viewed from the perspective of children with lower language skills, a 1-SD decrease in the BESA Language Index score nearly doubled the odds (exp(0.65) = 1.91) of producing a cross-language intrusion. A significant increase in cross-language intrusions in the dual-language context ($\chi^2(1) = 6.79$, $p = .009$) was modulated by the control variable Spanish exposure ($\chi^2(1) = 6.85$, $p = .009$) but not by language ability ($\chi^2(1) = 0.30$, $p = .58$). Thus, language ability had an effect on language control overall, but not on the ability to adapt to a dual-language context. With language ability in the model, the effect of SES on language control was no longer significant ($\chi^2(1) = 2.69$, $p = .10$), but the effect of age persisted ($\chi^2(1) = 7.93$, $p = .005$). The Language Index score was correlated with SES on the Likert scale ($r = .52$, $p < .001$), and children with low SES ($M = 94.69$, $SD = 11.46$) had significantly lower Language Index scores than children with high SES ($M = 110.34$, $SD = 8.42$), $t(65) = 6.32$, $p < .001$. However, these relationships were not so strong as to raise concerns of multicollinearity.

**The Effect of Cognitive Control on Language Control**

Controlling for the effects of age, SES, and Spanish exposure, cognitive control did not have a significant effect on language control overall ($\chi^2(1) = 0.51$, $p = .48$, $b = 0.15$, $SE$=0.21) or through an interaction with the effect of context ($\chi^2(1) = 1.46$, $p = .23$, $b = 0.09$, $SE$=0.07). The effects of the control variables (age, SES, Spanish exposure and its interaction with context) remained significant (all $p$s $\leq .01$). Children who failed the DCCS were not significantly more likely than children who passed to produce cross-language intrusions in general or to experience a stronger effect of dual-language context. However, it is possible that the influence of cognitive control on language control depended on children's level of language ability.

**Interrelated Effects of Language Ability and Cognitive Control on Language Control**

Table 4 presents the mixed-effects model in which cognitive control, language ability, and their interaction were included together with the control variables. Collapsing across levels of cognitive control, language ability exerted a significant main effect on language control ($\chi^2(1) = 6.34$, $p = .01$), and this effect did not depend on whether children passed or failed the DCCS ($\chi^2(1) = 0.18$, $p = .67$). For children with average levels of language ability, the overall effect of cognitive control remained non-significant ($\chi^2(1) = 0.66$, $p = .42$). However, there was a trend for the effect of context to vary by cognitive control ($\chi^2(1) = 3.08$, $p = .08$), such that children who failed the DCCS were more affected by the dual-language context than those who passed. Furthermore, this relationship between cognitive control and the effect of context appeared to strengthen with increasing language ability (see Figure 2, top panel), although the three-way interaction did not reach significance ($\chi^2(1) = 3.26$, $p = .07$).

Table 4. *Mixed-effects logistic regression model of linguistic and cognitive predictors of the odds of producing a cross-language intrusion, using the Pass/Fail measure from the DCCS.*

| Variable | Estimate | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Intercept | -2.03 | 0.22 | | |
| Age (standardized) | -0.58 | 0.23 | 6.41 | .01 |
| SES (High[-1] vs. Low[1]) | 0.42 | 0.25 | 2.69 | .10 |
| Spanish Input/Output (standardized) | -0.49 | 0.20 | 5.79 | .02 |
| Context (single[-1] vs. dual[1]) | 0.28 | 0.10 | 7.90 | .005 |
| Spanish Input/Output X Context | 0.19 | 0.07 | 7.31 | .007 |
| Language Index (standardized) | -0.65 | 0.26 | 6.34 | .01 |
| DCCS (pass[-1] vs. fail[1]) | 0.17 | 0.21 | 0.66 | .42 |
| Language Index X DCCS | 0.09 | 0.20 | 0.18 | .67 |
| Language Index X Context | 0.07 | 0.08 | 0.70 | .40 |
| DCCS X Context | 0.13 | 0.07 | 3.08 | .08 |
| DCCS X Context X Language Index | 0.13 | 0.07 | 3.26 | .07 |

Note: Dichotomous variables were automatically sum coded (-1 vs. 1) by the mixed() function used to evaluate the model. Coefficient estimates are in a log-odds scale.

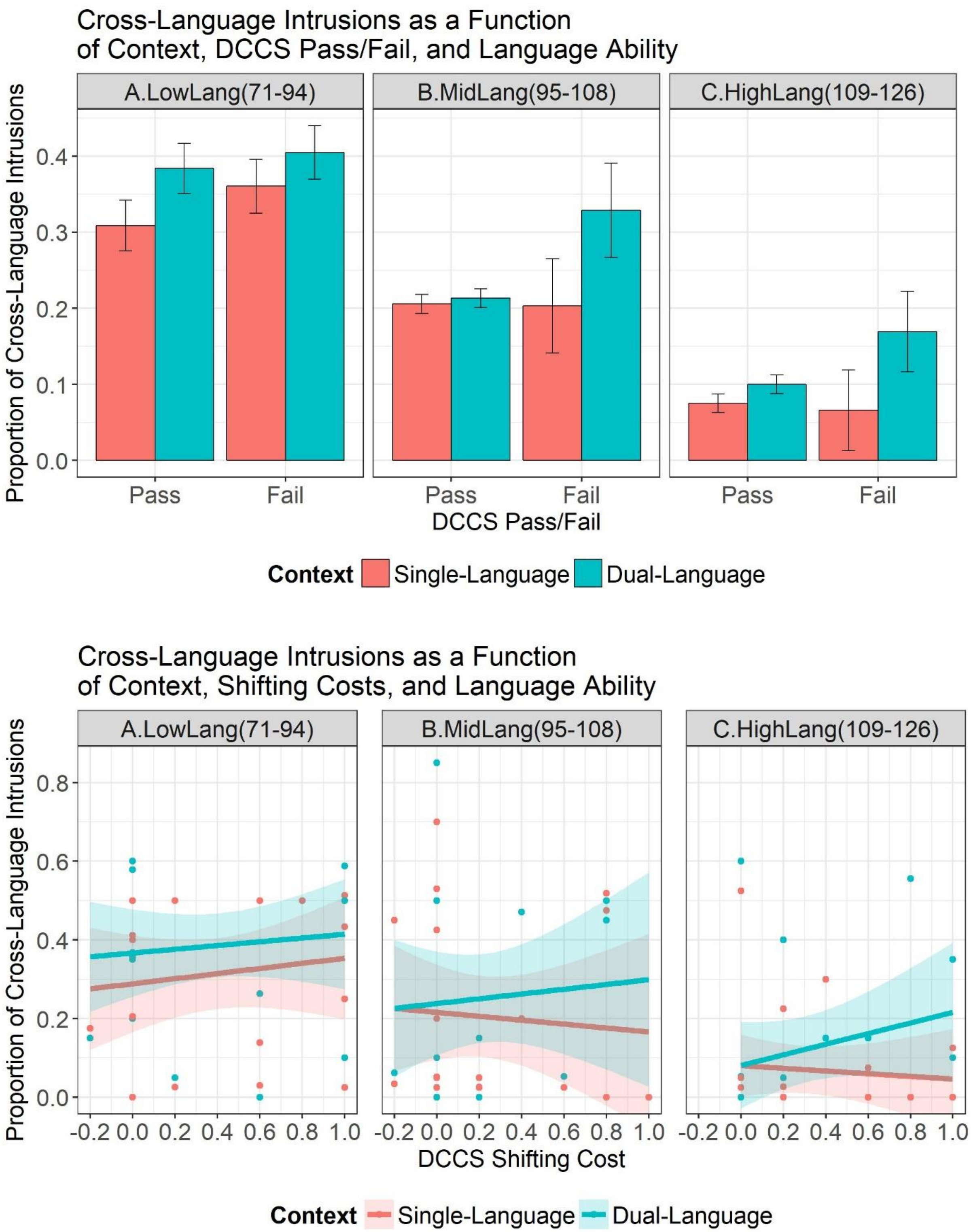


*Figure 2.* Cross-language intrusions (separated by dual-language vs. single-language context) as a function of language ability and cognitive control, operationalized as Pass/Fail on the DCCS post-switch condition (top) and shifting costs comparing DCCS pre-switch and post-switch performance (bottom). Larger shifting cost values reflect more difficulty shifting to a new sorting

rule. Language ability was divided into thirds for graphing, but the Language Index was a continuous variable in the analysis. Plots present raw data (aggregated by participant) and were created in R using the ggplot2 package (Wickham, 2009; version 2.2.1). Bars in the top plot represent condition means (averaged over participants) and error bars reflect one standard error, with corrections for repeated measures within subjects. Data points in the bottom plot represent individual participants (*n* = 62), and ribbons reflect the 95% confidence interval around a smoothed trend line using the glm method. Five participants with uncharacteristically negative shifting costs were excluded here, but the pattern of results was similar when they were included.

