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Cognate effects in bilinguals with a history of Developmental Language Disorder: Investigating word representation, processing, and metalinguistic awareness.

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Cognate effects in bilinguals with a history of Developmental Language Disorder: Investigating word representation, processing, and metalinguistic awareness

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Language and Communicative Disorders

by

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The dissertation of Jonathan Julius Deonn Robinson Anthony is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California San Diego

San Diego State University California State University

2022

DEDICATION

"This is dedicated to the one I love."

The Mamas & The Papas

EPIGRAPH

“We step out of our solar system into the universe seeking only peace and friendship, to teach if we are called upon, to be taught if we are fortunate.”

K. Waldheim

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PRESENTATIONS

Galvez-McDonough, A. , Sandoval, A., Barragan-Diaz, A., Ruvalcaba, V., Shaw, S., **Robinson Anthony, J.J.D.,** Blumenfeld, H. K., & Ries, S. (2022, March). Phonetic variation during speech production in Spanish-English bilingual adults: An online experiment. *San Diego State University 15th Annual Student Research Symposium,* San Diego, CA.

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Robinson Anthony, J.J.D. (2017, September). Language dominance is predictive of cognate effects and inhibitory control in young adult bilinguals. *SDSU/UCSD Joint Doctoral Program in Language & Communicative Disorders 21st Annual Doctoral Student Colloquium.* San Diego, CA.

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Duffy, C., Caballero, A., Osuna, D., Ghorbani, N., Sullivan, M., Higareda, R., Jeong, M., **Robinson Anthony, J.J.D.,** & Blumenfeld, H.K. (2017, March). Influence of linguistic, cognitive and musical skills on symbolic learning in monolinguals and bilinguals. *San Diego State University 10th Annual Student Research Symposium,* San Diego, CA.

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Robinson Anthony, J.J.D., Epstein, L., & Yu, B. (2016, April). Speech sound acquisition in a 5-year-old Spanish-English bilingual child. *San Francisco State University 2016 Graduate Research and Creative Works Showcase.* San Francisco, CA.

Robinson Anthony, J.J.D. (2014, April). Language learning disorders in middle school students. *19th Annual National Student Speech-Language Hearing Association Conference.* San Francisco, CA.

AWARDS AND SCHOLARSHIPS

SDSU Student Research Symposium President's Award (All-University), 2021

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ASHA Minority Student Leadership Program, 2018

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UCSD San Diego Fellowship (stipend, tuition, and fees), 2017-2019

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ABSTRACT OF THE DISSERTATION

Cognate effects in bilinguals with a history of Developmental Language Disorder: Investigating word representation, processing, and metalinguistic awareness

by

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Doctor of Philosophy in Language and Communicative Disorders

University of California San Diego, 2022
San Diego State University, 2022

Professor Henrike K. Blumenfeld, Chair
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Developmental Language Disorder (DLD) is characterized by a challenge in acquiring and using language. Vocabulary size is impacted, as adults with a history of DLD may experience a “vocabulary gap” in word knowledge, with fewer word representations stored in the mental lexicon.

Furthermore, adults with a history of DLD may experience lexical access delays, with slower form-to-meaning mapping during processing for word recognition. For bilinguals, word representations are stored in an integrated lexicon and crosslexical interaction influences word identification dynamics. Evidence of crosslexical facilitation is found in cognate effects, whereby translation equivalents that share similar form are more accurately and quickly recognized than those with little to no overlap. Whether crosslexical processing dynamics are disrupted by DLD remains an open question. Thus, this current dissertation investigates the intersection of DLD and word representation/processing within a bilingual model for word recognition. Findings suggest that language differences between adult bilinguals with and without a history of DLD may be limited to aspects of word knowledge and processing, with similar metalinguistic strategies for word recognition.

Chapter 1 provides an overview of bilingual word recognition dynamics and establishes a groundwork to make word recognition predictions based on participant-internal factors, such as language experience and a history of DLD, and task-internal ones, including form overlap between target words and translation equivalents. Chapter 2 establishes a relation between word recognition accuracy and language experience in typical bilingual adult. This relation is further investigated in Chapter 3, including an extension of investigations to bilingual adults with a history of DLD. Chapter 4 shifts from an investigation of word representation to word processing, detailing the relation between lexical access and language experience via button-press (overt response) and eye-gaze behavior (covert/subconscious response). Chapter 5 looks beyond the word identification system and seeks to explore the influence of higher-order processing, namely metalinguistic awareness, on word recognition. In conclusion, Chapter 6 summarizes and integrates findings from these studies to establish a baseline for understanding the impact of DLD on vocabulary during early adulthood for bilinguals, with potential future directions to fill gaps where current limitations lie.

CHAPTER 1: INTRODUCTION

Developmental Language Disorder (DLD), though typically diagnosed and treated during childhood, is a life-long condition with documented negative outcomes into adulthood in socio-emotional self-perception (e.g., Beitchman et al., 2001) and in career choice (e.g., Conti-Ramsden et al., 2018). Outside of outcomes data, little is known about the language skills of adults with a history of DLD. One area of primary deficit in DLD is vocabulary. Adults with a history of DLD have been shown to have lower performance on receptive vocabulary (e.g., Brownlie et al., 2016) and weakness in processing lexical-semantic information (e.g., Helenius et al., 2009). This suggests that word representations and word association networks that support processing may continue to be affected into adulthood. Word comprehension – the focus of the current dissertation work – is a fundamental skill for vocabulary development. Furthermore, our understanding on how the languages of bilinguals interact in the presence of DLD is developing (e.g., Grasso et al., 2018; Payesteh & Pham, 2021; Potapova & Pruitt-Lord, 2020). One remaining important part in understanding DLD in the context of bilingual processing is to examine the adult bilingual processing system in individuals with a history of DLD. Specifically, examination of the adult bilingual system may help elucidate how a history of DLD influences processes in matured language systems that are unique to the bilingualism, such as crosslexical interaction and scaffolding between the two languages. Across four studies, the current dissertation sets out to (1) establish a baseline of Spanish-English bilingual word knowledge and processing across language profiles in neurotypical bilinguals, and examine word knowledge (2), processing (3), and analysis (4) in the context of DLD.

The bilingual lexicon is crosslinguistically integrated

A handful of psycholinguistic models reflect the behavioral literature on bilingual processing and seek to explain bilingual word comprehension (e.g., Bilingual Interactive Activation model, BIA, Dijkstra & van Heuven, 1998; van Heuven, Dijkstra, & Grainger, 1998; Bilingual Model of Lexical Access, BIMOLA, Grosjean, 1997; Distributed Feature Model, de Groot, 1992; Self-Organizing Connectionist Model of Bilingual Processing, SOMBIP, Li & Farkas, 2002). Importantly, the models feature dynamic associations between linguistic levels and accounts for clustering of language-specific representations. For example, the SOMBIP is a computational model designed to illustrate how interactive activation and Hebbian learning can shape the architecture of the bilingual lexicon. The mechanism of Hebbian learning allows for the formation and strengthening of associations between form and meaning within lexical items and between lexical representations based on *language input*. This results in language representations that are unique to each bilingual's learning history and language use. The SOMBIP suggests that when a participant hears a word, the corresponding phonological representations are activated across languages. Activation feeds forward from phonological representations to related whole word and semantic representations. For example, the word pear is recognized when its corresponding features (e.g., /p/ /ɛ/ /ə/ /r/) at the phonological level become active, which then spreads to the whole word representation and corresponding semantic concepts (e.g., fruit, yellowish-green, sweet). A central feature of the SOMBIP is that it accounts for distinct patterns of bilingual lexical processing in a language non-selective manner. This means that the model does not posit language-specific sensitivity to auditory input; instead, the *two* *languages become active simultaneously when auditory input matches representations in both languages*.

Words are organized according to sublexical and semantic features that are represented by “maps.” Through interactions between word forms and their meanings, lexical entries self-organize into language clusters within these maps as the model is exposed to bilingual language input. Successful word comprehension occurs when a word is recognized or selected, characterized by the convergence of sublexical and semantic feature activation that ultimately leads to appropriate identification of a lexical entry or concept best matching the input information. Sublexical features (e.g., phonemes), as well as semantic qualities, are statistically processed across languages and are clustered based on co-occurrence patterns in the input. These language-specific cluster networks, according to simulations run by Li and Farkas (2002), are distinct from each other. Specifically, boundaries between languages (English and Chinese in the simulation by Li and Farkas) are discernable on both the phonological and semantic maps. Close proximity and overlap of representations on these maps suggest the *crosslinguistic integration of networks*.

Close proximity of similar-sounding translation equivalents (i.e., cognates) on representational maps has indeed been shown in simulations leading to a more recent model on bilingual auditory word recognition that was built using self-organizing maps (BLINCS, Shook & Marian, 2013) for language pairs with a more recent etymological root, such as Spanish and English. For example, in simulations by Shook and Marian, the English words *actor, doctor, and dolphin* were each situated closely to their Spanish cognate equivalents *actor, doctor, and delfin* after running iterations of word comprehension modeling. The English word *beaver* was however more distally situated to its Spanish noncognate equivalent *castor*. Though the hypothesis of connection distance between words and lexical processing has not been directly tested, the self-organizing language models' account of cognate words' spatial proximity in the lexicon aligns with behaviorally-established lexical processing advantages over noncognate words that have been well documented in the bilingualism literature for adults (e.g., Amengual, 2016; Lemhöfer et al., 2004; Gollan et al., 1997; Robinson Anthony & Blumenfeld, 2019; Van Hell & de Groot, 1998), as well as in typically developing bilingual children (e.g., Bosma et al., 2019; Robinson Anthony et al., 2020).

Bilingual word representations are input-driven

As bilinguals develop vocabularies that are representative of a crosslinguistically shared language experience, they use and are exposed to each of their languages only part of the time. The effects of splitting time across language contexts are most evident in monolingual-bilingual comparison studies, whereby bilingual adults have been shown to develop smaller language-specific vocabularies than their monolingual peers. For example, Bialystok and Luk (2012) measured the English receptive vocabularies of 797 monolingual English-speaking and 800 bilingual adults, ranging in age from 18 to 89 years old, using the PPVT-III. Broadly, results suggested that monolingual English speakers accurately recognized more English words than their bilingual counterparts, $F(1, 1603) = 138.4$, $p < .0001$, and older adults, with lifetimes of language use, had larger receptive vocabularies than their younger counterparts, $F(1, 1601) = 24.7$, $p < .0001$. Indeed, young monolingual English-speaking adults (*M* age = 23.9, *SD* = 8.4) recognized more words on this English task than young bilinguals (*M* age = 23.5, *SD* =

8). Importantly, the bilinguals of this study did have receptive vocabulary scores that fell within the expected language-typical range *(M* = 97.1, *SD* = 12.6). Other studies have also described bilinguals as having relatively smaller language specific vocabularies than monolinguals, though still within the language-typical range (e.g., Kaushanskaya et al., 2011). Such monolingual-bilingual differences in language specific vocabulary knowledge are likely due to bilinguals' language exposure and use across separate language contexts. Notably, it appears that this difference disappears for cognate words, where translation equivalents are highly similar for bilinguals across language contexts (e.g., Stadhagen-Gonzalez et al., 2013). Thus, translation equivalents that are similar in phonological form are likely to receive more input across languages, bolstering cognate activation.

Words that share form and meaning are recognized more accurately and quickly

Bilinguals' word processing dynamics differ from monolinguals' because of a crosslinguistically integrated lexicon and parallel processing of the two languages. For example, during auditory word comprehension, monolinguals and bilinguals have been shown to activate within-language words that overlap in form (e.g., *ham*mer and *ham*per, Blumenfeld & Marian, 2011), and bilinguals have also been shown to activate words that overlap in form across languages (e.g., *desk* and lid-translates to *Deckel* in German, Blumenfeld & Marian, 2007). Largely dependent on the stimuli and task, however, this dual-activation can be either facilitative or interfere with word comprehension efficiency. The focus in the current dissertation is on instances when the interaction between the two lexicons is facilitatory during comprehension, with bilinguals leveraging phonological overlap of lexical representations across languages to support comprehension skills.

Evidence consistently suggests that bilinguals process cognate words faster than noncognates. Crosslinguistic facilitation plays an important role in efficient lexical processing for bilinguals. For example, Brysbaert et al. (2017) found that 56 college-aged Dutch-English bilinguals had slower lexical decision reaction times on an English task for noncognates than cognates, reflecting that bilinguals benefited from crosslinguistic scaffolding by increased processing speed. Moreover, Van Assche et al. (2009) investigated eye movements during reading in 45 Dutch-English bilingual adults. Participants read native language Dutch sentences that were manipulated by embedding cognate words or controls (noncognates). Participants' reading speed and gaze patterns were measured using eye-tracking methods. Results suggested that embedded cognate words that overlapped with nondominant English translation equivalents marginally enhanced speed of initial gaze, $F(1, 1184) = 2.04$, $p = .09$. Thus, word form overlap may boost processing speed for word comprehension efficiency. Additionally, gaze duration ($F(1, 1172) = 3.82$, $p < .05$) and gaze regression-path duration ($F(1, 1163) = 3.61$, $p < .05$) were statistically shorter for cognate words than noncognates, further suggesting less effort or processing attention for cognates even in the dominant language. These findings are consistent with studies from adult bilinguals that show shorter reaction times for cognate than noncognate words at the single word level (e.g., Comesaña et al., 2018; Dijkstra et al., 1999, Dijkstra et al., 2010).

For typical bilingual adults, cognate relative to noncognate word advantages are consistently found across studies, particularly in the nondominant language (Amengual, 2016; Lemhöfer et al., 2004; Gollan et al., 1997; Van Hell & de Groot, 1998). For example, in Chapter 2 of the current dissertation (Robinson Anthony & Blumenfeld, 2019), we investigated cognate effects across a continuum of language dominance in 80 Spanish-English bilinguals (21yo). Participants were measured on receptive vocabulary in English using the PPVT-III and in Spanish using the PPVT-III's Spanish equivalent, the Test de Vocabulario en Imagenes Peabody (TVIP, Dunn, Lugo et al., 1997). Cognate effects were calculated based on accuracy of cognate versus noncognate words, and results demonstrated that cognate advantages were present in both the dominant and nondominant language of participants, with larger cognate effects (i.e., greater accuracy of cognate words relative to noncognate words) in the nondominant language. Specifically, the magnitude of cognate effects in both English and Spanish were strongly associated with language dominance indexed by a hybrid definition (average of self-reported proficiency, self-reported exposure, and expressive language knowledge) of language dominance, $t(78) = -2.81$, $p = .006$ and $t(78) = 6.52$, $p < .001$ in English and Spanish respectively. This suggests that bilinguals leverage knowledge from their more proficient language to accomplish comprehension goals in their less proficient language. While the reverse direction also occurs (i.e., leveraging knowledge from the less proficient language to accomplish comprehension goals in the more proficient language), the magnitude of this interaction is considerably reduced. In general, cognate effects, and thus shared word knowledge across languages, are a well-established and robust phenomenon in bilingual adults (e.g., Costa et al., 2000; Gollan et al., 2007; Hoshino & Kroll, 2008; Roselli et al., 2014).

One explanation for observed cognate effects is that translation equivalents that share form benefit from a *cumulative frequency effect of activation* across languages. Lexical selection is thought to occur once a lexical entry, in competition with other simultaneously activated related words and their features, garners sufficient activation. However, words are not equal at baseline activation in the mental lexicon. For example, Blanco-Elorrieta and Caramazza (2021) propose that lexical access involves the selection of a word entry with the most activation across multiple selection principles, including baseline word frequency and recency. Word frequency effects generally follow an observation that higher frequency words are processed and selected more accurately and more quickly than low frequency ones (for review see Brysbaert et al., 2017). As bilinguals share time between language contexts, cognate words that share form are activated more frequently across languages than less form-overlapping and more language-specific representations (noncognate).

Higher-order analytical decision processes also drive language behaviors

In addition, higher-order processes influence and are influenced by word recognition processes. The BIA model posits that word recognition is accomplished by both word identification systems and task/decision systems. Higher-order processes (i.e., task/decision) includes strategies and expectations that guide specific processing steps to accomplish task goals. These higher-order processes include metalinguistic awareness, or the ability to analyze and make decisions about language. For example, Nagy et al. (1993) sought to examine whether young Spanish-English bilinguals' knowledge and awareness of cognates would enhance their performance on English reading comprehension. Following the administration of reading comprehension passages, a multiple-choice, check-for-understanding measure was administered. Participants were then briefed on the concept of cognates and subsequently asked to identify cognates from the previous reading passages. Reading comprehension and cognate identification accuracy revealed that participants who demonstrated more accurate recognition of cognates from the reading passages also demonstrated higher accuracy in the check-for-understanding measure that required greater language analysis. Thus, the interactive nature of the bilingual lexicon, here being indexed by cognate advantages, may be extended to facilitation of word comprehension via more strategic higher-level processes based on bilingual knowledge (Metalinguistic awareness). This is especially relevant, for example, as at least one study suggests that adults with a history of DLD continue to show challenges related to higher-level processes (e.g., literacy) in post-secondary institutions (Del Tufo & Earle, 2020).

Bilingual DLD and cognate effects

There is a paucity of research concerning adults with a history of DLD. However, bilingual children with DLD may show cognate advantages similar to their typical peers. In the first study to examine cognate effects in bilingual children with DLD, Grasso et al. (2018) investigated the presence of cognate effects in 117 Spanish-English bilingual children (5;0-9;11yo) with and without DLD. Participants completed picture naming vocabulary tests in English and Spanish on the Expressive One-Word Picture Vocabulary Test - Spanish Bilingual Edition (EOWPVT-3, Brownell, 2001), for which cognate and noncognate items were previously identified. Overall, the children with DLD had lower accuracy in naming relative to age-matched peers ($\chi2 = 37.12$, $p < .0001$) and cognates were more likely to be named accurately than noncognates ($\chi2 = 226.47$,

$p < .0001$). There was no significant interaction between language ability (DLD, typical) and word type (cognate, noncognate), suggesting that the magnitude of cognate advantages was parallel for bilingual children with DLD relative to age-matched peers. These and similar findings (e.g., Payesteh & Pham, 2021) provide initial support that cognate words are an area of strength, even for bilinguals with a language disorder, at least earlier on in the language development process.

Overview of the Dissertation

Collectively, studies suggest that cognates are a class of words that are stable and facilitate word representation and word processing in bilinguals. The current dissertation work was conducted with the overarching goal to extend understanding of bilingual word comprehension efficiency, to establish initial findings that can inform applied practice for language disorder, and to understand the potential language support needs for bilingual college-age students. Leveraging cognates to boost crosslinguistic word comprehension may have practical implications in academic contexts, as suggested by initial studies conducted in children. Spanish cognate words (e.g., *motivo*) are often higher frequency vocabulary words than their English translation equivalents (e.g., English *motive*), and typical bilingual children have been shown to utilize this knowledge during reading comprehension (e.g., Kambranos et al., 2017).

The purpose of the current dissertation is to test initial hypotheses and generate additional predictions on lexical representation and lexical processing in bilingual adults with a self-reported history of DLD. Predictions are made in the areas of vocabulary size, word processing, and cognate effects in knowledge and processing. There is currently no literature on the longitudinal effects of a history of DLD on the language skills of bilingual adults. Studying cognate word comprehension may uncover a relative strength in the language skills of bilinguals with a history of DLD. Knowing more about word comprehension and cognate facilitation effects in bilingual adults with a history of DLD will allow for a more fine-tuned theoretical understanding of word representation and processing dynamics in integrated lexicons and has functional clinical implications for mitigating potential word recognition and vocabulary deficits for bilingual adults. Furthermore, as language ability has been linked to other long-term outcomes measures, gaining this knowledge is important in supporting bilingual adults with a history of DLD.

The dissertation is the first research (to our knowledge) to examine word recognition in bilingual adults with a history of DLD. As such, while the primary goal of the current dissertation work is not to conclusively identify language profiles of bilingual adults with a history of DLD, it is positioned to allow initial observations on this front. As a reference point, the monolingual adult literature is building a groundwork with which to identify DLD in adult populations. Fidler et al. (2011) lay the groundwork for using an index of language ability- comprised of weighted scores from a spelling task, a word identification task, and a sentence comprehension task- to identify adults with a history of DLD. In combination with a self-reported history of receiving language services (e.g., Earle & Ullman, 2021) and/or language concerns (e.g., McGregor et al., 2020), studies are investigating whether such group distinctions influence word learning and cognition in adults with a history of DLD, and with impactful findings. For example, in their study of college-age monolinguals, McGregor et al. (2020) report differences in initial word learning abilities between students who report language concern and their typical peers.

Importantly, while the students identified as having a history of DLD do have statistically significantly lower standardized performance in comparison to their neurotypical peers, neither groups' standardized scores fell below the average range. In fact, participants with a history of DLD performed in the average range on at least one component of the Fidler et al. (2011) DLD index- word identification- amongst other standardized measures of receptive and expressive vocabulary. Even less is understood concerning the bilingual adult with a history of DLD profile. For example, if initial word learning is negatively correlated with a history of DLD, it becomes unclear whether bilingual adults with a history of DLD require more input for initial word learning. If so, bilingual adults with a history of DLD may develop language profiles dissimilar from those being currently established in the monolingual literature, with typical language skills only in one language (e.g., the stronger language, language of the majority). Thus, this dissertation is motivated to begin investigation of word knowledge and processing in bilingual adults with a history of DLD using similar recruitment and identification methods in the current initial investigations.

In **Chapter 2**, the relation between cognate effects and language experience are explored in typical Spanish-English-speaking, college-age students. In **Chapter 3**, cognate word comprehension, an area of representational and processing strength for typical bilinguals, is examined as the dissertation seeks to form foundational knowledge as to whether bilinguals with a self-reported history of DLD continue to benefit from cognate effects. In **Chapter 4**, the dissertation quantitatively measures cognate versus noncognate word recognition in word identification accuracy, as well as button-press speed and the timecourse of lexical activation, as indexed by eye movements. In

Chapter 5, both quantitative and qualitative measures of metalinguistic awareness for cognate words are explored. In sum, this dissertation seeks to further cognitive research by extending cognate word knowledge, processing, and functionality to an understudied adult population using novel eye-tracking methods and experimental quantitative-qualitative designs. Knowing more about cognate facilitation effects will allow for a more fine-tuned theoretical understanding of word representation and processing dynamics in integrated lexicons and has functional clinical implications for mitigating word comprehension and vocabulary deficits for bilingual adults. In **Chapter 6**, these are summarized and integrated.

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CHAPTER 2: LANGUAGE DOMINANCE PREDICTS COGNATE EFFECTS AND INHIBITORY CONTROL IN YOUNG ADULT BILINGUALS

Abstract

Determining bilingual status has been complicated by varying interpretations of what it means to be bilingual and how to quantify bilingual experience. We examined multiple indices of language dominance (self-reported proficiency, self-reported exposure, expressive language knowledge, receptive language knowledge, and a hybrid), and whether these profiles related to performance on linguistic and cognitive tasks. Participants were administered receptive and expressive vocabulary tasks in English and Spanish, and a nonlinguistic spatial Stroop task. Analyses revealed a relation between dominance profiles and cognate and nonlinguistic Stroop effects, with somewhat different patterns emerging across measures of language dominance and variable type (continuous, categorical). Only a hybrid definition of language dominance accounted for cognate effects in the dominant language, as well as nonlinguistic spatial Stroop effects. Findings suggest that nuanced effects, such as cross-linguistic cognate effects in a dominant language and cognitive control abilities, may be particularly sensitive to operational definitions of language status.

Introduction

Studies across the lifespan of bilingual populations have outlined monolingual-bilingual differences across realms of processing, both linguistic (e.g., Kaushanskaya, Gross & Buac, 2014; Kaushanskaya & Marian, 2009a, 2009b) and nonlinguistic (e.g., Bialystok, Craik, Klein & Viswanathan, 2004; Blumenfeld & Marian, 2014; Poulin-Dubois, Blaye, Coutya & Bialystok, 2011; Yoshida, Tran, Benitez & Kuwabara, 2011). However, determining bilingual status has been complicated by varying interpretations of what it means to be bilingual (e.g., Hakuta & Garcia, 1989). Language dominance, a commonly-used measure of bilingual status, has been defined as the relative proficiency across languages in comprehension and usage (e.g., Gathercole & Thomas, 2009). Though not always the case, the primary or native language is frequently considered the dominant language. Yet for some bilinguals, the second language may be the dominant language (e.g., Miller & Kroll, 2002). Bilinguals' language dominance may also switch over time (e.g., Jia & Aaronson, 1999).

In addition to defining language dominance, how the bilingual experience is quantified has varied across studies, including the use of categorical versus continuous variables (Luk & Bialystok, 2013). Thus, the nuances that make up the bilingual experience are not always reflected in research, and further investigations of language dominance may offer novel perspectives of bilingual differences. Here, we investigate the extent to which various definitions of language dominance are predictive of linguistic and cognitive processing.

