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Language Control and Intra-Sentential Codeswitching among Bilingual Children with and without Developmental Language Disorder

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Abstract: The present study investigated bilingual language control among preschool children in a sentence repetition task containing unilingual stimuli and codeswitched stimuli within prepositional phrases (PPs). Cross-language errors, that is, codeswitches that were not part of the stimulus sentences, were taken as evidence of difficulties in language control. Specifically, we investigated cross-language errors as a function of stimulus sentence type (codeswitched or unilingual), CS site within the PP, directionality (English or Hebrew stimulus sentences), and group status (children with typical language development (TLD), and children with Developmental Language Disorder (DLD)). We also examined cross-language errors in terms of word class and locus in the sentence. The participants were 65 English (home language)–Hebrew (societal language) bilinguals with TLD and 13 with DLD, ages 5;5–6;10 (M = 5;11). Stimulus sentences contained five codeswitch conditions within prepositional phrases, for example, a codeswitched preposition (P) or a codeswitched preposition, determiner and noun (P+DET+N), and a 'no switch' condition. The stimuli were 36 English and 36 Hebrew sentences (+24 fillers) matched for semantic content and syntax. English sentences contained switches to Hebrew, and Hebrew sentences contained switches to English. The results showed more cross-language errors for codeswitched than unilingual sentence stimuli. The children with TLD showed a directionality effect, producing more cross-language errors in Hebrew sentence stimuli than in English, but the children with DLD did not. The children with DLD had more cross-language errors than their peers with TLD for English stimuli. Most cross-language errors appeared in the sentence-final, adverbial temporal phrase. Findings are discussed in terms of language co-activation and competition in order to account for the difference in performance on unilingual versus codeswitched stimuli and in light of sociopragmatic and psycholinguistic factors to account for the directionality effect among children with TLD and the lack thereof among children with DLD.

Keywords: bilingual children; intra-sentential codeswitching; language control; cross-language errors; Developmental Language Disorder (DLD)

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1. Introduction

1.1. Language Control and Cross-Language Intrusions

This study examines bilingual language control among bilingual children as reflected in cross-language errors produced in a sentence repetition task. Language control enables the bilingual to monitor speech production, in particular, to use the intended language and avoid interference from the non-target language (Branzi et al. 2016). Within the field of bilingual language control, psycholinguistic studies on language switching feature prominently. These studies typically examine the effects and relative cost of processing mixed and unilingual language in experiments on single words or sentences (e.g., Costa and Santesteban 2004; Ruigendijk et al. 2016; Thomas and Allport 2000). Relatively few studies have specifically focused on the production of what has been called variously "unintended" language switches, "cross-language errors", "intrusions", or "intrusion errors."[1] The phenomenon can be described as a failure to control inappropriate language responses, for instance, a Dutch–English bilingual saying "en" instead of "and." The lack of studies on language control is especially evident in the field of child bilingualism.

Cross-language errors should not come as a complete surprise as it is now commonly accepted that even in monolingual contexts, a second language is never completely deactivated (e.g., Bobb and Wodniecka 2013; Costa 2005; Grosjean 2001; Kroll et al. 2014). There is, however, no agreement regarding the origin of these errors (Zheng et al. 2018). For example, Poulisse and Bongaerts (1994) view an unintended language switch as an instance where language users erroneously activate the L2 lemma in L1 speech based on a model where language selection takes place via the spread of activation to an L1 or L2 lexical item. Lipski (2016), in contrast, argues that unintended switching cannot be explained only by assigning the wrong language to individual lemmas but that longer stretches of morpho-syntactic units may also be activated in the non-target language due to lack of lexical access in a speaker's weaker language. Accordingly, less fluent speakers plan their speech in their stronger language, which "takes over" (p. 141) when a translation equivalent is not available. Alternatively, it has been suggested that intrusion errors may originate in erroneous language selection (at the conceptual level) in addition to erroneous word selection (at the lexical level) (Zheng et al. 2018; for an extensive discussion, see Declerck and Philipp 2015).

Language control abilities have been associated with domain-general, cognitive control, or executive functioning skills (e.g., Festman et al. 2010; Prior and Gollan 2013). Festman et al. (2010, p. 1) define cognitive control as "the ability to flexibly adapt behavior to current demands by focusing on task-relevant information and behaviors over a period of time while dealing with interference and competition." Executive functions include inhibition, shifting, and working memory, assessed by a variety of non-verbal tasks such as the Flanker task, the Dimensional Card Sort task, and the backward digit recall task.

Several studies have examined the production of cross-language errors in adult bilinguals. These studies focused on the role of language proficiency and the grammatical properties of the cross-language errors, as well as their appearance in unilingual and mixed language settings. Poulisse (2000) and Poulisse and Bongaerts (1994) reported more unintended L1 utterances in L2 speech than vice versa in story retelling tasks and spontaneous speech samples. Furthermore, lower L2 proficiency led to the use of more unintended L1 in L2, particularly function words. This finding was explained by lower activation and higher resting levels of the non-dominant L2 among beginning L2 learners as compared to more proficient bilinguals. Poulisse (2000) also suggested that less fluent speakers have less automaticity in speech production and more difficulty suppressing automatized responses. Gollan and colleagues examined intrusion errors in eye tracking experiments where bilinguals read monolingual or mixed language paragraphs aloud. Here, too, intrusion errors involved function words more than content words. These studies further reported that more errors resulted for dominant language target words than for non-dominant target words (Gollan et al. 2014; Schotter et al. 2019). Another study involving reading grammatical and ungrammatical codeswitching (CS) found that more intrusion errors occurred in passages with ungrammatical CS and in passages with a high number of switches (Gollan and Goldrick 2016). Gollan et al. (2014) reported more cross-language errors in mixed than unilingual passages. Likewise, Declerck et al. (2017) noted more intrusion errors when bilinguals were asked to produce a sentence during a language switch trial than during trials that took place in the same language as the previous trial. The authors interpreted this finding in terms of increased between-language interference in bilingual as compared to unilingual language settings.

Bilingual language activation and control have been assessed in natural speech via elicited narratives and, as noted above, with experimental paradigms involving CS (e.g., Kootstra et al. 2010; Hofweber et al. 2016). Kootstra et al. (2010), for instance, employed a picture description task with two dialogue partners, in which the confederate's CS patterns were manipulated. The results showed that in terms of syntax and tendency to codeswitch, the participants tended to adapt their CS patterns to those of their interlocutor. Green and Wei (2014) proposed the Control Process Model of Code-switching to account for different kinds of language control depending on the type of CS. For instance, dense CS, where there is frequent back-and-forth language switching within an utterance, entails a high level of language co-activation. This is described as an 'open control' mode with relatively little need for language inhibition of the non-target language (Green and Wei 2014). In contrast, insertional CS (switching of individual lexical items of one language into a grammatical frame of another) involves 'coupled control,' in which language control is ceded from one language to the other with the dominant language 'gate' open and the other 'on the latch' (Green and Wei 2014, p. 502). Hofweber et al. (2016) introduce the notion of monitoring, "a cognitive control mechanism involving the management of co-activated conflicting task-schemata allowing for flexible and rapid adaptation to changes in behavioural goals or task requirements" (p. 649). They argue that to prevent cross-language interference, monolingual contexts involve the least amount of language monitoring, while insertional and dense CS involve the most. The present paper is focused on language control during insertional CS.

There are various functions and motives for CS. Psycholinguistic motivations include a lack of word knowledge, difficulty retrieving a word, or the sense that meaning may be better conveyed in the alternate language (Genesee and Nicoladis 2009; Greene et al. 2012; Heredia and Altarriba 2001). CS has also been linked to sociolinguistic factors, including changes in social setting or topic of conversation, the role or identity of the interlocutors, and the different contexts for using the first language (L1) versus that of the L2 (Gumperz 1982; McClure 1981; Myers-Scotton 1993b; Raichlin et al. 2019). Pragmatic functions of CS include attention-getting, emphasis or focus, clarification, or disagreement (Grosjean 1982; Wei 1998; Zentella 1997).

Some of these factors might account for cross-language intrusions. For instance, a child may not be aware of the conversational partner's identity and sociolinguistic norms. Furthermore, she may have trouble with grammatical or lexical features in one of her languages due to imbalanced language skills. Sequential bilingual children are expected to codeswitch more from L1 (the minority/home language) to L2 (the majority/societal language) than vice versa since they often experience language shift where the L2 becomes the stronger language over time (Basnight-Brown and Altarriba 2007; Ebert and Kohnert 2016). This CS directionality effect has been corroborated in several studies reporting CS from a weaker into a stronger language (Greene et al. 2012; Halmari 2005; Kuzyk et al. 2020; Peynircioğlu and Durgunoğlu 2002; Ribot and Hoff 2014). Similarly, cross-language intrusions may be more common from L1 to L2.

CS directionality can also be a function of sociolinguistic factors, specifically switching from the home to the societal language. Gutiérrez-Clellen et al. (2009) found that English-dominant 5 to 6-year-olds tended to switch from Spanish (home language) to English (societal language), whereas their Spanish-dominant peers did not switch from English to Spanish. The authors attributed the directionality patterns to the children's awareness of the societal language. Kapantzoglou et al. (2021) reported that, regardless of proficiency, a majority of the 7-year-old Spanish-English children in their study codeswitched from Spanish (home language) to English (societal language), but only a very small percentage (10%) did so in the opposite direction. The authors concluded that "sociocultural" factors might outweigh "psycholinguistic" factors. Montanari et al. (2019) reported no directionality effects for children entering preschool but a clear preference for switching from the home language to the societal language a year later. These authors also ascribed this shift to the children's understanding of sociolinguistic factors such as language status and use in the children's community. Smolak et al. (2020), in a study of bilinguals aged 31–39 months, found that exposure was a predictor of CS directionality for Spanish–English in the southwest US, whereas proficiency predicted CS directionality for French–English in Montreal. Similar patterns have been reported for other language pairs. Iluz-Cohen and Walters

(2012) found more CS from English (home language) into Hebrew (societal language), which the authors attributed to the children's "sociolinguistic sensitivity" (p. 71). Likewise, Raichlin et al. (2019) reported more CS from Russian (home language) into Hebrew (societal language), which was attributed not just to the children's language proficiency but also to the children's greater exposure to the societal language, the language with the greatest use in a wide range of social settings.