To further explore the possibility that the effects of cognitive control on language control are modulated by language ability, we ran an additional model (see Table 5) using shifting costs from the DCCS as a more nuanced measure of cognitive control. Language ability continued to have a robust overall effect on language control ($\chi^2(1) = 6.52$, $p = .01$) that did not vary with shifting costs ($\chi^2(1) = 0.11$, $p = .74$). For children with average language ability, there was no overall effect of cognitive control ($\chi^2(1) = 0.14$, $p = .71$), but cognitive control did significantly modulate the effect of context ($\chi^2(1) = 5.46$, $p = .02$). A 1-SD increase in shifting costs increased the effect of context by a factor of 1.19. Furthermore, a significant three-way interaction ($\chi^2(1) = 4.87$, $p = .03$) revealed that the strength of this relationship increased by a factor of 1.18 for each 1-SD increase in the Language Index score and decreased by a factor of 0.85 for each 1-SD decrease in the Language Index score. As shown in the bottom panel of Figure 2, children with higher language ability exhibited a greater effect of cognitive control on their ability to adapt to the dual-language context.

Table 5. *Mixed-effects logistic regression model of linguistic and cognitive predictors of the odds of producing a cross-language intrusion, using the Shifting Cost measure from the DCCS.*

| Variable | Estimate | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Intercept | -2.10 | 0.22 | | |
| Age (standardized) | -0.54 | 0.24 | 4.78 | .03 |
| SES (High[-1] vs. Low[1]) | 0.39 | 0.27 | 2.05 | .15 |
| Spanish Input/Output (standardized) | -0.47 | 0.21 | 4.67 | .03 |
| Context (single[-1] vs. dual[1]) | 0.29 | 0.10 | 7.07 | .008 |
| Spanish Input/Output X Context | 0.17 | 0.07 | 5.77 | .02 |
| Language Index (standardized) | -0.69 | 0.27 | 6.52 | .01 |
| DCCS Shifting Cost (standardized) | 0.08 | 0.21 | 0.14 | .71 |
| Language Index X Shifting Cost | 0.07 | 0.21 | 0.12 | .74 |
| Language Index X Context | 0.04 | 0.08 | 0.17 | .68 |
| Shifting Cost X Context | 0.18 | 0.07 | 5.46 | .02 |
| Shifting Cost X Context X Language Index | 0.16 | 0.07 | 4.87 | .03 |

Note: Dichotomous variables were automatically sum coded (-1 vs. 1) by the mixed() function used to evaluate the model. Coefficient estimates are in a log-odds scale.

## Discussion

The goal of the current study was to test a framework for understanding children's language control that included both linguistic and cognitive factors. In terms of linguistic factors, we were particularly interested in the role of overall language ability in a broad sample ranging from children with impaired language to those with superior language skills. We found that overall language ability had a robust effect on language control, such that children with better language skills were less likely to produce cross-language intrusions during the scripted confederate dialogue task. This effect did not interact with context, indicating that language ability predicted language control overall, but it did not play a greater role in language control in the dual-language context than the single-language context. With regard to cognitive control, we observed the opposite pattern. Cognitive control did not have an overall effect on language control, but it did interact with context. Children with poorer cognitive control showed a larger increase in cross-language intrusions in the dual-language context relative to the single-language context. Crucially, this effect was further modulated by a three-way interaction with language ability; the effect of cognitive control on children's ability to adapt to the dual-language context was more robust in children with higher language ability.

**The Effect of Language Ability on Language Control**

The finding that overall language ability is a robust continuous predictor of cross-language intrusions contributes to the current literature about linguistic predictors of language control in bilingual children. Past work in children with typical language development has focused on language-specific skills as constraining children's ability to adjust their language choice to accommodate the current conversation partner or language context (e.g., Cantone & Muller, 2005; Gawlitzek-Maiwald & Tracy, 1996; Genesee et al., 1995; Genesee et al., 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Secco, 2000; Ribot & Hoff, 2014). Contributions of overall language ability to language control have been examined mostly in children with language impairment (e.g., Aguilar-Mediavilla et al., 2015; Greene et al., 2013; Greene et al., 2014; Gutierrez-Clellen et al., 2009; Iluz-Cohen & Walters, 2012; Mammolito, 2015; Silva, 2011). The current study demonstrated a relationship between overall language ability and language control in bilingual children across a broad spectrum of ability ranging from impaired to above-average.

Why might overall language ability affect language control? One possibility is that language control is part of the overall integrity of the bilingual language system and is a component of language use that develops as children gain competence as communicators. If the goal of conversation is to achieve mutual understanding through *interactive alignment* (e.g., Garrod & Pickering, 2004; Kootstra, 2009, 2015), then this goal will be most successfully achieved if children use the language that their listener will understand best. Otherwise, they will experience an “interaction cost,” or a disruption to the conversation, which Green and Abutalebi (2013, p. 521) describe as the motivation for exercising language control. Sensitivity to this interaction cost may be related to overall language ability. Such a relationship would be in line with the observation by both Greene and colleagues (2013) and Iluz-Cohen and Walters (2012) that children with language impairment may be less sensitive to sociolinguistic context. In both of their studies, children with language impairment exhibited more language switching from the majority language to their home language than their typically developing peers, who were more likely to switch toward the language with more social prestige. Although we did not specifically examine the direction of switches in the current study, our children with lower language, similar to the rest of the sample, were more likely to switch from Spanish to English than vice versa. However, this may reflect a greater tendency toward English dominance, similar to the participants in Mammolito’s (2015) study, rather than sociolinguistic awareness.

Another possibility is that better underlying language ability gives bilingual children the metalinguistic resources to employ within-language lexical strategies (e.g., circumlocution, using a more general word, using a word with similar meaning) instead of switching into the non-target language when they have gaps in lexical or syntactic knowledge in the target language. Although Greene and colleagues (2014) did not find any differences in the lexical strategies employed by children with low vs. high language ability, their language samples were elicited in the context of telling a narrative in English independently or with support from a clinician. The relationship between language ability and the use of lexical strategies to maintain language control may warrant further investigation in more discourse-based contexts that include both languages, as in the current study.

Yet another possibility is that the effect of overall language ability in the current study was driven by language-specific knowledge. Children with lower overall language ability may have more lexical/syntactic gaps in each language, while children with higher overall language ability may have fewer lexical/syntactic gaps, even in their weaker language. To examine whether overall language ability plays an independent role in language control, over and above the effects of language-specific knowledge, further analysis controlling for lexical gaps is necessary. As evidence that lexical gaps may be dissociated from overall communicative competence, Bonifacci, Barbieri, Tomassini, and Roch (2018) demonstrated that typically developing bilinguals produced narratives in Italian (their second language) with similar story grammar, cohesion, and complexity to their monolingual peers, even though they exhibited lower levels of linguistic knowledge in Italian, particularly in vocabulary. If two children with similar lexical gaps in their less dominant language, but different levels of overall language ability, still show differences in language control, then this would lend support to a role for overall language ability in supporting language control. Such a role for overall language ability would have clinical significance in helping to distinguish language control difficulties that are due to typically distributed linguistic knowledge from those that may reflect an underlying impairment in the bilingual language system.