Measuring language dominance

Approaches to categorizing participants according to language dominance have widely varied across studies. For example, in early childhood populations, one of the most common measures of bilingual status is parent-report of language exposure (e.g., Bedore, Peña, Griffin & Hixon, 2016; Bialystok & Feng, 2009; Carlson & Meltzoff, 2008; Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993; Poulin-Dubois et al., 2011). Research in adult populations also relies on self-report as a tool to establish language proficiency. Questionnaires such as the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian, Blumenfeld & Kaushanskaya, 2007) and the Language History Questionnaire (LHQ, Li, Sepanski & Zhao, 2006; LHQ 2.0, Li, Zhang, Tsai & Puls, 2014) have been employed to determine bilinguals' relative proficiency across languages (e.g., Blumenfeld & Marian, 2014; Grant & Dennis, 2017; Jonczyk, Boutonnet, Musiał, Hoemann & Thierry,2016; Mercier, Pivneva & Titone,2014; Titone, Libben, Mercier, Whitford & Pivneva, 2011). In fact, adult studies frequently rely exclusively on self-reports to determine dominance (e.g., Amengual, 2016; Gollan, FennemaNotestine, Montoya & Jernigan, 2007; Lemhöfer, Dijkstra & Michel, 2004; Paap & Greenberg, 2013).

Another common method for quantifying bilingual status has been the use of objective measures. Objective performance correlates of self-reported dominance have been identified in adult studies (translation speed: Bilingual Dominance Scale, Dunn & Tree, 2009; naming: MINT, Gollan, Weissberger, Runnqvist, Montoya & Cera, 2012; various measures: LEAP-Q, Marian et al., 2007; grammar: Yudes, Macizo & Bajo, 2010). On the other hand, in child populations, reliance on objective measures to determine dominance has been more common, including language sample analysis (e.g., Paradis, Crago, Genesee & Rice, 2003), mean length of utterance (e.g., Yip & Matthews, 2006), vocabulary knowledge (e.g., Cromdal, 1999), grammar (e.g., Lemmon & Goggin, 1989), and picture naming (e.g., Mägiste, 1992), to name a few. Typically, as with questionnaire data, research using objective measures to determine language dominance has designated the language with a higher score as the dominant language (e.g., Bahrick, Hall, Goggin, Bahrick & Berger, 1994; Bedore, Peña, Summers, Boerger, Resendiz, Greene, Bohman & Gillam, 2012).

While studies have primarily focused on delineating definitions of language dominance, a relatively novel approach of treating bilingualism as a continuous variable has been emerging in recent literature (e.g., De Cat, Gusnanto & Serratrice, 2018; Dunn & Tree, 2009; Incera & McLennan, 2018; Gollan et al., 2012). In 2009, Dunn and Tree recognized that inconsistencies in determining language dominance negatively impacted comparisons between studies, and therefore sought to develop a practical language dominance scale. They recruited young Spanish–English adults to participate in a questionnaire that focused on language acquisition, use, and shifting due to changes in environment. Using factor analyses, they extracted items from their questionnaire that uniquely captured English and Spanish dominance and used difference scores to determine language dominance as a scaled (continuous) variable. The researchers found a relation between language dominance and translation speed in a separate group of bilinguals.

Moreover, as previously mentioned, many researchers have determined language dominance based on selfreported proficiency, and Dunn and Tree (2009) questioned the validity of such measures. This approach was further challenged in 2012 when Gollan et al. investigated the relation between subjective and objective operational definitions of language proficiency (dominance) in young and older bilingual adults. The researchers administered a language history questionnaire for self-reported proficiency and an English vocabulary test, as well as language proficiency interviews and picture naming tasks. They conducted a variety of analyses, including correlations between difference scores (subtracting Spanish from English across measures), contrasts between measures as categorical variables (Spanish-dominant, English dominant, balanced), and contrasts between measures as continuous variables. The researchers concluded that self-reports were generally good predictors of language dominance indexed by objective definitions, though the relation between subjective and objective definitions of language dominance was not strong enough to solely rely on any single definition in establishing language dominance. These findings were supported by Luk and Bialystok (2013), who investigated the relation between language proficiency and use. They recruited a heterogeneous group of adult bilinguals and administered a language and social background questionnaire, a picture vocabulary task, and an expressive vocabulary task. Using exploratory/confirmatory factor analyses, they found that the bilingual experience was characterized by multiple factors across questionnaire responses and standardized tests. They found strong correlations between self-reported proficiency in English and performance on receptive and expressive language tasks and briefly discussed the value of using a “composite score” to assess bilingual proficiency (also see Bedore et al., 2012). In sum, various language dominance measures have been employed and linked to bilinguals’ linguistic performance, but it remains unclear whether continuous and hybrid measures of dominance can provide additional nuance in indexing bilinguals' profiles and predicting their cognitive-linguistic performance. Here, we examine multiple measures of language ability, including subjective, objective, and hybrid ones, in defining dominance. Further, we use previously-employed methods to determine difference scores across languages in deriving language dominance measures (e.g., Dunn & Tree, 2009, Gollan et al., 2012).

Language dominance and linguistic performance

Language dominance has emerged as a useful predictor of various speech and language skills in bilinguals, including expressive language (Bahrick et al., 1994; Dickinson, McCabe, Clark-Chiarelli & Wolf, 2004), receptive language (Bahrick et al., 1994), semantics and morphosyntax (Basnight-Brown & Altarriba, 2007; Bedore et al., 2012), verbal fluency (e.g., Blumenfeld, Bobb & Marian, 2016) and stuttering (Flege, MacKay & Piske, 2002; Lim, Lincoln, Chan & Onslow, 2008), as well as voice-onset-timing sensitivity (Bullock, Toribio, González & Dalola, 2006). In addition to examining how language dominance relates to language specific performance across modalities, researchers have examined how language dominance may relate to cross-linguistically shared knowledge. For example, a well-researched phenomenon, the cognate effect, has been linked to language dominance (e.g., Pérez, Peña & Bedore, 2010; Rosselli, Ardila, Jurado & Salvatierra, 2014). As bilinguals may house overlapping representations for words across their languages (Dijkstra & van Heuven, 2002; Kroll & Stewart, 1994), cognate words that share similar orthographic or phonological form have been shown to have facilitatory effects in processing (e.g., Gollan et al., 2007; Kelley & Kohnert, 2012; for review see Costa, Santesteban & Caño, 2005). Cognate effects have been found to be robust across bilinguals' different languages and language profiles (e.g., de Groot & Keijzer, 2000; Costa, Caramazza & Sebastián-Gallés, 2000; Dijkstra, van Hell & Brenders, 2015; Gollan et al., 2007; Hoshino & Kroll, 2008; Lemhöfer et al., 2004; Rosselli et al., 2014).

Pérez et al. (2010) aimed to investigate whether there was a relation between cognate facilitation and language proficiency during naming. Results indicated that Spanish–English balanced bilinguals had similar cognate facilitation effects in both languages, while unbalanced bilinguals presented with greater cognate facilitation in their less dominant language. Similarly, Rosselli et al. (2014) found a link between language dominance (indexed by vocabulary knowledge) and cognate effects, with smaller cognate facilitation in the dominant language. Thus, we explore which language dominance measures predict cognate facilitation and whether similar patterns emerge across dominance profiles.

Language dominance and cognitive control

Beyond predicting linguistic performance, it is also possible that language dominance profiles may predict aspects of COGNITIVE processing in bilinguals. One of the most researched areas of executive function in bilingual populations has been inhibitory control. Bilinguals have at times been shown to outperform their monolingual counterparts in specific inhibition tasks (e.g., Bialystok et al., 2004; Blumenfeld & Marian, 2014; Hernández, Costa, Fuentes, Vivas & SebastiánGallés, 2010; Martin-Rhee & Bialystok, 2008; but see, for example, Paap & Greenberg, 2013). Where bilingual-monolingual differences in inhibitory control have been found, researchers have reasoned that, since bilinguals must juggle two language systems, they require some mechanism to manage the activation/suppression of the target/non-target language. Accordingly, models have posited involvement of executive function skills in language processing (Dijkstra, van Heuven & Grainger, 1998; Green, 1986, 1998), and it is implicit in such accounts that the relative strength of bilinguals' two languages influences the extent to which such cognitive control processes are engaged.

Recent studies have suggested that cognitive control mechanisms engaged for bilingual processing may be domain-general because of links between linguistic processes and nonlinguistic inhibitory control tasks (e.g., de Bruin, et al., 2014; Liu, Rossi, Zhou & Chen, 2014; Hervais-Adelman, Moser, Mercer, & Golestani, 2011). Accordingly, neural correlates of linguistic and nonlinguistic inhibitory control have been found to overlap (e.g., Weissberger, Gollan, Bondi, Clark & Wierenga, 2015). Though there are relatively few studies that have examined the specific relation between nonlinguistic inhibitory control and language dominance, links have been found in children (Prior, Goldwasser, Ravet-Hirsh & Schwartz, 2016; ThomasSunesson, Hakuta & Bialystok, 2018) and older adults (Goral, Campanelli & Spiro, 2015). In child populations, balanced bilinguals demonstrate better nonlinguistic inhibition skills than their unbalanced peers (dominance defined by expressive/receptive vocabulary, Prior et al., 2016; dominance defined by receptive vocabulary, Thomas-Sunesson et al., 2018). However, in older adults, unbalanced bilinguals fare better on nonlinguistic executive function tasks than balanced bilinguals (dominance defined by self-reported proficiency, Goral et al., 2015). Other adult studies report null findings (e.g., dominance defined by receptive/expressive language skills, Rosselli, Ardila, Lalwani & Vélez-Uribe, 2016; dominance defined by self-reported proficiency, Yow & Li, 2015), and further investigation is required to clarify which measures of language dominance predict nonlinguistic inhibition and to document variation across the lifespan. Here we aim to investigate the relation between nonlinguistic inhibitory control and language dominance in young adult bilinguals.

Current study

We examined the relation between language dominance as a continuous and categorical variable and linguistic and nonlinguistic ability. Previous studies have not directly examined how different operational definitions of dominance predict interaction of bilinguals' languages, or how dominance predicts performance on nonlinguistic inhibitory control tasks. Based on previous studies, we indexed language dominance by multiple measures: self-reported proficiency, current exposure, receptive language, expressive language, and a hybrid index. We then investigated how these definitions of language dominance varied in predicting dominance profiles, and whether language dominance as a continuous or categorical variable would predict cognate effects (indexing lexical knowledge across languages) and nonlinguistic Stroop effects (indexing inhibitory control skills).

Here, we chose to employ a nonlinguistic spatial Stroop task to index inhibitory control, given previous literature revealing a link between nonlinguistic Stroop performance and bilingual processing (Blumenfeld & Marian, 2013; Giezen, Blumenfeld, Shook, Marian & Emmorey, 2015; Mercier et al., 2014). We will refer to the inhibitory control effect (incongruent minus congruent trials) on our nonverbal spatial Stroop task as "nonlinguistic Stroop effect". In the framework of Kornblum's Dimensional Overlap Model (Kornblum, Hasbroucq&Osman,1990), Stroop effects are considered to be a class of effects indexing inhibitory control where two dimensions of the same stimulus interfere with each other. The current spatial nonlinguistic Stroop task shares these characteristics with the well-known classic Stroop effect (i.e., interference of stimulus dimensions on incongruent trials is between ink color and text on the classic Stroop task and between arrow direction and location on the current nonlinguistic Stroop task). Use of a nonlinguistic cognitive control task avoids confounds with automaticity in language processing due to proficiency (e.g., Tzelgov, Henik & Leiser, 1990).

The purpose of the present study was threefold. First, we aimed to investigate whether multiple language exposure and proficiency variables differed in how they predicted language dominance in Spanish–English bilinguals. Based on previous findings, we expected that subjective and objective measures would differ in predicting language profiles (Bedore et al., 2012; Luk & Bialystok, 2013; Sheng, Lu & Gollan, 2014). Second, we examined whether language dominance measures differed in how they predicted cross-linguistic lexical knowledge, as indexed by cognate effects. We predicted that language dominance as a continuous variable would best capture linguistic ability (Dunn & Tree, 2009; Luk & Bialystok, 2013), and that both subjective and objective measures of dominance would be good predictors of cognate effects (Pérez et al., 2010; Rosselli et al., 2014). Third, we examined whether language dominance measures differed in how they predicted bilingual participants' inhibitory control skills. We predicted that language dominance as a continuous variable would also relate to cognitive ability (De Cat et al., 2018; Incera & McLennan, 2018), but that nonlinguistic inhibitory control performance might not be predicted equally by all dominance measures, given variability in previous findings (Rossellietal.,2016; Goral et al., 2015; Yow & Li, 2015).

Method

Participants

Eighty Spanish–English bilingual young adults were recruited from San Diego State University's undergraduate and graduate student population, provided informed consent, and participated for class credit or monetary compensation. All participants reported normal to corrected-to-normal vision, absence of learning disabilities, and proficiency in both English and Spanish. Formal testing revealed normal hearing across participants (ASHA, 1996). See Table 1 for participants' current ages, years of education, self reported proficiencies and exposures, ages of language acquisition and fluency, as well as bilingual experience, and functional bilingualism. Participation for this study was contingent upon proficiency in, exposure to, and knowledge of only the targeted languages (Spanish– English), excluding those who reported scores less than four across the 10-point proficiency scales of the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian et al., 2007), or who reported multilingual skills (i.e., more than three languages with scores of four or higher across the 10-point LEAPQ scales). A wide range of self-reported proficiencies (i.e., 4–10 on the LEAP-Q) in each language was allowed for the current study to achieve variability in language dominance profiles.

Table 2.1 Language Experience and Proficiency Questionnaire Group Data

N = 80 (7 males)	*M* (*SD*)	Range
Age	21.67 (2.88)	18–32
Years of education	16 (1.67)	12–20
Self-reported proficiency in English	9.38 (0.71)	7.33–10
Self-reported proficiency in Spanish	8.32 (1.30)	4–10
Self-reported exposure to English (%)	65.82 (17.43)	16.75–98
Self-reported exposure to Spanish (%)	31.80 (15.84)	2–65
Age of acquisition – English	4.08 (3.46)	0–20
Age of acquisition – Spanish	1.85 (3.27)	0–15
Age when fluent in English	6.61 (3.87)	0–23
Age when fluent in Spanish	5.40 (4.42)	0–21
Years of bilingual experience	16.88 (4.58)	4–30
Years of functional bilingualism	13.31 (4.96)	1–29

Materials and procedures

Language Experience and Proficiency Questionnaire (LEAP-Q)

The LEAP-Q (Marian et al., 2007) is a questionnaire used in multilingual adult populations to measure relative exposure and proficiency across languages. We administered the LEAP-Q to gather demographic information, as well as self-reported proficiency and exposure ratings in both English and Spanish.

Peabody Picture Vocabulary Test-Third Edition (PPVT-III) and Test de Vocabulario en Imágenes Peabody (TVIP)

The PPVT-III (Dunn & Dunn, 1997) and TVIP (Dunn, Lugo, Padilla & Dunn, 1997) are equivalent picture identification tasks designed to measure English and Spanish receptive vocabulary, respectively. Participants were read a stimulus word and were instructed to choose one of four pictures that best represented each word. The PPVT-III consists of 17 sets, with each set containing 12 trials, for a total of 204 trials. In accordance with administration rules of the test, participants started the PPVT-III at set 13. A basal was established when participants correctly identified ten items in a set. Participants continued until set 17 or until they missed eight or more items within a completed set. Only data sets 13 to 16 of the PPVT-III were analyzed, as these sets were consistently administered to each participant. The TVIP consists of 125 trials. Participants started at the first item and continued until they missed six within eight consecutive items.

Words on the PPVT-III and TVIP were divided into cognate and noncognate items by objective and subjective criteria(Potapova,Blumenfeld&Pruitt-Lord,2015) .The Crosslinguistic Overlap Scale for Phonology (COSP) was used as an objective measure of cognate identification (Kohnert, Windsor & Miller, 2004; Potapova et al., 2015). English words and their Spanish translations were compared on initial sounds, number of syllables, overlap in consonants, and overlap in vowels. Consistent with Kelley and Kohnert (2012), words on the PPVTIII and TVIP with COSP ratings 6 were considered objective cognates. In contrast, the subjective measure of cognate status followed a 50% translation criterion by monolingual speakers (Friel & Kennison, 2001; Potapova et al., 2015), where English monolinguals completed a translation task to guess the meaning of Spanish translation equivalents. Words that were successfully translated back into English by 50% of the participants were considered subjective cognates. Potapova et al.'s (2015) PPVT-III groupings were used for the current study. To create similar subjective cognate/noncognate groupings for the TVIP, we divided the 125 items of the TVIP into two sets, balanced for the increasing level of word difficulty, and English monolingual undergraduate students were asked to guess the English translation of each Spanish word. The students were additionally given a brief questionnaire adapted from the LEAP-Q to determine languages spoken and proficiencies. Of the 65 students who participated, 22 were identified as effectively monolingual English speakers (M Age = 21.57, SD = 3.65; one participant did not report her age) as indexed by self-reported proficiency scores averaged across speaking, understanding, and reading on a 10-point Likert scale (M English = 9.86, SD = 0.37; M Spanish = 0.84, SD = 1.03). Words on the TVIP were catalogued as cognates if 50% of participants successfully translated the Spanish target either to its exact match, root match (e.g., "lubricant" for lubricate from Spanish lubricar), or a synonym (e.g., "disillusioned" for disappointed from Spanish desilusión) in English (see Table 2).

Table 2.2 TVIP items identified as cognates by COSP and translation

TVIP Form A item	Criteria met for cognate status	TVIP Form A item	Criteria met for cognate status	TVIP Form A item	Criteria met for cognate status
1	COSP	53	COSP, 50%	91	COSP
2	COSP, 50%	54	COSP	92	COSP, 50%
5	COSP, 50%	55	COSP, 50%	93	COSP, 50%
8	COSP, 50%	56	COSP, 50%	94	COSP, 50%
14	COSP, 50%	58	COSP, 50%	95	COSP, 50%
15	COSP	60	50%	96	COSP, 50%
19	COSP, 50%	61	COSP, 50%	97	COSP, 50%
20	COSP	63	COSP	98	COSP, 50%
22	COSP	67	COSP, 50%	100	COSP, 50%
25	COSP	68	COSP, 50%	101	COSP, 50%
27	COSP	70	COSP, 50%	104	COSP, 50%
28	COSP, 50%	71	50%	105	COSP, 50%
29	COSP, 50%	72	COSP, 50%	107	COSP
30	COSP, 50%	73	COSP	108	COSP, 50%
31	COSP, 50%	75	COSP, 50%	109	COSP, 50%
32	COSP, 50%	76	COSP, 50%	110	COSP, 50%
33	COSP, 50%	79	COSP	112	COSP, 50%
36	COSP, 50%	80	COSP	113	COSP, 50%
37	COSP	81	COSP, 50%	114	COSP
38	COSP, 50%	83	COSP	115	COSP, 50%
40	COSP, 50%	84	COSP, 50%	118	COSP, 50%
44	50%	85	COSP	119	COSP
45	COSP, 50%	88	COSP, 50%	122	COSP, 50%
47	COSP, 50%	89	COSP, 50%	123	COSP
51	COSP, 50%	90	COSP	124	COSP, 50%
				125	COSP

Woodcock-Johnson Tests of Cognitive Abilities III-Picture Vocabulary subtest (WJ III) and Batería III Woodcock-Muñoz-Vocabulario Sobre Dibujos subtest (Batería III)

The WJ III Picture Vocabulary subtest (Woodcock, McGrew & Mather, 2001) and the corresponding Batería III Vocabulario Sobre Dibujos subtest (Muñoz-Sandoval, Woodcock, McGrew & Mather, 2005) are picture naming tasks with 23 trials designed to measure English and Spanish expressive vocabulary, respectively. Participants were shown a picture and were asked to name it. The full subtest was administered to each participant.

Nonlinguistic spatial Stroop task

The nonlinguistic spatial Stroop task (e.g., Blumenfeld & Marian, 2011, 2014; Giezen et al., 2015) is a test of inhibitory control. Participants were instructed to click buttons corresponding to the direction in which arrows pointed on a screen in 210 trials. The arrows varied in direction (left or right facing) and location (left, middle, or right of screen). Congruent trials were characterized by matched arrow direction and arrow location (e.g., a right-facing arrow appeared on the right side of the screen) and incongruent trials were characterized by a mismatch between arrow direction and arrow location (e.g., a right-facing arrow appeared on the left side of the screen). Arrows that appeared in the center of the screen, regardless of direction, were considered neutral. The task was split into two blocks, each containing 105 trials. All participants completed both blocks.

Data coding and analyses

Language dominance

Language dominance was established using five different operational definitions. Two subjective definitions of language dominance were established using ratings of (1) self-reported proficiency and (2) self-reported current exposure to each language. Two objective definitions were established using scores from (3) receptive language and (4) expressive language tasks. Finally, a hybrid definition was established as (5) an averaged composite score of all subjective and objective measures. All measures, except for the receptive language definition, were included as predictors of cognate effects; all five measures were included as predictors of inhibitory control (see footnote 1). For the first four definitions of language dominance, English and Spanish responses and scores were transformed into proportions (e.g., items correct divided by total items), and a difference score was calculated by subtracting the Spanish from the English proportions. For example, one participant reported an average of nine (across speaking, understanding, and reading) out of ten, or .9, in English proficiency and an average of eight out of ten, or .8, in

Spanish. This participant's language dominance score was therefore .1. Positive dominance scores indexed English language dominance, negative scores indexed Spanish language dominance, and 0 indicated balanced dominance. For the fifth definition, the difference scores from the subjective and objective definitions were averaged to index language dominance.

Logistic regressions were used to investigate whether differences existed in how the five language measures determined dominance classifications. Each of the five measures was converted into a categorical variable (English-dominant, Spanish-dominant). Language dominance scores >0 were converted to a 1, indexing English dominance, and scores <0 were converted to 0, indexing Spanish dominance. Balanced dominance was not included in these analyses to maintain a binomial distribution in line with logistic regressions (Maxwell & Delaney, 2004): eight data points from balanced participants were omitted for the receptive language measure, five were omitted for expressive language, and 12 were omitted for self-reported proficiency. After running the omnibus model mapping the five measures onto dominance profiles, ten pairwise comparisons of these definitions were further investigated. A Bonferroni adjustment for multiple (10) comparisons was employed (with α corrected to .005).

Cross-linguistic interaction: cognate effects

Cognate effects were calculated based on participants' PPVT-III and TVIP scores. The percentage correct of noncognate words was subtracted from the percentage correct of cognates. For both the English and Spanish cognate effects, the subjective and objective criteria (50% back translation criteria, COSP criteria) were collapsed within each language due to high correlation (i.e., subjective and objective cognate effects were averaged for each participant in both English and Spanish). This yielded one English and one Spanish cognate effect score for each participant.

Simple linear regressions were used to investigate whether the language dominance measures predicted the magnitude of cognate effects. Only four of the five language dominance definitions were included as explanatory variables because cognate effects were derived from receptive language tasks. The hybrid definition of language dominance was also adjusted to exclude receptive language (i.e., only scores for self-reported proficiency, self-reported exposure, and expressive language were averaged in creating the hybrid index of language dominance). A Bonferroni adjustment for multiple (4) comparisons was employed (with α corrected to .0125).

Inhibitory control

Nonlinguistic Stroop effects were derived for each participant to index their inhibitory control skills. Bin scoring was used to measure these effects, as this method has been shown to reliably and robustly capture cognitive control (Hughes, Linck, Bowles, Koeth & Bunting, 2014; Prior, Degani, Awawdy, Yassin & Korem, 2017). Outliers more than three standard deviations from the mean, incorrect trials, and trials with response times less than 200ms were removed, and each participant's average response time on congruent trials was calculated. For each participant, mean congruent response times were then subtracted from responses on each incongruent trial, creating difference scores. Difference scores were assigned to one of ten bins, where the smallest tenth of all data fell into the 1st bin (valued at 1) and the largest tenth fell into the 10th bin (valued at 10). Each incorrect trial was assigned to a bin valued at 20. Bin scores were calculated by summing the bin values for each participant, where smaller values indexed better inhibitory control (see Hughes et al., 2014 for a description of this method).

To investigate whether language dominance measures predicted inhibitory control skills, the five definitions of language dominance were transformed to absolute values similar to transformations in Dunn and Tree (2009) and Prior et al. (2016). In transforming definitions of language dominance to absolute values, 0 indexed balanced bilingualism and positive scores indexed unbalanced bilingualism regardless of language (either English or Spanish dominance). A Bonferroni adjustment for multiple (5) comparisons was employed (with α corrected to .01)

Language dominance as a categorical variable

To examine the effectiveness of using a categorical versus continuous language dominance variable when predicting cognate effects, each of the four dominance measures (excluding receptive language knowledge) was recoded into a categorical variable. For each definition, participants were sorted based on dominance profiles and medially split. These groupings represented the “more English dominant” and “less English dominant” participants, and a Bonferroni adjustment for multiple (4) comparisons was employed (with α corrected to .0125).

To analyze the relation between dominance categories and nonlinguistic Stroop effects, all five transformed (absolute values) dominance profiles were medially split. These groupings represented participants with the “most balanced dominance” and “most unbalanced dominance” and a Bonferroni adjustment for multiple (5) comparisons was employed (with α corrected to .01).

Results

Comparing definitions of language dominance

Results of logistic regressions revealed that language dominance definitions varied in the count of English dominant participants and Spanish-dominant participants they yielded (see Table 3). The hybrid definition of self-reported exposure, proficiency, and objective receptive/expressive vocabulary yielded the most English dominant classifications (n = 66). Instead, determining dominance by receptive knowledge alone yielded the most Spanish-dominant classifications (n = 32), and grouping participants by self-reported language exposure alone yielded the most balanced classifications (n = 12).