1.2. Language Control in Bilingual Children

Ineffective language control in bilingual children has been examined through picture-naming/description tasks in single- and mixed-language trials (Gross and Kaushanskaya 2018, 2020, 2022; Jia et al. 2006; Kohnert 2002; Kohnert et al. 1999). A breakdown in language control in these studies was reported when children labeled or described the picture stimuli in the non-target language. These studies showed more cross-language naming errors when children were required to name pictures under more demanding, bilingual conditions (e.g., a picture naming task in which the language cue alternated between two languages) than under less demanding monolingual conditions (Gross and Kaushanskaya 2018; Jia et al. 2006; Kohnert 2002; Kohnert et al. 1999).

Gross and Kaushanskaya (2018) examined the relationship between domain-general cognitive control and domain-specific language control in children. In their 2018 study, poorer performance on a shifting task was associated with a greater number of cross-language errors. Two additional studies worthy of note for their methodological innovation further examined language switching and executive functions in bilingual children (Gross and Kaushanskaya 2020, 2022). In these studies, Spanish–English bilingual children and confederates took place in a dialogue describing pictures in turns. The confederates were introduced as either English or Spanish-speaking monolinguals. Three different contexts were assessed for cross-speaker errors (involving the use of non-target language English with a Spanish-speaking confederate, and vice versa): a unilingual Spanish session, a unilingual English session, and a dual language, Spanish–English session. The 2020 study reported no overall relationship between cognitive control and language control but a greater role for cognitive control in the dual language context than in the single language sessions. Based on Green and Abutalebi (2013), the authors attributed this greater role to higher control demands (such as inhibition and task disengagement) for dual-language settings. The 2022 study compared cross-language, inter-sentential CS (using English with a Spanish-speaking confederate and vice versa) with intra-sentential CS (inserting English words in the target language Spanish, and vice versa). The authors reported an association between executive skills and language control skills for inter-sentential CS but not for intra-sentential CS. This finding is in line with a study on French–English bilingual children's CS, which reported no association between executive skills and intra-sentential CS (Kuzyk et al. 2020).

Gross and Kaushanskaya (2020) also addressed proficiency and reported more cross-language intrusions for children with weaker overall language skills in both single and dual language sessions. More intrusions occurred when the confederate spoke the child's weaker language. The authors attributed the relationship between intrusions and language skills to less developed communicative and sociolinguistic competence and more linguistic gaps among children with lower language abilities.

Given the findings for the relative independence of cognitive and language control (particularly in intra-sentential CS), the present study focused on the unique features of language control in bilingual children by asking preschool children to repeat sentences involving intra-sentential CS.

1.3. Bilingual Children with Developmental Language Disorder (DLD)

Developmental language disorder (DLD) refers to a language disorder that is characterized by comprehension and production impairment in connection with grammar, vocabulary, and discourse. The language abilities of individuals with DLD are defined as below those of their peers, resulting in communicative, social, and academic repercussions. DLD is also defined by exclusion of motor or auditory impairments, emotional or neurological problems, and below-average non-verbal intelligence (American Psychiatric Association 2013). DLD has been estimated to occur in 7.4% of preschool children in the US (Tomblin et al. 1997).

Children with DLD are a heterogeneous group whose language profile may show difficulties in morphology, syntax, phonology, and pragmatics (Leonard 2014), with some children affected in just one language module, others in several (Friedmann and Novogrodsky 2008). Children with DLD may also have lexical–semantic problems, manifested in a delay in vocabulary acquisition and difficulty with lexical naming and novel word learning (Lahey and Edwards 1999; Rice et al. 1994).

Bilingual children with DLD present with language difficulties in both of their languages, albeit not necessarily the same difficulties (e.g., Armon-Lotem and Walters 2010). Bilingual DLD has been defined as below-norm performance in both languages on standardized or locally-normed assessments (Armon-Lotem and Meir 2016; Ebert and Kohnert 2016; Håkansson et al. 2003; Meir et al. 2015). Some of the language phenomena reported for bilingual children with DLD are omission/substitution of prepositions (Armon-Lotem et al. 2008), errors in complex structures involving non-linear relations (Meir et al. 2015), and gaps in lexical–semantic skills (McMillen et al. 2020). See Novogrodsky and Meir (2020) for a comprehensive review of bilingual DLD covering lexical, phonological, morphosyntactic, syntactic, and narrative abilities.

Some of the language difficulties apparent in bilingual children with a language disorder overlap with those observed in bilingual children with typical language development (TLD) (Degani et al. 2019; Meir and Armon-Lotem 2015; Paradis 2010). Such similarities could result in misdiagnosis of both populations: Children with DLD may be underdiagnosed, while those with typical development may be incorrectly labeled as language impaired (Bedore and Peña 2008; Rothweiler 2007). Identification of DLD among sequential bilingual children remains a challenge (Ebert and Kohnert 2016). CS abilities are under-investigated as a potential marker of bilingual DLD, and this avenue is clearly worthy of pursuit. The study we describe below on cross-linguistic intrusions is an attempt to move in this direction.

Until recently, studies on CS in children with DLD have been scarce and inconclusive. By far, the most innovative and sophisticated research on CS in bilingual children with DLD is Gross and Kaushanskaya's 2022 study described above. This study found that the children with DLD had more cross-language errors than the children with TLD when speaking in Spanish (home language) to a Spanish speaking confederate. No differences between children with TLD and DLD were reported for intra-sentential CS, with both groups inserting more English (societal language) words into Spanish than vice versa. Performance on executive skills, too, was found to be similar in the two groups. On this basis, the authors suggest that the higher rate of cross-language errors in this population may be attributed to lower pragmatic and metalinguistic skills and a greater likelihood of home language attrition.

Several other studies have examined the impact of language impairment on CS frequency and directionality. Iluz-Cohen and Walters (2012), using a narrative elicitation and story retelling task involving interlocutors introduced as unilingual or bilingual, examined English–Hebrew bilingual 5 to 7-year-olds and reported a higher rate of CS for children with DLD than children with TLD. Furthermore, while TLD children switched more from their L1 (weaker language) to L2 (dominant), children with DLD tended to switch in both directions. Similarly, O'Toole and Hickey (2012), based on interviews with therapists, noted that language-impaired children codeswitched more frequently and did so from the majority language (English) to the minority language (Irish). Greene et al. (2012), using semantic-expressive tasks with 5-year-old Spanish–English bilinguals, found that language-impaired children mixed more in English (into Spanish) than their TLD peers, while the TLD children mixed more in Spanish. Similarly, Sheng et al. (2012), using a word association task with 7 to 9-year-olds, noted that the children with TLD switched more from Spanish to English, while the language-impaired children switched more from English to Spanish. Mammolito (2015) analyzed narratives from 5 to11-year-old Spanish–English bilinguals and noted more CS for children with more severe language impairment. In contrast to these studies, Gutiérrez-Clellen et al. (2009), studying 6-year-old Spanish–English bilingual children's narratives and conversations, reported that the language-impaired children did not differ from their TLD peers in terms of frequency of CS. Finally, in a story retelling task with 5 to 7-year-old Spanish-English bilinguals, Kapantzoglou et al. (2021) found significantly more CS from English to Spanish than vice versa for both TLD and DLD children and no difference in CS frequency between the two groups. In sum, the data regarding CS frequency and directionality among children with DLD are inconsistent.

1.4. Sentence Repetition

In order to examine the production of non-targeted CS (i.e., cross-language intrusions), the present study employed a sentence repetition (SRep) task. In this task, the participants are instructed to listen carefully to sentence stimuli and to repeat them exactly as heard. SRep involves listening, phonological short-term memory, and production skills. When the sentences are of sufficient length, the task goes beyond simple parroting, requiring the decoding and encoding of underlying syntactic, semantic, and phonological representations from long-term memory (Marinis and Armon-Lotem 2015; Riches 2012). SRep has been used widely to examine language abilities in a variety of populations (Vinther 2002), including monolinguals (Komeili and Marshall 2013), bilinguals (Meir et al. 2015), and foreign language learners (Rast and Dommergues 2003). SRep has also been used to assess the grammaticality of CS via intra-sententially codeswitched sentences (Azuma and Meier 1997; Lipski 2017; Soesman and Walters 2021). Finally, SRep has been shown to be a discriminator of children with DLD from those with TLD (Armon-Lotem and Meir 2016; Ebert 2014; Pratt et al. 2021). The lower performance of children with DLD on SRep tasks has been attributed to impairments in language representation and/or processing (Marinis and Armon-Lotem 2015).

1.5. The Present Study

The current study investigates cross-language errors in an SRep task containing unilingual and intra-sententially codeswitched sentence stimuli. It operationalizes cross-language errors as those instances where a non-codeswitched item from the stimulus sentence is produced as a codeswitch. We refer to such CS as "non-targeted CS".

The present study differs from previous work on cross-language errors in several ways. First, previous research on bilingual children and language control has used picture stimuli in either single language or mixed-language trial blocks, exposing the participants to lesser or greater language co-activation and competition (e.g., Gross and Kaushanskaya 2020; Jia et al. 2006). In contrast, the present study uses a task in which there are varying degrees of language activation within a single language block with participants exposed to alternating unilingual and codeswitched stimuli. In processing and producing a codeswitched sentence, the child needs to continuously adjust the activation levels of the two languages, necessitating a relatively high activation level of both languages (Green and Abutalebi 2013; Kroll et al. 2014; Litcofsky and Van Hell 2017; Van Hell et al. 2015). Although we argue that both languages are activated throughout the task, more intense bilingual activation results when hearing and repeating a codeswitched sentence, and less intense bilingual activation when hearing and repeating a unilingual stimulus. In light of this, we hypothesize more non-targeted CS for stimulus sentences with CS, which is expected to elicit greater bilingual language competition and interference (e.g., Declerck et al. 2017; Hofweber et al. 2016).