Although language ability had an overall effect on language control in the current study, it did not affect children's ability to adapt to the dual-language context, as the interaction between language ability and context was not significant. In other words, lower language ability did not make children more susceptible to increased language control difficulties when faced with the additional challenge of having to switch back and forth between languages. This finding could reflect floor effects. If children with lower language ability had difficulty aligning their language choice to their conversation partner even in a single-language context, either due to reduced sensitivity to interaction costs and/or to insufficient skills in the target language, then they may have exhibited this difficulty with language control regardless of context. In addition, the interpretation of reduced sociolinguistic awareness would suggest that children with lower language may also have been less sensitive to the change in context, making their own language choices for each picture description based on their individual abilities or preferences regardless of the interlocutor(s). From a theoretical perspective, it is also possible that language ability contributes to the ability to maintain a particular target language in any context, and the additional challenge of having to shift from one target language to another in a dual-language context relates more to cognitive control.

**The Effect of Cognitive Control on Language Control**

In the current study, there was no main effect of cognitive control on language control, whether cognitive control was measured by a pass/fail criterion on the DCCS or by the more nuanced shifting cost measure. This result diverges from our previous work on language control in children at the single-word level (Gross & Kaushanskaya, 2018), where cognitive control (as measured by accuracy during the mixed phase of the DCCS) predicted cross-language intrusions overall, regardless of context. It is possible that a decontextualized picture-naming paradigm at the single-word level taxes cognitive control even in a single-language context more so than our scripted confederate dialogue paradigm at the discourse level. When children are forced to produce a particular lexical item to name a picture and the only cue to language selection is the auditory cue ("Say" vs. "Diga") produced as the picture appears, children may have to engage their cognitive control skills to a greater extent to inhibit the picture name in the non-target language and to activate the picture name in the correct language. In the single-language condition of the scripted confederate dialogue paradigm, children have more flexibility in the way that they choose to describe the picture and can select other words that are more easily accessible in the target language if there is a specific word that they do not know. In addition, processing input from the confederate in the target language throughout the task may increase the activation of the target language in children's own lexical system, such that less effort is required from domain-general cognitive control to inhibit the non-target language.

This same line of reasoning could explain why in the current study we observed an interaction between cognitive control and context, where the effect of cognitive control on language control was greater in the dual-language context than in the single-language context. Although language priming from the confederate and flexibility to select more accessible words for their picture descriptions may reduce cognitive control demands for inhibiting the non-target language in a single-language discourse context, the dual-language context introduces the additional demand of having to switch between languages. According to the Adaptive Control Hypothesis (Green & Abutalebi, 2013), a single-language context requires goal maintenance to establish the target language and interference control to suppress the non-target language, but a dual-language context requires additional cognitive control processes to monitor the environment for cues that a language switch may be necessary and to execute that switch by disengaging from the current language and engaging the new language. While the children may still have benefitted from language priming through interactive alignment (e.g., Kootstra, 2009, 2015; Kootstra et al., 2010) as they processed the confederate's picture description in the target language prior to having to produce their own picture description, they would only have had brief exposure to this priming effect on the trial following a language switch. Thus, while there are aspects of the discourse paradigm that may have reduced the demands on cognitive control relative to a single-word paradigm, the need to switch languages in the dual-language context still imposed increased demands on cognitive control. The interaction between cognitive control and context in the current study is consistent with the predictions of the Adaptive Control Hypothesis (Green & Abutalebi, 2013) and also with adult language control studies that identified a relationship between cognitive control skills and cross-language intrusions specifically in a dual-language context (e.g., Festman, 2012; Festman & Münte, 2012; Festman, Rodriguez-Fornells & Münte, 2010; Gollan et al., 2014; Gollan & Goldrick, 2016; Prior & Gollan, 2013). The finding of a more global effect of cognitive control in our previous work at the single-word level (Gross & Kaushanskaya, 2018) may reflect heightened demands on language control in the single-language context due to the decontextualized nature of picture-naming tasks.

Another difference from our previous work is the variable from the DCCS used to index cognitive control. In our study with 5-7 year olds, we used overall accuracy during the mixed phase of the DCCS. In the current study, we focused on performance during the post-switch phase, either through a pass/fail criterion or shifting costs that compared post-switch performance to a pre-switch baseline. As shown in the top and bottom panels of Figure 2, both the pass/fail criterion and the shifting cost measures revealed a similar pattern of having a larger impact on language control in the dual-language context, but the more nuanced shifting cost measure may have been more sensitive for detecting a significant effect. It is interesting to note that these measures, which reflect the ability to shift from one dimension to another, were associated with language control in a dual-language context where children had to switch back and forth between languages rather than only shifting once. The mixed phase of the DCCS might have engaged more similar control processes to the dual-language condition of the language control task, but children in the age range for the current study had great difficulty with the mixed phase of the DCCS, consistent with previous work that included 4-year olds (e.g., Frye et al., 1995; Zelazo, 2006; Zelazo et al., 2013).

Based on the results of the post-switch phase of the DCCS, the interaction obtained in the current study suggested that children with better cognitive control skills were more able to meet the increased demands of the dual-language context without exhibiting costs to language control, while children with poorer cognitive control showed an increased production of cross-language intrusions in the dual-language context relative to the single-language context. However, this effect of individual differences in cognitive control depended on children's language ability.

**Inter-related Effects of Cognitive Control and Language Ability on Cognitive Control**

The finding of a three-way interaction among context, cognitive control, and language ability was consistent with our hypothesis that cognitive and linguistic factors may interact in their effects on language control. Specifically, children with higher language ability showed a greater effect of cognitive control on their ability to adapt to a dual-language context. In formulating our hypotheses, we suggested two possible reasons for an increased role for cognitive control at higher levels of language ability. One possibility was a threshold phenomenon. At low levels of language ability, limited linguistic skills may sufficiently constrain children's ability to exercise language control that any variability in cognitive control may not exert additional effects. Alternatively, low language ability may be associated with cognitive control difficulties, such that the effects of language ability and cognitive control would be more intertwined at low levels of language ability.

The latter possibility was not supported by the current study. Comparisons between children who passed and failed the DCCS did not reveal lower language ability among children who failed. Furthermore, shifting costs, our more nuanced measure of cognitive control, were not correlated with language ability ($r$ = -.09, $p$ = .49). Among the 12 children meeting our criteria for SLI, the DCCS pass/fail rate did not differ from the rest of the sample (7/12 vs. 35/55, $p$ = .99), and they did not exhibit significantly higher shifting costs ($p$ = .34), although the numeric difference was in the expected direction ($M_{TD}$ = 0.29, $SD$ = 0.4; $M_{SLI}$ = 0.38, $SD$ = 0.4). Even in the literature on cognitive control in children with language impairment, deficits in shifting skills have been inconsistent (e.g., Dibbets et al., 2006; Im-Bolter et al., 2006; Laloi, 2015; Pauls & Archibald, 2016). In addition, there has been limited work on cognitive control in bilingual children with SLI, and it is possible that they may not show the same level of difficulty with cognitive control as has been observed in monolingual children with SLI (e.g., Peets & Bialystok, 2010). Although Farrant and colleagues (2012) observed deficits in monolingual children with SLI using the DCCS, it is possible that the specific version of the DCCS and/or the outcome measures selected in the current study were not sufficiently sensitive to cognitive control difficulties in bilingual children with low language. Our findings would need to be verified by further work using multiple measures of cognitive control. However, based on the findings obtained in the current study, a threshold effect appears to better explain the interaction obtained between cognitive control and language ability.

A threshold effect would suggest that a certain level of language ability is necessary before cognitive control skills can exert an influence on language control. Viewed from the opposite perspective, a threshold effect could also suggest that, in children with low cognitive control skills, the effects of language ability on language control are constrained. Better language skills may help these children to achieve language control in single-language contexts, but they are still likely to struggle with language control in dual-language contexts due to their difficulties with cognitive control, yielding a gap between performance in single-language and dual-language conditions.