Of the ten pairwise comparisons between language dominance definitions, three showed significant differences in dominance classifications (see Table 4). Dominance classifications based on receptive language knowledge differed significantly from classifications based on self-reported exposure ($\chi 2 = 14.65$, $p < .001$), classifications based on expressive language knowledge ($\chi 2$ = 10.73, p = .001), and classifications based on the hybrid index ($\chi 2$ = 9.46, p = .002). The difference between dominance classifications based on self-reported proficiency and based on self-reported exposure did not reach the Bonferroni-adjusted significance threshold of α= .005 ($\chi 2$ = 5.12, p = .02).

Table 2.3 Count of English dominant and Spanish dominant participants by language dominance index

Language dominance index	Count of English dominant participants	Count of Spanish dominant participants	Count of balanced participants
Self-reported proficiency	56	19	5
Self-reported exposure	61	7	12
Receptive language knowledge	48	32	0
Expressive language knowledge	61	11	8
Hybrid	66	14	0

Table 2.4 Pairwise comparisons of language dominance measures in predicting English and Spanish dominance

	Self-reported proficiency	Self-reported exposure	Receptive language knowledge	Expressive language knowledge	Hybrid
Self-reported proficiency					
Self-reported exposure	$\chi^2 = 5.12$				
Receptive language knowledge	$\chi^2 = 3.72$	$\chi^2 = 14.65^*$			
Expressive language knowledge	$\chi^2 = 2.25$	$\chi^2 = 0.77$	$\chi^2 = 10.73^*$		
Hybrid	$\chi^2 = 1.40$	$\chi^2 = 1.54$	$\chi^2 = 9.46^*$	$\chi^2 = 0.14$	

Language dominance and cognate effects

Simple linear regressions revealed that our continuous measures of language dominance varied in significantly predicting the magnitude of cognate effects (see Figure 1). After Bonferroni corrections ($\alpha = .0125$), the magnitude of cognate effects in both English and Spanish was significantly predicted by language dominance as defined by the hybrid index (English: $\beta = -0.30$, $t_{1,78} = -2.81$, $p = .006$; Spanish: $\beta = 0.59$, $t_{1,78} = 6.52$, $p < .001$). Instead, after Bonferroni corrections, only cognate effects on the Spanish task were significantly predicted by language dominance defined by self-reported proficiency (English: $\beta = -0.27$, $t_{1,78} = -2.47$, $p = .02$; Spanish: $\beta = 0.56$, $t_{1,78} = 5.91$, $p < .001$), self reported exposure (English: $\beta = -0.26$, $t_{1,78} = -2.34$, $p = .02$; Spanish: $\beta = 0.48$, $t_{1,78} = 4.84$, $p < .001$), and expressive language knowledge (English: $\beta = -0.24$, $t_{1,78} = -2.21$, $p = .03$; Spanish: $\beta = 0.45$, $t_{1,78} = 4.52$, $p < .001$). As language dominance values increased, indexing more English dominance, cognate effects decreased in English and increased in Spanish. Correspondingly, as language dominance values decreased, indexing less English dominance, English cognate effects increased, and Spanish cognate effects decreased.

Regressions for CATEGORICAL language dominance variables were similarly found to vary across languages (see Figure 2). For English, the cognate effect was not significantly predicted by language dominance categories among self-reported proficiency ($\beta = -0.05$, $t_{1,78} = -1.82$, $p = .07$), self-reported exposure ($\beta = -0.06$, $t_{1,78} = -2.28$, $p = .03$), expressive language knowledge ($\beta = -0.05$, $t_{1,78} = -1.73$, $p = .09$), or the hybrid index ($\beta = -0.04$, $t_{1,78} = -1.66$, $p = .10$) after Bonferroni corrections ($\alpha = .0125$). For Spanish, the magnitude of cognate effects, however, was significantly predicted by language dominance as determined by all definitions (self-reported proficiency: β= 0.08, t1,78 = 4.70, $p < .001$; self-reported exposure: β = 0.06, t1,78 = 3.18, $p = .002$; expressive language knowledge: β = 0.08, t1,78 = 5.02, $p < .001$; hybrid: β= 0.14, t1,78 = 12.26, $p < .001$). For each categorical definition of language dominance, smaller cognate effects on the Spanish task were associated with less English dominance.

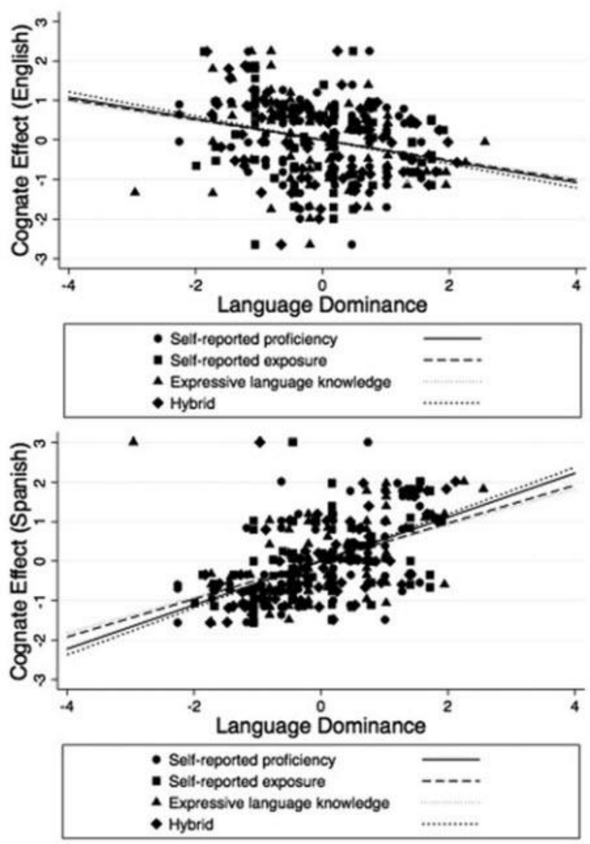

Figure 2.1 Relation between cognate effects and language dominance as continuous variables in English (top) and Spanish (bottom)

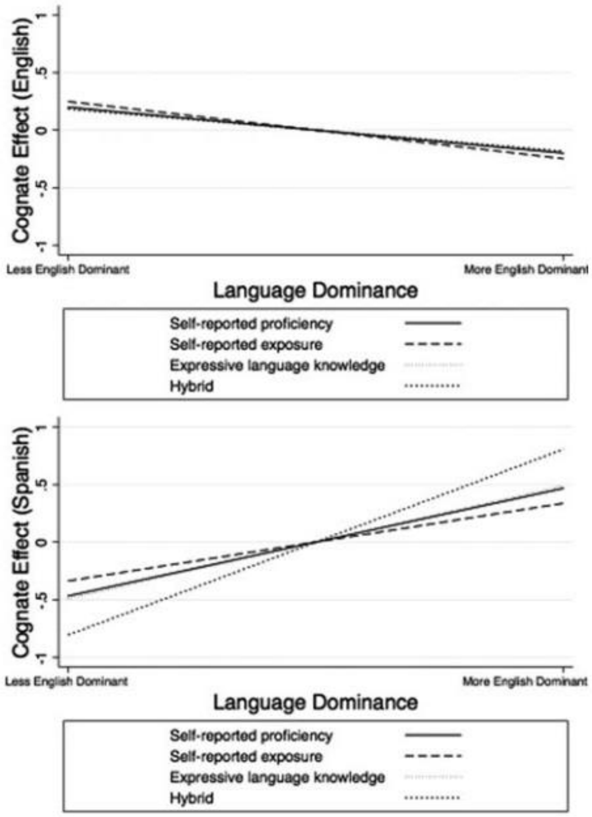

Figure 2.2 Relation between cognate effects and language dominance indices as categorical variables in English (top) and Spanish (bottom)

Language dominance and nonlinguistic Stroop effects

Simple linear regressions of continuous dominance measures revealed that only the hybrid index of language dominance significantly predicted the magnitude of nonlinguistic Stroop effects after Bonferroni corrections ($\alpha = .0125$, $\beta = -186.88$, $t_{1,78} = -2.68$, $p = .009$), while self-reported proficiency ($\beta = -167.15$, $t_{1,78} = -1.68$, $p = .10$), self-reported exposure ($\beta = -52.50$, $t_{1,78} = -1.81$, $p = .07$), receptive language knowledge ($\beta = -136.73$, $t_{1,78} = -0.78$, $p = .44$), and expressive language knowledge ($\beta = -114.41$, $t_{1,78} = -1.51$, $p = .14$) by themselves did not significantly predict nonlinguistic Stroop effects (see Figure 3). Specifically, the more unbalanced bilinguals were in their hybrid language profiles, the smaller their nonlinguistic Stroop effects were, suggesting more efficient inhibitory control in more unbalanced bilinguals.

Regressions for categorical dominance definitions similarly revealed that only the hybrid index significantly predicted the magnitude of the nonlinguistic Stroop effect after Bonferroni corrections ($\alpha = .0125$, $\beta = -42.85$, $t_{1,78} = -2.66$, $p = .009$). Self-reported proficiency ($\beta = -26.85$, $t_{1,78} = -1.62$, $p = .11$), self-reported exposure ($\beta = -28.45$, $t_{1,78} = -1.72$, $p = .09$), receptive language knowledge ($\beta = -27.05$, $t_{1,78} = -1.64$, $p = .11$), and expressive language knowledge ($\beta = -21.5$, $t_{1,78} = -1.29$, $p = .2$) did not significantly predict nonlinguistic Stroop effects (see Figure 4). Consistent with the continuous hybrid definition of dominance, the categorical hybrid definition revealed that more unbalanced bilinguals showed smaller nonlinguistic Stroop effects.

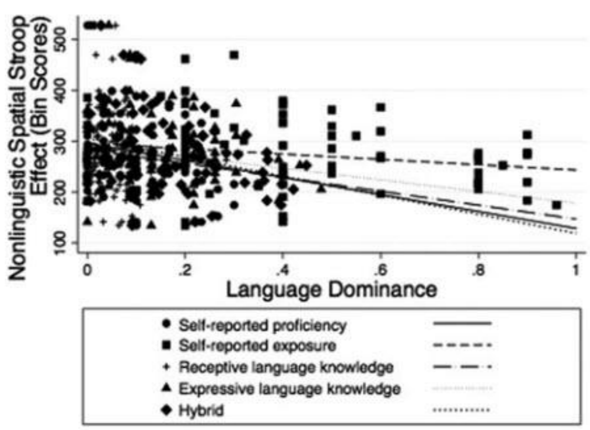

Figure 2.3 Relation between nonlinguistic spatial Stroop performance, measured by bin scores, and language dominance indices as continuous variables

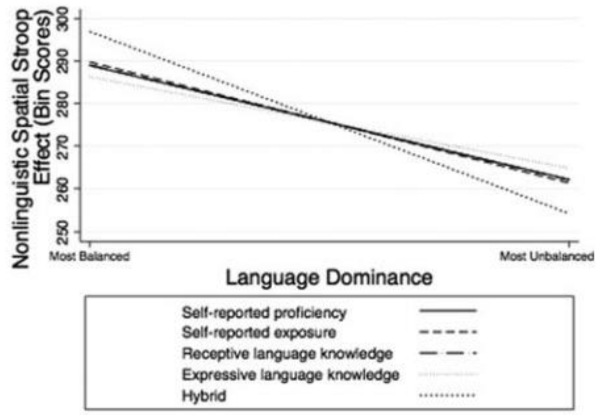

Figure 2.4 Relation between nonlinguistic spatial Stroop performance, measured by bin scores, and language dominance indices as categorical variables

Discussion

The purpose of the present study was threefold. First, we aimed to investigate whether multiple language proficiency and exposure variables differed in how they predicted language dominance in Spanish–English bilinguals. Second, we examined whether language dominance measures differed in how they predicted cross-linguistic lexical knowledge, as indexed by cognate effects. Third, we examined whether language dominance measures differed in how they predicted bilingual participants' inhibitory control skills.

Comparing definitions of language dominance

We found that self-reported proficiency, self-reported exposure, expressive language knowledge, and our hybrid index were the most similar in predicting language dominance, identifying 70% (self-reported proficiency) to 83% (hybrid) of our participants as English-dominant. Instead, receptive language knowledge differed the most from other definitions and was statistically only similar to self-reported proficiency.

Notably, based on the receptive language definition, only 60% of our participants were identified as English-dominant, with a substantial percentage of individuals identified as Spanish-dominant (40%). It is unclear why language dominance operationalized by receptive language knowledge only aligns with dominance operationalized by self-reported proficiency. It is possible that bilinguals' self-judgment of language proficiency is particularly closely related to their understanding of languages. For example, Marian et al. (2007) found that receptive language knowledge was significantly correlated with self-reported proficiency in participants' second language. For many Spanish–English bilingual heritage speakers in the United States, it is the case that Spanish is the primary or only language heard at home for the first few years of development. It is only when the child reaches formal education that English becomes the dominant language in relation to exposure rates and opportunities for receptive/expressive language. However, bilinguals may have awareness of their receptive language skills in the non-dominant, heritage language as it is common for bilinguals to report "I understand more than I can speak." As such, language dominance measured by self-reported proficiency and receptive language may be metalinguistically similar, as evidenced by our current findings, as well as the findings of Marian et al. (2007).

The results of our present study converge with previous findings that operational definitions of language dominance differ in classifying participants (Bedore et al., 2012). Bedore et al. found that their objective measures (morphosyntax, semantics) differed in predicting language dominance profiles in children. Similarly, we found a statistically significant difference after Bonferroni corrections between the two objective measures of language dominance (receptive language knowledge, expressive language knowledge). We additionally found that objective (receptive language knowledge) and subjective (self-reported exposure) measures differ in predicting dominance profiles. Though Sheng et al. (2014) compared a subjective definition of language dominance (self-reported proficiency) to three objective expressive definitions in adults and found that the subjective definition of dominance did not differ from the objective definitions, we contribute a possible new distinction with the addition of a receptive language measure. There are few studies that have compared definitions of language dominance but, together with Bedore et al., we can suggest caution when comparing bilinguals across studies; as different definitions of language dominance might yield distinct bilingual groupings.

Language dominance and cognate effects

While different operational definitions of linguistic skills were shown to yield somewhat different classifications into English-dominant and Spanish-dominant groupings, it is ultimately of interest to establish which language dominance profiles are most closely associated with linguistic and cognitive behaviors. In doing so, the predictive value of specific language dominance metrics can be identified. Here, we examined how dominance measures would predict cognate effects, a well-documented linguistic phenomenon that has been linked to proficiency.

Language dominance defined by a continuous hybrid definition significantly predicted cognate effects in both English and Spanish. Yet only in the less dominant language (Spanish) were all continuous and categorical variables significant predictors of cognate effects. Specifically, a continuous pattern of increased cognate effects was revealed as proficiency in the target language decreased relative to the non-target language. These findings are consistent with studies that have looked at the relation between language dominance as a categorical variable and cognate effects (e.g., Costa et al., 2000; Gollan et al., 2007; Pérez et al., 2010; Rosselli et al., 2014). For example, Costa et al. (2000) investigated the facilitatory effects of cognate word recognition in young adult Catalan–Spanish bilinguals. They found patterns of greater cognate facilitation in the less dominant language than the more dominant language on a picture naming task. While others have linked language dominance as a CONTINUOUS measure to linguistic knowledge (Bedore et al., 2012; Bedore et al., 2016; Dunn & Tree, 2009; Gollan et al., 2012), to our knowledge we link cognate processing to continuous dominance for the first time here.

The degree of language dominance is relevant in both of bilinguals' languages when investigating the magnitude of cognate effects. However, the magnitude of cognate effects in the LESS DOMINANT LANGUAGE might not be critically attached to any one operational definition, either subjective, objective, or a hybrid of the two. This may be the case because cognate effects have been found to be most robust in non-dominant languages (Pérez et al., 2010; Rosselli et al., 2014) and participants were more variable along all experiential dimensions of their less dominant language, thus allowing each single predictor to capture variability in cognate effects.

Operationalizing language dominance categorically may not produce equivalent relations to language processing as found with continuous dominance variables. We did not find that categorical variables mapped onto the magnitude of cognate effects on our English language task, though all categorical definitions of dominance significantly predicted effects on the Spanish language task. Since our participants were all highly proficient English users, it is possible that our categorical measures of dominance were not powerful enough to adequately capture cognate effects. As a categorical variable with a small range and standard deviation of scores, for example, self-reported proficiency in English may not have accounted for English cognate effects in the same way that a wider range of self-reported Spanish proficiency scores could account for cognate effects in Spanish. However, we do demonstrate that a continuous and hybrid measure of dominance includes enough variability to capture cognate effects in dominant and nondominant languages, even when variation in proficiency is limited. Taken together, the current findings make the novel contribution that predicting the magnitude of cognate effects in a less dominant language does not seem to rely on specific definitions of language dominance; instead, in a more dominant language, predicting cognate effects may require a more nuanced measure of bilinguals' overall skills and exposure to capture less robust and less variable effects.

Language dominance and nonlinguistic Stroop effects

Though language dominance and cognate effect results demonstrated differences between the predictability of dominance measures as categorical versus continuous, as well as objective versus subjective versus hybrid, only the hybrid index of language dominance predicted inhibitory control skills as both a continuous and categorical variable; the participants with more unbalanced language dominance profiles showed more efficient inhibitory control (smaller nonlinguistic Stroop effects) than participants with more balanced language dominance.

Our findings are consistent with a previous study in older adults where unbalanced bilinguals outperformed balanced bilinguals on nonlinguistic executive function (Goral et al., 2015). Our results stand in apparent contrast to previous studies that balanced bilinguals demonstrate better inhibitory control than unbalanced bilinguals (albeit in children: Prior et al., 2016; Thomas-Sunesson et al., 2018) or that language dominance is not significantly related to nonlinguistic inhibitory control (Yow & Li, 2015).

We believe there to be at least two explanations for our contrasting results. First, since linguistic and cognitive systems may change across development (e.g., Prior et al., 2016; Diamond, 2013), language-cognition links may differ between children and adults. For example, Crivello, Kuzyk, Rodrigues, Friend, Zesiger, and Poulin-Dubois (2016) show that cognitive and bilingual skills in children develop in tandem. Second, the competition between languages is assumed to drive engagement of cognitive control mechanisms (e.g., Green, 1998). It is possible that unbalanced bilingual children are not yet proficient enough in their two languages to trigger crosslinguistic competition, while cross-linguistic competition is known to be strong in the less dominant language of adult bilinguals.

The relative inhibitory advantage that more unbalanced bilinguals were found to have in the current study may be related to more effort in language juggling in adult bilinguals with two established language systems. For example, unbalanced bilingual adults have been shown to work harder at inhibiting their dominant language from intruding into their less dominant language (e.g., Sandoval, Gollan, Ferreira & Salmon, 2010), and switching from their less dominant language to their more dominant language (e.g., Costa & Santesteban, 2004). It is possible that, while balanced bilingualism confers an ability to better insulate linguistic processes from cross-linguistic interference (e.g., MacWhinney, 2012), by doing so it establishes a context where fewer cognitive resources must be routinely recruited for language processing, thus potentially limiting engagement of cognitive resources that are recruited for nonlinguistic conflict resolution tasks. Yet we do note that there have been studies linking language dominance to LINGUISTIC inhibitory control (Yow & Li, 2015; Zied, Phillipe, Karine, Valerie, Ghislaine & Arnaud, 2004), with balanced bilinguals outperforming unbalanced bilinguals, likely due to group differences in proficiency and extent of cross-linguistic interference. Separately from language dominance, there are also studies that have linked bilinguals' proficiency in their less dominant language to performance on inhibitory control (Blumenfeld & Marian, 2013; Singh & Mishra, 2013), and higher proficiency in the non-dominant language predicted better inhibition in these cases. Post-hoc analyses suggest that, in the current study, neither English ($p > .1$) nor Spanish proficiency ($p = .09$) was linked to performance on the inhibitory control task. Language dominance and proficiency are related but not identical, and future studies should investigate them in tandem to delineate their unique influences on cognitive control.

Our current findings may provide one explanation for the variability that we see between studies investigating the relation between bilingual experience and cognitive control. In many studies, language profiles were operationalized by a single definition of language dominance, or by a singular aspect of the language experience (e.g., self-reported proficiency, parent-reported exposure). For example, in Paap and Greenberg (2013), where no link was identified between bilingualism and cognitive control, participants were categorized as bilinguals if they reported spoken proficiency in English and another language as a four or greater on a 7-point Likert scale, and were categorized as monolingual if they reported a three or less on the same scale in a language other than English. Self-reported proficiency, even on a larger 10-point Likert scale and averaged across reading, writing, and understanding, was not a significant predictor of nonlinguistic inhibitory control in our current findings. Overall, our findings suggest that nuanced cognitive effects might only reveal themselves when characterizing language profiles by a multifactorial definition of dominance, which is evident in both continuous and categorical variables. Simple operational definitions of language profiles may not give weight to the everyday factors that make the language experience, and therefore do not adequately measure linguistic profiles (see reviews by Costa, Hernández, Costa-Faidella & Sebastián-Gallés, 2009, and Hilchey & Klein, 2011).

Composite scores may thus be overall more reliable indices than single scores. This increased reliability stems from a more precise measure of underlying language profiles, conceivably yielding a better predictor of linguistic-cognitive skills. This may especially be the case since it remains unknown which aspects of bilingualism influence cognitive processes. Here, the language dominance composite score equally represents multiple areas of bilingual experience, as well as receptive and expressive language, all of which are strongly implicated in language ability (e.g., Gollan et al., 2012; Marian et al., 2007). Further, the language dominance composite score considers both subjective and objective assessments. It has been noted that subjective self reports of language proficiency capture bilinguals' overall linguistic skills, as perceived over time and settings (e.g., Marian et al., 2007; Kaushanskaya, Blumenfeld & Marian, under review). On the other hand, objective testing captures bilinguals' specific skills at one point in time. Our composite score gives weight to both receptive/expressive and subjective/objective measures, considering how language dominance can be determined through both internal and external assessments. We therefore argue that the confluence of these aspects of bilingual experience and proficiency may best account for individual differences in linguistic and cognitive domains. Based on our findings, and results from other studies (e.g., De Cat et al., 2018; Bedore et al., 2012; Kaushanskaya et al., under review; Luk & Bialystok, 2013), we believe that bilinguals' language dominance is best determined if a variety of measures are taken into consideration. Here, we recommend that both receptive/expressive and subjective/objective language proficiency data be collected across participants' languages in creating nuanced language dominance profiles.

Limitations and future directions

The current findings are from a sociolinguistic context with a clear majority language where unbalanced language dominance profiles are common. Future research can examine whether the identified patterns can also be seen in environments where balanced bilingual use and proficiency is more frequent. In such an environment, more balanced bilinguals, as well as bilinguals dominant in either one of two languages, may be found. It must be noted that, given our current participants, our categorical variables for the cognate analyses do not delineate English dominance versus Spanish dominance since they were derived from a median split in a mostly English-dominant sample. Instead the categorical variables arbitrarily capture greater and lesser English dominance. We expect that given the linear trends identified here with continuous variables, similar patterns will be found in future studies that have clear English- and Spanish-dominant categories.

Further, there were notably more female than male participants in the current study. Effects of sex are not commonly cited in the literature regarding our particular population of young adults. However, Upadhayay and Guragain (2014) found no significant sex differences on an Eriksen Flanker inhibitory control task and Shokri, Akbarfahimi, Zarei, Hosseini, and Farhadian (2016) found no significant sex differences on a linguistic Stroop task. Nevertheless, a more well-balanced female-male distribution should be considered in future studies for better generalizability.

We believe that the current literature is trending toward suggesting multiple measurements of proficiency in determining language status for clinical and research purposes. However, there is still much work that needs to be done to determine the exact components of a language dominance composite score that would best account for individual variability. Here, we used measurements of self-reported proficiency and exposure, as well as receptive and expressive single word vocabularies. Measurements of proficiency, such as morphosyntax, phonology, translation speed, mean lengths of utterances, and narrative skills are all meaningful in defining language dominance patterns, though more research is required to determine which are the most accurate and most parsimonious predictors of language dominance. Future studies concerning bilingualism can build on and benefit from our findings in selecting meaningful ways to characterize participants in analyses and a priori designs.

Conclusions

In summary, definitions of language dominance have varied between studies of language and cognition in bilinguals (e.g., Gollan et al., 2012; Paap & Greenberg, 2013; Yow & Li, 2015; Yudes et al., 2010). These definitions differ somewhat in predicting individual language dominance patterns. We show here that only a well-rounded hybrid definition of language dominance seems to account for cognate effects in the dominant language, as well as cognitive performance across participants. Instead, the very robust cognate effects observed in participants' less dominant language can be accounted for by a variety of language dominance measures. The current findings suggest that detailed hybrid descriptions of linguistic dominance profiles across studies may bring greater cohesion to the bilingualism literature, particularly when phenomena that are less robust or rely on specific linguistic experiences are examined.