Some studies on intrusion errors have focused on intra-sentential CS via read-aloud tasks (e.g., Gollan and Goldrick 2016) or corpus studies (Lipski 2016) with adults. Other studies have analyzed errors based on picture naming (e.g., Zheng et al. 2018) or language samples from story retelling and spontaneous speech (Poulisse 2000; Poulisse and Bongaerts

1994). However, no studies of bilingual children we are aware of have experimentally manipulated stimuli via SRep with CS at different points in a sentence.

Several features of the present study make it distinctive. First, it examines which type of CS in the stimulus sentence triggers cross-language switching. The participants hear intra-sentential codeswitches, which were incorporated at different loci within a prepositional phrase (PP). These included single noun or preposition switches or longer word stretches, such as full PPs. We hypothesize that the larger the switched constituent in the stimulus sentence, the more the language of this constituent will be activated and subsequently produced. Moreover, while previous research has looked at the linguistic status of cross-language errors in terms of function versus content words (e.g., Schotter et al. 2019), the present study also examines for which sentence constituent cross-language errors are most likely to occur.

Furthermore, the present study analyzes directionality effects by comparing non-targeted CS in English stimuli containing CS to Hebrew (the societal language) with Hebrew stimuli containing CS to English (the home language). We hypothesize that the participants will respond differently to a switch from the home language to the societal language than vice versa (Gutiérrez-Clellen et al. 2009; Iluz-Cohen and Walters 2012).

Finally, this study compares cross-linguistic errors in children with TLD and DLD. We expect more difficulty with language control among children with DLD (e.g., Gross and Kaushanskaya 2022) and hence more non-targeted CS for this group than for children with TLD.

Specifically, the study addressed the following questions:

1. **Stimulus CS condition, Language and Group**: To what extent will codeswitched sentence stimuli in five different sites elicit more non-targeted CS than non-codeswitched/unilingual stimuli? To what extent will there be a frequency difference in non-targeted CS between English and Hebrew sentence stimuli? To what extent will there be a difference in non-targeted CS between children with TLD and DLD?
2. **Sentence constituent**: In which sentence constituent will most non-targeted CS occur? To what extent will there be a frequency difference in non-targeted CS between English and Hebrew sentence stimuli? To what extent will there be a difference in non-targeted CS between children with TLD and DLD?

2. Methods

The present study is part of a larger project investigating linguistic markers of bilingual DLD based on the first author's PhD dissertation (Soesman 2018). Portions of the participants, materials, and procedure sections overlap with those reported in a study on grammatical aspects of CS in bilingual preschool children (Soesman and Walters 2021). The questions addressed here, the data analyses, and the findings on cross-linguistic errors are unique to the present study.

2.1. Participants

A total of 78 English–Hebrew bilingual children (41 girls), ages 5;5–6;10 (M = 5;11), participated in the study. Background information was obtained from a parent questionnaire. All of the children were raised in English-speaking homes and were exposed to Hebrew, the societal language, for at least 17 months. Fifty-six children were sequential bilinguals who acquired Hebrew at least three months after birth; 22 were exposed to Hebrew from birth. The participants were recruited from public, Hebrew-speaking regular, and "language" preschools in Israel. All of the children were administered Raven's Colored Progressive Matrices non-verbal IQ test (Raven 1998). Only children with standard scores above 90 were included in the study.

To evaluate language proficiency, the children were administered standardized tests in both languages, the CELF-2 Preschool for English (Wiig et al. 2004) for English and the Goralnik Screening Test for Hebrew (Goralnik 1995). The CELF includes six sub-tests: sentence structure, word structure, word classes, expressive vocabulary, concepts and following directions, and sentence repetition. The Goralnik test assesses vocabulary, sentence repetition, listening comprehension, expression, pronunciation, and storytelling. The participants who scored more than 1SD below the monolingual mean in L1 English were considered to be below the normal range for English, whereas those who scored more than 1.5 SD below the monolingual mean in L2 Hebrew were considered to be below the normal range for Hebrew. These cut-off points align with previous studies with the same population in Israel (Iluz-Cohen and Armon-Lotem 2013; Iluz-Cohen and Walters 2012; Meir et al. 2015). Since sequential bilingual children are exposed to L1 from birth, and they are exposed to L2 around the age of 24 months (see Table 1), the cut-off point is not identical for the two languages. Their Hebrew skills are expected to be lower compared to monolinguals due to lower exposure. In the literature on diagnosing bilingual children with DLD, a range between −1 SD and −2 SD is used depending on the tests, the amount of exposure, and the specific population (Altman et al. 2021; Peña et al. 2020; Thordardottir 2015.)

Children were considered typically developing (TD) if they scored within the monolingual norms in at least one of their languages. The raw scores on both tests were converted to z-scores based on the standardized criteria.

Children were classified as bilingual DLD if they met all of the following criteria:

1. They had scores below the norm on both English and Hebrew assessments (Armon-Lotem and Meir 2016; Ebert and Kohnert 2016; Håkansson et al. 2003; Kohnert 2010).
2. To ensure that low scores on the Hebrew screening test were not a result of lack of exposure to L2/Hebrew but rather due to language impairment, Length of Exposure (LoE) was taken into account for classifying a child with DLD. Only children in one of the following categories were included in the DLD group:
    a. LoE from birth AND z-scores from −1.50 to −1.74;
    b. LoE greater than 36 months AND z-scores from −1.75 and −1.99;
    c. LoE from 24–36 months AND z-scores from −2.00 to −2.99;
    d. LoE from 16–23 months AND z-scores lower than −2.99.
3. Exclusionary criteria for DLD, i.e., no auditory, visual, neurological, or emotional impairments, as well as no history of otitis media (Leonard 2014; Tallal and Stark 1981) based on information provided by parents.

Table 1 displays demographic, exposure, and proficiency background data for the two groups. The table shows that in terms of demographic data (age, gender, socioeconomic status (mother's education)), there were no significant differences between the groups. The data further indicate that there were no significant differences in length of exposure to Hebrew and age of onset (AoO) of Hebrew.

Table 1. Demographic, exposure (LoE, AoO), proficiency and other background data from children with TLD and DLD.

	TLD (*N* = 65)	**DLD (*N* = 13)**	***t***	***p*-Value**	***t*-Tests**
Age in months (SD)	70.06 (3.48)	73.77 (5.79)	2.230	0.043	DLD > TLD
Mother's education in years (SD)	16.98 (2.81)	17.45 (1.86)	0.533	0.596	-
LoE in months (SD)	51.11 (16.38)	50.00 (20.29)	0.214	0.831	-
AoO in months (SD)	18.95 (16.96)	23.77 (20.20)	0.905	0.368	-
Eng. prof. (*CELF*) z-score (SD)	−0.50 (1.00)	−1.93 (0.73)	4.896	< 0.001	TLD > DLD
Heb. prof. (*Goralnik*) z-score (SD)	−0.88 (1.40)	−2.73 (1.42)	4.346	< 0.001	TLD > DLD
Non-verbal IQ	121.42 (14.06)	108.54 (8.88)	4.27	< 0.001	TLD > DLD

LoE: Length of exposure to Hebrew; AoO: Age of Hebrew onset.

The children in the TLD group had significantly higher scores than the children in the DLD group for both English (CELF) and Hebrew proficiency (Goralnik). The children in the TLD group scored significantly higher on non-verbal IQ and were younger than the children in the DLD group. We, therefore, added the IQ standard score and Age as fixed factors to the GLMM analysis of non-targeted CS.

2.2. Materials and Design

The stimuli consisted of 36 sentences in English and 36 in Hebrew. Each sentence included an NP subject, an intransitive V, a PP consisting of P+DET+N, and a temporal phrase. The following prepositions were included in the stimulus sentences: *around* (saviv), *inside* (betox), *over* (me'al), *next to* (leyad), *before* (lifney), and *after* (axrey). The temporal phrase did not contain a preposition. Each of the 36 sentences was rearranged into a set of six conditions where the following element(s) were codeswitched: a single N, a DET+N, a single P, a P+DET, a P+DET+N. Each set also included a unilingual stimulus sentence (no-switch condition). An example of a set with the six conditions appears in (1) for English and (2) for Hebrew.

(1) An example set of English stimulus sentences with Hebrew switches

	Subject	**Verb**	**Prepositional Phrase**	**Temporal Phrase**
Non-CS	The girl	played	inside the bedroom	all day
CS-N	The girl	played	inside the XEDER	all day
CS-DET+N	The girl	played	inside HA- XEDER	all day
CS-P	The girl	played	BETOX the bedroom	all day
CS-P+DET	The girl	played	BETOX HA- bedroom	all day
CS-P+DET+N	The girl	played	BETOX HA- XEDER	all day

(2) An example set of Hebrew stimulus sentences with English switches

	Subject	**Verb**	**Prepositional Phrase**	**Temporal Phrase**
Non-CS	Ha- yalda	sixqa	betox ha- xeder	kol ha- yom
CS-N	Ha- yalda	sixqa	betox ha- BEDROOM	kol ha- yom
CS-DET+N	Ha- yalda	sixqa	betox THE BEDROOM	kol ha- yom
CS-P	Ha- yalda	sixqa	INSIDE ha- xeder	kol ha- yom
CS-P+DET	Ha- yalda	sixqa	INSIDE THE xeder	kol ha- yom
CS-P+DET+N	Ha- yalda	sixqa	INSIDE THE BEDROOM	kol ha- yom

English and Hebrew sentences were constructed to be identical in terms of syntax and semantics. The lexical items in the stimulus sentences were early-acquired vocabulary taken primarily from Hart and Risley (1995). Lexical items were adapted to the Israeli context following feedback from children, parents, and teachers and based on pilot work. The stimuli did not include English-Hebrew cognates in order to preclude cross-linguistic activation effects due to similar phonology and meaning (Van Hell et al. 2015).