However, the pattern of findings obtained in the current study would suggest that language ability moderates the effects of cognitive control rather than the other way around. We obtained a robust main effect of language ability on language control in all models, whether cognitive control was included or not. In contrast, there was no main effect of cognitive control or even any interaction between cognitive control and context in the model containing cognitive control and the covariates. It was only once the interaction with language ability was included in the model that a role for cognitive control emerged, and only when the more nuanced shifting cost measure was used.

**Limitations and Future Directions**

The current study represents an initial step in the attempt integrate linguistic and cognitive factors in a model of language control in children. To build on these findings, there are limitations that need to be addressed in future work. First, we only administered one measure of cognitive control, and thus the relationships observed in the current study may be specific to the DCCS and the particular version that we employed. Our chosen outcome measure from the DCCS could also have influenced our findings. To gain a better understanding of the contributions of cognitive control to language control, future work should consider a latent variable approach based on multiple measures and tapping multiple constructus.

Second, we focused our analysis of linguistic predictors of cognitive control on a measure of overall language ability. To better understand why overall language ability had a robust effect on language control, future work should also consider language-specific skills and lexical gaps. As a related point, in the current study we examined cross-language intrusions overall, collapsing across target languages. It is possible that the effects of overall language ability and cognitive control observed in the current study may have varied depending on whether the target language was English or Spanish (in terms of sociolinguistic phenomena) or on whether the target language was the child's dominant or non-dominant language.

Third, there are very likely factors other than language ability and cognitive control that exert an influence on language control. Even though language ability was a robust predictor of language control, there was still great variability in language control among children with a similar level of overall language ability. Spanish input/output was included as a covariate in the current study, but further work should consider various measures of exposure to each language and to dual-language input as predictors of interest. Social factors are another key area to explore. We suggested that low language ability may affect language control through reduced sociolinguistic awareness, but we did not directly measure pragmatics or social skills in the current study.

Fourth, a more detailed coding scheme for children's picture descriptions may yield additional insights. For example, anecdotal observation revealed that children varied in the strategies they used when they had limited skills in the target language (e.g., simplifying their response, using a more general word, using a word with similar meaning, abandoning the utterance, saying “I don’t know”, etc.). Further work should consider the linguistic and cognitive factors that predict children’s selection of a productive within-language strategy, as opposed to producing a cross-language intrusion or abandoning the utterance. A related issue is the quality of children’s picture descriptions. Just as Liu and colleagues (2015) observed an increase in morphosyntactic errors following a language switch in bilinguals with lower inhibitory control skills, it is possible that additional effects of cognitive and linguistic factors on language control may be revealed in the semantic and morphosyntactic accuracy of children’s picture descriptions in the dual-language vs. the single-language context.

Fifth, the relationships observed in the current study were correlational and no claims can be made about directionality or causality. Longitudinal work is needed that links changes in linguistic and cognitive skills over time to children’s developing language control skills.

Finally, the current study included a relatively small number of children meeting our criteria for language impairment. While the results based on our continuum approach suggest that children with SLI may be at risk for language control difficulties due to their low language skills, we cannot necessarily conclude that children with SLI produce more cross-language intrusions than children with typical development. A larger sample of children with SLI would be necessary to formally evaluate this claim by conducting group comparisons.

**Conclusion**

The current study revealed a robust effect of language ability and a more limited effect of cognitive control on children’s ability to adjust their language choice to accommodate different monolingual conversation partners in single-language and dual-language settings. Taken together, these findings suggest the need for an integrated model of language control in children that incorporates both linguistic and cognitive factors. The current study has attempted to bridge the gap in past work on language control between the focus on linguistic skills in children and the focus on cognitive control in adults. Although there is still much work to be done to confirm and better understand the pattern of results obtained in the current study, we tentatively suggest an integrated model of language control in children in which linguistic skills play a primary role in determining language control. Once children have sufficient language ability to be able to exercise language control in any context, then the extent to which they are able to adapt to a dual-language context may be predicted by their cognitive control skills.

**Notes**

1. A total of 86 Spanish/English bilingual children in the 4-6 age range were initially recruited to participate in the project, but 19 were excluded from the final sample due to failing the hearing screening ($n$ = 3), suspected neurological impairment ($n$ = 1), growing up abroad with more diverse language exposure than the rest of the sample ($n$ = 3), acquiring Spanish after 12 months ($n$ = 1), choosing not to complete the study ($n$ = 8), being unwilling to participate in all conditions of the scripted confederate dialogue task ($n$ = 1), or demonstrating extremely limited English expressive skills compared to the rest of the sample ($n$ = 2).

## Chapter 4: General Discussion

This dissertation examined the contributions of cognitive and linguistic factors to language control at the discourse level in 4-6 year-old Spanish/English bilingual children with a broad range of language ability, including those with specific language impairment (SLI). I designed a computerized scripted confederate dialogue paradigm to measure children's ability to control their language choice when describing pictures to different confederates who were monolingual speakers of English or Spanish. The measure of language control was children's production of *cross-language intrusions* (i.e., at least one word produced in the language not spoken by their current conversation partner). Aim 1 was to examine whether a dual-language context exerted the same costs on language control at the discourse level as have been shown in picture-naming paradigms at the single-word level (Chapter 2). Aim 2 was to examine whether individual differences in language ability and cognitive control had an overall effect on language control and/or modulated the effect of context, and whether these factors interacted with each other in their effects on language control (Chapter 3). Aim 3 was to explore the language control abilities of children with SLI compared to a matched group of typically developing peers, and to contrast the findings from this approach to an analysis where language ability was treated as a continuum (poster in the Appendix). Below I summarize the main findings for each of the three aims, followed by a more in-depth discussion of the issues and questions raised in the General Introduction.

**Aim 1: Effects of dual-language context.** The findings from this study were not straightforward and depended on the inclusion of partner language (i.e., whether the confederate spoke the child's dominant or non-dominant language) in the model. When partner language was not included, the effect of context on language control was significant, with children tending to produce more cross-language intrusions in the dual-language context than in the single-language context. When partner language was included in the model, which is the standard practice for language switching studies at the single-word level, there was a robust effect of partner language, but the effect of context was no longer significant. There was no interaction between partner language and context, indicating that an overall context cost was not being masked by asymmetrical costs in each language. As a source of comparison, our previous picture-naming study in a similar sample of children (Gross & Kaushanskaya, 2018) yielded a robust effect of context, similar in magnitude to the effect of partner language. Thus, when language control is assessed at the discourse level, a dual-language context does not appear to exert the same cost on language control as has been observed in single-word picture-naming paradigms (e.g., Gross & Kaushanskaya, 2018; Jia, Kohnert, Collado, & Aquino-Garcia, 2006; Kohnert, 2002; Kohnert, Bates, & Hernandez, 1999). Instead, children's tendency to produce cross-language intrusions at the discourse level may be more related to whether they are addressed in their dominant or non-dominant language, regardless of context.

**Aim 2: Contributions of language ability and cognitive control.** Language ability had a robust overall effect on children's language control, where children with lower overall language ability were more likely to produce cross-language intrusions. The effect of language ability did not interact with context, suggesting that the extent to which children experienced costs in the dual-language context did not depend on their level of language ability. Cognitive control had a more restricted effect on children's language control that was only observed once cognitive control and language ability were included in the same model. Unlike language ability, cognitive control did not have an overall effect on language control, but it did interact with the effect of context. This interaction suggested that children with poorer cognitive control were more likely to show costs in the dual-language context. However, this effect of cognitive control on children's ability to adapt to a dual-language context was further moderated by an interaction with language ability, which suggested that cognitive control played a greater role in children with higher language skills.

**Aim 3: Exploratory SLI vs. TLD comparisons.** The comparison between children with SLI and a matched group of children with typical language development suggested that children with SLI had more difficulty with language control, but this difficulty was not magnified in a dual-language context. An exploration of the types of language control errors produced by each group revealed that children with SLI did not produce more mixed-language responses than their typically developing peers. Thus, the group difference in language control appeared to be driven by a greater tendency among children with SLI to provide picture descriptions that were fully in the non-target language. Within the full sample, a model in which language ability was treated as a continuous variable provided a better fit to the data than a model in which the effect of language ability was examined as a categorical contrast between children with and without SLI.