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CHAPTER 3: VOCABULARY AND COGNATE EFFECTS IN BILINGUAL ADULTS WITH AND WITHOUT A HISTORY OF DEVELOPMENTAL LANGUAGE DISORDER

Abstract

Purpose: We examine the vocabulary size and word recognition patterns of bilingual adults with (HxDLD) and without (NoDLD) a history of Developmental Language Disorder. We examine whether HxDLD have reduced vocabularies compared to their NoDLD peers. Of key interest is whether HxDLD bilinguals show a cognate effect, namely higher performance on words that share form and meaning across languages (cognates) than words with minimal crosslinguistic overlap (noncognates).

Method: Twenty-seven Spanish-English bilinguals, aged 18–21, were grouped as HxDLD or NoDLD based on self-report. Participants completed standardized tests of English and Spanish, as well as receptive vocabulary measures in each language. Analyses investigated vocabulary size and cognate effects in English, Spanish, and total language. Cognate effects were further examined by word difficulty.

Results: NoDLD participants demonstrated larger Spanish and total vocabularies than their HxDLD peers. Both groups demonstrated more accurate recognition of cognates than noncognates, and more accurate recognition of easy to medium to hard words. Interactions between group and word type suggested that HxDLD participants demonstrated a larger difference between cognate and noncognate accuracy in Spanish and in total vocabulary, which were pronounced for the most difficult words.

Conclusion: Results suggest that a history of DLD may affect bilingual adults' overall vocabulary size. For bilinguals with or without a history of DLD, word recognition seems to be facilitated by cross-linguistic knowledge (i.e., cognates), particularly in the relatively weaker language, and for the most difficult words.

Introduction

Developmental Language Disorder (DLD) is defined as the difficulty in using and comprehending language without a known biomedical condition (Bishop et al., 2017). For multilingual individuals, this difficulty in using and comprehending language is apparent in all target languages (Kohnert et al., 2020). Though typically diagnosed and treated during childhood, DLD is a life-long condition that has been associated with poorer outcomes in adulthood, including social and emotional wellbeing (e.g., Beitchman et al., 2001), as well as academic success and career choice (e.g., Conti-Ramsden et al., 2018).

One recognized area of difficulty for individuals with DLD is vocabulary. Monolinguals with a history of DLD have shown lower performance on receptive vocabulary tasks when compared to peers across the lifespan (e.g., Brownlie et al., 2016, ages 19 - 31; Rice & Hoffman, 2015, ages 2 - 21). In a set of studies conducted in the United Kingdom, some participants with DLD continued to show reduced word comprehension into adulthood (e.g., Bartak et al., 1975; Howlin et al., 2000; Mawhood et al., 2000). At the first time point (Bartak et al., 1975), 22 children diagnosed with DLD (*M* age = 8) performed more than one standard deviation below expected norms (*M* = 71.1, *SD* = 19.1) on the Peabody Picture Vocabulary Task (PPVT, Dunn, 1959). By the third time point in Howlin et al. (2000) and Mawhood et al. (2002), 19 of the original children with DLD (*M* age = 24 years) were assessed using the British Picture Vocabulary Scale (Dunn et al., 1982), a British adaptation of the PPVT. Standardized scores were not reported for normalized comparisons. However, the authors described four adults with a history of DLD (21% of the sample) as having scores below a 10-year-old level. This suggests that at least some individuals with a history of DLD continue to demonstrate reduced word recognition into adulthood.

Little is known about the language skills of bilingual adults with a history of DLD. Though there have been studies comparing vocabulary size between typical bilingual and monolingual adults (e.g., Bialystok, 2012), there have not been studies comparing bilingual adults with a history of DLD to their typical bilingual peers. Similar to the monolingual DLD literature (e.g., Rice & Hoffman, 2015,), bilingual adults with a history of DLD might show lower performance on vocabulary tasks than typical bilingual adults.

Bilingual vocabularies differ substantially from monolinguals' as word representations are integrated across two languages (e.g., Lijewska, 2020; Shook & Marian, 2013). During comprehension, languages are activated in parallel for bilinguals, which results in crosslinguistic interaction at the phonological and lexico-semantic levels of processing (e.g., Blumenfeld & Marian, 2007; Freeman et al., 2016; Marian & Spivey, 2009). As multiple language structures and features are activated, crosslinguistically overlapping representations and connections further boost activation, resulting in positive interactions or facilitation effects.

One example of facilitation effects is a processing advantage that has been identified for cognates or words that overlap in form and meaning (e.g., English-Spanish *pear-pera*). Typical bilingual adults recognize cognates more accurately than noncognates (e.g., English-Spanish *hammer-martillo*). For example, in Robinson Anthony and Blumenfeld (2019), adults completed receptive vocabulary tasks in English, using the Peabody Picture Vocabulary Test (PPVT-III, Dunn & Dunn, 1997), and in Spanish, using the PPVT-III's Spanish equivalent, the Test de Vocabulario en

Imagenes Peabody (TVIP, Dunn, Lugo et al., 1997). Cognate and noncognate words were identified across the two tests (see also Potapova et al., 2016), and cognate effects were calculated based on accuracy of the cognate words minus accuracy of the noncognate words.

When comparing between the two languages of bilingual adults, larger cognate effects have been found in the nondominant language (Costa et al., 2000; Robinson Anthony & Blumenfeld, 2019; Rosselli et al., 2014). This pattern of larger cognate effects in the nondominant language is thought to be due to greater crosslinguistic influence from a more proficient language to a less proficient one during cognate word processing (e.g., Blumenfeld & Marian, 2007). Moreover, reduced knowledge of noncognate words in the nondominant language contribute to the larger gap between cognates and noncognates, resulting in a larger cognate effect in the nondominant language. While cognate effects across languages and relatively larger effects in the nondominant language are robustly found in typical bilingual adults, it remains an open question whether these effects will also hold for bilingual adults with a history of DLD.

To our knowledge, there are no studies available on cognate performance for bilingual adults with a history of DLD. There are initial findings in the child literature that show that bilingual children with DLD show a comparable cognate advantage as their typically developing peers (e.g., Grasso et al., 2018). However, cognate effects may differ by expressive or receptive modality (Payesteh & Pham, 2021). Grasso and colleagues (2018) measured cognate effects in bilingual children with and without DLD (5 to 9 years old) on a picture naming task. The majority of children demonstrated a cognate effect: for children with or without DLD, there was a greater probability of naming a word in English or Spanish if the word was a cognate. Payesteh and Pham (2021) replicated the cognate effect in an English picture naming task with a different sample of bilingual children with DLD. However, cognate effects were less consistent on an English receptive vocabulary task, with only 31% percent of children showing the effect, which was moderate in magnitude (d = .51). Potapova et al. (2015) have shown in bilinguals without language impairment that cognate effects in receptive vocabulary tasks stabilize from childhood (where 60% of participants showed the effect) into adulthood (where 76% of participants showed the effect). Whether a similar developmental trajectory exists for bilinguals with DLD remains an open question.

To further understand cognate effects in our participants, we consider word difficulty as a factor that has been shown to modulate cognate effects (Kelley & Kohnert, 2012; Payesteh & Pham, 2021). In a study of typically developing bilingual children, Kelley and Kohnert (2012) found that participants recognized cognates more accurately than noncognates (p = .047, h = .07; very-small effect), with very-small effects on easy trials (p = .03, h = .13), small-medium effects on medium difficulty trials (p < .001, h = .39) and hard trials (p < .001, h = .29). These participants demonstrated more consistent cognate effects on an expressive vocabulary task across all levels of difficulty, ps < .001, h = .30 to .53, with small-medium to medium effects. Payesteh and Pham (2021) also found that word difficulty influenced cognate effects in bilingual children with DLD. On the receptive vocabulary task, overall cognate effects were minimal and emerged only in the medium difficulty words, p < .001, d = .73 (medium effect size) when items were split into three levels (i.e., easy, medium, hard). In contrast, participants demonstrated a more robust cognate effect on the expressive vocabulary task across easy, medium, and hard levels of difficulty, $ps < .01$, with medium to large effect sizes. In sum, bilingual children with and without DLD show more consistent cognate effects in the expressive domain, and among more difficult word items. Because cognate effects have yet to be examined in bilingual adults with a history of DLD, it is an open question whether word difficulty will have a similar influence in adult populations, with and without DLD.

Present study

The present study extends the literature on bilingualism and DLD to the study of bilingual adults with a history of DLD. As a first step, we examine vocabulary size and cognate effects in this population in the following research questions:

1. Do bilingual adults with a history of Developmental Language Disorder (DLD) have reduced vocabularies relative to their typical peers?
2. Do bilingual adults with a history of DLD differ in their performance on cognate relative to noncognate words compared to typical peers?
3. Is cognate performance influenced by word difficulty in bilingual adult populations?

Similar to monolingual DLD studies (e.g., Brownlie et al., 2016), we predict that bilingual adults with a history of DLD will show reduced receptive vocabulary than their typical bilingual peers. Group differences for language-specific vocabularies in English and Spanish will also be examined for bilingual adults with a DLD history, a new population to the literature. For the second research question, we predict that both bilingual groups (with and without a history of DLD) will demonstrate an advantage for cognate relative to noncognate words based on the robust literature with typical bilingual adults (e.g., Robinson Anthony & Blumenfeld, 2019) and emerging findings from bilingual children with DLD (e.g., Payesteh & Pham, 2021). Relatively stronger cognate effects may be apparent in the nondominant language, consistent with findings from typical bilingual adults (e.g., Costa et al., 2000). For the third research question, we predict the magnitude of cognate effects will be more pronounced for more difficult word levels. This prediction is based on cognate studies with bilingual children with and without DLD (e.g., Kelley & Kohnert, 2013; Payesteh & Pham, 2021).

Method

Recruitment

This study was approved by the university's institutional review board (IRB). Recruitment took place online via IRB-approved social media accounts and by word of mouth. Recruitment materials were written in Spanish and English and targeted bilingual adults with a wide skill range, including individuals with difficulties in language (i.e., fliers stated "*We are looking for 18-21 year olds who express their ideas in disorganized ways, have difficulty with organization and lose things, and/or dislike/avoid reading"*). All participants provided their written consent prior to participating.

Participants

Twenty-seven bilingual adults participated in this study, with a history of DLD (HxDLD, n = 10) or without a history of DLD (NoDLD, n = 17). Inclusionary criteria were: (1) average self-rated speaking and listening skills in Spanish and English of 6 (described as *slightly more than adequate*) or more out of 10 (*perfect*) in each language using the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian et al., 2007; Kaushanskaya et al., 2019); and (2) participant ages between 18-21 years.

Participants who self-reported as having a history of language disorder were included in the HxDLD group (i.e., reported speech-language services and/or current language concern). Exclusionary criteria were: (1) sufficient knowledge of a third language as indexed by an average score of 4 (*slightly less than adequate*) or more out of 10 using the LEAP-Q; and (2) hearing impairment as indexed by self-report.

To complement self-report, all participants also completed direct measures of English and Spanish using the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF4, Semel et al., 2003) and its Spanish equivalent the Clinical Evaluation of Language Fundamentals-Fourth Edition-Spanish (CELF4-Span, Wiig et al., 2006). Because these tests are standardized through age 21, we calculated Core Language scores for each language based on four subtests: Recalling Sentences, Formulating Sentences, Word Classes, and Word Definitions. Scores for the administered questionnaire and tests are summarized in Table 1. Data were initially collected for 31 participants. One participant was excluded due to self-reported hearing and visual concerns; three additional participants did not complete the Spanish session, resulting in analysis of 27 participants.

All participants showed similar language experience and exposure. As shown in Table 1, NoDLD and HxDLD groups did not differ in age or years of education. Additionally, for both English and Spanish background measures, participants reported similar first age of acquisition, current exposure, and proficiency speaking, understanding, and reading across each language. In terms of language performance, there were no group differences in English or Spanish Core Language scores after controlling for multiple comparisons. The group averages of CELF4 English and

Spanish standard scores suggest that language skills were within the typical range across languages (i.e., standard score > 85).

Table 3.1 Language experience and proficiency (LEAP-Q) and core language skills (CELF-4)

N=27	No history of DLD (n = 17; 15 female, 2 male)			Self-reported history of DLD (n = 10; 8 female, 2 male)			
Scale	***Mean***	***SD***	***Range***	***Mean***	***SD***	***Range***	***p***
LEAP-Q							
Age	19.71	1.31	17-21	19.90	1.29	19-21	.71
Years Education	14.82	1.70	12-18	14.65	1.29	14-16	.78
LEAP-Q English Background							
Age of Acquisition (years)	4.95	3.75	1-15	3.50	1.72	0-11	.40
Exposure (percentage)	65.24	20.62	15-95	62.00	20.62	25-90	.69
Speaking (max of 10)	8.65	1.27	5-10	8.30	1.49	6-10	.53
Understanding (max of 10)	9.12	.93	5-10	8.40	1.51	8-10	.14
Reading (max of 10)	9.00	1.17	6-10	8.20	1.40	7-10	.12
LEAP-Q Spanish Background							
Age of Acquisition (years)	4.00	5.62	0-12	1.30	2.06	0-19	.09
Exposure (percentage)	34.76	19.75	5-85	38.00	19.75	10-75	.69
Speaking (max of 10)	7.82	1.74	5-10	7.30	1.34	5-10	.42
Understanding (max of 10)	8.29	1.93	5-10	8.80	.92	5-10	.37
Reading (max of 10)	7.35	2.26	2-10	6.60	1.78	3-10	.38
CELF4 English							
Core Language Skills (SS)	105.65	10.22	90-123	100.30	10.51	84-119	.21
CELF4 Spanish							
Core Language Skills (SS)	112.29	24.33	87-138	95.40	22.87	51-134	.04

Procedures

Participants completed the present study in three separate sessions as part of a larger study. The first two sessions were conducted in English only and the final session was conducted in Spanish. The order of English first followed by Spanish was held constant across all participants. It was reasoned that adult participants recruited from US-based settings of higher education might be generally stronger in English, and completing tasks in English first would provide valuable scaffolding to successfully complete the tasks in Spanish. All sessions were conducted by a trained researcher fluent in both languages. On average, participants completed all sessions within two weeks; the maximum time length to completion was four weeks. English and Spanish sessions were separated by three to seven days.

Data collection took place from 01/2021 to 05/2022. Sessions were completed remotely due to social distancing policies during the COVID-19 pandemic. Tests were modified for online data collection, which has been found to be a reliable method of administration (e.g., Castilla-Earls et al., 2022; Waite et al., 2012). Paper materials were adapted to Qualtrics software (https://qualtrics.com) to capture participants' responses digitally (e.g., images were presented on screen with answer choices pinned to the bottom of the screen). Sessions were administered via Zoom (https://zoom.us) using screen sharing for joint viewing and remote-control access allowing the participant to click and point to targets.

Tasks and scoring

To measure knowledge of cognates, relative to noncognates, the present study used the *Peabody Picture Vocabulary Test-Third Edition* (PPVT: Dunn & Dunn, 1997) and its Spanish equivalent*, the Test de Vocabulario en Imágenes Peabody* (TVIP: Dunn et al., 1986). The PPVT and TVIP are similar picture identification tasks designed to index English and Spanish receptive vocabulary, respectively. Participants listened to a stimulus word and chose one picture out of four that best represents the word. It is important to note that the PPVT is not normed for a Spanish-English bilingual population, and the TVIP is not normed for populations over the age of 18. Thus, all items on the PPVT and TVIP were administered rather than relying on basal and ceiling rules (for a similar approach, see Potapova et al., 2016). The PPVT consists of 204 trials and the TVIP consists of 125 trials. Dependent measures were the proportion of words correctly identified from the PPVT (out of 204), and from the TVIP (out of 125) to measure English-only and Spanish-only vocabulary, respectively. Total vocabulary was measured as the average of the proportion of items correct from the PPVT and proportion of items correct from the TVIP.

Cognates on the PPVT and TVIP have been previously identified using COSP (Crosslinguistic Overlap Scale for Phonology, Kohnert et al., 2004); words and their translation equivalents were compared on initial sounds, number of syllables, overlap in consonants, and overlap in vowels (see Potapova et al., 2016, and Robinson Anthony and Blumenfeld, 2019, for appendices containing lists of items that are cognates/noncognates). For example, English-Spanish translation equivalents *piano-piano* share maximal form overlap (COS*P* = 10); in contrast English-Spanish translation equivalents *apple-manzana* share minimal form overlap (COS*P* = 1). Consistent with the cognate/noncognate classification rules used by Kelley and Kohnert (2012), words on the PPVT and TVIP with COSP ratings ≥6 were considered cognate words on the PPVT Form A (102/204 words, .50 proportion of items) and TVIP Form A (73/125 words, .58 proportion of items). Cognate effects were measured as cognate accuracy (the proportion of cognates correctly identified) minus noncognate accuracy (the proportion of noncognates correctly identified). To measure cognate and noncognate accuracy, individual raw scores for cognate and noncognate items were divided by the total number of trials designated as cognates (PPVT = 102, TVI*P* = 73) and noncognates (PPVT = 102, TVI*P* = 52). For example, Participant A correctly identified 94 cognates and 86 noncognates on the PPVT; thus, this participant has an English cognate proportion correct of 94/102 = .92 and English noncognate proportion correct of 86/102 = .84. Participant A correctly identified 68 cognates and 33 noncognates on the TVIP; thus, this participant has a Spanish cognate proportion correct of 68/73 = .93 and Spanish noncognate proportion correct of 33/52 = .63 on the TVIP. For the combined English and Spanish score, both languages were weighted equally by averaging cognate proportion correct means and noncognate proportion correct means across languages; thus this participant has a total cognate proportion correct of .93 (the average of PPVT .92 and TVIP .93) and a total noncognate proportion correct of .74 (the average of PPVT .84 and TVIP .63).

Word difficulty was also examined using the PPVT and TVIP. Because these tasks are standardized tests designed to increase in item difficulty, word items from the PPVT and TVIP were divided into thirds to distinguish between easy, medium, and hard difficulty levels (e.g., Payesteh & Pham, 2021). Though several factors contribute to word difficulty, we verified these difficulty levels by examining word frequency, given that high frequency words tend to be easier to process than low frequency words (Brysbaert et al., 2012). The frequency of each word was tallied using the Clearpond database (https://clearpond.northwestern.edu/index.php) English corpus and Spanish corpus. Word frequencies were recorded as counts per million. A 2x3 ANOVA, comparing word frequencies on test (PPVT, TVIP) by level of difficulty (easy, medium, hard), yielded a significant effect of word frequency, $F(5,307) = 5.68$, $p = .04$. Pairwise comparisons (Bonferroni corrected alpha = .017) reveal that word frequencies for easy words are marginally-larger to significantly-larger than word frequencies for medium words (mean difference = 35.95 words per million, SE =15.22, $p = .019$) and hard words (mean difference = 51.78 words per million, *SE* =16.04, p = .001); descriptively, word frequencies for medium words were larger, though not significantly, than hard words (mean difference = 15.83 words per million, *SE* =15.97, p = .32). Because there was no significant main effect of task, p = .47, nor interaction between task and difficulty, p = .92, we conclude that as word difficulty increased, word frequency decreased on both the PPVT and TVIP.

Analyses

Three 2 (group) x 2 (word type) x 3 (difficulty level) ANOVAs were conducted to evaluate performance in English, in Spanish, and across the two languages. To answer the first research question, we focus on main effects of group (NoDLD, HxDLD). A significant main effect of group would indicate vocabulary size differences between bilinguals with and without a history of DLD. To answer the second research question, we focus on main effects of word type (cognate, noncognate) and interactions between word type and group. A significant main effect of word type would indicate accuracy differences between cognate and noncognate words, and a significant word type by group interaction would indicate group differences in cognate effects. To answer the third research question, we focus on main effects of word difficulty (easy, medium, hard) and interactions between difficulty and group, as well as difficulty and word type. A significant main effect of difficulty would indicate that levels of difficulty influence word recognition. Significant interactions between difficulty and group would indicate that bilinguals with and without DLD are influenced differently by word difficulty. Significant interactions between difficulty and word type would indicate that word difficulty has a different influence on cognate versus noncognate performance. Follow-up pairwise comparisons were conducted for significant interactions and when significant effects were found for a variable with multiple levels. Analyses were conducted using SPSS version 28.0.1 (IBM Corp., 2022).

Results

In the following, results are presented for English, Spanish, and across languages to align with the analytical plan. Each research question (RQ) is referenced in the Results and summarized in the Discussion.

Effects in English

There was no significant main effect of group, $F(1,25) = 2.27$, $p = .15$, $\eta^2_p = .08$, as participants with ($M = .81$, $SE = .02$) and without ($M = .84$, $SE = .01$) a history of DLD recognized a similar proportion of English words (RQ1). However, there was a significant main effect of word type (RQ2), $F(1,25) = 65.56$, $p < .001$, $\eta^2_p = .72$, indicating that cognates ($M = .85$, $SE = .01$) were recognized more accurately than noncognates ($M = .79$, $SE = .02$) on this English task (RQ2). There was no significant word type by group interaction, $F(1,25) = .01$, $p = .94$, $\eta^2_p < .01$, as participants with and without DLD did not differ on cognate versus noncognate performance.

There was a significant main effect of word difficulty (RQ3), $F(2,24) = 340.48$, $p < .001$, $\eta^2_p = .97$. Pairwise comparisons of difficulty (Bonferroni corrected alpha = .05/ planned analyses x3 = .017) demonstrate that easy words ($M = .99$, $SE < .01$) were more accurate overall than medium words ($M = .91$, $SE = .01$) and hard words ($M = .57$, $SE = .02$), $ps < .001$, and medium words were more accurate overall than hard words, $p < .001$. Further, an interaction emerged between difficulty and word type, $F(2,24) = 29.93$, $p < .001$, $\eta^2_p = .71$. Pairwise follow-up comparisons (Bonferroni corrected alpha =

.017) revealed that cognates were more accurately identified than noncognates for hard words (*M* difference = .15, *SE* =.02, $p < .001$); there was no significant difference between cognate and noncognate accuracy for easy words (*M* difference = .004, *SE* =.01, $p = .47$) or medium words (*M* difference = .03, *SE* =.02, $p = .13$) (See Figure 1).

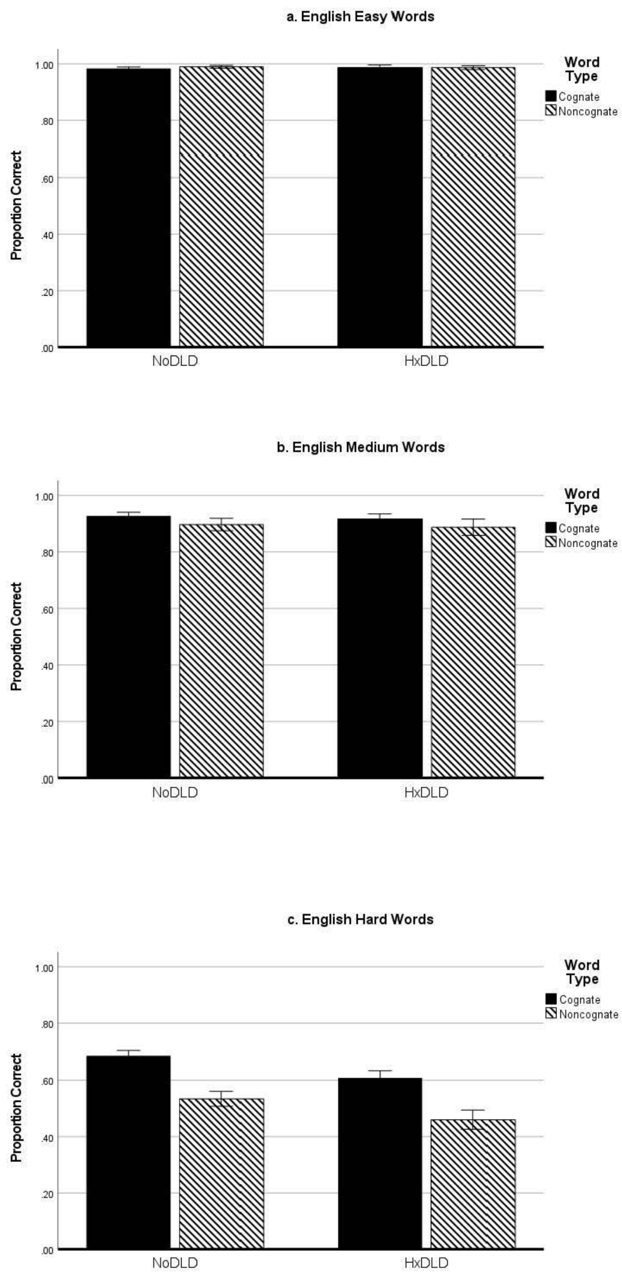

Figure 3.1 Proportion of English words correctly identified by group and word type across easy (a., top), medium (b., middle), and hard (c., bottom) difficulty

Effects in Spanish

There was a main effect of group (RQ1), $F(1,25) = 4.52$, $p = .04$, $\eta^2_{p} = .15$, as HxDLD participants (*M* = .75, *SE* =.03) recognized a lower proportion of words overall than NoDLD participants (*M* = .83, *SE* =.02) on the Spanish task.

There was also a significant main effect of word type (RQ2), $F(1,25) = 71.50$, $p < .001$, $\eta^2_{p} = .74$, as cognates (*M* = .87, *SE* =.01) were recognized more accurately than noncognates (*M* = .71, *SE* =.03) overall in Spanish. There was a significant word type by group interaction, $F(1,25) = 4.45$, $p = .05$, $\eta^2_{p} = .15$, with pairwise follow-up comparisons (Bonferroni corrected alpha = .05/ planned analyses x2 = .025) indicating that NoDLD and HxDLD participants recognized a similar proportion of cognates (M difference = .04, *SE* =.02, *p* = .11) while NoDLD participants recognized more noncognates than their HxDLD peers (*M* difference = .12, *SE* =.05, *p* = .04).