For each language, six experimental lists were created with six items for each CS condition in English and six parallel items for each CS condition in Hebrew. Each list included a total of 36 test items, with one sentence from each of the 36 sets. Thus, no participant was presented with the same sentence in more than one condition. Twenty-four unilingual filler sentences were interleaved among the codeswitched sentences, yielding a total of 60 stimulus sentences. The filler sentences differed syntactically from the test sentences, and they were not coded or scored in the present study. The six conditions and distractor sentences appeared in the same, pseudorandom order in each list. Sentences from the same CS condition as well as identical lexical items did not appear consecutively. Each experimental list started with a filler sentence followed by a unilingual test sentence. The participants were assigned randomly to lists in both English and Hebrew.

2.3. Procedure

The study was approved by the university Institutional Review Board and the Israel Ministry of Education Chief Scientist's office. The participants' parents signed consent forms after they were informed about the aims of the study. Each participant completed the Raven's non-verbal IQ test, the CELF English proficiency, and the Goralnik Hebrew screening test. The sentence stimuli were recorded with a fluent bilingual female speaker of English and Hebrew reading the sentences. The recording was condcuted with an AKG C1000 condenser microphone in a sound-proof studio and digitized by means of an M Audio Delta interface. The recordings were then incorporated into a PowerPoint© presentation.

The participants were tested individually in a separate room in their kindergarten where only the tester and child were present. The stimulus sentences were presented via PowerPoint© via a laptop computer with audio headphones. The children were asked to repeat the sentences verbatim. To ensure that the participants understood the task, three practice sentences were presented at the beginning of each session. Two of these sentences were unilingual, while the third contained a codeswitch. After the child repeated the third sentence, the experimenter verified that the child had noticed that the last sentence was special since it contained words from both languages. After repeating 10 sentences, the child received a sticker as a means of encouragement.

Half of the participants were tested on the English sentences in the first session and on the Hebrew stimuli a week later. The other half were tested in Hebrew first and English a week later. All the interactions between the tester and the child were in English during the English session and in Hebrew during the Hebrew session. Each session was audio-recorded on a Toshiba laptop via Audacity© software. In addition, the children's responses were recorded manually.

2.4. Coding and Analysis

The recordings were transcribed and coded off-line following each session. Cross-language errors were analyzed for all instances of non-targeted CS. Non-targeted CS was defined as any language switching by the participants that (1) was not present in the original stimulus sentence, (2) occurred in a sentence constituent outside of the PP for codeswitched sentence stimuli (i.e., in the NP subject phrase, in the V phrase or in the temporal phrase in sentence-final position), and (3) occurred in any sentence constituent within the unilingual sentence stimuli. Codeswitches in the PP were excluded from the analysis since the PP was the very site of the **targeted** CS, and the focus of the current study was on **non-targeted** CS. (For a detailed discussion on children's modifications of switches within the PP, see Soesman and Walters (2021)).

For the English stimulus sentences, a non-targeted switch meant a switch into Hebrew; for the Hebrew stimulus sentences, it meant a switch into English. Examples of non-targeted codeswitches are underlined and are given in *UPPERCASE* in (3) and (4). Codeswitches in the stimulus sentences appear in **bold**.

(3). Stimulus sentence: The builder works inside the **bayit** every morning
'The builder works inside the house every morning.'
Non-targeted CS: The builder works inside the bayit <u>*KOL*</u> morning
'The builder works inside the house every morning.'
(4). Stimulus sentence: ha- yalda sixqa **inside the bedroom** kol ha- yom
the girl play-PAST inside the bedroom whole the day
'The girl played inside the bedroom the whole day.'
Non-targeted CS: ha- yalda sixqa inside the bedroom <u>*ALL THE TIME*</u>

The frequency of non-targeted CS was computed for each of the six CS conditions (no switch, CS-N, CS-DET+N, CS-P, CS-P+DET, and CS-P+DET+N). A non-targeted codeswitch consisting of more than one word within a phrase (e.g., "all the time") was counted as a single switch. Non-targeted elements that were self-corrected were not included in the analysis.

All of the analyses were performed in R (R Core Team 2012). The main measure in all analyses was the frequency of non-targeted codeswitches. Generalized Linear Mixed Models (GLMM) analyses with Poisson distribution were performed, examining the effect of fixed factors and random intercepts. Poisson distribution allows analyzing frequencies (counts), and the mixed models approach allows accounting for individual performance. The following fixed factors were tested in all analyses: Language (English/Hebrew), Group (TLD/DLD), and their interaction. For RQ1, we also tested the effect of CS condition (non-CS, CS-N, CS-DET+N, CS-P, CS-P+DET, CS-P+DET+N). For RQ2, we tested for Sentence constituent (Noun, Verb, Temporal phrase). The following covariates were also tested: Age, AoO, and non-verbal IQ. The participants were included as random intercepts. In all analyses, the Laplace approximation was set to 0 (nAGQ = 0), since with this option on (nAGQ = 1), the model failed to converge. In order to determine the contribution of each fixed factor, likelihood ratio tests were performed, and based on the results, optimal models were created. The estimates of each fixed factor are reported in Appendix A. Significant interactions were explored using the *emmeans* package (Lenth et al. 2022) by means of pairwise contrasts. Predicted frequencies of non-targeted CS based on significant interactions were plotted using the *plot model* function of the *sjPlot* library (Lüdecke et al. 2022) for ease of interpretation.

3. Results

By way of background, a large majority of children (73%) produced at least one non-targeted switch in either English, Hebrew, or both languages. Approximately one-third of all children produced at least one non-targeted switch in English sentences, whereas a little more than half did so in Hebrew. Moreover, while 71% of the TLD children had at least one non-targeted switch, in the DLD group, this number reached 85%. Further, while the majority in the DLD group (7 out of 11) produced non-targeted switches in both English and Hebrew sentences, in the TLD group, only a small minority (approximately 10%) did.

3.1. Frequency of Non-Targeted CS as a Function of CS Condition, Language and Group

The frequencies of non-targeted CS for unilingual and codeswitched sentences are presented in Table 2.

Table 2. Mean frequency, range, and sum of non-targeted CS for six CS conditions in English and Hebrew stimuli for children with TLD and DLD.

	TLD (*N* = 65)			**DLD (*N* = 13)**		
	Mean Frequency	**Range**	**Sum (No. of Children)**	**Mean Frequency**	**Range**	**Sum (No. of Children)**
Condition						
English						
Non-CS	0.08	0–2	5 (*N* = 4)	0.15	0–2	2 (*N* = 1)
N	0.09	0–2	6 (*N* = 4)	0.38	0–2	5 (*N* = 4)
DET+N	0.11	0–1	7 (*N* = 7)	0.54	0–4	7 (*N* = 4)
P	0.15	0–2	10 (*N* = 8)	0.38	0–2	5 (*N* = 3)
P+DET	0.06	0–2	4 (*N* = 3)	0.15	0–1	2 (*N* = 2)
P+DET+N	0.14	0–2	9 (*N* = 7)	0.46	0–3	6 (*N* = 4)
Total Eng.	0.11		41	0.34		27

Table 2. *Cont.*

	TLD (*N* = 65)			DLD (*N* = 13)		
	Mean Frequency	Range	Sum (No. of Children)	Mean Frequency	Range	Sum (No. of Children)
Condition						
Hebrew						
Non-CS	0.03	0–1	2 (*N* = 2)	0	0–0	0
N	0.25	0–3	16 (*N* = 10)	0.54	0–3	7 (*N* = 4)
DET+N	0.35	0–6	23 (*N* = 11)	0.38	0–3	5 (*N* = 3)
P	0.29	0–3	19 (*N* = 11)	0.46	0–2	6 (*N* = 5)
P+DET	0.23	0–3	15 (*N* = 12)	0.08	0–1	1 (*N* = 1)
P+DET+N	0.58	0–5	38 (*N* = 19)	0.77	0–3	10 (*N* = 9)
Total Heb.	0.29		113	0.37		29

Table 2 suggests that more non-targeted CS resulted for the CS conditions than the unilingual condition; more non-targeted CS resulted for Hebrew stimulus sentences than for English (for the TLD children), and more non-targeted CS resulted for children with DLD than children with TLD.

In order to test the effects of CS Condition, Language, Group, and their interactions, a GLMM analysis was conducted. Age, AoA, and non-verbal IQ were also tested as potential covariates. The full list of the fixed factors and their order, as well as the outcome of the likelihood ratio tests, are presented in Table A1 in Appendix A. Based on the results of the likelihood ratio tests, the optimal model was created which included the following fixed factors that came out significant: Condition, $\chi2 = 53.21$, $p < 0.001$, Language, $\chi2 = 26.65$, $p < 0.001$, and Group*Language, $\chi2 = 8.44$, $p = 0.004$. The Condition*Language interaction was not significant, $\chi2 = 10.80$, $p = 0.06$, nor were Group*Condition*Language, $\chi2 = 17.34$, $p = 0.30$, Age, $\chi2 = 0.81$, $p = 0.37$, AoO, $\chi2 = 0.37$, $p = 0.55$ and non-verbal IQ, $\chi2 = 0.61$, $p = 0.43$. These covariates were thus excluded from further analyses. Table 3 presents the model's summary. The fixed factors explained 19% of the variance, and the random factors explained an additional 27%.

Table 3. Estimates of the model predicting the frequency of non-targeted CS.

Predictors	***Incidence Rate Ratios***	**CI**	***p***
(Intercept)	0.08	0.03–0.19	**<0.001**
Condition [CS-N]	3.78	1.81–7.88	**<0.001**
Condition [CS-P]	4.44	2.16–9.16	**<0.001**
Condition [CS-P+DET]	2.44	1.13–5.31	**0.024**
Condition [CS-DET+N]	4.67	2.27–9.59	**<0.001**
Condition [CS-P+DET+N]	7.00	3.48–14.07	**<0.001**
Language	1.07	0.64–1.81	0.789
Group	0.24	0.11–0.53	**<0.001**
Language * Group [TLD]	2.57	1.36–4.84	**0.004**
	Random Effects		
σ^2		2.02	
$\tau_{00\ ID}$		1.01	
ICC		0.33	
N_{ID}		78	
Observations		936	
Marginal R^2/Conditional R^2		0.193/0.462	

Note: For condition, non-targeted CS is the reference group; * denotes interaction.