## Costs to Language Control in a Dual-Language Context

In the first paper devoted to the question of whether there are costs to language control in a dual-language context at the discourse level, there were no significant costs once partner language was also included in the model, and any possible effect of context appeared to be less robust than costs obtained at the single-word level in a similar sample of bilingual children (Gross & Kaushanskaya, 2018). Given that costs in a dual-language context relative to a single-language context are usually interpreted to reflect the functioning of control processes, such as inhibition and monitoring (e.g., Bobb & Wodniecka, 2013; Christoffels, Firk, & Schiller, 2007; Kroll, Bobb, Misra, & Guo, 2008; Wang, Kuhl, Chen, & Dong, 2009), this finding could be interpreted to suggest that a dual-language context does not impose increased demands on cognitive control at the discourse level. However, such an interpretation is not consistent with the Adaptive Control Hypothesis (Green & Abutalebi, 2013), which describes the dual-language interactional context as requiring more cognitive control processes to maintain language control than a single-language context.

The findings from the second paper, in which the role of cognitive control was directly examined, shed additional light on the extent to which a dual-language context may increase demands on cognitive control. In this paper, a significant interaction between cognitive control and context was observed. This interaction reflected that children with better cognitive control were less likely to exhibit a cost to language control in the dual-language context relative to the single-language context. Thus, it may be that there are increased demands on cognitive control in the dual-language context at the discourse level, but whether they result in an observable cost depends on children's cognitive control skills and their ability to adapt to those demands. According to Green and Abutalebi (2013), the additional cognitive control processes required in a dual-language context relative to a single-language context include *cue detection* to determine when a language switch is necessary, *selective response inhibition* and *task disengagement* to stop speaking the current language, and *task engagement* to start speaking the new target language.

There are several features of the discourse context that may have facilitated these processes, provided that children had sufficient cognitive control to take advantage of them. There were a variety of salient cues to help children recognize the need to switch languages. The appearance of a new speaker may have helped to signal an upcoming change, and cues from her appearance and prior knowledge of what language she speaks may have helped children to anticipate what the target language should be (e.g., Martin, Molnar, & Carreiras, 2016; Woumans et al., 2015). However, children with poor cognitive control may have had difficulty allocating the attentional resources to benefit from these additional cues.

In addition, children had the opportunity to listen to their partner describe a picture in the target language before they had to produce anything in that language themselves. Studies have shown that comprehending speech in one language prior to having to produce speech in a different language can slow down production or increase errors (e.g., Gambi & Hartsuiker, 2016; Liu, Dunlap et al., 2016; Liu et al., 2018). By the same token, processing input from the confederate in the new target language following a language switch may have increased the activation of that language in the child's own linguistic system, such that less effort was required to engage the new target language once it was the child's turn to speak. In his interactive alignment model of code-switching, Kootstra (2009, 2015) suggests that language activation can spread from one conversation partner to another through priming to facilitate alignment of language choice. However, in the dual-language condition of the current study, this pre-exposure to the target language was only brief following a switch in confederate, compared to the accumulated exposure in the single-language condition. For children who were successful at shifting dimensions on the DCCS, this brief opportunity to listen to the target language may have been sufficient to facilitate the language switch such that they were not any more likely to produce a cross-language intrusion than they would be in the single-language condition. Children who had difficulty shifting dimensions on the DCCS may not have benefitted from this brief priming effect. Therefore, the interaction between context and cognitive control may reflect that children with poor cognitive control were more affected by the increased demands of the dual-language context.

In contrast, our previous work at the single-word level (Gross & Kaushanskaya, 2018) revealed a significant main effect of cognitive control and no interaction with context. This finding may reflect challenges specific to the decontextualized picture-naming task that increased the need for cognitive control even in a single-language context. Green and Abutalebi (2013) note that even the single-language context requires cognitive control processes to set the target language (*goal maintenance*) and to avoid using the non-target language (*interference control*). In the picture-naming task, children heard only a single-word cue ("Say" vs. "Diga") to indicate which language they should use to name the picture, while at the discourse level they had repeated exposure from the confederate to help them remember the target language. This repeated exposure to the target language may also have helped with interference control by increasing the activation of the target language in the child's own linguistic system. Furthermore, in the picture naming task children were required to produce a particular lexical item to name the picture, which might have been a word they did not know in the target language or a word that was more accessible to them in the non-target language, requiring increased interference control. In the discourse context, children had more flexibility to choose how to express their message instead of having to access a particular word. Tare and Gelman (2010) made a similar argument to explain why children in their study exhibited more cross-language intrusions when they were asked to name pictures compared to when they engaged in conversation during free play, even though both tasks were conducted in single-language contexts.

To summarize the complex pattern of findings across our studies at the single-word level and the discourse level, I suggest that the dual-language context does pose increased demands for cognitive control at both the single-word level and the discourse level, consistent with the Adaptive Control Hypothesis. However, the increased contextual support from the discourse context may make it easier for children with good cognitive control to adapt to those demands without exhibiting costs to language control.

**Integrating Cognitive and Linguistic Predictors of Language Control**

This dissertation has been the first study to demonstrate a role for cognitive control in the ability of bilingual children to exercise language control at the discourse level. While adult models (e.g., Green, 1998; Green & Abutalebi, 2013; see Declerck & Philipp, 2015 for an overview) and empirical studies of language control (e.g., Festman & Münte, 2012; Festman, Rodriguez-Fornells & Münte, 2010; Gollan, Sandoval, & Salmon, 2011; Gollan, Kleinman, and Wierenga, 2014; Gollan & Goldrick, 2016; Prior & Gollan, 2013; Zheng, Roelofs, & Lemhöfer, 2017) have focused heavily on the role of cognitive control, work on language control in children has generally focused on their linguistic skills as the limiting factor in the ability to exercise language control (e.g., Cantone & Muller, 2005; Gawlitzek-Maiwald & Tracy, 1996; Genesee, Nicoladis & Paradis, 1995; Genesee, Boivin & Nicoladis, 1996; Lanvers, 2001; Lanza, 1992; Nicoladis & Secco, 2000; Ribot & Hoff, 2014). The current findings suggest the need to consider both linguistic and cognitive skills as predictors of language control in children.

Although the second paper identified a role for cognitive control, specifically in children’s ability to adjust to a dual-language context, this interaction between context and cognitive control was further moderated by a three-way interaction among overall language ability, cognitive control, and context. Specifically, the interaction between context and cognitive control became less robust as children’s overall language ability decreased. In children with higher language ability, better cognitive control meant that they were less likely to show costs to language control in the dual-language condition. In children with lower language ability, having better cognitive control did not affect whether they showed costs in the dual-language condition.

Furthermore, there was a robust main effect of overall language ability such that children with lower language skills exhibited more cross-language intrusions overall. Cognitive control, however, did not exert a main effect on language control. Taken together, these findings suggest an integrated model of language control in children in which language ability is the main limiting factor, consistent with the focus of previous research. However, once children have sufficient language ability, additional variability in language control (particularly in a more challenging dual-language context) may be accounted for by individual differences in cognitive control. In adults, whose linguistic systems are already developed, cognitive control may be the main limiting factor in their ability to exercise language control (e.g., Festman et al., 2010; Festman, 2012). Therefore, the relative importance of linguistic and cognitive predictors of language control may shift with development.