There was a significant main effect of difficulty (RQ3), $F(2,50) = 130.12$, $p < .001$, $\eta^2_{p} = .92$. Pairwise comparisons of difficulty (Bonferroni corrected alpha = .017) demonstrate that easy words (*M* = .97, *SE* =.01) were more accurate overall than medium words (*M* = .87, *SE* =.01) and hard words (*M* = .57, *SE* =.02), *ps* < .001, and medium words were more accurate overall than hard words, *p* < .001. Further, a significant interaction emerged between difficulty and word type, $F(2,24) = 23.07$, $p < .001$, $\eta^2_{p} = .66$. Pairwise follow-up comparisons (Bonferroni corrected alpha = .017) revealed that cognates were more accurately identified than noncognates for medium words (*M* difference = .12, SE - .03, *p* < .001) and hard words (*M* difference = .30, *SE*

=.03, $p < .001$), and there was no significant difference between cognate and noncognate accuracy for easy words (*M* difference = .04, *SE* =.02, $p = .03$).

Finally, a significant interaction was found between difficulty and group, $F(2,24) = 5.37$, $p = .01$, $\eta^2_{p} = .31$, Pairwise follow-up comparisons (Bonferroni corrected alpha = .017) indicated that while NoDLD and HxDLD participants were similar in the overall proportion of words identified at easy difficulty (*M* difference = .03, *SE* =.02, $p = .23$) and medium difficulty (*M* difference = .34, *SE* =.4, $p = .41$); however, NoDLD participants correctly identified a higher proportion of hard words than HxDLD participants (*M* difference = .17, *SE* =.06, $p = .007$) (see Figure 2).

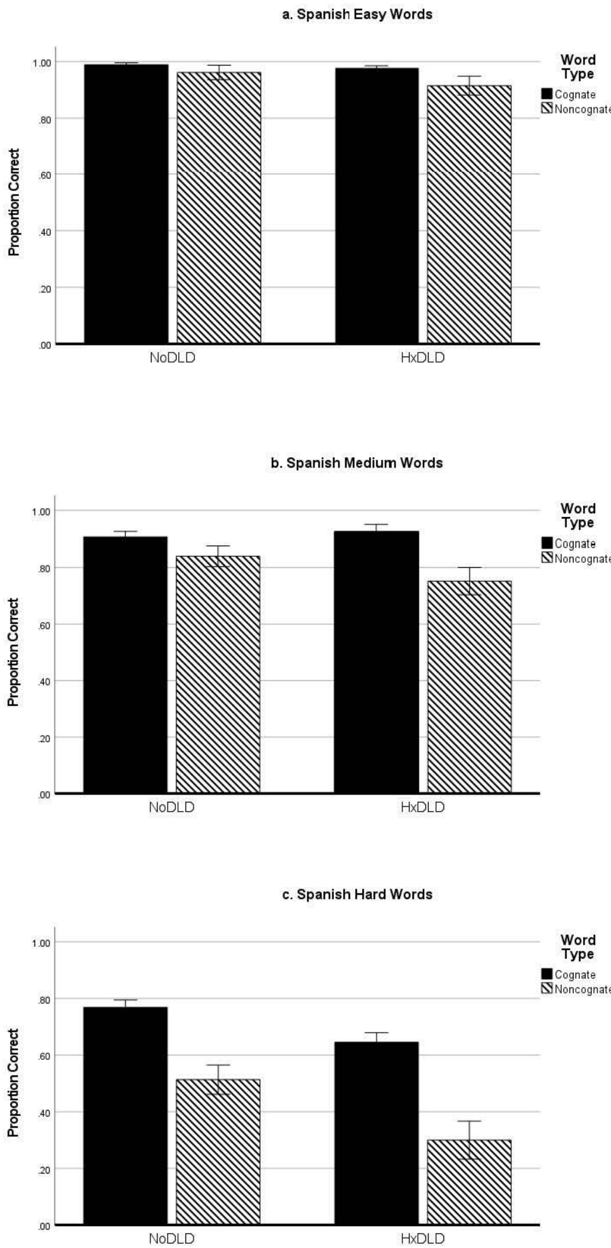

Figure 3.2 Proportion of Spanish words correctly identified by group and word type across easy (a., top), medium (b., middle), and hard (c., bottom) difficulty

Effects in total vocabulary

There was a significant main effects of group (RQ1), $F(1,25) = 6.46$, $p = .02$, $\eta^2_{p} = .21$, as HxDLD participants ($M = .78$, $SE = .02$) recognized a lower proportion of words overall than NoDLD participants ($M = .83$, $SE = .01$) on total vocabulary.

There was also a significant main effect of word type (RQ2), $F(1,25) = 144.30$, $p < .001$, $\eta^2_{p} = .85$, as cognates ($M = .86$, $SE = .01$) were recognized more accurately than noncognates ($M = .76$, $SE = .01$) overall. Additionally, there was a significant word type by group interaction, $F(1,25) = 4.45$, $p = .05$, $\eta^2_{p} = .15$, and pairwise comparisons (Bonferroni corrected alpha = .025) indicated that NoDLD and HxDLD participants recognized a similar proportion of cognates (M difference = .03, $SE = .02$, $p = .05$) while NoDLD participants recognized more noncognates than their HxDLD peers (M difference = .07, $SE = .03$, $p = .02$).

Finally, there was a significant main effect of difficulty (RQ3), $F(2,24) = 304.09$, $p < .001$, $\eta^2_{p} = .96$. Pairwise comparisons of difficulty (Bonferroni corrected alpha = .017) demonstrate that easy words ($M = .97$, $SE = .01$) were more accurate than medium words ($M = .88$, $SE = .01$) and hard words ($M = .56$, $SE = .02$), $ps < .001$, and medium words were more accurate than hard words, $p < .001$.

A significant interaction emerged between difficulty and word type, $F(2,24) = 53.33$, $p < .001$, $\eta^2_{p} = .82$. Pairwise follow-up comparisons (Bonferroni corrected alpha = .017) revealed that cognates were more accurately identified than noncognates for medium words (M difference = .12, SE - .03, $p < .001$) and hard words (M difference = .30, $SE = .03$, $p < .001$), and there was only a marginal difference between cognate and noncognate accuracy for easy words (M difference = .04, $SE = .02$, $p = .03$). An interaction was also found between difficulty and group, $F(2,24) = 5.37$, $p = .01$, $\eta^2_{p} =$ .31. Pairwise follow-up comparisons (Bonferroni corrected alpha = .017) indicated that while NoDLD and HxDLD participants were similar in the overall proportion of words identified at easy difficulty (*M* difference = .01, *SE* =.01, $p = .27$) and medium difficulty (*M* difference = .02, *SE* =.02, $p = .34$), NoDLD participants correctly identified a higher proportion of hard difficulty words overall (*M* difference = .12, *SE* =.04, $p = .002$) (see Figure 3).

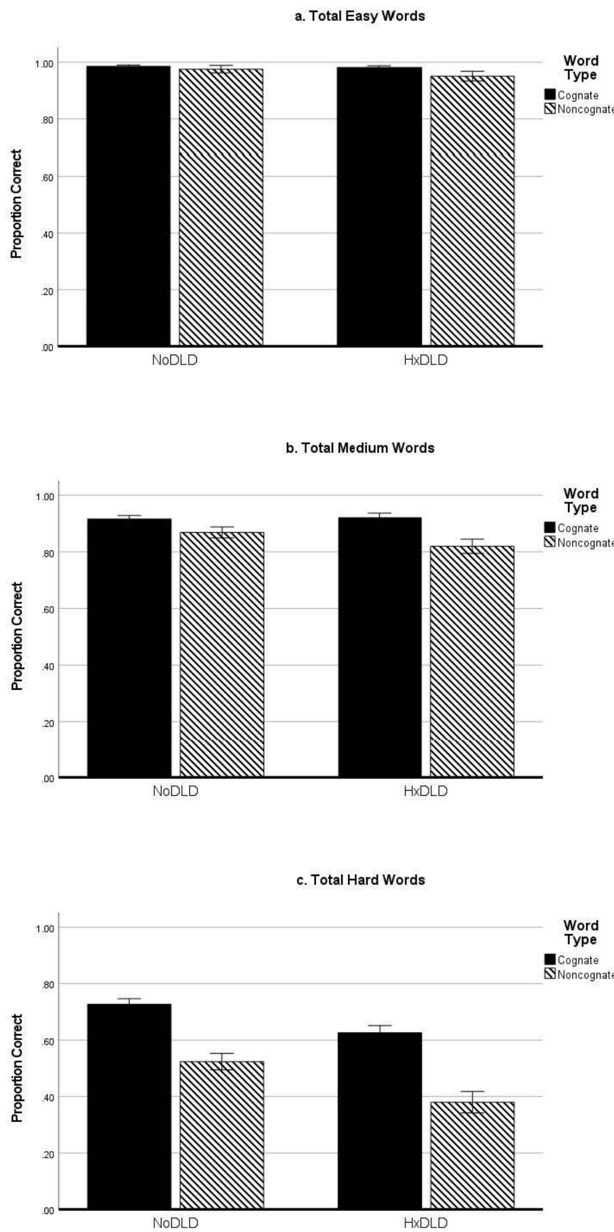

Figure 3.3 Proportion of total words correctly identified by group and word type across easy (a., top), medium (b., middle), and hard (c., bottom) difficulty

Discussion

This study examines the vocabulary size and word recognition patterns of bilingual adults with and without a history of Developmental Language Disorder. We examine whether bilingual adults with a self-reported history of DLD have reduced vocabularies compared to the NoDLD group. Of key interest is whether bilinguals with a history of DLD show a cognate effect, namely higher performance on words that share form and meaning across languages (cognates) than words with minimal crosslinguistic overlap (noncognates), and whether cognate effects are mediated by difficulty, across easy, medium, and hard words.

Vocabulary

The first research question asks whether participants with and without a history of DLD differ in vocabulary size. Significant differences in total vocabulary score suggest that a history of DLD may impact bilingual vocabulary development, extending studies of DLD from monolingual populations to a bilingual one. The identified vocabulary differences between HxDLD and NoDLD participants are supported by the literature on monolinguals with DLD, where young adult English speakers have demonstrated smaller receptive vocabularies when compared to their typical peers on similar receptive vocabulary tasks. (e.g., Brownlie et al., 2016; Bartak et al., 1975; Howlin et al., 2000; Mawhood et al., 2000; Rice & Hoffman, 2015).

The present study adds to a constellation of studies that have used versions of the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) and Test de Vocabulario en Imagenes Peabody (Dunn et al., 1997) to investigate receptive vocabulary skills. For example, Rice and Hoffman (2015) noted a 15-point difference between the average PPVT standard scores across groups of 2-to-20-year-old monolingual children and adults with DLD (*M* = 84.99) and without DLD (*M* = 100.79). Castilla-Earles et al. (2022) reported a 22-point (50 words) difference between the average PPVT standard scores across five-year-old, bilingual children with (*M* = 72.27, average raw score = 45.28) and without (*M* = 94.95, average raw score = 95.10) DLD; they reported a 12-point (20 words) difference between the average TVIP standard scores for children with (*M* = 77.66, average raw score = 19.06) and without (*M* = 88.75, average raw score = 38.26) DLD. Comparably, we find an average 6-word difference on the PPVT between participants with (*M* raw score = 165.60) and without (*M* raw score = 171.89) a history of DLD from the present study; similarly, there is an average 7-word difference on the TVIP between participants with (*M* raw score = 97.50) and without (*M* raw score = 105.24) a history of DLD. It is likely that with intervention, vocabulary differences across groups with and without DLD become smaller from childhood into adulthood (e.g., Damn et al., 2020; Wright et al., 2018). It is also possible that the vocabulary difference between participants in the current sample is particularly small since all participants were college students in good standing (i.e., academically successful) and since all participants were recruited based on experiencing some difficulties with language. Nevertheless, the current findings suggest that subtle differences between participants with and without a history of DLD are best captured when both languages are considered together (Pearson et al., 1993).

When investigating language specific vocabularies, results indicated that participants with and without a history of DLD have similar vocabularies when considering only English. Similar performance across groups on PPVT can reflect the similar educational background in the US that involves instruction primarily in English. Conversely, there are group differences on the Spanish task, showing that HxDLD participants recognized fewer Spanish words than the NoDLD group. Because this is the first study of bilingual adults with a history of DLD, the history of DLD profiles warrant further study. To better understand the manifestation of DLD in bilingual populations, further research is needed beyond investigations of word representation, typically indexed by accuracy. For example, investigations of cognitive-linguistic processing (e.g., crosslinguistic effects and metalinguistic awareness, Candry et al., 2017) or processing speed (e.g., cognate effects during eye-tracking, Blumenfeld & Marian, 2007) may offer more insight into the bilingual language profile beyond word accuracy.

Cognate effects

The second question asks whether participants with and without a history of DLD differ in cognate versus noncognate word performance. Main effects of word type across English, Spanish, and total vocabulary converge to highlight cognates as an area of strength during word recognition. Cognates are correctly recognized more frequently than noncognates for both groups of participants. These results extend studies of observed cognate effects in typical college-age bilinguals using similar receptive vocabulary tasks (e.g., Potapova et al., 2016; Robinson Anthony & Blumenfeld, 2019) to include participants of varying language ability. Potapova et al. (2016) have shown in bilinguals without language impairment that cognate effects in receptive vocabulary tasks stabilize from childhood (where 60% of participants showed the effect) into adulthood (where 77% of participants showed the effect) on an English task. In combination with observed cognate effects in bilingual child studies with and without DLD (e.g., Kelley & Kohnert, 2012; Payesteh & Pham, 2021) and findings of this present study, evidence suggests that cognate word identification is comparable for bilinguals with and without DLD.

Interestingly, a significant word type by group interaction found in Spanish and total vocabulary further suggests that cognate effects are larger for HxDLD participants, driven by significant differences in noncognate word recognition. NoDLD participants outperform their HxDLD peers in noncognate word recognition across Spanish (by 4%) and total vocabulary (by 7%). These results add to the literature that cognate word recognition in the heritage language (Spanish) and across total vocabulary is a relative and accessible strength for bilinguals with a history of DLD, while noncognate word knowledge may be more vulnerable. These findings should be further investigated to confirm larger cognate effects on receptive vocabulary tasks in bilinguals with DLD than in their typical peers, including an expansion to the expressive language modality, where cognate effects have been robustly found in bilingual children with DLD (e.g., Payesteh & Pham, 2021).

Word difficulty

The third research question asks whether levels of word difficulty influenced cognate effects. The main effect of difficulty demonstrated that for both groups, word recognition accuracy decreased as words became more difficult.

A significant interaction between difficulty and word type further details that cognate effects were observed only for hard level words in English, and for medium and hard level words in Spanish and total vocabulary. In comparison, typically-developing, bilingual language learners have demonstrated cognate effects across easy, medium, and hard word levels on a receptive vocabulary task (Kelley & Kohnert, 2012) and bilingual children with DLD have demonstrated a cognate effect only on medium difficulty words on a receptive vocabulary task (Payesteh & Pham, 2021). One reason for these differences between studies may be that children have less stable vocabulary systems than adults. Relatedly, near ceiling accuracy for easy words and chance accuracy for hard words may not be contexts in which cognate effects are prominent (Payesteh & Pham, 2021). Though a significant main effect of group was only found on the TVIP and combined total, their results together suggest that cognate words are a preferred word type for bilingual word recognition, and especially for bilinguals with a history of DLD.

DLD profile in bilingual adults

Though not an explicit research question, this first study of bilingual adults with a history of DLD initiates a discussion on what the DLD profile could be for this population. Participants in the current study were grouped based on self-report. This approach is similar to McGregor et al., (2020), and presented an attainable first step in the current study as there is no established protocol for diagnosis of DLD in adulthood, particularly in bilingual adults.

Based on the child literature, it is expected for DLD to impact two languages for bilinguals (i.e., low in both languages, see Kohnert et al., 2020 for an overview). Yet, bilingual adult participants in the present study show typical language skills in at least one language. Typical language performance has also been found in monolingual adults with a history of DLD in McGregor et al. (2020) based on results from subtests of the CELF3 and CELF4, as well as the PPVT. This study contributes to the emerging literature of adults with a history of DLD to examine whether adults with DLD transition into the typical range, as least using standardized language tests. If this DLD profile holds for adult populations, then future investigation using experimental measures might be more sensitive to capturing long-term language difficulties.

Regarding how the DLD profile might appear in adults who speak two languages, this study shows interesting results based on the standardized tests for English and Spanish. Of the 27 participants, 18 participants (67%) scored in the typical range for both languages (i.e., scored at 90 or higher on the CELF4-English and CELF4-Spanish Core Language Index) and nine participants (35%) were in the typical range for one language and not the other. Of the nine participants who scored below the typical range in one language, 7 participants (78%) were in the typical range for English but not Spanish, and 2 participants (22%) were in the typical range for Spanish but not English. It thus makes sense that differences between the NoDLD and HxDLD groups emerged primarily in Spanish (generally the weaker language) and when both languages were considered together.

Finally, of the 10 participants who self-reported a history of DLD (HxDLD group), only two (20%) score in the typical range in both languages and eight (80%) score low in one language. The proportion of participants who perform low in one language is descriptively higher in the HxDLD group (80%) than the NoDLD group (6%, 1 out of 17). To be clear, being outside of the typical range in one language is not an indicator of a disorder, as bilinguals fluctuate in relative language strength over time and by context and task demands (Kohnert et al., 2020). This higher proportion of individuals with low performance in at least one language needs to be further investigated in additional studies with bilingual adults with a history of DLD.

Concluding remarks

In this study, bilingual adults with a history of DLD show lower Spanish vocabulary and total vocabulary. In combination with the literature from monolingual populations, our findings suggest that DLD is a lifelong phenomenon. In addition, crosslinguistic influence is present and may be amplified in bilingual adults with a history of DLD. Present findings showing cognate words as an area of strength support the use of cognates as a strategy for new word learning, especially when presented with difficulty (low frequency) vocabulary.

Questions remain about the bilingual profiles of adults with a history of DLD, and whether bilingual adults with a history of DLD develop typical language skills in one or both of their languages in comparison to their bilingual adult peers. Future research can examine in more detail how potential lifetime exposure to each language in individuals with and without a history of DLD may influence outcomes in adulthood for receptive vocabulary.

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CHAPTER 4: A PRELIMINARY REPORT ON LEXICAL ACCESS AND COGNATE EFFECTS DURING EYE-TRACKING IN BILINGUAL ADULTS WITH AND WITHOUT A HISTORY OF DEVELOPMENTAL LANGUAGE DISORDER

Abstract

Purpose: We examine whether bilingual adults with and without a history of Developmental Language Disorder (HxDLD, NoDLD) have lexical access differences in accuracy and response time; and whether both groups show a cognate effect, namely faster recognition on words that share form and meaning across languages (cognates) than words with minimal crosslinguistic overlap (noncognates). Moreover, we examine whether participants are sensitive to the lexical status of phonologically unrelated distractor words on the display.

Method: Twenty-three Spanish-English bilinguals, aged 18–21 years, completed eye-tracking-while-listening tasks for word recognition in English and Spanish. Analyses in each language investigated accuracy, response time, and the proportion of looks to the target (cognate versus noncognate), in the presence of either cognate or noncognate distractor words.

Results: In English, NoDLD participants were more accurate than HxDLD participants; the HxDLD participants showed faster response times, suggesting a speed-accuracy tradeoff. Groups did not differ in the proportion of looks to the target. In Spanish, NoDLD participants were more accurate, had faster response times, and looked more to target images than their HxDLD peers. Cognate effects were observed in both groups for accuracy and response times on the Spanish task only. Finally, an interaction between target word and distractor type revealed a complex cognate distractor effect in eye-gaze behavior across groups on the English and Spanish tasks.

Conclusion: Results revealed similarities and differences in lexical processing for bilingual adults with and without a history of DLD. Both groups showed cognate effects

in Spanish and were sensitive to the lexical status of distractors. As expected, HxDLD participants showed delayed lexical access with slower response times and more looks to distractors in their less dominant language, as well as differences in online processing dynamics during the early stages of word recognition.

Introduction

The current dissertation chapter is a preliminary report on the temporal dynamics of lexical access in individuals with and without a history of Developmental Language Disorder (DLD). Additional data will be collected prior to submission for publication of the manuscript.

Nearly one in 15 children will be diagnosed with DLD (Norbury et al., 2016; Tomblin et al., 1997) and will experience challenges with acquiring, using, and comprehending language (Bishop et al., 2016). Studies of vocabulary knowledge gaps (e.g., Rice & Hoffman, 2015) and word processing differences in adults with a history of DLD (Helenius et al., 2009; McMurray et al., 2019) suggest that language abilities are impacted across the early lifespan. Not much is known about adults with a history of DLD, particularly *bilingual* adults. In a recent study, we have shown that bilingual adults with a history of DLD are very similar but lag somewhat behind their peers without DLD, in terms of lexical knowledge across their two languages (Robinson Anthony et al., under review). The purpose of the current study is to investigate whether a history of DLD has consequences into adulthood on the *temporal aspects* of lexical processing.

Bilinguals who are exposed to two languages instead of one have been shown to process words differently than their monolingual peers, with crosslinguistic influences evident (e.g., Marian & Spivey, 2003; Spivey & Marian, 1999). When bilinguals' languages have translation equivalents that are phonologically similar (cognates; e.g., English-Spanish *pear-pera*), they have been shown to understand these words more accurately and quickly than words that share little to no phonological form (noncognates, e.g., English-Spanish *apple-manzana*; Lemhöfer & Dijkstra, 2004; Robinson Anthony & Blumenfeld, 2019, Robinson Anthony et al., 2020).

In addition to such behavioral cognate effects, noncognate words have been observed to elicit stronger N400 responses than cognates, suggesting more ease in making form-meaning connections for cognate translation equivalents (Midgley et al., 2011). This cognate effect is explained by parallel activation of languages, whereby both of bilingual's languages are simultaneously active during word recognition and facilitate overlapping cognate representations (e.g., Li & Farkas, 2002; Shook & Marian, 2013). For example, in a word recognition study of bilinguals using a visual world eye-tracking paradigm, English-German and German-English bilinguals performing an English word recognition task were shown to co-activate German competitor words with shared phonological onsets to English target words, suggesting parallel language activation (i.e., the English target *desk* and the German competitor *Deckel* or lid, Blumenfeld & Marian, 2007). Further, this crosslinguistic effect was stronger for cognate than noncognate targets, suggesting that cognate activation may boost parallel language activation, while Marian and Spivey (2003) and others have shown that phonologically related words are activated within and across languages during auditory word recognition. Such activation of phonological networks was found in an initial study of lexical activation in 14-19-year-old monolinguals with DLD (McMurray et al., 2019). The adolescents of their study completed picture-word identification tasks, where a target English word (e.g., *mug)* was identified in a visual field paradigm of phonologically related distractors (e.g., *mitt*). The participants with DLD of their study demonstrated smaller proportions of looks to target images.

Present study

The purpose of this preliminary study was to investigate the temporal dynamics of lexical processing of auditorily presented information in bilinguals with and without a history of DLD. Using a web-based eye-tracking method, the current study adapted a visual world paradigm, whereby participants are presented with an auditory word target and are asked to match the word to one of two simultaneously-presented visual stimuli. Eye-movements are considered to be largely automatic, and studies that use a visual world paradigm, where participants match pictures to the words they hear, have shown that eye fixations can be time locked to unfolding speech recognition, which makes possible the analysis of lexical processing in real time (Cooper, 1974; see Tanenhaus et al., 2000). The variables of interest are button-press accuracy and response time as indices of word knowledge and processing (overt response), as well as eye-gaze patterns as an additional index of word processing (covert/subconscious response). Participant-internal factors (a history of DLD, no history of DLD) and task-internal factors (cognate word target, noncognate word target, cognate word distractor, noncognate word distractor) were targeted to examine whether and how a history of DLD impacts lexical processing dynamics in an integrated bilingual system.

As in Blumenfeld and Marian (2007), crosslinguistic cognate facilitation effects were probed by examining the accuracy and timecourse of cognate versus noncognate target word activation. Differently from Blumenfeld and Marian (2007) and to reduce lexical competition in this initial study with participants with HxDLD, distractors on the visual world display were phonologically *unrelated* to the target. Instead, a more subtle manipulation was chosen with distractors being cognate words in half of all trials and noncognate words in the other half. The task was thus designed with modifications for a Spanish-English population and with the removal of crosslinguistic phonological competitors. Simplification of the task in this manner was intended to capture simple cognate facilitation effects in this initial study with HxDLD.