The analysis indicates that a significant difference emerged among the conditions. A post-hoc analysis using the *emmeans* function from the *emmeans* library with Tukey corrections showed that less non-targeted CS occurred for the Non-CS condition than for CS-N ($p = 0.005$), CS-P ($p < 0.001$), CS-DET+N ($p < 0.001$), and CS-P+DET+N ($p < 0.001$). CS-N resulted in less non-targeted CS than CS-P+DET+N ($p = 0.04$), and CS-P+DET, too, resulted in less non-targeted CS than CS-P+DET+N ($p < 0.001$). The rest of the differences were not significant.

The analysis also yielded a significant Group effect and a significant Group*Language interaction. The interaction was explored using the *emmeans* function testing for contrasts and plotting the predicted values (see Figure 1).

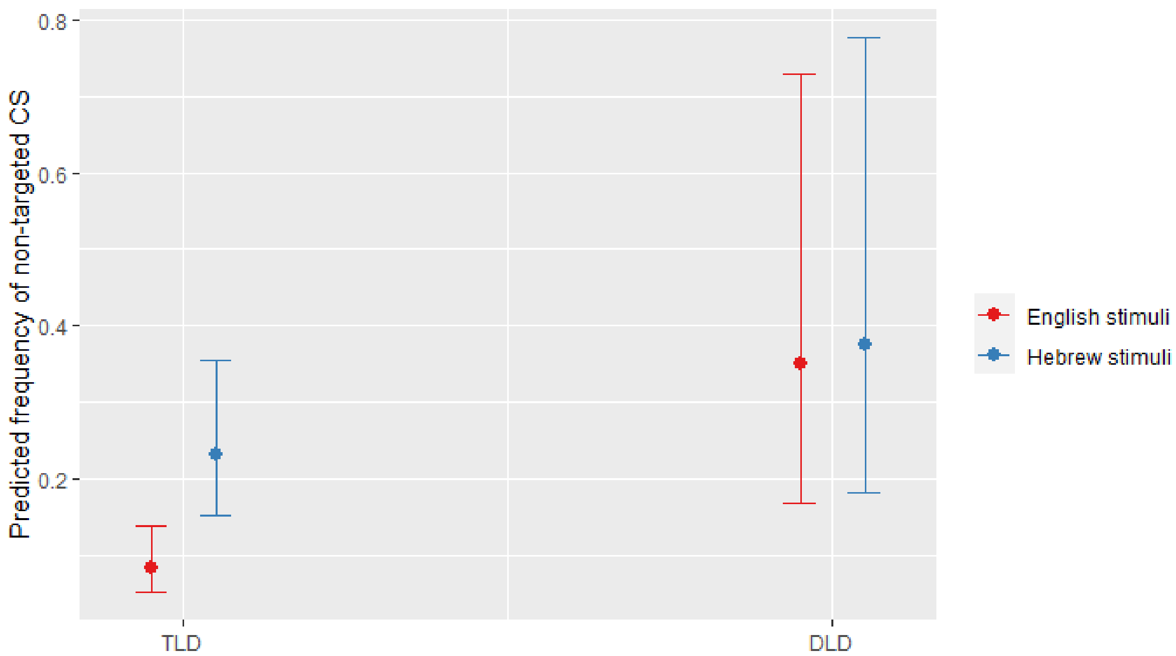

Figure 1. Predicted frequencies of non-targeted CS for the interaction of Group and Language.

Visual inspection of Figure 1 shows higher predicted frequencies of non-targeted CS for children with DLD and greater variability than for children with TLD. In addition, the graph shows no differences between English and Hebrew stimulus sentences for children with DLD but higher predicted frequencies for Hebrew stimuli than for English stimuli for children with TLD.

Post-hoc analysis with Turkey corrections confirmed that children with DLD are predicted to use a similar frequency of CS in English and Hebrew ($p = 0.79$), while children with TLD are predicted to use significantly more in Hebrew than in English ($p < 0.001$). This interaction can also be interpreted as follows: In English, children with DLD are predicted to use more non-targeted CS than children with TLD ($p < 0.001$), while in Hebrew, the two groups did not differ ($p = 0.21$).

3.2. Sentence Position of Non-Targeted CS

Table 4 demonstrates the means, ranges, and frequencies of non-targeted CS for each of the three sentence constituents: the NP Subject phrase, the Verb phrase, and the Temporal phrase. As can be seen from the table, the sentence-final temporal phrase resulted in the largest amount of non-targeted CS in both English and Hebrew sentences.

Table 4. Means, ranges, and frequencies of non-targeted CS for three grammatical constituents in English and Hebrew, for children with TLD and DLD.

	TLD (N = 65)			DLD (N = 13)		
	Mean Frequency	**Range**	**Sum (No. of Children)**	**Mean Frequency**	**Range**	**Sum (No. of Children)**
Sentence Constituent						
English						
NP Subject	0.09	0–1	6 (N = 6)	0.77	0–2	10 (N = 6)
V Phrase	0.17	0–4	11 (N = 6)	0.31	0–4	4 (N = 1)
Temporal phrase	0.32	0–5	21 (N = 11)	0.92	0–4	12 (N = 4)
Totals English			38			26
Hebrew						
NP subject	0.18	0–4	12 (N = 7)	0.54	0–4	8 (N = 5)
V phrase	0.18	0–3	12 (N = 9)	0.46	0–2	6 (N = 5)
Temporal phrase	1.35	0–13	88 (N = 25)	1.15	0–4	15 (N = 7)
Totals Hebrew			112			29

Note: The non-CS condition was excluded from this analysis since it was not relevant to the locus of non-targeted CS and there were very few instances in this condition.

A GLMM analysis was performed on the frequency of non-targeted CS, testing the effects of Sentence constituent, Language, Group, and their interactions. The full list of the fixed factors and their order, as well as the outcome of the likelihood ratio tests, are presented in Table A2 in Appendix A. The optimal model included the following fixed factors that came out significant based on the likelihood ratio tests: Sentence constituent, $\chi2 = 94.33$, $p < 0.001$, Language, $\chi2 = 29.01$, $p < 0.001$, Sentence constituent*Language, $\chi2 = 9.34$, $p = 0.009$, Group, $\chi2 = 5.86$, $p = 0.02$, Group*Sentence constituent, $\chi2 = 11.26$, $p = 0.004$, and Group*Language, $\chi2 = 6.23$, $p = 0.01$. A Group* Sentence constituent*Language interaction was not significant, $\chi2 = 3.04$, $p = 0.22$. The model's estimates are presented in Table 5. The fixed factors explained 24% of the variance, and the fixed and random factors together explained 56%.

Table 5. Estimates of the model predicting the frequency of non-targeted CS.

	Frequency		
Predictors	***Incidence Rate Ratios***	**CI**	***p***
(Intercept)	0.61	0.27–1.41	0.250
Sentence constituent [Temporal]	1.08	0.52–2.25	0.844
Sentence constituent [Verb]	0.63	0.26–1.51	0.298
Language	0.77	0.36–1.64	0.494
Group	0.10	0.04–0.28	**<0.001**
Sentence constituent [Temporal] * Language	2.09	0.94–4.68	0.072
Sentence constituent [Verb] * Language	0.86	0.32–2.30	0.762
Sentence constituent [Temporal] * Group	3.30	1.47–7.38	**0.004**
Sentence constituent [Verb] * Group	2.24	0.81–6.21	0.120
Language [Hebrew] * Group	2.37	1.21–4.66	**0.012**

Table 5. *Cont.*

	Frequency		
Predictors	***Incidence Rate Ratios***	**CI**	***p***
	Random Effects		
σ^2	1.50		
$\tau_{00\ ID}$	1.13		
ICC	0.43		
N_{ID}	78		
Observations	468		
Marginal R^2/Conditional R^2	0.238/0.564		

Note: * signals interaction.

For Sentence constituent, a post-hoc analysis using the *emmeans* function with Tukey corrections showed that non-targeted CS is predicted to be more frequent in the Temporal phrase than in the Subject position ($p < 0.001$). Non-targeted CS is also predicted to be more frequent in the Temporal phrase than in the Verb position ($p < 0.001$). The difference between the Subject and the Verb position was not significant ($p = 0.85$) for both groups and in both languages. The main effects of Language and Group were significant, as well as the interactions of Sentence constituent and Group and Language and Group. Post-hoc analyses with Tukey corrections were conducted, and the predicted frequencies for the interaction of Sentence constituent and Group are plotted in Figure 2. For the interaction of Language and Group, the results replicated those reported above for overall non-targeted CS (see Figure 1).