An alternative explanation of the interrelationship among cognitive and linguistic predictors could be that children with low language also tend to have lower levels of cognitive control, and their difficulties with language control could thus be due to overlapping effects of both low language and poor cognitive control. Such an explanation would be consistent with work showing deficits in inhibition and shifting in children with SLI (e.g., Engel de Abreu, Cruz-Santos, & Puglisi, 2014 [in bilinguals]; Epstein, Shafer, Melara, & Schwartz, 2014; Farrant, Maybery, & Fletcher, 2012; Henry, Messer, & Nash, 2012; Iluz-Cohen & Armon-Lotem, 2013 [in bilinguals]; Kapa & Plante, 2015; Marton, 2008; Pauls & Archibald, 2016; Roello, Ferretti, Colonnello, & Levi, 2015; Sandgren & Holmstrom, 2015 [in bilinguals]; Spaulding, 2010; Vissers, Koolen, Hermans, Scheper, & Knoors, 2015). However, the results in this dissertation were not consistent with this account. Children with lower language ability did not have significantly higher shifting costs on the DCCS, and children who failed the DCCS did not tend to have lower language ability. Even within the literature on cognitive control in children with SLI, there is some disagreement as to whether children with SLI show deficits in shifting (e.g., Dibbets, Bakker, & Jolles, 2006; Im-Bolter, Johnson, & Pascual-Leone, 2006; Laloi, 2015), and the meta-analysis by Pauls and Archibald (2016) revealed less robust effects for switching. Based on these findings, the threshold account described above appears to better explain the reduced effect of cognitive control on language control in children with low language.

**Language Control in Children with Specific Language Impairment**

The results of this dissertation suggested that children with lower language ability had more difficulty with language control than their typically developing peers. Furthermore, it was specifically their low language skills, and not necessarily associated deficits in cognitive control, that appeared to contribute to difficulties with language control. These findings are based on a continuous analysis in which language ability was considered as a continuous variable, with children with SLI occupying the lower end of the continuum. These results are in line with the findings of Mammolito (2015), who observed an increased rate of switches into the non-target language among children with SLI who had a more severe impairment (i.e., lower language scores). The finding with regard to the reduced effect of cognitive control at low levels of language ability is a new contribution, as other studies of language control including children with SLI have not examined cognitive control.

Most other studies of language control in children with SLI have taken a group comparison approach (e.g., Aguilar-Mediavilla, Buil-Legaz, Pérez-Castelló, López-Penadés, & Androver-Roig, 2015; Greene, Peña, & Bedore, 2013; Greene, Bedore, & Peña, 2014; Gutierrez-Clellen, Simon-Cereijido, & Leone, 2009; Iluz-Cohen & Walters, 2012; Silva, 2011). When I adopted this approach in an exploratory analysis comparing the 12 children who met my criteria for SLI with a matched group of typically developing peers, the children with SLI produced significantly more cross-language intrusions overall. These findings are in line with other studies that identified group differences in language control (e.g., Aguilar-Mediavilla, et al., 2015; Greene et al., 2013; Iluz-Cohen & Walters, 2012; Silva, 2011), some of which had similarly small samples. However, these studies all examined language control in single-language tasks. Even though Iluz-Cohen and Walters (2012) increased potential interference by asking children to retell a story heard in Hebrew to an English-speaking puppet, and vice versa, they did not have to switch back and forth repeatedly between different partners. The exploratory analysis revealed that children with SLI did not show increased costs in a dual-language context compared to typically developing peers. Drawing on the findings from the second paper, this may be because costs in the dual-language context were associated with cognitive control, and cognitive control appeared to have a limited effect on language control in children with low language.

It should be noted that the matching criteria in the exploratory analysis made a difference. When I initially included gender as a matching criterion and as a result had to relax my criteria for age and Spanish exposure, the group difference did not reach significance, even though it was numerically in the same direction. When I abandoned gender as a matching criterion in order to prioritize age, SES, nonverbal IQ, and Spanish exposure, there was a significant group difference. A continuous analysis of the full sample with age, SES, and Spanish exposure as covariates yielded the same basic finding without raising the concern that the results may be influenced by the particular children selected as matches. Furthermore, a model with language ability as a continuous variable had better measures of fit than a model with impairment status as a categorical variable. These findings suggest that in research on the effects of language impairment in bilingual children, recruiting a broad sample and examining language ability as a continuous variable may be a viable approach.

Whether language ability was treated as a continuous or categorical variable, the results of the current dissertation still diverged from those of studies that did not find group differences in language control (e.g., Gutierrez-Clellen et al., 2009; Greene et al., 2014). One methodological difference is that the study by Gutierrez-Clellen and colleagues only measured intra-sentential code-switching, while in the current dissertation cross-language intrusions could be mixed-language utterances or responses provided fully in the non-target language. In the exploratory analysis, I examined mixed-language responses in particular and discovered that they did not differ by group, and they were not significantly predicted by language ability as a continuous variable. These findings are in line with those of Gutierrez-Clellen and colleagues (2009) and suggest that the rate of language mixing within sentences does not appear to be related to language impairment. Instead, children's tendency to respond fully in the non-target language appeared to be driving the relationship between language ability and difficulties with language control. It is possible that mixed-language responses are more related to lexical gaps, which are likely to be experienced by children even with typical language ability, given the phenomenon of distributed linguistic knowledge (e.g., Kohnert, 2010; Oller, Pearson, & Cobo-Lewis, 2007). Responses provided fully in the non-target language may reflect reduced sensitivity to the "interactional cost" (Green & Abutalebi, 2013, p. 521) of using the language not spoken by the conversation partner. This account would be in line with other studies that have identified patterns of language switching by children with SLI that did not conform to sociolinguistic expectations (Iluz-Cohen & Walters, 2012; Greene et al., 2013).

An increased tendency to respond in the non-target language could have important implications for future language development. Two recent studies (Ribot, Hoff, & Burridge, 2018; Rojas et al., 2016) have found a significant relationship between the language children use to address others and their growth in expressive language skills. In particular, Ribot and colleagues (2018) found that, controlling for the amount of English input at home, children who sometimes responded in Spanish when they were addressed in English showed lower English expressive vocabulary skills and slower growth. Ribot and colleagues (2017) only reported growth in English skills, but it is possible that responding in English when addressed in Spanish may similarly curtail Spanish growth. There also may be a bi-directional relationship, such that children are less likely to use a language if their skills in that language are low, but in turn that reduced output constrains further growth. These studies were conducted in children with typical development, but the effects could be even larger in children with SLI, given the suggestion that children with SLI are particularly vulnerable to language attrition (e.g., Anderson, 2012). Thus, difficulties with language control in the form of failure to align with the language of the current conversation partner may contribute to further limitations in expressive language growth in children with SLI.

## Limitations and Future Directions

This dissertation has initiated new directions in the study of language control in children by introducing a paradigm to be used at the discourse level and by examining the contributions of both linguistic and cognitive skills. As such, the methods and findings presented here represent an initial approach, and there are several limitations to be considered and addressed through future work. Limitations specific to each study have been discussed in the previous chapters. Here I will focus on broad limitations relevant to the project as a whole.

In this dissertation, overall language ability was the linguistic predictor used to evaluate relative contributions of linguistic and cognitive predictors of language control. I chose this predictor because of my particular interest in specific language impairment and whether deficits in underlying language ability, rather than gaps in language-specific knowledge, might have an effect on children's ability to control their language choice. However, to isolate the effects of overall language ability, it will be necessary to also control for individual differences in language-specific knowledge and lexical gaps.

A related issue is the effect of partner language. Partner language was included in the first paper examining costs of the dual-language context, and children's level of cross-language intrusions was robustly related to whether they were being expected to respond in their dominant or non-dominant language. However, partner language was not included in the second paper examining the effects of language ability and cognitive control. Because the focus was on overall language ability (rather than language-specific knowledge) and because there was an equal number of experimental trials in each language, it seemed appropriate to collapse across English and Spanish trials. However, it is possible that the effects of overall language ability and cognitive control may have varied depending on whether the target language was English or Spanish, and furthermore on whether that language was the child's dominant or non-dominant language. Thus, a more complete analysis should consider both partner language and the child's abilities in that language, to determine whether overall language ability and/or cognitive control explain any additional variance. For example, if two children have similarly limited Spanish skills, but one child has high overall language ability and one child has language impairment, will these two children show different levels of language control when addressed in Spanish?

The measure of cognitive control may also have been a limitation. It was somewhat surprising that children with SLI did not exhibit difficulties on the DCCS compared to children with typical language, especially given that another study using the DCCS in a similar age group did find deficits in children with SLI (Farrant et al., 2012). It is possible that the DCCS version employed in this project, or the particular variables selected, may not have been sensitive enough. Furthermore, using only a single measure of cognitive control may have introduced task impurities. The cognitive control findings, especially with regard to children with low language, should be verified with a different measure of cognitive control or with a latent variables approach based on multiple measures.