Previous work has shown that participants implicitly name images on a visual display, even in the absence of matching auditory input (Chabal et al., 2022). Further, cognate words are known to have faster naming times than noncognate words (e.g., Hoshino & Kroll, 2008; Starreveld et al., 2014). It was thus reasoned that, if participants with HxDLD implicitly named items on the visual world display, as has been shown in NoDLD participants, they might be sensitive to the cognate distractor manipulation. Specifically, more efficient implicit naming of cognate distractor words might facilitate target identification, potentially modulating and reducing the cognate effects observed during target identification. The research questions were as follows:

1. Do Spanish-English bilinguals with HxDLD demonstrate a difference in lexical access when compared to bilinguals with NoDLD? (RQ1)
2. Does the timecourse of lexical access differ for cognates versus noncognates and is this effect more pronounced in one group than the other? (RQ2)
3. Are the temporal dynamics of cognate effects in the two groups modulated by processing context? That is, does it make a difference if the phonologically unrelated distractor on the display is a cognate (which may yield faster implicit naming) or a noncognate? (RQ3)

It was predicted that overall word comprehension efficiency would be lower for bilinguals with a history of DLD than language-matched peers (e.g., Helenius et al., 2009; Rice et al., 2015). Evidence to support a delay in lexical access for bilinguals with a history of DLD would include overall 1) less accurate and slower reaction times on button-presses across word types (cognate, noncognate) and a smaller proportion of looks, as well as a slower rate in change across time in proportion of looks, to target images in early time windows, suggesting slower activation of target words in real-time (RQ1). In addition, evidence of crosslinguistic activation during cognate word processing would be a finding where cognate effects emerge early in the processing timecourse for both groups (RQ2). Finally, evidence for slower lexical activation during implicit naming of target and distractor items would be a smaller influence (i.e., interaction effect) of the lexical status of distractor words on target words between participants with HxDLD versus NoDLD (RQ3).

Method

Recruitment

This study was approved by the university's institutional review board (IRB). Recruitment took place online via IRB-approved social media accounts and by word of mouth. Recruitment materials were written in Spanish and English and targeted bilingual adults with a wide skill range, including individuals with difficulties in language. All participants provided their written consent prior to participating.

Participants

Twenty-three bilingual adults (NoDLD = 14, HxDLD = 9) participated in this study. Inclusionary criteria included (1) reporting an average self-rated speaking and listening skills in Spanish and English of 6 (described as *slightly more than adequate*) or more out of 10 (*perfect*) across languages using the Language Experience and Proficiency

Questionnaire (LEAP-Q, Marian et al., 2007) and (2) being of an age between 18-21 years. Participants who reported speech-language services and/or current language concern were included in the HxDLD group. Exclusionary criteria included (1) sufficient knowledge of a third language as indexed by an average score of 4 (*slightly less than adequate*) or more out of 10 using the LEAP-Q and (2) reporting a hearing impairment.

All participants also completed direct measures of English and Spanish using the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF4, Semel et al., 2003) and its Spanish equivalent the Clinical Evaluation of Language Fundamentals-Fourth Edition-Spanish (CELF4-Span, Wiig et al., 2006). Core Language scores for each language were calculated based on four subtests: Recalling Sentences, Formulating Sentences, Word Classes, and Word Definitions. Scores for the administered questionnaire and tests are summarized in Table 1.

All participants showed similar language experience and exposure. As shown in Table 1, NoDLD and HxDLD groups did not differ in age or years of education. Additionally, for both English and Spanish background measures, participants reported similar first age of acquisition, current exposure, and proficiency speaking, understanding, and reading across each language. In terms of language performance, there were no significant group differences in English or Spanish Core Language scores.

Table 4.1 Language experience and proficiency (LEAP-Q) and core language skills (CELF-4)

N=23	No history of DLD (n = 14; 10 female, 4 male)			Self-reported history of DLD (n = 9; 7 female, 2 male)			
Scale	***Mean***	***SD***	***Range***	***Mean***	***SD***	***Range***	***p***
LEAP-Q							
Age	19.64	1.27	17-21	20.00	1.32	18-21	.53
Years Education	14.21	1.37	12-17	14.83	1.22	13-17	.28
LEAP-Q English Background							
Age of Acquisition (years)	3.43	2.06	0-7	3.55	1.81	0-5	.88
Exposure (percentage)	68.14	17.14	40-95	58.89	18.16	20-75	.23
Speaking (max of 10)	8.57	1.45	5-10	8.33	1.58	5-10	.71
Understanding (max of 10)	9.07	.92	7-10	8.44	1.59	5-10	.24
Reading (max of 10)	8.93	1.38	6-10	8.33	1.41	6-10	.33
LEAP-Q Spanish Background							
Age of Acquisition (years)	4.57	6.05	0-19	1.44	2.13	0-7	.15
Exposure (percentage)	31.86	17.14	5-60	41.11	18.16	25-80	.23
Speaking (max of 10)	7.57	1.40	5-10	7.22	1.40	5-9	.56
Understanding (max of 10)	8.00	1.88	5-10	8.67	.87	7-10	.33
Reading (max of 10)	6.79	2.19	2-9	6.67	1.87	3-9	.89
CELF4 English							
Core Language Skills (SS)	107.43	9.41	90-123	99.33	10.67	85-119	.07
CELF4 Spanish							
Core Language Skills (SS)	105.31	23.74	51-134	98.78	21.45	59-125	.52

Materials: Word Comprehension Eye-Tracking Task in English and Spanish

The eye-tracking tasks were conducted on the Labvanced online platform. This platform allows for presentation of audiovisual stimuli, collection of accuracy and reaction time data, as well as collection of eye-tracking data via participants' webcams. Participants heard a target word and were instructed to choose one of two pictures that best represented the target word by using a key press. Further, to simplify the task for the web-based testing platform with spatially less sensitive eye-tracking equipment, two pictures were presented per visual world display instead of the customary 4 pictures (see Andras et al. 2022 for a similar approach). Images were presented diagonally from each other (i.e., in the top left and bottom right or top right and bottom left) to maximize the distance between images for eye tracking data collection.

Cognate and noncognate targets were chosen based on criteria of objective sound overlap (Crosslinguistic Overlap Scale for Phonology, COSP, Kohnert et al., 2004) that our group has employed in previous work (Potapova et al., 2016; Robinson Anthony & Blumenfeld, 2019); words and their translations were compared on initial sounds, number of syllables, overlap in consonants, and overlap in vowels. For example, English-Spanish translation equivalents panda-panda maximally share form overlap (COSP = 10); in contrast English-Spanish translation equivalents whale-ballena share few to zero form overlap (COSP = 1). Consistent with Konhert et al. (2004), words with COSP ratings ≥6 were considered cognates.

Twenty-three cognate-noncognate stimulus pairs, as well as an unrelated 23 noncognate-noncognate pairs and an unrelated 23 cognate-cognate pairs, were used in both the English and the Spanish versions of the task. This design was chosen so each target type would appear with either a cognate or a noncognate distractor. Images corresponding to cognate-noncognate stimulus pairs were repeated four times: twice concurrently with the auditory cognate target, and twice concurrently with the auditory noncognate target. Images corresponding to noncognate-noncognate and cognate-cognate stimulus pairs were each repeated twice: once with each auditory target. This resulted in a total of 184 trials in both the English and Spanish scripts and yielded a cognate target (92 trials) to noncognate target (92 trials) ratio of 1:1 across the task, with an equal number of trials in each of the four conditions, (n = 46). Trials were pseudorandomized to present no more than four cognate targets in a row, and four presentation sequences were generated to avoid order effects. The trials were presented across four blocks of 46 trials each, with each block containing 23 cognate targets (where 11-12 trials included noncognate distractors and 11-12 trials included cognate distractors) as well as 23 noncognate targets (where 11-12 trials included noncognate distractors and 11-12 trials included cognate distractors). No repetitions of auditory targets or specific stimulus pairs occurred within a block. Stimulus words chosen for each condition (cognate, noncognate) were controlled for lexical frequency and neighborhood density and were chosen to be semantically and phonologically unrelated to each other.

Target images were situated in one of four quadrants in a two-by-two visual field. All images were found by Google search with the “free to use, share, or modify " filter, adapted in photoshop for to include a white background, and normed for name agreement on a separate sample population of 32 Spanish-English adults. Corresponding audio files for each target item were recorded in Spanish by a native Spanish speaker and in English by a native English speaker.

Procedures

Sessions were completed remotely due to social distancing policies during the COVID-19 pandemic. Tests were modified for online data collection (e.g., Castilla-Earls et al., 2022; Waite et al., 2012). Paper materials were adapted to Qualtrics software (https://qualtrics.com) to capture participants’ responses digitally (e.g., images were presented on screen with answer choices pinned to the bottom of the screen) and were administered via Zoom (https://zoom.us).

Participants completed the present study in two separate sessions as part of a larger study. Sessions were conducted in English only and Spanish only. The order of English first followed by Spanish was held constant across all participants, as participants were generally stronger in English and would provide valuable scaffolding to complete the Spanish tasks. All sessions were conducted by a trained researcher fluent in both languages, and all sessions were completed within two weeks.

Preliminary data collection took place from 01/2021 to 05/2022. Participants were instructed to run eye-tracking tasks in well-lit areas with minimal environmental noise using only a personal computer or laptop on Google Chrome (no tablets or phones were allowed). Each eye-tracking task began with a brief set of four practice trials for task familiarization followed by automated, 15-point eye calibration (lasting approximately 3-4 minutes). This calibration was completed to ensure that participants' eye-gazes to specific locations on the screen were reliably captured and that looks to visual stimuli were similarly captured across participants, as screen sizes varied across computers. Each trial presentation ran 3700ms or shorter depending on participant responses. This included an initial fixation cross presented in the middle of the screen for 500ms, which was immediately followed by the presentation of the stimulus image. At 200ms after the presentation of the picture, the target audio file was initiated. The stimulus photo remained on the display until a key press was recorded or 3000ms elapsed from the initiation of the target audio file (Figure 1).

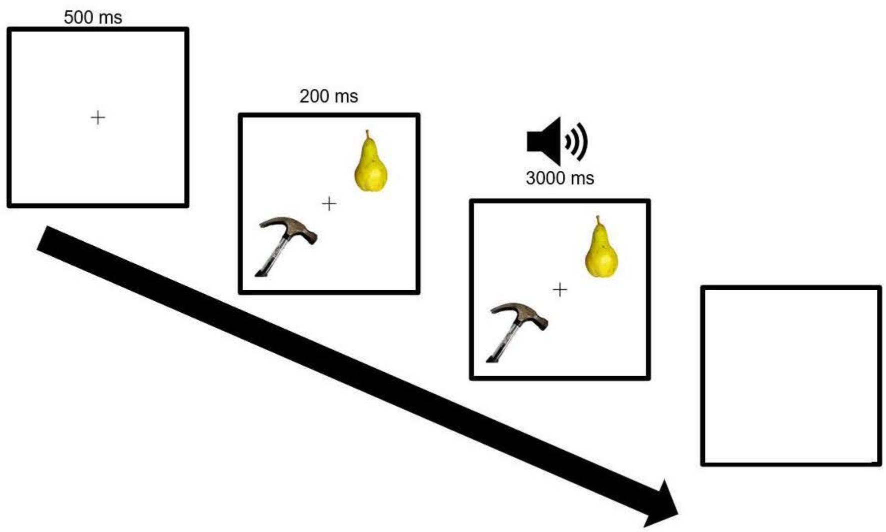

Figure 4.1 Word comprehension eye-tracking task

Coding and Analyses

Accuracy and response times in English and Spanish

Accuracy and reaction times were analyzed across trials with ANOVA methods using IBM SPSS version 28.0.1 (IBM Corp., 2022). Raw scores from the English and the Spanish versions of the word comprehension eye-tracking task were analyzed for proportion correct. Cognate and noncognate accuracy in English and Spanish were analyzed for cognate effects on each.

Reaction times only included correct trials and were calculated from the onset of each auditory target until a manual response was registered (e.g., Blumenfeld et al., 2016). Individual reaction times for each condition were calculated by averaging the reaction times of correctly identified trials designated as part of each condition.

Eye-gaze

Lexical activation across trials and looks was analyzed using linear mixed effects modeling in RStudio and the lme4 package (Bates et al., 2015; Mirman et al., 2008). Analyses of proportion of looks only considered correct trials and were analyzed across 100ms bins. These time bins were most appropriate given the varying and relatively low sampling rate across participants in the webcam-based data collection modality. Data were analyzed starting at 200ms post auditory target onset based on findings that it takes approximately this amount of time to plan eye-movements (Hallett, 1986). The time window chosen for analysis spanned from 400ms (i.e., 200ms auditory stimuli delay and 200ms window for eye-movement programing) to 1400ms. The 1400ms cutoff was chosen following 1) 2SDs above the average reaction time and 2) visual inspection of eye-tracking data (for a similar approach see Giezen et al., 2015).

The locations of gazes were coded as proportions of looks to targets, distractors, and other (blank quadrants). Looks were mapped to 1 of 4 quadrants, including the two quadrants where target and nontarget images were presented. This location mapping was achieved by normalizing the raw location data exported from the Labvanced platform onto a standardized four-quadrant space. This space was necessary to account for differences across participants' personal screens. Trials in which the participants failed to select the correct target were excluded from analysis.

The proportion of looks from the English and the Spanish versions of the word comprehension eye-tracking task were analyzed to examine the timecourse of lexical access to cognate and noncognate targets in each language and in the presence of cognate versus noncognate distractors.

Results

Eye- tracking data were successfully collected and available for 11/14 NoDLD participants and 8/9 HxDLD in English, as well as for 9/14 NoDLD participants and 7/9 HxDLD participants in Spanish. Data for correct trials only were analyzed in response time and eye tracking results. Data were cleaned to exclude response times that were +/-3SDs of the average response time for each participant, resulting in the removal of 1.2% of the data. This was done to reduce the influence of outliers to meet assumptions of data normality.

Accuracy and response time

Four by-items 2x2x2 mixed ANOVAs were completed with items as the unit of analysis. Two ANOVAs investigated the influence of group (NoDLD = 11, HxDLD = 8) as between-subjects factor, and target word type (cognate, noncognate) and distractor word type (cognate, noncognate) as within-subjects factors on accuracy and response times on the English task. Two similar ANOVAs were completed for the Spanish task (NoDLD = 9, HxDLD = 7).

For the English task (Figure 2), there was a significant main effect of group on accuracy with very small effect size, $F(1,3488) = 7.64$, $p = .006$, $\eta^2_p = .002$. NoDLD participants ($M = .95$, $SE = .005$) were more accurate overall than HxDLD participants ($M = .93$, $SE = .006$). There was also a significant interaction between target word type and distractor word type with very small effect size, *F(*1,3488) = 4.65, *p* = .031, η^2_{p} = .001. Cognates (*M* = .95, *SE* = .008) were recognized more accurately than noncognates (*M* = .93, *SE* = .008) only when the distractor was a noncognate (M difference = .02, *SE* = .001, *p* = .02, Bonferroni alpha = .025). Finally, there was a significant effect of group on response time with very small effect size, *F(*1,3250) = 24.90, *p* < .001, η^2_{p} = .001. HxDLD participants (*M* = 795.18, *SE* = 11.75) were faster to respond overall than NoDLD participants (*M* = 871.84, *SE* = 9.90). Accuracy and response time results may reflect a speed-accuracy trade-off between groups.

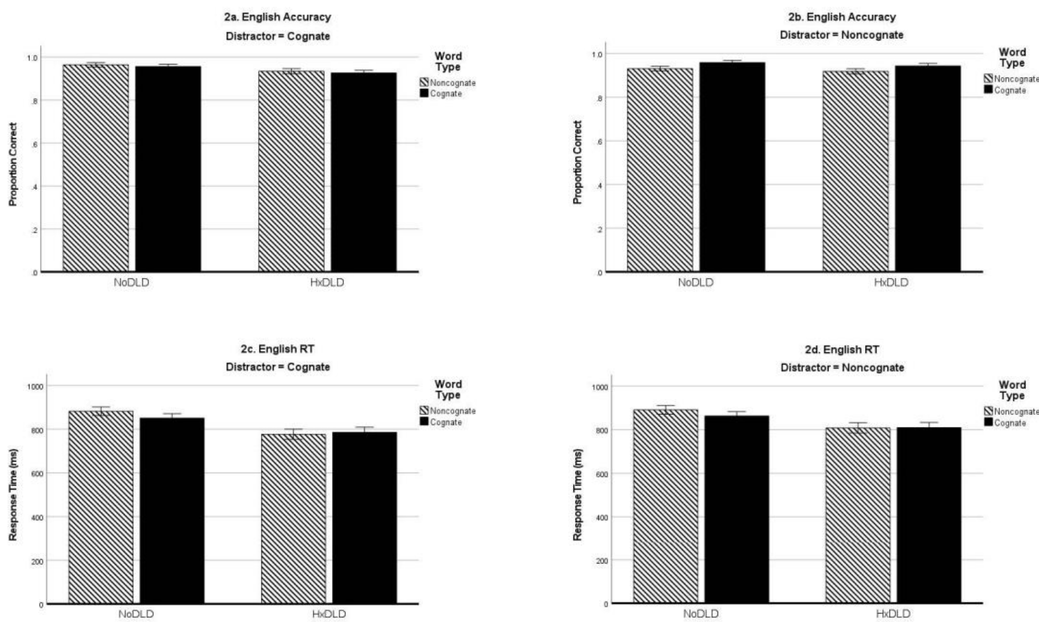

Figure 4.2 Accuracy on English task with cognate (a.) and noncognate (b.) distractor contexts, and response time by cognate (c.) and noncognate (d.) distractor contexts

On the Spanish task (Figure 3), there was a significant effect of target word type on accuracy with very small effect, *F(*1,2936) = 5.32, *p* = .021, η^2_{p} = .002. Cognates (*M* = .97, *SE* = .005) were recognized more accurately overall than noncognates (*M* = .95, *SE* = .005). There was also a significant interaction between target word type and distractor word type with very small effect, $F(1,2936) = 20.76$, $p < .001$, $\eta^2_p = .007$. As in the English task, cognates (*M* = .98, *SE* = .008) were recognized more accurately than noncognates (*M* = .93, *SE* = .008) only when the distractor was a noncognate (*M* difference = .05, *SE* = .011, $p < .001$, Bonferroni alpha = .025). For response time, there was no main effect for group. There was a significant effect of target word type on response time with very small effect, $F(1,3294) = 24.91$, $p < .001$, $\eta^2_p = .008$, and a marginally significant effect of group on response time with very small effect, $F(1,2809) = 3.62$, $p = .057$, $\eta^2_p = .001$. Cognates (*M* = 758.35, *SE* = 11.61) were recognized more quickly overall than noncognates (*M* = 823.72, *SE* = 11.72), and NoDLD participants (*M* = 775.38.18, *SE* = 10.94) were quicker to respond overall than HxDLD participants (*M* = 806.69, *SE* = 12.35).

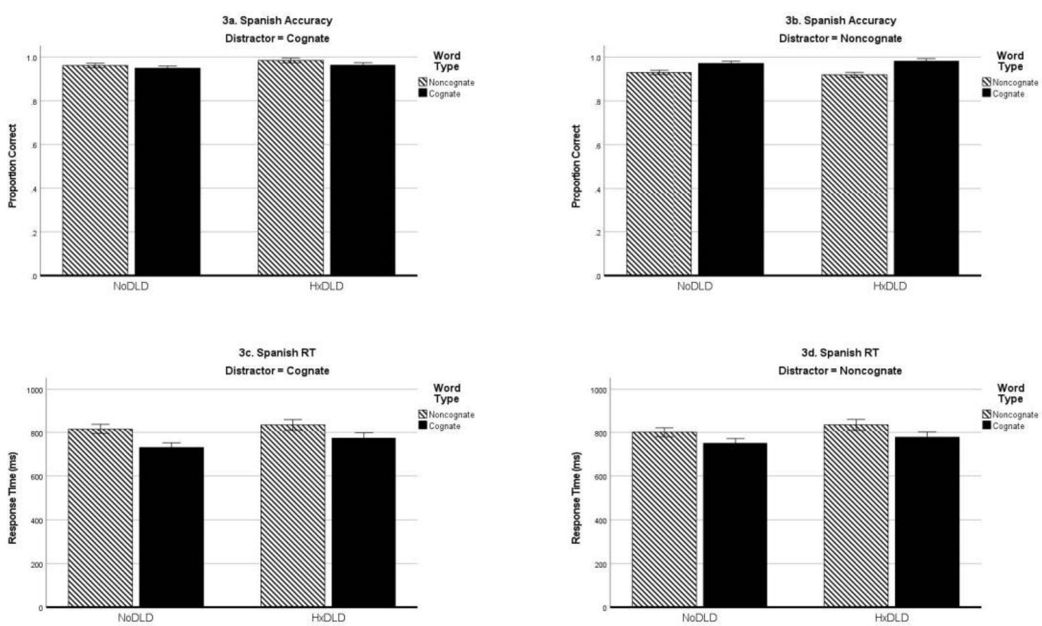

Figure 4.3 Accuracy on Spanish task with cognate (a.) and noncognate (b.) distractor contexts, and response time by cognate (c.) and noncognate (d.) distractor context

Eye-gaze

A preliminary linear mixed effects model investigated the influence of group (NoDLD = 11, HxDLD = 8), target word type (cognate, noncognate), distractor word type (cognate, noncognate) and bin (400ms-1400ms) and their interactions on the proportion of looks to target images on the English task. A similar linear mixed effects model was completed for the Spanish task (NoDLD = 9, HxDLD = 7).

For the English task (Figure 4), there was a significant effect of bin on the proportion of looks to the target image with medium effect, $F(1,1064) = 6.10$, $p < .001$, $\eta^2_p = .069$, suggesting participants looked more to the target image as time elapsed post auditory stimuli presentation (200ms delay). There was also a significant group by distractor word type crossover interaction with small effect, $F(1,1064) = 5.74$, $p = .02$, $\eta^2_p = .005$. NoDLD participants demonstrated a negative change in the proportion of looks to target images from noncognate distractor ($M = .52$, $SE = .008$) to cognate distractor ($M = .50$, $SE = .008$) contexts, $p = .12$; conversely HxDLD participants demonstrated a positive change in the proportion of looks to target images from noncognate ($M = .50$, $SE = .009$) to cognate ($M = .53$, $SE = .009$) distractor contexts, $p = .10$ (Research Question 1, RQ1). There were no differences in means between cognate and noncognate distractor conditions, but the significant interaction reflects a difference in slopes.

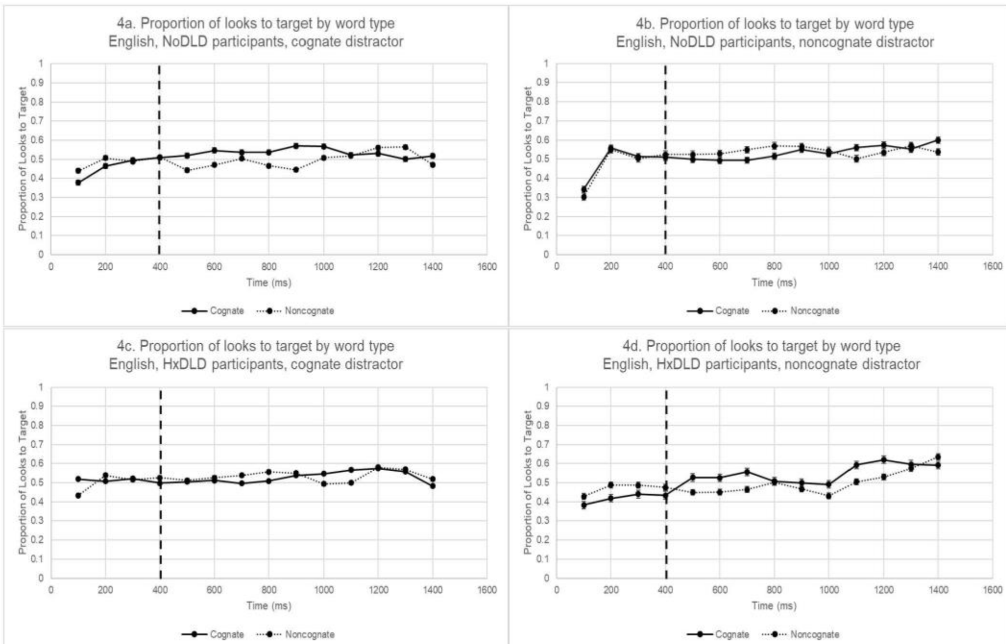

Figure 4.4 Proportion of looks to target images on English task for NoDLD participants with cognate distractors (a.), NoDLD participants with noncognate distractors (b.), HxDLD participants with cognate distractors (c.), and HxDLD participants with noncognate distractors (d.)