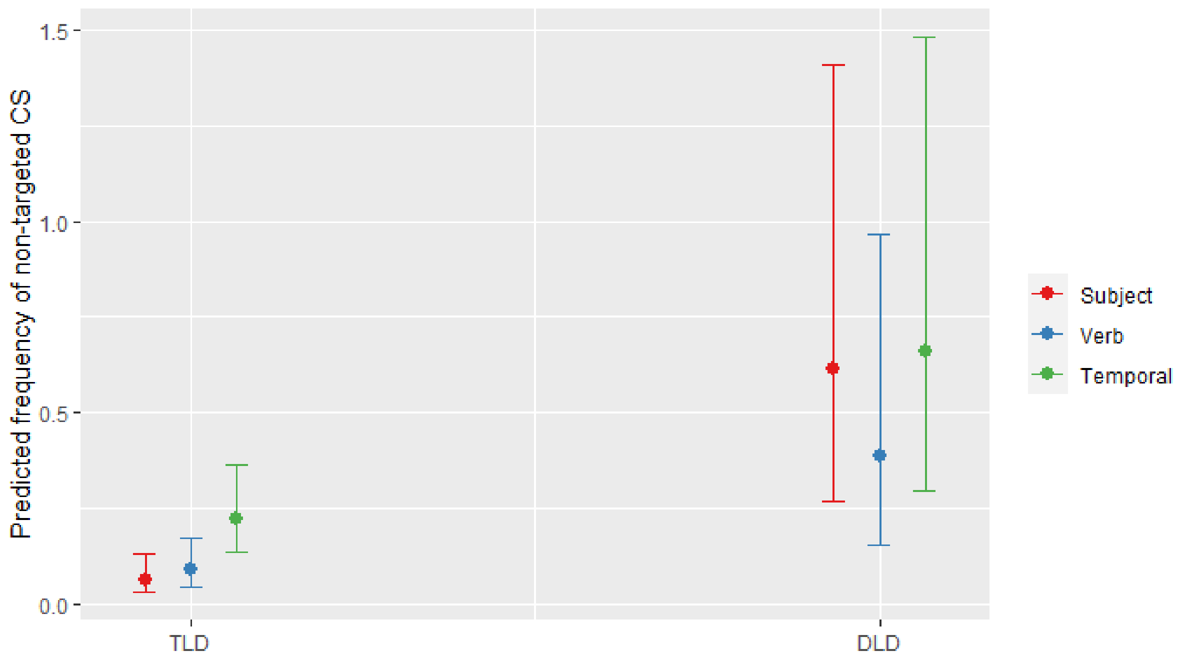

Figure 2. Predicted frequencies of non-targeted CS for the interaction of Sentence constituent and Group.

The post-hoc analysis indicated that children with DLD are predicted to use more non-targeted CS in the Temporal phrase than in the Verb ($p = 0.02$), whereas the differences between Temporal and Subject ($p = 0.33$) and between Verb and Subject ($p = 0.36$) were not significant. For TLD, the predicted values of non-targeted CS showed a significant difference between the Temporal phrase and Subject ($p < 0.001$) as well as between the Temporal phrase and Verb ($p < 0.001$), but not between the Subject and Verb ($p = 0.69$).

3.3. Non-Targeted CS within the Temporal Phrase

The category of Temporal phrase was subcategorized into grammatical constituents to assess which grammatical constituent in the temporal phrase resulted in most non-targeted CS: determiner (DET), determiner and noun (DET+N), noun (N), or other switches (for example, *tomorrow* for *etmol* 'yesterday'; or *shuv ve shuv* 'again and again' for *again and again*). These subcategories are displayed in Table 6.

Table 6. Means, ranges, and frequencies of non-targeted CS for constituents within the temporal phrase in English and Hebrew, for children with TLD and DLD.

	TLD (N = 65)			DLD (N = 13)		
	Mean	**Range**	**Sum (No. of Children)**	**Mean**	**Range**	**Sum (No. of Children)**
Temporal Phrase Constituent						
English						
DET	0.18	0–5	12 (N = 7)	0.38	0–4	5 (N = 2)
DET+N	0.09	0–1	6 (N = 6)	0.31	0–3	4 (N = 2)
N	0.03	0–1	2 (N = 2)	0.08	0–1	1 (N = 1)
Other	0.02	0–1	1 (N = 1)	0.15	0–1	2 (N = 2)
Totals English			21			12
Hebrew						
DET	0.72	0–10	47 (N = 18)	0.31	0–2	4 (N = 3)
DET+N	0.48	0–10	31 (N = 11)	0.09	0–3	7 (N = 4)
N	0.02	0–1	1 (N = 1)	0.03	0–1	1 (N = 1)
Other	0.14	0–3	9 (N = 6)	0.02	0–2	3 (N = 2)
Totals Hebrew			88			15

To further explore the non-targeted CS within the Temporal phrase, a GLMM analysis was performed with the following fixed factors: Constituent, Language, Constituent*Language, Group, Group*Constituent, Group*Language, and Group* Language*Constituent. The following factors were significant: Constituent, Language, and Group*Language. The results of the likelihood ratio tests are included in Table A3 in Appendix A. The summary of the optimal model is presented in Table 7. The fixed effects explained 30% of the variance, and the random effects explained another 29%.

For the constituents within the temporal phrase, a post-hoc analysis indicated that for both groups, predicted frequencies of non-targeted CS on DET are more frequent than on N ($p < 0.001$) and on other constituents in the Temporal phrase ($p < 0.001$). Similarly, the analysis of non-targeted CS showed that predicted frequencies of non-targeted CS on Det+N were more frequent than on N ($p < 0.001$) and on other constituents in the Temporal phrase ($p < 0.001$).

For the interaction of Group and Language, based on post-hoc analysis with Tukey corrections, children with DLD are predicted to produce a similar amount of non-targeted CS in both languages ($p = 0.56$), whereas children with TLD are predicted to produce more non-targeted CS in Hebrew than in English ($p = < 0.001$). This Group by Language interaction has the same structure as the interaction displayed above in Figure 1.

Table 7. Estimates of the model predicting the frequency of Non-targeted CS withing the Temporal phrase.

Predictors	*Incidence Rate Ratios*	*CI*	*p*
(Intercept)	0.36	0.15–0.91	**0.031**
Constituent [Det+N]	0.71	0.49–1.02	0.065
Constituent [N]	0.07	0.03–0.18	**<0.001**
Constituent [Other]	0.22	0.13–0.39	**<0.001**
Language	1.25	0.59–2.67	0.565
Group	0.26	0.09–0.74	**0.011**
Language * Group	3.35	1.37–8.21	**0.008**
Random Effects			
σ^2	2.14		
$\tau_{00\ ID}$	1.48		
ICC	0.41%		
N_{ID}	78		
Observations	624		
Marginal R^2/Conditional R^2	0.302/0.587		

Note: * signals interaction.

4. Discussion

The present study investigated non-targeted CS (cross-language errors) in preschool children with and without DLD by means of an SRep task. The main findings were as follows:

1. Stimulus condition: More non-targeted CS emerged for sentence stimuli containing a codeswitch than for unilingual stimuli.
2. Directionality: More non-targeted CS occurred in Hebrew than in English stimuli for children with TLD, but not for the children with DLD, who showed no directionality difference.
3. Group Status: Children with DLD produced more non-targeted CS than children with TLD for English stimuli.
4. Sentence constituent: Most non-targeted codeswitches occurred sentence-finally, in the temporal phrase, and most involved determiners.

We discuss these four main results in terms of (1) language co-activation and competition in order to account for the difference in performance on unilingual versus codeswitched stimuli; (2) psycholinguistic and sociopragmatic factors related to home and societal language to account for the directionality effect among children with TLD and the lack thereof among children with DLD; (3) language competence and processing in children with DLD; and (4) the locus and grammatical properties of the non-targeted switches.

4.1. Codeswitched vs. Unilingual Stimuli: Frequency of Non-Targeted CS as a Function of the Type of Stimulus Sentence

Intra-sententially codeswitched stimuli resulted in more cross-language intrusions than unilingual stimuli. This result is in line with research on bilingual language co-activation. Kootstra and colleagues propose the notion of primed CS and demonstrate that a speaker's inclination to codeswitch is primed by the frequency of CS used by the conversation partner (Kootstra et al. 2010; Fricke and Kootstra 2016). Other research on language intrusions has shown that intrusions are more common when bilinguals are functioning in a bilingual setting in which they codeswitch frequently (Gollan and Goldrick 2016; Gollan et al. 2014, 2017; Grosjean 2001) or when performing language tasks in bilingual versus monolingual language trials (Gross and Kaushanskaya 2018, 2020; Jia et al. 2006; Kohnert 2002; Kohnert et al. 1999; Prior and Gollan 2013).

Processing intra-sententially codeswitched sentences (as compared to unilingual sentences) challenges language control processes due to enhanced language co-activation and competition (Bobb et al. 2016; Declerck and Philipp 2015; Green and Abutalebi 2013; Green and Wei 2014). The lower number of cross-language intrusions in unilingual sentences aligns with Green and Wei's (2014) proposal that in the monolingual language mode, the non-target language is 'locked,' whereas during intra-sentential CS, a 'coupled' control mode allows more opportunity for CS and thus for cross-language intrusions since the gate to the non-target language is not 'locked.' In line with Gollan et al.'s (2017) notion that continuous inhibition is cognitively less taxing than repetitively regulating inhibition for successive lexical items, the participants in the present study were required to exercise more control when repeating codeswitched stimuli than unilingual stimuli. Similarly, Hofweber et al. (2016) assume more language monitoring and/or competition during intra-sentential CS, that is, under conditions where the two languages are highly activated, as compared to monolingual modes. In contrast, in order to avoid unintended interference (viz., cross-language intrusions) from the second language, a monolingual mode requires "prolonged global inhibition" of the second language and minimal language monitoring.

The setting of the present study provided a high level of language co-activation. The participants were exposed to both languages throughout the experiment since the codeswitched stimuli were interleaved with the unilingual stimuli in the same session. Thus, the co-activation of two languages was probable even when processing the unilingual stimulus sentences. Indeed, the fact that there were some cases of non-targeted CS when repeating unilingual stimuli attests to this. Nonetheless, the higher incidence of cross-language intrusions for codeswitched stimuli argues for more language co-activation, more language interference, and more difficulty controlling the two languages when exposed to intra-sentential codeswitched stimuli as compared to unilingual stimuli.

More intrusions resulted when the PP in the stimulus sentence was codeswitched in its entirety than when only part of the PP contained a codeswitch, particularly for Hebrew sentence stimuli. This suggests that when participants process a comparatively longer codeswitch (P+DET+N vs. N, DET+N, or P), the language of that switch is more strongly primed and activated. This additional activation results in a greater challenge to language control and more non-targeted CS. Beyond the length of the switch, it is also possible that activation of the codeswitched language is stronger when the participants encountered a switch in a full syntactic constituent rather than part of one, where some elements remain in the non-switched language. Thus, a full constituent may lead to a boost in activation. This idea aligns with Fricke and Kootstra's (2016) suggestion that the more unambiguously words belong to a particular language, the greater the likelihood that that language will be activated.