At each level of cognitive control and language ability, there was still great variability in language control among children. In the spirit of creating an integrated model of language control, future work should add social and environmental components as well. With regard to social factors, Tare and Gelman (2010) suggest that Theory of Mind may play a role in children's ability to adjust their language use with different conversation partners. Other researchers have suggested that limited awareness of sociolinguistic context in children with SLI may affect language control (e.g., Iluz-Cohen & Walters, 2012; Greene et al., 2013). Paradis and Nicoladis (2007) also suggest that sociolinguistic context may interact with language dominance in affecting children's language control. With regard to environmental factors, the Adaptive Control Hypothesis (Green & Abutalebi, 2013) indicates that bilinguals tend to adapt their control processes to the interactional context in which they most frequently use their languages. This dissertation manipulated the interactional context within the experiment itself, but it is important to consider the interactional contexts in which the children normally interact. Children from dense code-switching environments, for example, may have had more difficulty separating their languages in the experimental task.

In addition to the predictors, it is also important to consider the outcome variable. In this dissertation, language control was measured in terms of cross-language intrusions, which were defined very broadly as any picture description containing at least one word in the non-target language. The exploratory analysis of children with SLI revealed different patterns for responses that contained a mixture of both languages and responses that were fully in the non-target language. Analyses that consider mixed-language responses as partial attempts at alignment, quantified in terms of the proportion of words in the target language, may reveal additional insights. In addition, the relationship between low language ability and the tendency to respond fully in the non-target language warrants further investigation, controlling for children's language-specific skills in the target language.

Limitations in the task itself need to be considered. When children provided a picture description in the non-target language and the confederate still selected a picture, children may have assumed that the confederate understood them. Attempts were made to minimize this possibility by having the confederate state explicitly "I only speak English" or "solo hablo español" and by having the confederate indicate that she would take her best guess if she was not sure which picture to choose. However, if the confederate did not understand the language used by the child, a more natural response would have been to express confusion in some way, such as indicating "I don't understand" or "I'm not sure." Including such a contingency in future work and examining what predicts children's ability to use this feedback to adjust their language choice may improve the paradigm.

Finally, this dissertation was limited to single-language and dual-language interactional contexts with a stringent definition of language control. While there are times when children may need to be able to use a single target language with a monolingual speaker, children often find themselves in bilingual settings where code-switching is common and represents a productive strategy for pooling resources across their two languages. For example, Yow, Tan, and Flynn (2017) found that increased rates of code-switching among bilingual preschoolers were associated with higher language competence both concurrently and at a future timepoint. Particularly for children with language impairment who may have more limited resources in both languages, it will be important to examine the factors that predict their ability to use an opportunistic mode of language control that allows them to combine their languages most effectively to communicate in a code-switching context.

## Conclusions

This dissertation contributes to the current literature on language control in bilingual children by presenting an approach for studying language control in children in a naturalistic interactive context while still maintaining experimental control. Using this approach, it was found that a dual-language context in which children must switch back and forth between languages to address different partners does not pose the same robust costs to language control that have been observed in picture-naming language switching paradigms. This finding suggests that it will be important in future work to measure language control directly at the discourse level to address questions about mechanisms of language control during conversation, as single-word paradigms may inflate costs by removing the cues available from social and linguistic context.

This dissertation also contributes to our understanding of how individual differences among children, including the presence of SLI, may affect their ability to exercise language control. Consistent with past work, language ability was found to be a robust predictor of language control among children with a broad range of language skills. For children with higher language ability, cognitive control also played a role in predicting the ability to adapt to a dual-language context. For children with low language skills, however, language ability appeared to fully constrain their ability to exercise language control, such that there was no additional role to be played by cognitive control. These findings suggest the need for an integrated model of language control that considers the inter-related contributions of both linguistic and cognitive skills. For children with SLI, these findings suggest that they are more likely to struggle with language control than their typically developing peers due to their low levels of language ability. Difficulties with language control are important to consider because they may have implications for children's ability to communicate effectively and for their future language growth.

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## Appendix: Exploratory Analysis of Children with Specific Language Impairment

These exploratory analyses were conducted for a poster presented at the 2108 Symposium for Research in Child Language Disorders. The 12 children identified as meeting criteria for SLI were compared to a matched group of typically developing peers. The groups were matched pairwise on age (within 6 months), socio-economic status (low vs. high), nonverbal IQ (within 10 points), and language dominance (stronger in English or stronger in Spanish). All pairs were matched on Spanish input/output within 10%, except for one pair that could only be matched within 30%. Eight pairs were matched exactly on age of first English exposure, one pair within 12 months, two pairs within 18 months, and one pair within 26 months. Non-parametric Wilcoxon rank sum tests revealed that the groups were distribution matched on all variables, as well as on parent-reported Spanish use with the child, exposure to both languages in the same setting, and parent-reported language mixing. To achieve this level of matching on variables that were expected to have an effect on language control, the groups could not be matched on gender. However, gender did not have a significant effect on language control within the full sample ($\chi^2 = 0.47$, $p = .49$). Earlier matching attempts that included gender as a criterion, but were less close on other variables, yielded group differences that did not reach significance (*p*s .06 - .13), although the pattern of results was the same. One typically developing child with extremely high levels of cross-language intrusions (75%) was excluded from the analyses in this poster because he appeared to artificially inflate cross-language intrusion levels for children with typical language. The analyses included a comparison of matched groups, a comparison between children with SLI and the full TD sample, and an analysis of the full sample with language ability as a continuous variable. These analyses were conducted on cross-language intrusions overall, as well as on mixed-language responses in particular.

# Language Control in Bilingual Children with and without Language Impairment

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## BACKGROUND

- Effective bilingual communication requires **language control**, the ability to select, maintain, and switch languages to accommodate different conversation partners.
- Lapses in language control (unsolicited switching or failing to switch) are often attributed to gaps in language-specific knowledge (e.g., Nicoladis & Secco, 2000), but it is unclear how they are related to overall language ability and language impairment.
- Studies have yielded mixed results as to whether language switching is more frequent or follows different patterns in children with language impairment compared to typically developing peers (e.g., Aguilar-Mediavilla et al., 2015; Greene et al., 2013; Iluz-Cohen & Walters, 2012 **vs.** Greene et al., 2014; Gutierrez-Clellen et al., 2009).

## RESEARCH QUESTIONS

1. Do bilingual children with specific language impairment (SLI) exhibit more difficulty with language control (in terms of cross-language intrusions overall or in terms of mixed-language responses more specifically) than typically developing (TD) peers? Are these differences magnified in a dual-language context?
2. Is the relationship between language ability and language control better modeled with language ability on a continuum or as discrete diagnostic categories?

## PARTICIPANTS

| Characteristic | TD | $p^*$ | SLI | $p^*$ | Matched TD |
|---|---|---|---|---|---|
| *n* | 54 (19 boys) | | 12 (8 boys) | | 12 (3 boys) |
| Age (years) | 5.27 (0.91) | .31 | 5.56 (0.94) | .98 | 5.61 (0.87) |
| SES (1-6 Likert Scale)[a] | 3.48 (1.80) | .018 | 2.08 (1.00) | .56 | 1.92 (1.08) |
| SES (1-3 Low; 4-6 High) | 23 Low, 31 High | .006 | 11 Low, 1 High | -- | 11 Low, 1 High |
| NVIQ (Leiter-3) | 104.87 (7.10) | .13 | 101.00 (7.64) | .88 | 100.50 (5.02) |
| English AoA (months) | 10.39 (14.33) | .58 | 15.00 (18.36) | >.99 | 13.83 (16.08) |
| Spanish Input/Output[b] | 0.53 (0.16) | .69 | 0.57 (0.17) | .95 | 0.55 (0.15) |
| Parent Spanish Use[c] | 0.66 (0.32) | .71 | 0.71 (0.26) | >.99 | 0.68 (0.31) |
| Parent Lang Mixing 0-30[d] | 11.44 (8.51) | .38 | 14.50 (10.17) | .89 | 14.92 (11.16) |
| "Both" Input/Output[e] | 0.50 (0.28) | .91 | 0.52 (0.30) | .95 | 0.54 (0.32) |
| BESA Language Index[f] | 106.26 (9.74) | <.001 | 83.50 (7.61) | <.001 | 101.42 (8.34) |
| Spanish Morphosyntax | 90.89 (16.08) | <.001 | 67.17 (8.88) | .001 | 86.50 (14.13) |
| Spanish Semantics | 106.31 (12.65) | <.001 | 91.25 (9.89) | .013 | 102.50 (10.11) |
| English Morphosyntax | 98.32 (16.32) | <.001 | 73.82 (8.02) | .041 | 90.36 (18.24) |
| English Semantics | 103.59 (12.38) | <.001 | 85.83 (13.04) | .077 | 97.25 (14.55) |

Children with SLI were identified by meeting at least two of the following criteria: BESA Language Index of 85 or lower, parent language concerns, and/or an existing diagnosis or history of language services.