For the Spanish task (Figure 5), there were significant effects of group with small effect size, *F(*1,896) = 13.36, $p < .001$, $\eta^2_{p =}$ .015, distractor word type with small effect size, *F(*1,896) = 9.08, $p = .003$, $\eta^2_{p =}$ .01, bin with large effect size, *F(*13,896) = 11.92, $p < .001$, $\eta^2_{p =}$ .15, and significant interactions between group and target word type with very small effect size, *F(*1,896) = 12.48, $p <.001$, $\eta^2_{p =}$ .014, target word type by distractor word type with small effect size, *F(*1,896) = 11.22, $p < .001$, $\eta^2_{p =}$ .013, and target word type by distractor word type by bin with small effect, *F(*13,896) = 1.75, *p* =

.05, η^2_{p} = .027. NoDLD participants (*M* = .52, *SE* = .006) demonstrated a higher proportion of looks to target images than their HxDLD peers (*M* = .49, *SE* = .006; RQ2). Overall, participants looked more to the target image when the context was a noncognate distractor (*M* = .51, *SE* = .006) than when the context was a cognate distractor (*M* = .49, *SE* = .006) and more to the target image as time elapsed post auditory stimuli presentation (RQ3). The group by distractor word type interaction indicated that NoDLD participants had a smaller negative change (*M* difference = .018, *SE* = .012, *p* = .14, Bonferroni alpha = .025) in the proportion of looks to target images in the context of noncognate distractors (*M* = .53, E = .008) to the context of cognate distractors (*M* = .51, *SE* = .008) than HxDLD participants (*M* difference = .034, *SE* = .014, *p* = .013) from noncognate distractor (*M* = .50, *SE* = .008) to cognate distractor (*M* = .47, *SE* = .008) contexts (RQ2, RQ3). The target word type by distractor word type interaction further suggests that the proportion of looks to noncognate target images changes more negatively (*M* difference = .055, *SE* = .013, *p* < .001, Bonferroni alpha = .025) from noncognate distractor (*M* = .52, *SE* = .009) to cognate distractor (*M* = .47, *SE* =.009) contexts than the proportion of looks to cognate target images (*M* difference = .003, *SE* = .013, *p* = .82), from noncognate distractor (*M* = .503, *SE* = .009) to cognate distractor contexts (*M* = .506, *SE* = .009; RQ1, RQ3). The significant three-way interaction between target word type, distractor word type, and bin confirms the described differences in the proportion of looks to target images across time for varying target and distractor word type combinations.

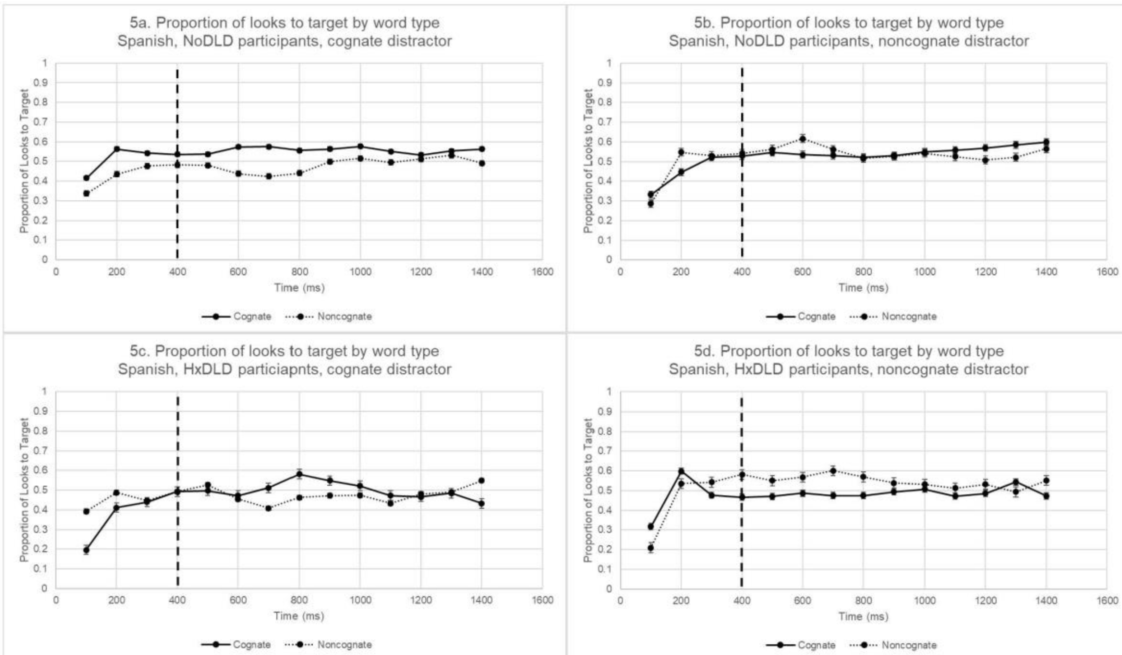

Figure 4.5 Proportion of looks to target images on Spanish task for NoDLD participants with cognate distractors (a.), NoDLD participants with noncognate distractors (b.), HxDLD participants with cognate distractors (c.), and HxDLD participants with noncognate distractors (d.)

Discussion

We examined the timecourse of word recognition in bilingual adults with and without a history of DLD. Of specific interest was determining whether HxDLD and NoDLD bilinguals share similar lexical processing dynamics, with the timecourse of lexical access indexed by active (overt) button-press responses and subconscious (covert) eye-gaze patterns while listening to words and identifying corresponding pictures. Specifically, we investigated whether bilinguals with HxDLD demonstrate a delay in lexical access when compared to bilinguals with NoDLD (RQ1), whether the timecourse of lexical access differs for cognates versus noncognates and for HxDLD versus NoDLD participants (RQ2), and whether the temporal dynamics of cognate effects for HxDLD versus NoDLD participants are modulated by the distractor context (RQ3).

Evidence in English does not support a lexical access differences for participants with a history of DLD, although evidence in Spanish suggests otherwise. In the majority language of English, there were no group differences in proportion of looks to target images (RQ1), though lexical processing differences between groups were influenced by the distractor context on lexical access (RQ3). Though statistically, there is not a mean difference between the proportion of looks to target cognate versus noncognate images (RQ2) across distractor contexts, NoDLD participants exhibited a smaller proportion of looks to target images in noncognate than cognate distractor contexts, while HxDLD participants demonstrated a greater proportion of looks for noncognate than cognate distractors. One reason for this pattern may be that implicit naming of cognate word distractors induces a greater top-down influence than implicit naming of noncognate word distractors during word recognition in a visual world setting. Chabal et al. (2022) demonstrated that implicit naming occurs during receptive processing of visually presented images, even when no auditory stimulus is provided. This is the scenario for the distractor items in the current study-there is no phonological bottom-up input provided that matches them, yet participants' sensitivity to the distractors' lexical status suggests that these items are implicitly named, consistent with Chabal et al.'s findings.

Based on previous bilingual naming findings, it would be expected that cognate distractor words would be named faster than noncognate distractor words (Hoshino & Kroll, 2008; Starreveld et al., 2014). Relevant to the present study, faster implicit naming of cognates as a distractor item would potentially steer attention away from the target word and explain the smaller proportion of looks to target items in the presence of cognate distractors. Indeed, NoDLD participants demonstrated this influence. However, evidence from HxDLD participants on this English task do not support a greater cognate influence claim in English. Instead, HxDLD participants may look more to target images in cognate distractor contexts, a sign that they may be more successful at ruling out a cognate distractor than a noncognate distractor on the English task.

Spanish task results help to clarify English task results and further reveal the anticipated lexical access delay for HxDLD participants (RQ1), as NoDLD participants made faster responses and demonstrated more looks to target images than their HxDLD peers. The reduced number of looks to target images in HxDLD participants suggests that they spent more of their time looking at unrelated distracter images, consistently with slower target word identification times. In contrast to the English task results, on the Spanish task *both* groups demonstrated a smaller proportion of looks to target images in the presence of cognate word distractors than in the presence of noncognate word distractors (RQ3), and this pattern was the most pronounced for HxDLD participants. These findings match the pattern identified for NoDLD participants in English and suggest that cognate word distractors may divert attention away from target images potentially because of stronger top-down activation. In the non-dominant language, this top-down cognate activation may span both of bilinguals' languages (e.g., Blumenfeld & Marian, 2007) and may thus be particularly distracting.

Here, in Spanish, the top-down influence of cognate distractors is more apparent in participants who may have lexical processing challenges, HxDLD participants. One explanation for these findings may be that, in a less proficient language, bilinguals with HxDLD rely more on top-down lexical activation and experience delays in bottom-up phonological activation. That is, with slower target word activation and identification, there is more time for top-down activation to accrue and influence lexical selection. McMurray et al. (2019) investigated the response times and eye-gaze patterns of NoDLD/HxDLD adolescents and young adults (14 – 19 years old). Similar to the present study, McMurray et al. observed that HxDLD participants looked less to target images overall. Weakness in bottom-up phonological activation for the current group of HxDLD participants is consistent with McMurray et al., as activation did not spread into phonological networks in HxDLD participants in their study.

Another potential explanation may be cognitive control differences between groups, as inhibition is necessary to resolve conflict between competing lexical representations (e.g., Blumenfeld & Marian, 2011, 2013). Specifically, it is possible that the broader crosslinguistic activation that is triggered by top-down cognate naming must be muted to process bottom-up target input and that HxDLD participants are less efficient at this process. Future investigations that include indices of linguistic and nonlinguistic control would help to explain the results of this bilingual study. Thus, the present findings add to the current literature that DLD may affect the temporal aspect of word processing in bilingual adults, with consideration for the effect of top processing.

Processing dynamics and target identification efficiency differed across participants' languages. There were no significant differences in target word cognate versus noncognate word identification in the English task, while faster response times and more looks were found to cognate than noncognate targets in the Spanish task (RQ2). These results indicate that cognate words induce more activation during lexical processing in non-majority languages, a product of interactive and convergent activation across language systems (e.g., Shook & Marian, 2012). This boosted activation for cognate words is further evidenced by a significant reduction in looks to target images in the presence of cognate distractors, especially in Spanish for participants with a history of DLD (RQ3). These results help to clarify previous findings of cognate effects in word knowledge of individuals with HxDLD, where cognate words are recognized more accurately than noncognates in Spanish, as well as in English and Spanish combined (Robinson Anthony et al., under review). Preliminary findings in the current study confirm that cognate effects are present during auditory word recognition in bilinguals with HxDLD and extend these findings by suggesting that these cognate effects emerge early during online processing.

In the present findings, cognate effects were observed on word targets in terms of accuracy, reaction times, and looks to the target in Spanish, as well as on distracters, as indicated by accuracy and eye-tracking findings in both languages (R2). This suggests that both bottom-up sublexical processing of cognates (as indexed by cognate effects on the word targets for which phonological input was provided) as well as top-down lexico-semantic processing of cognates (as indexed by implicitly named distracter items) played a role in the lexical processing dynamics of both participant groups. With pictures displayed 200ms before onset of the auditory target, it appears from the current preliminary findings that implicit naming of distractors influenced even the early stages of lexical activation captured by eye-tracking. Together, the current preliminary results provide further evidence for the effect of sublexical as well as lexico-semantic similarity across languages in guiding crosslinguistic temporal processing dynamics of cognates.

Concluding remarks

In this preliminary study, bilingual adults with a history of DLD demonstrated subtle lexical processing differences across languages when compared to their peers without a history of DLD. Some of these group differences emerged in terms of processing efficiency, as indexed by accurate and speedy reaction times in the Spanish task. Other group differences emerged in terms of processing differences, as indexed by eye-tracking differences in varying distractor word contexts on English and Spanish tasks. In combination with the literature from monolingual populations, our findings suggest that DLD is a lifelong phenomenon that affects temporal processing dynamics. In addition, crosslinguistic influence (cognates) may boost lexical processing dynamics, though the context of this activation determines whether this activation is faciliatory for speed of word recognition. This is a preliminary report and questions remain as to whether these observed patterns will hold with more power (increased N) for observed effects.

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CHAPTER 5: METALINGUISTIC AWARENESS AND COGNATE EFFECTS IN YOUNG BILINGUAL ADULTS WITH AND WITHOUT A HISTORY OF DEVELOPMENTAL LANGUAGE DISORDER: A MIXED-METHODS APPROACH

Abstract

Purpose: This study investigates the influences of bilingualism and Developmental Language Disorder (DLD) on vocabulary and metalinguistic awareness in adults.

Method: Twenty-nine Spanish-English adults with (HxDLD) and without (NoDLD) a history of DLD completed a multiple-choice word definition task. In reviewing their answers, participants were recorded as they were encouraged to talk about their thought processes following a Think Aloud protocol. Task accuracy was analyzed by word type (cognate, noncognate), and verbal responses during the Think Aloud interview were transcribed and coded for metalinguistic awareness type.

Results: Across groups, participants were similarly more accurate for cognate words than noncognates and demonstrated a similar pattern in proportion of coded responses by metalinguistic type. Idiosyncratic, cognate, and sound-symbolic associations were among the top metacognitive strategies cited across participants, and cognate awareness was more frequently cited than other types of crosslexical awareness.

Conclusion: Cognate word knowledge and cognate awareness are general strengths for bilingual adults, with and without a history of DLD, when making word to meaning mappings.

Introduction

Developmental Language Disorder (DLD) is a high prevalence condition thought to affect close to 7% of children, approximately two children in every classroom (Norbury et al., 2016; Tomblin et al.,1997). When followed into adulthood, a history of DLD is related to a high probability of differential academic and vocational outcomes (Beitchman et al., 2001; Conti-Ramsden et al., 2018; DuBois et al., 2020), as well as psychosocial and emotional ones (Clegg et al., 2005). DLD is characterized by a difficulty to acquire and comprehend language with no known biomedical etiology (Bishop et al., 2016). Though challenges with morphosyntax are hallmark to DLD in the early school years, monolingual adults with a history of DLD have been shown to have difficulties with acquiring words and developing robust vocabularies (McGregor et al., 2020; McGregor et al., 2013); difficulties with early vocabulary development may contribute to a lifelong “vocabulary gap” (Rice & Hoffman, 2015).

DLD seems to affect the lexico-semantic system and processing across the lifespan (Hall et al., 2017; Helenius et al., 2009). For typical bilinguals, lexico-semantic systems and processing are integrated and dynamic (Li & Farkas, 2002; Shook & Marian, 2013), and consequently bilingual vocabulary development and word processing are often demonstrated to be facilitated by crosslinguistic interaction (i.e., cognate effects). However, it is unclear whether bilingual adults with or without a history of DLD utilize overt crosslinguistic strategies to support language skills. Thus, this current study is motivated to investigate metalinguistic awareness strategies as reported by bilingual adults on a language task.

Metalinguistic awareness is defined by one's ability to consciously evaluate the underlying processes of language, as opposed to the content of language itself. Bialystok and Ryan (1985) define metalinguistic awareness by two components, cognitive control- participants' ability to select, coordinate, and schedule mental operations- and language analysis- participants' ability to think about, structure, and classify language knowledge. Here, we focus on language analysis. Metalinguistic language analysis include phonological awareness, lexical awareness, syntactic awareness, and pragmatic awareness among other areas (Bialystok, 1988; Bialystok et al., 2014). Children as young as preschool have demonstrated a sensitivity to language structures on metalinguistic awareness tasks (e.g., Robinson Anthony et al., 2020). However, the required focus on language structures for metalinguistic manipulation is considered to be acquired later in development, around six years of age (Duncan et al., 2005).

For bilingual adults, there is evidence to suggest that second language proficiency is also related to expansion of metalinguistic awareness. Renou (2001) examined the relation between performance on grammaticality judgment tasks and French proficiency in a sample of advanced-French-language learners who were proficient in their first language (L1), English (mean age = 21 years). Results describe a moderate positive correlation between written/oral judgment modalities and French proficiency, though only in a subset of bilinguals who reported learning French in a context where grammatical form was the center pedagogy. Roehr (2008) similarly examined and linked performance on language tasks with second language (L2) proficiency. German L2 learners who were more proficient (i.e. fourth-year language learners) demonstrated a stronger correlation between L2 proficiency and metalinguistic task outcomes than their less proficient peers (i.e. first-year language learners). As participants were more proficient in their L2, they demonstrated more accurate performance on metalinguistic tasks.

Studies of cognate word processing and metalinguistic awareness further suggest that bilinguals who recognize crosslinguistic similarities are able to leverage bilingual interaction for comprehension accuracy. Cognates are words that share a similar form (lexical) and meaning (semantic): English-Spanish *pear-pera*. Noncognates are translation equivalents that have little to no overlap in form: English-Spanish *table-mesa*. However, the current literature documenting this phenomenon of metalinguistic awareness for crosslinguistic overlap is limited to children and adolescents (e.g., Cenoz et al., 2021; Garcia, 1998; Velasco & Fialais, 2018). Across English and Spanish, approximately one-third or 10,000-15,000 words may be considered cognates (Nash, 1997), and Spanish cognate translation equivalents are often higher frequency vocabulary words than their English translations (e.g., English-Spanish *castigate-castigar*, Lubliner & Hiebert, 2011; Schepens et al., 2013). In one study, Dressler et al. (2011) used reading passages and found that explicit instruction for cognate awareness promotes resolving meaning for challenging English vocabulary words. Young 5th grade bilinguals and their English monolingual peers completed reading comprehension tasks and participated in interviews, where participants described their thought processes to index metalinguistic awareness. Participants of this study verbalized multiple metalinguistic and metacognitive strategies, including explicit cognate awareness for decoding words. The strategies varied between bilingual and monolingual groups, and it was the bilingual group who were able to capitalize on cognate awareness for word accuracy. Thus, from an early age, bilinguals utilize crosslinguistic awareness to accomplish language goals. Whether bilingual adults with a history of DLD similarly approach linguistic tasks using crosslinguistic strategies remains an open question.

Reliance on cognate word knowledge when bilinguals reason about vocabulary can be tied to a robust behavioral cognate advantage, where cognate words are recognized more accurately and rapidly than noncognate words in typical bilinguals (e.g., Lemhöfer & Dijkstra, 2004; Potapova et al., 2016). We have recently identified a similar pattern of faster and more accurate cognate word recognition in bilingual adults with a history of DLD (Robinson Anthony, Blumenfeld, & Pham, under review; Robinson Anthony et al., in progress). For typical bilingual adults, such cognate advantages for word knowledge have been observed in both the dominant (albeit less consistently) and nondominant language, with individuals recognizing a larger percentage of cognate words than noncognate words in the nondominant language (Robinson Anthony & Blumenfeld, 2019). Given recent findings that adults with a history of DLD rely on crosslinguistic knowledge during word identification and processing tasks, it is possible that they also reason about crosslinguistic overlap in a manner that is comparable to typical peers.

Present study

In the present study, we ask the following two research questions:

1. Do Spanish-English bilinguals with HxDLD demonstrate a cognate effect on a multiple-choice vocabulary task in English similar to their NoDLD peers?

2. Do Spanish-English bilinguals with HxDLD employ metalinguistic awareness strategies to complete the multiple-choice vocabulary task similar to bilinguals with NoDLD?

First, it is predicted that all participants will more accurately identify cognate words than noncognate words (Robinson Anthony et al., 2019; Potapova et al., 2016). If participants demonstrate a cognate effect, this suggests that words that share similar form and meaning are a strength in identifying word definitions for bilinguals with and without HxDLD. Should there be no observed cognate effect for HxDLD participants, this may be because vocabulary differences associated with HxDLD may impact word knowledge as it relates to crosslexical influence. Should there be no observed cognate effect for any group, one explanation may be that the task is not challenging enough to capture intended effects.

The second research question is exploratory in nature. It is broadly predicted that all participants will offer a variety of metalinguistic strategies to reason about and define words on the vocabulary task (Candry et al., 2017; Deconinck et al., 2010; Deconinck et al., 2014). If participants with and without HxDLD demonstrate a similar pattern of metalinguistic awareness, this suggests that language challenges associated with DLD may not critically impact metacognition as it relates to word processing. Should participants with and without DLD differ in metalinguistic strategies, a qualitative reflection may highlight the nature in which participants diverge.

Method

Recruitment

This study was approved by the university's institutional review board (IRB). Recruitment took place online via IRB-approved social media accounts and by word of mouth. Recruitment materials were written in Spanish and English and targeted bilingual adults with a wide skill range, including individuals with difficulties in language (i.e., fliers stated "*We are looking for 18-21 year olds who express their ideas in disorganized ways, have difficulty with organization and lose things, and/or dislike/avoid reading*"). All participants provided their written consent prior to participating.

Participants

Twenty-nine bilingual adults participated in this study, with a history of DLD (HxDLD, n = 10) or without a history of DLD (NoDLD, n = 19). Inclusion in the study was based on an average score across self-rated speaking and listening skills of 6 (described as *slightly more than adequate*) or more out of 10 (described as *perfect*) in each language using the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian et al., 2007). In addition, all participants needed to be between 18-21 years old to allow for standardized testing as part of the current study. Participants who reported having a history of language disorder were included in the HxDLD group (i.e., reported speech-language services and/or current language concern). Exclusionary criteria included sufficient knowledge of a third language as indexed by an average score of 4 (*slightly less than adequate*) or more out of 10 using the LEAP-Q, or a reported hearing impairment (Table 1).

To complement self-report, all participants also completed direct language measures in English and Spanish using the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF4, Semel et al., 2003) and its Spanish equivalent the Clinical Evaluation of Language Fundamentals-Fourth Edition-Spanish (CELF4-Span, Wiig et al., 2006). We calculated Core Language scores for each language based on four subtests: Recalling Sentences, Formulating Sentences, Word Classes, and Word Definitions.

Participants across the NoDLD and HxDLD groups reported similar ages and years of education. In both English and Spanish, participants reported similar first age of acquisition, current exposure, and proficiency speaking, understanding, and reading. Additionally, there were no significant group differences in English or Spanish Core Language scores. The group averages of CELF4 English and Spanish standard scores indicated that language skills were within the typical range across languages (i.e., standard score > 85). As McGregor et al. (2020) have previously found that adults with a history of DLD can enter the typical range in language tasks, it was deemed appropriate to identify our DLD group based on self-report only as was done in McGregor. Of the 10 HxDLD participants, two score in the typical range in both languages and eight score low in one language only. The proportion of participants who perform low in one language is descriptively higher in the HxDLD group (80%) than the NoDLD group (5%, 1 out of 19).

Table 5.1 Language experience and proficiency (LEAP-Q) and core language skills (CELF-4)

N=29	No history of DLD (n = 19; 15 female, 4 male)			Self-reported history of DLD (n = 10; 8 female, 2 male)			
Scale	***Mean***	***SD***	***Range***	***Mean***	***SD***	***Range***	***p***
LEAP-Q							
Age	19.68	1.34	17-21	19.90	1.29	18-21	.69
Years Education	14.79	1.78	12-18	14.65	1.29	13-17	.83
LEAP-Q English Background							
Age of Acquisition (years)	4.95	3.69	0-15	3.50	1.72	0-5	.25
Exposure (percentage)	62.58	19.78	15-90	61.50	21.28	25-90	.89
Speaking (max of 10)	8.42	1.46	5-10	8.30	1.49	5-10	.84
Understanding (max of 10)	9.00	1.00	7-10	8.40	1.51	5-10	.21
Reading (max of 10)	8.84	1.30	6-10	8.20	1.40	6-10	.23
LEAP-Q Spanish Background							
Age of Acquisition (years)	3.05	4.78	0-19	1.30	2.06	0-7	.28
Exposure (percentage)	37.37	19.75	10-85	37.50	19.33	10-75	.99
Speaking (max of 10)	8.00	1.67	5-10	7.30	1.34	5-9	.26
Understanding (max of 10)	8.32	1.89	5-10	8.80	.92	7-10	.45
Reading (max of 10)	7.42	2.17	2-10	6.60	1.78	3-9	.31
CELF4 English							
Core Language Skills (SS)	105.00	9.80	84-123	100.30	10.51	85-119	.24
CELF4 Spanish							
Core Language Skills (SS)	114.13	23.89	51-138	95.40	22.87	59-126	.06

Materials: Cognate Awareness Test (CAT, August, et al., 2001)

The CAT is a measure of English word knowledge with consideration for Spanish cognates. Participants were given a list of 56 words that consisted of both cognates and noncognates (August et al., 2001). As it was not clear from August et al. (2001) which words on the measure should be considered cognates or noncogantes, we used a Crosslinguistic Overlap Scale for Phonology (COSP) approach (cf., Kelley & Konhert, 2012) to code each word as cognate or noncognate. Within the COSP coding scheme, translation equivalents were allotted points based on the crosslinguistic overlap in 1) initial sounds, 2) syllable count, 3) consonant sounds, and 4) vowel sounds. Words that had a score of 6 or greater (e.g., English-Spanish literature-literatura COSP=9) were designated as high overlap, cognate words, and words that have a score less than 6 (e.g., English-Spanish gritty-arenoso COSP=0) are designated as low overlap, noncognate words. This resulted in 31 cognates and 25 noncognate items on the CAT.

On each item of the task, participants saw a cognate or noncognate target word and were asked to select one of four choices that best matched the meaning of each target word. While the CAT was initially developed for young students, initial pilot data from nine 18-21year-old Spanish-English bilingual adults with no reported history of DLD (comparable to NoDLD participants in the current study) suggested that accuracy rates would fall below ceiling in adults (*M* accuracy = 84.13%, *Range* = 67.86% - 94.64%, *n* = 9).

Procedures

Participants completed the present study in one session with a trained researcher fluent in English and Spanish as part of a larger study (Robinson Anthony, Blumenfeld, & Pham, under review). Sessions were completed remotely due to social distancing policies during the COVID-19 pandemic. Tests were modified for online data collection (e.g., Castilla-Earls et al., 2022; Waite et al., 2012). Paper materials were adapted to Qualtrics software (https://qualtrics.com) to capture participants' responses digitally (e.g., images were presented on screen with answer choices pinned to the bottom of the screen) and were administered in a one-on-one live interaction between the participant and an experimenter via Zoom (https://zoom.us).