Recent proposals maintain that distinct CS typologies affect language control processes differently (Green and Abutalebi 2013; Green and Wei 2014; Hofweber et al. 2016). For instance, according to the Control Process Model of Code-switching (Green and Wei 2014), dense CS, which is characterized by multiple switches of both grammar and lexicon within an utterance, is predicted to involve minimal language control, while insertion of single lexical items or phrases engages language control more extensively. The present study also raises the possibility that even for insertional CS, the extent of language control may fluctuate as a function of which constituent (N, DET+N, P, P+DET, P+DET+N) is codeswitched.

4.2. Directionality: Frequency of Non-Targeted CS as a Function of the Language of the Stimulus Sentence

Language control was also affected by the directionality of the codeswitch. Among children with TLD, the findings showed more non-targeted CS for Hebrew than for English stimulus sentences. More specifically, this asymmetry resulted from more frequent switching into English for Hebrew stimulus sentences than switching into Hebrew for English sentences. Unilingual stimulus sentences showed no directionality effect.

Directionality effects result from both psycholinguistic factors (lexical access difficulties in the home language) and sociopragmatic factors (extensive language exposure to the societal language and awareness of the setting and the prominence of that language).

Both sets of these factors should favor switching to the societal language. Thus, for the sequential bilingual children in the present study, similar to those in previous studies with English–Hebrew and Russian–Hebrew bilingual preschool children in Israel (Iluz-Cohen and Walters 2012; Raichlin et al. 2019), the preferred direction of switching was expected to be into Hebrew. These children grow up in a context where Hebrew is the language of daily communication in the preschool, neighborhood, and society at large, media included. Hebrew is also the language brought into the home by older siblings. English, on the other hand, is found primarily in the home. The directionality effect discussed here is in line with data reported in other language contexts, which noted more CS into the societal language than into the home language (Gutiérrez-Clellen et al. 2009; Kapantzoglou et al. 2021; Kuzyk et al. 2020; Montanari et al. 2019; Vu et al. 2010).

In contrast, the present finding of more non-targeted switching from Hebrew (the societal language) to English (the home language) for children with TLD runs counter to the preferred direction. We propose that children with TLD are not able to apply typical CS directionality patterns due to the experimental demands of sentence repetition. Typical CS directionality (into the societal language) probably involves a frequency metric in natural conditions (outside the laboratory), and it may not be accessible or relevant when the child is asked to repeat sentences with CS verbatim and in different locations. Another reason for this anomalous finding may be due to relatively stronger activation of English when processing an English codeswitch within a Hebrew stimulus sentence, i.e., when processing a codeswitch in an "atypical" direction (from the societal to the home language). It is this heightened activation of English, in competition with the psycholinguistically and sociopragmatically preferred language, Hebrew, which may have led to more cross-language intrusions into English. Thus, children with TLD may have attempted to perform the task strictly on the basis of the heightened activation of English.

The children in the DLD group did not show this directionality effect: they produced similar frequencies of non-targeted CS for English and Hebrew stimulus sentences. This is discussed in detail in the following section.

4.3. Non-Targeted CS as a Function of Group Status (TLD-DLD)

Children with DLD differed from those with TLD in two principal ways: higher rates of non-targeted CS for English stimuli and the lack of a directionality effect. They also showed a distinct pattern in terms of the sentence position of their non-targeted CS (discussed in the following section).

CS frequency. It should be noted at the outset that while the difference in predicted frequency of non-targeted CS between TLD and DLD was significant only for English stimuli, examination of individual data showed that a larger percentage of children with DLD produced non-targeted CS for both English and Hebrew stimuli.

Non-targeted CS may be a consequence of impaired linguistic competence for children with DLD. Language control is challenged due to limitations in overall language skills, which may impact sensitivity to using the required language in a particular context (Gross and Kaushanskaya 2020, 2022). Furthermore, as noted by Poulisse (2000), more cross-language errors emerge when language use is less automatized and requires more attention. These factors might be relevant for children with DLD, too. The language control difficulties of children with DLD may also stem from impaired lexical-semantic knowledge in either or both languages, as suggested by Gross and Kaushanskaya (2020, 2022). Thus, it is possible that the children with DLD in the present study activated and selected lexical items in the "wrong" language due to lexical gaps, difficulty in lexical access, and other underlying lexical-semantic difficulties.

In addition, the higher frequency of non-targeted CS among children with DLD may be a reflection of the greater prevalence of CS in their day-to-day communication. Children with DLD may be more used to codeswitching than children with TLD for reasons of lexical access difficulty and/or socio-pragmatics (Greene et al. 2012; Heredia and Altarriba 2001; Iluz-Cohen and Walters 2012; Walters 2005). Therefore, activating a lexical item in the non-target language may be an option that is more natural and acceptable to children with DLD as compared to children with TLD.

The finding that children with DLD had higher rates of cross-language intrusions is consistent with two recent studies examining language control in bilingual children and language control (Gross and Kaushanskaya 2020, 2022). In these studies, Spanish-English preschool bilinguals were asked to describe picture scenes to either a monolingual speaker of Spanish or a monolingual speaker of English. In the 2020 study, cross-language intrusions were defined as utterances in the language not understood by these speakers. The study reported an inverse correlation between language proficiency and language intrusions, implying that stronger language abilities were related to fewer intrusions. Likewise, the 2022 study found that children with DLD had more "cross-speaker switches" (cross-language intrusions in the 2020 study) when they interacted with a Spanish speaker.

Notwithstanding the differences in data collection procedures, findings regarding intra-sentential CS are very relevant here. In the 2022 study, Gross and Kaushanskaya reported no significant differences between the typically developing and language-impaired children for either frequency or directionality of intra-sentential CS. These results run counter to those of the study reported here. Gross and Kaushanskaya's (2022) results for intra-sentential CS are consistent, however, with both Gutiérrez-Clellen et al. (2009) and Kapantzoglou et al. (2021), who also found no differences between the quantity of CS for children with TLD and DLD. The inconsistency between these studies and our own probably should be attributed to the task used in the present study, where participants operated in a bilingual language mode in order to produce intra-sententially codeswitched sentences in particular locations. In the other studies, in contrast, children were engaged in more flexible, retelling, and conversational tasks either in monolingual settings (Gutiérrez-Clellen et al. 2009; Kapantzoglou et al. 2021) or in a setting in which participants were explicitly told that the interlocutors knew only one language (Gross and Kaushanskaya 2022).

It could also be argued that these latter tasks were less demanding. The SRep task, unlike conversation in monolingual settings, is an attempt to push the child's language control processes to their limits in a laboratory setting. It challenges the child's language control processes in a number of ways. The child is asked to reproduce the stimulus sentence exactly as s/he heard it, but the CS varies in where it appears in the PP in the stimulus sentence. The amount of CS in the task is far greater than the child would encounter in a natural setting or even in the experimental settings of these other studies. This has implications for language control. First and foremost, there is a high level of activation of both languages (in order to be ready to repeat the content and codeswitch in the appropriate places). Requirements to codeswitch in particular locations—along with working memory and processing limitations known to exist among children with DLD (Boerma and Blom 2020; Henry et al. 2012; Im-Bolter et al. 2006; Marton et al. 2007; Montgomery 2002) are taxing for language and cognitive control processes (cf. Thomas and Allport 2000; Van Hell et al. 2015; Von Studnitz and Green 2002, among others, for discussions on the processing costs of CS). The finding of more non-targeted CS for children with DLD shows they were less able to cope successfully with recalling the sentence content, formulating a verbatim response, and producing the codeswitched elements in their appropriate location. This multi-level semantic, morphosyntactic, and bilingual juggling act led to more cross-language intrusions in children with DLD.

The challenges to language control that CS via SRep poses for children with DLD have also been attested to in a previous study (Soesman 2018). That study found more non-targeted CS among this population for an SRep task of codeswitched single nouns. In addition, that study showed that children with DLD had a lower tendency to codeswitch elements within a PP and greater failure to codeswitch single nouns and single verbs when prompted to do so via the stimulus sentences. Like Festman et al. (2010), we consider both cross-language errors and failure to switch when prompted to do so as instances of language interference errors, indicating difficulty with language control.

Directionality effect. The other finding for children with DLD is that, in contrast to children with TLD, children with DLD did not show the directionality effect of more non-targeted CS in Hebrew stimuli as compared to English. The lack of a directionality effect may point to a different kind of difficulty in language control, one related to sociopragmatic sensitivity. For this population, the English switches in Hebrew sentences may have appeared just as commonplace as the Hebrew ones in English sentences. Therefore, there was no "red light" that turned on for the DLD children when processing a Hebrew to English CS, that is, a codeswitch in an "atypical" direction, from the societal to the home language. Children with DLD have been reported to have less developed pragmatic and social skills (Hage et al. 2021; Marton et al. 2005; Norbury et al. 2014) and to be less sensitive to language use in different social settings (Kapantzoglou et al. 2021). However, since we do not have data about the sociopragmatic skills of the children in the present study, this explanation is only a conjecture based on the population from which they were recruited.

The lack of a directionality effect is in line with other research that has shown that bilingual children with DLD do not show the pattern of bilinguals with TLD, who tend to codeswitch more from the home to the majority language than vice versa (Iluz-Cohen and Walters 2012; Sheng et al. 2012). In addition to socio-pragmatic sensitivity, this may be a function of the nature of bilingual DLD, viz., language impairment in both languages (Armon-Lotem and Meir 2016; Ebert and Kohnert 2016; Håkansson et al. 2003). Thus, since bilingual children with DLD have two weak languages, they may not have a clear preference for switching directions. Another, more speculative interpretation for the lack of an effect for directionality among children with DLD comes from the field of statistical learning. In this framework, children are said to monitor input for statistical probabilities, which helps them determine what language constructions are appropriate (Yim and Rudoy 2013). Children with bilingual DLD may have successfully monitored for the amount of CS in the experiment but may not have been statistically sensitive to the direction of the switching.