*p-values based on non-parametric Wilcoxon rank sum tests.
[a] Scale: 1 = < HS, 2 = HS/GED, 3 = Some College, Technical/Associate's degree, 4 = BS, 5 = MS, 6 = Doctorate; SES observed to better predict language control as a categorical variable contrasting Low (1-3) vs. High (4-6).
[b] Bilingual Input Output Survey (BIOS) from the Bilingual English Spanish Assessment (BESA, Peña et al., 2014).
[c] Parent's self-report of the proportion of time that they use Spanish with their child (Language Mixing Scale, Byers-Heinlein, 2013).
[d] Language Mixing Scale (Byers-Heinlein, 2013), where a score of 30 indicates the most mixing.
[e] Proportion of waking hours in which the child is hearing/using both languages, as reported during the BIOS.
[f] Composite score from the BESA that combines the best morphosyntax and semantics scores across languages.

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## SCRIPTED CONFEDERATE DIALOGUE PARADIGM (adapted from Hartsuiker et al., 2004; Kootstra et al., 2010)

Single-Language Games
20 trials each
Sessions 1-2 or 2-3


"Me llamo Maria y solo hablo español."


"My name is Ashley and I only speak English."

Dual-Language Game, 20 trials
Session 3 or 1


"Me llamo Ximena y solo hablo español."
"And my name is Samantha and I only speak English. I'm going to play with you too!"

**Guessing Phase**

"La niña está escondiendo el libro detrás de la silla. ¿Puedes encontrar este dibujo?"

**Description Phase**

"Ahora te toca a ti. Cuéntame de tu dibujo y lo voy a buscar."
**Will child use Spanish?**

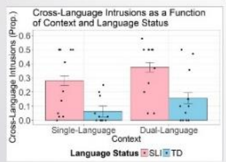
**Outcome Measure**

**Cross-language intrusion:** using at least one word in the language not spoken by the current partner

| Mixed | Fully Switched |
|---|---|
| El niño está comiendo **bread en la kitchen.** | **The boy is eating bread in the kitchen.** |

## RESULTS: Do children with SLI show more cross-language intrusions?

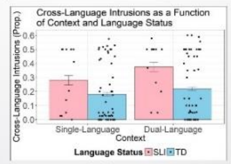
### Matched Groups




Log-odds of cross-language intrusion

| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | 0.53 | 0.17 | 8.53 | .003 |
| **Group** | **0.88** | **0.26** | **10.07** | **.002** |
| Context X Group | -0.16 | 0.16 | 0.93 | .33 |

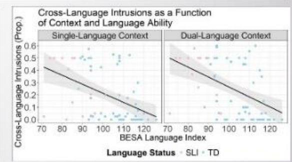
### Whole Sample with Covariates (Age, SES, Exposure)




Log-odds of cross-language intrusion

| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | 0.26 | 0.09 | 7.57 | .006 |
| **Group** | **0.50** | **0.26** | **3.47** | **.06** |
| Context X Group | 0.02 | 0.09 | 0.04 | .85 |

AIC: 3134.2, BIC: 3265.3, dev: 3092.2




Log-odds of cross-language intrusion

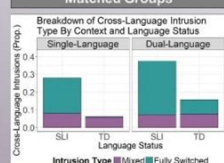
| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | 0.26 | 0.09 | 6.58 | .01 |
| **LangIndex** | **-0.73** | **0.25** | **8.17** | **.004** |
| Context X LangIndex | 0.05 | 0.08 | 0.31 | .58 |

**AIC: 3122.5, BIC: 3253.5, deviance: 3080.5**

- Children with language impairment produce more cross-language intrusions than matched TD peers.
- Cross-language intrusions decrease with higher language ability; continuum is a better fit than diagnostic categories.
- A dual-language context does not pose an even greater challenge to language control for children with lower language.

## RESULTS: Do children with SLI show more within-sentence language mixing?

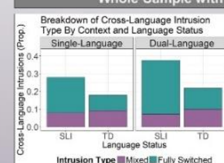
### Matched Groups




Log-odds of mixed-language response

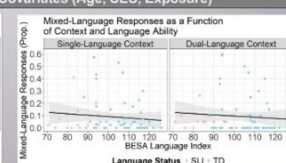
| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | 0.30 | 0.21 | 2.13 | .14 |
| Group | 0.05 | 0.26 | 0.04 | .84 |
| Context X Group | -0.06 | 0.17 | 0.13 | .72 |

### Whole Sample with Covariates (Age, SES, Exposure)




Log-odds of mixed-language response

| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | -0.02 | 0.15 | 0.01 | .90 |
| Group | 0.21 | 0.34 | 0.39 | .53 |
| Context X Group | -0.07 | 0.12 | 0.28 | .60 |




Log-odds of mixed-language response

| Predictor | *b* | *SE* | $\chi^2$ | *p* |
|---|---|---|---|---|
| Context | 0.05 | 0.14 | 0.11 | .74 |
| LangIndex | -0.40 | 0.31 | 1.63 | .20 |
| Context X LangIndex | 0.05 | 0.09 | 0.32 | .57 |

- Children with language impairment do not exhibit more language mixing than TD peers (matched or full sample).
- Within-sentence language mixing is not associated with overall language ability as a continuous predictor.
- A dual-language context does not increase the rate of within-sentence language mixing.
- Group differences in overall cross-language intrusions appear to be driven by fully switched responses.

## DISCUSSION

**Language control difficulties in children with impairment?**

- Children with language impairment do appear to have more difficulty than their typically developing peers in selecting the appropriate language and shifting languages for a new conversation partner, but this difficulty is not magnified in a dual-language context. This finding may reflect a reduced sensitivity to sociolinguistic context in children with impairment (e.g., Greene et al., 2013; Iluz-Cohen & Walters, 2012).
  - Confounding effects of limited expressive skills in the target language need to be considered. Do children with typical overall language ability but limited skills in one language show this same mis-alignment of language choice or use different strategies?
- Mixed-language responses do not appear to be related to overall language ability (e.g., Gutierrez-Clellen et al., 2009, but see Aguilar-Mediavilla et al., 2015). However, examining variability within the mixed-language responses may reveal different underlying processes.

A niña is **eating** comida en the cocina. vs. El **boy** está comiendo pan.

**Measuring language ability: continuum vs. categories**

- Within the SLI literature, it is debated whether children with language impairment form the lower end of a continuum of ability or represent a unique category of learners (e.g., Dollaghan, 2011; Leonard, 2014).
- Our findings suggest that language ability has a graded effect on language control and is associated with variability in language control even among children with typical language.
- This finding provides support for taking a continuum approach within a broad sample when examining the effects of low language ability, especially for bilinguals for whom it is difficult to define a strict diagnostic boundary.

**Implications: Could difficulties with language control serve as a potential sign of language impairment in bilinguals?**

- Our results suggest that increased language mixing is not suggestive of impairment, but mis-alignment of language choice may be associated with lower language ability.
- Our findings need to be confirmed with a larger sample and more detailed analyses that take into account both language-specific knowledge and overall language ability.