The lack of directionality differences reported here for children with DLD stands in contrast to several other studies involving this population, where more CS in the societal language than in the home language was found (Gross and Kaushanskaya 2022; Gutiérrez-Clellen et al. 2009; Kapantzoglou et al. 2021). This lack of consensus, too, may be a function of task differences. These latter studies used storytelling, conversation, and picture description tasks, which involved more interactive language use. The SRep task in the present study, along with codeswitched stimuli at different sites within a PP, did not invoke the same sociopragmatic schemata that a more interactive task would have. Thus, typical schemata for directionality may not have played a role for the language-impaired children, who were coping with the language control demands of the task.

4.4. Sentence Position of Non-Targeted CS

Another objective of the present study was to determine where in the sentence the children produced non-targeted codeswitches. The results showed that most cross-language intrusions were produced in sentence-final position, in the temporal phrase, particularly in Hebrew. One explanation for CS in this constituent is that the temporal phrase came directly after the PP, the element in the sentence stimuli that contained the target codeswitch. After processing and producing the codeswitch, the constituent immediately following this codeswitch may have been 'triggered' due to cross-linguistic priming (cf. Kootstra Gerrit Jan and van Hell 2020). Thus, in these instances, children continued using the (codeswitched) language to which they were already exposed in the PP. This finding is similar to intrusions reported in a reading-aloud task, which occurred immediately after their codeswitched antecedent (Kolers 1966). Moreover, the temporal phrase was the last element in the sentence, ruling out other candidates for intrusion.

The constituents preceding the PP–the subject and the verb–resulted in little non-targeted CS. Regarding the subject, the well-known "serial position effect" (Ebbinghaus 1913) shows better recall for items at the beginning of a list than those in the middle (e.g., Modigliani and Hedges 1987; Tan and Ward 2000). Primacy effects have been observed in children with TLD and DLD both in and outside of sentence contexts (Coady et al. 2010). For SRep tasks, fewer omissions and substitutions and better performance have been reported for sentence-initial elements than those occurring later in the sentence (e.g., Alloway and Gathercole 2005; Butterworth et al. 1986; Isham and Lane 1993). Thus, fewer cross-language intrusions of sentence-initial elements in the present study may be due to a primacy effect where sentence subjects were more accessible in the language in which they were presented.

Relatively few intrusions also occurred for the verb in the stimulus sentence. One reason may be the difficulty of codeswitching finite verbs. This difficulty has been attributed to the assumption that verbs are pivotal sentence constituents in terms of their role in case assignment and establishing the type and number of arguments (Klavans 1985; Myers-Scotton 1993a; Treffers-Daller 1993). Matras (2009) has suggested that because of this central role, codeswitching an inflected verb would lead to confusion in establishing the base language and is therefore avoided.

Within the temporal phrase, most cross-language errors involved the determiner. Other studies have reported that function words are more prone to language intrusions than content words such as nouns and verbs (Poulisse and Bongaerts 1994; Gollan and Goldrick 2016; Gollan et al. 2014; Schotter et al. 2019). Poulisse and Bongaerts (1994) propose several explanations for this content-function difference. First, since function words convey less semantic information than content words, they are less salient and may draw less attention. Non-fluent language learners, in particular, have fewer resources to attend to less salient elements and monitor their formulation. Less monitoring of function words may also be related to their shorter length, making them less prone to checking mechanisms and hence more prone to production in the 'wrong' language (cf. Gollan et al. 2014). Finally, Poulisse and Bongaerts (1994) suggest that since function words are more frequent, less activation is needed to select and produce them. This may result in more frequent cross-language errors. Schotter et al. (2019) proposed a complementary explanation, suggesting that function words are more predictable and, consequently, easier to retrieve.

Both groups had more intrusions in the temporal phrase than in the other constituents. However, children with DLD showed a pattern which differed from children with TLD regarding the sentence position of cross-language intrusions. The children with TLD made distinctions between the temporal vis-à-vis both subject and verb whereas the children with DLD only distinguished between temporal and verb in their non-targeted CS. These group differences may be due to less developed linguistic skills, specifically less sensitivity to grammatical constituents. Moreover, their efforts to cope with the demands of a codeswitched SRep task may have led them to be less attentive to grammatical properties.

4.5. Limitations and Suggestions for Future Research

The present study examined language control processes in intra-sentential CS as reflected in cross-language intrusions by means of an SRep task where only the PP was switched in the stimulus sentences. The study of language control in CS would benefit from a comparison of intra-sentential, inter-sentential, and even cross-speaker CS. Building on Green and Wei's (2014) grounding of dense CS, insertion, and alternation in different sociolinguistic contexts, a study of CS in bilingual children would help clarify the discrepancy in findings reported here for directionality in switching. This kind of study is also likely to contribute to the assessment and diagnosis of bilingual children with DLD.

Beyond the limitations in statistical power resulting from the small number of children with DLD (a problem endemic to most studies of bilingual DLD), larger numbers of children would have allowed us to look more closely at differences in language proficiency and language dominance and their role in language control. Moreover, it would allow further exploration of directionality effects in language control as a function of language competence. For instance, balanced bilinguals and Hebrew-dominant bilinguals might show different patterns in cross-language errors. Furthermore, we know from other work (Novogrodsky and Meir 2020) that L1 dominant children do not have the same morphosyntactic and narrative abilities as L2 dominant and balanced bilinguals. These differential language competencies may, in turn, affect language control abilities among children with DLD.

Another promising research avenue would be to compare the same children's CS on an SRep task with more interactive tasks such as conversation, narrative, and role-playing. Such comparisons should show a range of CS frequency and intrusion errors, providing valuable evidence about the nature of intra-sentential CS for different tasks.

In addition, it would be edifying to compare language pairs that are typologically more similar than English and Hebrew and CS for grammatical structures other than PPs. Finally, as noted at the outset, the current study set out to examine language control, not domain-general cognitive control. A comparison of the abilities for shifting and inhibition tasks could shed light on the link between impaired executive functioning and non-targeted CS in children with TLD and DLD.

5. Conclusions

Codeswitching is the signature feature of bilingualism. Since it involves the integration of multiple levels of a bilingual speaker's two languages, it is perhaps the phenomenon that can contribute most to our understanding of language control in bilingualism. In addition to structural integration of phonetic, morphosyntactic, syntactic, semantic, lexical, and pragmatic information, CS involves cross-language activation and competition as well as priming and triggering (cousins of activation) and interference and inhibition. The present paper experimentally manipulated CS in an SRep task, investigating language control as reflected in cross-language intrusions. More errors occurred for codeswitched than for unilingual sentence stimuli, highlighting increased language competition when processing intra-sentential CS. We also found that different control processes may be at work during intra-sentential CS, with greater challenges for language control when processing diverse codeswitched constituents. For children with TLD, most errors occurred in Hebrew sentences containing switches to English. For children with DLD, in contrast, relatively equal numbers appeared in both languages. This result underscores the importance of considering directionality effects and testing bilingual children in both of their languages. Children with DLD produced more cross-language errors in English stimuli than children with TLD. Occasionally, errors produced by children with DLD qualitatively differed from those made by children with TLD. These dissimilarities, along with directionality differences, point to non-targeted CS as a potential diagnostic marker for bilingual DLD.

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Appendix A

Table A1. Estimates of the GLMM model predicting the frequency of non-targeted CS by CS condition.

Fixed Factor	*AIC*	*BIC*	*logLik*	*Deviance*	*Chisq*	*Df*	*p*
Condition	1000.9	1034.8	−493.45	986.9	53.213	5	**<0.001**
Language	976.25	1015.0	−480.13	960.25	26.645	1	**<0.001**
Condition * Language	975.45	1038.4	−474.72	949.45	10.804	5	0.055
Group	972.1	1015.7	−477.05	954.1	6.1525	1	**0.013**
Group * Condition	978.45	1046.2	−475.23	950.45	3.6488	5	0.601
Group * Language	965.66	1014.1	−472.83	945.66	8.4373	1	**0.004**
Group * Condition * Language	978.31	1099.3	−464.15	928.31	17.359	15	0.298
Age	966.85	1020.1	−472.42	944.85	0.8144	1	0.367
AoO	967.3	1020.5	−472.65	945.3	0.3672	1	0.545
Non-verbal IQ (Raven)	967.05	1020.3	−472.53	945.05	0.6128	1	0.434

Table A2. Estimates of the GLMM model predicting the frequency of non-targeted CS by Sentence constituent.

Fixed Factor	*AIC*	*BIC*	*logLik*	*Deviance*	*Chisq*	*Df*	*p*
Sentence constituent	810.08	826.67	−401.04	802.08	94.327	2	**<0.001**
Language	783.07	803.8	−386.54	773.07	29.008	1	**<0.001**
Sentence constituent * Language	777.73	806.77	−381.87	763.73	9.3401	2	**0.009**
Group	773.87	807.06	−378.93	757.87	5.8628	1	**0.015**
Group * Sentence constituent	766.61	808.09	−373.3	746.61	11.262	2	**0.004**
Group * Language	762.37	808.01	−370.19	740.37	6.2317	1	**0.013**
Group * Sentence constituent * Language	763.33	817.26	−368.66	737.33	3.0448	2	0.218

Note: * signals interaction.

Table A3. Estimates of the GLMM model predicting the frequency of non-targeted CS by Constituent within the Temporal phrase.

Fixed Factor	AIC	BIC	logLik	Deviance	Chisq	Df	*p*
Constituent	660.86	683.04	−325.43	650.86	83.654	3	**<0.001**
Language	625.04	651.66	−306.52	613.04	37.818	1	**<0.001**
Constituent * Language	627.67	667.6	−304.83	609.67	3.3716	3	0.338
Group	625.37	656.42	−305.68	611.37	1.676	1	0.196
Group * Constituent	626.47	670.83	−303.23	606.47	6.5763	4	0.160
Group * Language	620.58	656.07	−302.29	604.58	8.466	2	**0.015**
Group * Language * Constituent	628.75	704.17	−297.38	594.75	9.8221	9	0.365

Notes

1 These terms are used interchangeably in the present paper. We also use 'non-targeted CS'.

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