The CAT was administered following an *explanatory-sequential, mixed-method design* (e.g., Ivankova et al., 2006; Figure 1). After completing the CAT, participants were given their response sheets and encouraged to concurrently verbalize their thought processes (*Think Aloud protocol*, Ericsson & Simon, 1993) with prescribed cueing ("*Do you think you would change any answer on this test and why*"). Following recommendations for administration of a think aloud protocol, examiners were trained to (1) minimize experimenter-participant interactions, (2) explicitly ask participants to describe what they were thinking during the tasks, and (3) use communication strategies to promote the experimenter as an active listener (e.g., affirmative vocalizations, recasting and rephrasing participants' responses, asking for clarification).

After reviewing their responses at the first time point, participants were then briefed on cognate word properties as a crosslinguistic prime for metalinguistic awareness. Subsequently, participants were reintroduced to their CAT response sheet for a second time and again encouraged to concurrently verbalize their thought processes ("*With this information, do you think you would change any answers on this test and why*"). All discussions were audio recorded for analysis.

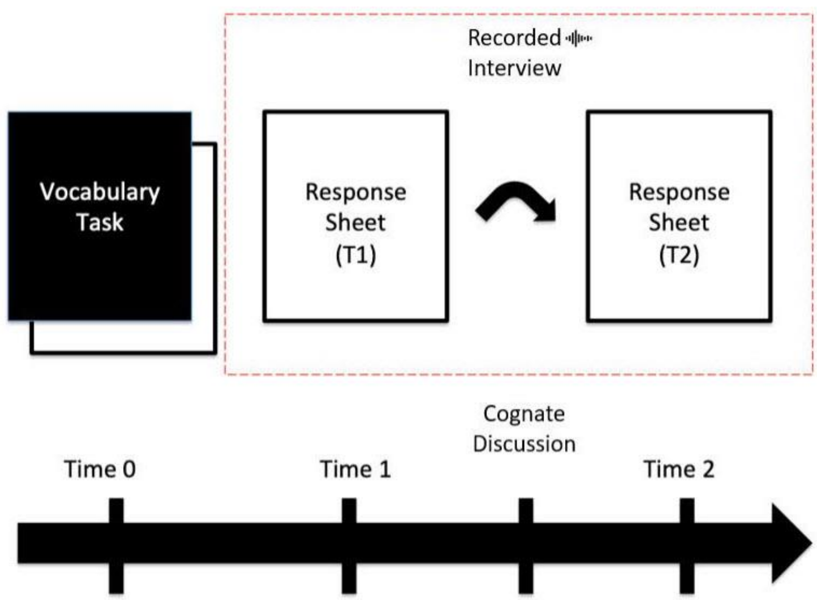

Figure 5.1 Task procedure

Coding and Analyses

Cognate Awareness Test (CAT) scoring

Participant responses on the CAT were automatically scored for accuracy via coding in Qualtrics, and accuracy scores were averaged across cognate and noncognate conditions for further analyses.

Metalinguistic awareness scoring

The audio files recorded during test-review at T1 (beginning) and T2 (end, see Figure 1) for each participant were fully transcribed and participants' responses were initially coded for pre-established themes (Candry et al., 2017; Deconinck et al., 2010; Deconinck et al., 2014; for examples and further definitions, see Table 2): Cross-lexical associations (CLA), sound-symbolic associations (SSA), word-form comparisons (WFC), idiosyncratic associations (IA), and morphological associations (MA). Following an iterative, grounded approach (e.g., Deconinck et al., 2010), pre-established themes were further subdivided to account for observations in the data that did not fit the initial themes. CLA were subdivided into CLAr (resemblance) and CLAnr (no-resemblance). WFC were subdivided into WFCc (cognate) and WFCwl (within-language).

Cross-lexical associations (CLA) was when the target word presented to the participant triggered a connection with another word from their lexicon but did not share the same semantic equivalence. These connections were further characterized whether the words in the association resembled one another (*CLA resemblance*) or not (*CLA no resemblance*). *Sound-symbolic associations* were defined as when the participant noticed symbolic features in the target word's sounds, spelling and letters, or shape and structure. *Word-form comparisons* were defined as when the participant compared the resemblance of the target word to a prior known word in English (*WFC within-language*) or Spanish (*WFC cognate*) that had form and semantic equivalence. *Idiosyncratic associations* were defined as when the participant's meaningful response was unable to either explicitly be placed in one category and/or lacked a clear pattern. Morphological associations were defined as when the participant associated prior knowledge of acquired morphology to the presented target. Participants either segmented the word into specific morphemes or correlated specific word classes or numbers to the target. See table 2 for examples.

Table 5.2 Metalinguistic type, description, and example from data

Type	Description	Example from data
Word-form comparisons-cognates (WFCc)	Target English word compared to Spanish word that share the similar form and meaning	**epoch**-epoca (period in history) "I put epoch because in Spanish epoca is like a *period in time*"
Word-form comparisons-within-language (WFCwl)	Target English word compared to English word that share the similar form and meaning.	**jest**-jester "I didn't fully know what jest means but I know a jester is... I think it's someone who makes *jokes*"
Cross-lexical associations-resemblance (CLAr)	Target English word associated with a Spanish word with resemblance in word form.	**gritty**-gritar (to cry, shout) "I think it could be *rough* cause in Spanish gritar means to yell"
Cross-lexical associations-no-resemblance (CLAnr)	Target English word associated with a Spanish word with no resemblance in word form.	**literature**-psicológico (psychological) "literature is one, I think [um] cause I know for psychology, its psicológico"
Sound-symbolic associations (SSA)	Target English word referenced by sound or shape features.	**hoist**-harm "I obviously haven't used this word either and for me it kind of sounds something bad like harm"
Morphological associations (MA)	Target English word referenced by morphological features.	**feasibility**-feasible "the root word for **feasibility** is feasible so it means like *easy to do*"
Idiosyncratic associations (IA)	Target English word referenced by no discernable pattern.	**modern**-Moderna (vaccine) "my initial thought was Moderna [um] the vaccine people, so *new* vaccine"

Intercoder reliability for both transcription of the interviews and assignment of metalinguistic codes was maintained according to recommendations for qualitative research (e.g., O'Connor & Joffe, 2020). First, there were a minimum of two independent and trained transcribers and coders (examiners) for each interview. After initial transcription and coding by one examiner, a minimum of 10% of the transcription and coding were subsequently reviewed by a second examiner. If both trained examiners were in at least 90% agreement, then the transcription and coding were acceptable for further analysis. If agreement did not reach the 90% threshold for reliability, both examiners discussed disagreements, resulting in an appropriate agreement threshold.

Analysis of coded response data were only completed for data at T1 of the procedure. The focus of this current study was to investigate metalinguistic awareness strategies without the influence of or priming from external (e.g., experimenter) factors. Thus, coded responses following the cognate discussion are reserved for future analyses.

Results

Accuracy and cognate effect on the Cognate Awareness Test

A 2x2 ANOVA was completed to investigate the influence of group (NoDLD, HxDLD) and target word type (cognate, noncognate) on proportion correct words identified on the English Cognate Awareness task (Figure 2). There was a significant effect of word type on proportion correct, $F(1,54) = 41.48$, $p < .001$, $\eta^2_{p} =$ .43. Cognates (M = .90, SE = .017) were recognized more accurately (M difference = .16, SE = .02, $p < .001$) than noncognates (M = .74, SE = .017). There was no difference between groups in the total proportion of words identified, $p = .32$, nor was there a significant group by target word type interaction, $p = .26$. Both NoDLD participants ($M = .83$, $SE = .014$) and HxDLD participants ($M = .81$, $SE = .02$) demonstrated a similar proportion correct for word recognition.

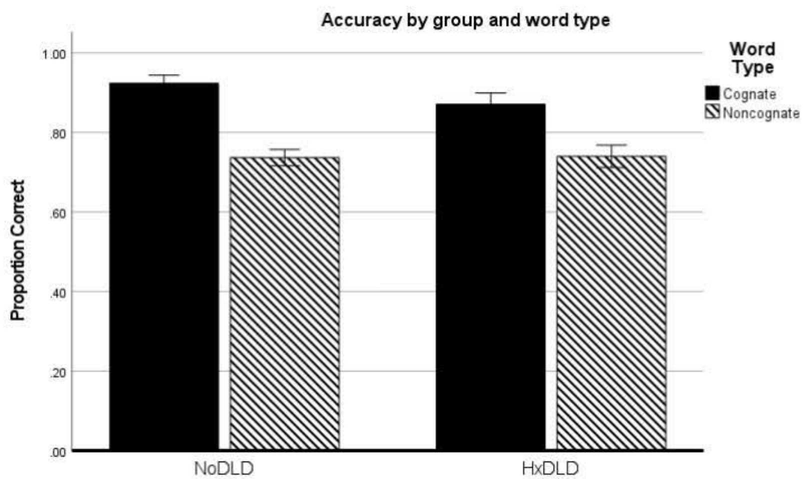

Figure 5.2 Proportion of words correctly identified by group and word type

Metalinguistic awareness on the Think out Loud Task

A chi-squared test was completed to investigate the relation between group (NoDLD, HxDLD) and metalinguistic awareness type (CLAr, CLAnr, WFCc, WFCwl, SSA, MA, IA). There was no difference between the proportion of metalinguistic strategies out of all responses employed across groups while reasoning about word definitions, $X^2(6, N = 29) = 1.29$, $p = .97$ (Figure 3).

A 2x2x7 ANOVA was also completed to investigate the effect of group (NoDLD, HxDLD), accuracy in identifying word definitions (correct, incorrect), and metalinguistic awareness type (CLAr, CLAnr, WFCc, WFCwl, SSA, MA, IA) on the proportion of metalinguistic responses (Figure 4). There were significant effects of metalinguistic awareness type, $F(6,378) = 10.69$, $p < .001$, $\eta^2_p = .15$, and accuracy, $F(1,378) = 21.64$, $p < .001$, $\eta^2_p = .05$, as well as a significant interaction between metalinguistic awareness type and accuracy, $F(6,378) = 5.19$, $p < .001$, $\eta^2_p = .08$. Pairwise comparisons of metalinguistic awareness type (Bonferroni corrected alpha = .05/ planned analyses x21 = .002) demonstrate that IAs were more commonly employed than CLAr, CLAnr, WFCwl, and MA, ps < .001, and WFCcs, as well as SSAs, were more commonly referenced than CLAr, CLAnr, and WFCwl, *ps* < .001. Participants used idiosyncratic, cognate, and sound-symbolic associations for word recognition more than crosslexical and morphological associations. Additionally, metalinguistic awareness strategies were more likely to be described by participants for correct responses than incorrect responses, especially for idiosyncratic and cognate associations . Participants were more likely to discuss their thought processes during correct trials overall. Finally, pairwise comparisons of the marginal means for the interaction between metalinguistic awareness type and accuracy demonstrate that WFCcs (*M* difference = .10, SE = .018) and IAs (*M* difference = .07, SE = .018) were more likely to be observed in accurate trials than inaccurate ones. There were no significant effects of group, no significant interaction between group and metalinguistic awareness type, and no significant interaction between group and accuracy.

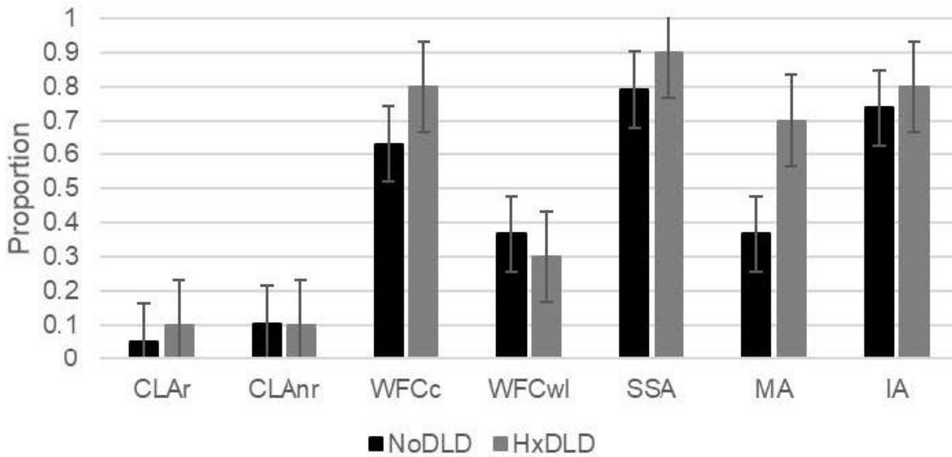

Figure 5.3 The relation between group and metalinguistic awareness

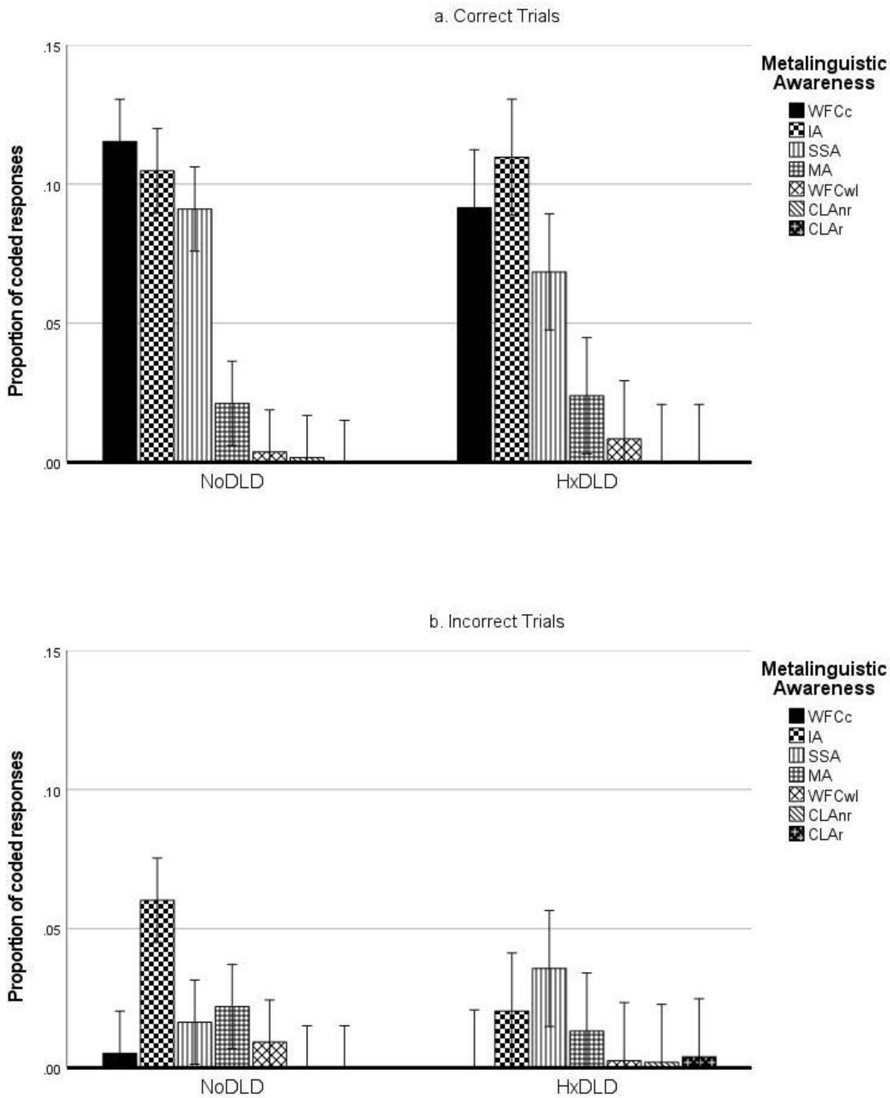

Figure 5.4 Proportion of coded responses by group and metalinguistic awareness for correct (a.) and incorrect (b.) trials

Discussion

The goals of the present study were to determine whether bilingual adults with and without a history of DLD similarly demonstrate metalinguistic awareness, specifically a cognate effect when defining academic vocabulary, and how bilinguals think about language during a vocabulary task that allows for overt reflection.

First, the results of the current study support that for both bilingual groups, cognate status is associated with more successful identification of correct definitions than is noncognate status on an English multiple-choice vocabulary task. However, factors like lexical frequency may explain how a greater difference between cognate and noncognate accuracy is observed on an English task, given that challenging (low) frequency words are employed. Indeed, in another investigation of cognate effects on an auditory receptive vocabulary task in bilingual adults with and without a history of DLD, cognates were identified more accurately than noncognates but only for "hard" (lower frequency) words (Robinson Anthony et al., under review). Though further investigation may be warranted to clarify whether this larger cognate effect is related to the nature of the task (picture identification and multiple-choice vocabulary), these results further evidence the utility of crosslexical influence for word-meaning mapping.

Furthermore, in the current findings, the word-form connection between English-Spanish cognate translation equivalents emerged to be a salient and dependable cue to assign meaning to words. Almost all instances where participants employed cognate awareness strategies yielded correct responses, even when participants explicitly stated they did not know the English target word; when participants made word-form comparisons for cognates, they were highly likely to accurately define target words. Four instances of this strategy are included below:

> NoDLD Participant 1: **adorned**... I don't think I would heard this word in English but because I thought of <u>adornar</u> in Spanish It makes sense to me that it *decorate* but really I don't think I would have used this one in my English vocabulary.
>
> NoDLD Participant 2: I choose *punished* because **castigate** is close to <u>castigar</u> in Spanish which means punish.
>
> HxDLD Participant 1: **profundity**… I don't know what it means, but I chose *deep* cause in Spanish <u>profundo</u> means like deep.
>
> HxDLD Participant 2: For **tranquil** I also thought about the Spanish word <u>tranquilo</u> which means to be *calm*.

In contrast, there were no observations where knowledge of crosslinguistic translation equivalents contributed to linguistic analysis when *no* form overlap was present between translation equivalents (i.e., they were noncognates). When participants made crosslexical associations across words that were *not* translation equivalents, they were either linking target English words to a Spanish word that did or did not resemble the target word. However, these Spanish associations that were not translation equivalents often required more elaboration to come to a correct response.

> Examiner: It seems like you're thinking about this one [**jocose**]?
> NoDLD Participant 3: like even though it doesn't have the same character… like the same sounds as the word jugar… it makes me think of the word jugar and then jugar means to play and then with playing, like with playing it means like something could be a little *funny* so it makes me wanna change a little bit towards funny.

While the participant comes to the correct response in the above example, it isn't without hesitation. Though there were far fewer instances recorded of crosslexical associations of this type, these responses are noticeably more elaborate and tangential (e.g., linking jocose to jugar, jugar to playing, playing to funny, funny to jocose). This may suggest that bilinguals spend more time processing words that do not share form and meaning across languages than they do with cognate words on linguistic analysis tasks. Thus, these results may add that cognates (relative to other types of crosslexical associations) are not only recognized accurately and quickly (Lemhöfer & Dijkstra, 2004; Potapova et al., 2016), but also more parsimoniously (i.e., with more direct strategies/associations made for word recognition goals).

Second, participants with and without HxDLD demonstrate similar patterns in proportion of metalinguistic awareness. Of the seven coded metalinguistic awareness types, idiosyncratic, cognate, and sound-symbolic associations are cited more frequently than all other types. For comparison, Candry et al. (2017) found that crosslexical associations, word form comparisons, and morphological awareness were among the top strategies cited by Dutch speaking, English language learning adults who identified English word definitions. Deconick et al. (2014) alternatively described that sound-symbolic associations and word form comparisons were among the top metalinguistic types in a similar group of Dutch-English bilingual adults completing a word definition task. It is unclear why patterns vary so across studies, though variability in population (e.g., Dutch-English versus Spanish-English) and vocabulary tasks (e.g., word learning versus word recognition) may account for observed differences. For example, individuals with lower proficiency in the target language (e.g., adult language learners) may rely more on crosslexical scaffolding, and thus report more crosslexical associations amongst other input-driven, form-meaning mapping strategies. Instead, more proficient bilinguals be able to rely more on context and experience (e.g., idiosyncratic associations) to derive the meaning of target words before crosslexical, word-form, or sound-symbolic association strategies become relevant. In fact, the most cited strategy employed by participants here is idiosyncratic associations, whereby participants commonly discuss unique contexts in which they learned the meaning of target words. In the examples below, participants describe that they are unfamiliar with the target English words other than in context in which they were exposed to the words.

> HxDLD Participant 3: For **discard**, also this word is in video games. So like they're like oh would you like to discard this thing from your pockets? And if it wasn't for that I wouldn't be able to know the word.
>
> NoDLD Participant 4: I [uh] actually just [uh] read an article on grit so I knew like I had grit… I knew **gritty** was like to [uh] persevere to, I don’t know, [uh]

have faith in something. So *rough*, I thought like [uh] they have perseverance, they're rough… they're, you know, determined.

Cognate and sound-symbolic associations are proportioned similarly in the data. It thus appears that, across groups, participants make use of sublexical and lexical information to map meaning onto the words they encounter. In examples of cognate awareness, participants make whole word connections between English targets and Spanish translation equivalents. For sound-symbolic associations, participants describe either similar initial sounds, rhymes, or spelling in their descriptions of these processes.

> HxDLD Participants 4: I don't know what **strife** meant, but when think of strife it kind of rhymes with <u>knife</u> so it kind of means like *fight*, so I went with fight.
> NoDLD Participant 5: oh like **tattered** it kinda sounds like *torn* in a way.
> NoDLD Participant 6: **hoist**… I don't think its anything to do with that… maybe it is to *lift* something but definitely with that I was also thinking well hoist starts with an "h" so why not just go ahead and go with <u>harm</u>.

Deconick et al. (2014) reason that language learners apply symbolic and referential value to the sound and shapes of target words, though they may have difficulty in verbalizing these complex phenomena. However, similar to these present findings, Deconick et al. (2014) found that sound-symbolic associations were among the most cited strategies on a word definition task. In contrast, Candy et al., 2017, found that these associations were amongst the least cited, possibly due to there being fewer target words designed in their study design that enlisted this strategy.

The remaining four strategies (MA, CLAr, CLAnr, WFCwl) are sparingly represented in the data, with only a handful of cases coded across each. In fact, only 3 participants describe crosslexical associations that are not translation equivalents, and word form comparisons that are not cognates. Morphological associations are reported generously across both participant groups, though they do not make for more accurate responses on trials. The results suggest that there are no differences in the proportion of morphological awareness responses that are correct or incorrect; participants are less accurate in mapping words to their meaning using this strategy. One explanation for the relatively low reporting of these four metalinguistic awareness types may be that the stimulus items do not contain sufficient English targets that specifically elicit these types of responses. For example, participants commonly noted for one stimulus item (malevolent) that “mal” means bad, and therefore chose a response with a negative connotation. For stimulus items such as “wily” and “jest” with low word frequencies and minimal morpheme constructions, crosslexical and morphological associations may be less apparent and are ultimately not considered.

When faced with a multiple-choice response on a vocabulary task, overall, it seems bilinguals with and without a history of DLD use similar metacognitive strategies to map words to their meanings. This is a positive note for the DLD literature, as differences in language skills (e.g., vocabulary and form-meaning mapping, morphology), is hallmark to DLD. The present findings suggest that Spanish-English adults’ analytic language functions are not impacted by a history of DLD. Instead, these data suggest that bilingual adults reason about language in a similar manner, regardless of language history or abilities.

Limitation

This study is an exploration into the higher-order processes bilinguals utilize to accomplish form to meaning mapping for word recognition. One limitation in this study concerns the grouping of participants based on self-report of a history of DLD, as participants report having speech-language services or current language concern. For example, bilingual children are commonly misidentified for services related to language difference (e.g., English as a second language) versus language disorder (e.g., DLD; Bedore & Pena, 2008). However, the scope of this study is not to diagnose DLD in adulthood; rather, we seek to understand how a *history* of DLD longitudinally effects the behavioral projection of cognitive processes related to word recognition. The groups of this study do not differ on metrics of language experience or ability and are only distinguished based on this history of DLD. An absence of meaningful differences in the current study may suggest that broadly bilinguals with a history of DLD develop metalinguistic awareness skills as adults that are comparable to their peers. It is also possible that this kind of finding is limited to only the most academically successful individuals with a history of DLD.

Educational implications and future directions

The results of this study suggest that bilinguals use similar strategies to accomplish word recognition goals. The top three strategies include employing idiosyncratic associations, followed by cognate word recognition and sound-symbolic associations. These top three may be areas of relative strength for bilinguals in being strategies that connect the most salient features of the input to mental concepts and may be used for scaffolding metalinguistic awareness on tasks. Conversely, less common strategies used, including morphological awareness and general crosslexical associations, are not as robustly reported by bilinguals as useful strategies for word recognition. Instead, such strategies could be taught to broaden students' tools for word recognition. Future studies may investigate the utility of these metalinguistic types for word recognition by systematically investigating their stimulability and likelihood of yielding a correct response in bilinguals with and without a history of DLD. Such an investigation would highlight a step forward in providing language support to bilinguals in higher education who may struggle with vocabulary word comprehension, either because of language differences to the majority language (English) or because of challenges associated with a history of language disorder.

Conclusion

In summary, bilinguals with and without a history of DLD demonstrate a positive influence of crosslexical interaction, as words on an English task that share form and meaning with Spanish words are recognized more accurately for both groups. This cognate effect is consistent with other adult studies and is elaborated here by the inclusion of cognate association description in qualitative analysis. When participants recognize words that are the same across English and Spanish, they are highly accurate in defining those words' meanings. Bilinguals actively use word form-to-meaning and sound strategies as likely as idiosyncratic ones and are less likely to report morphological or other cross language associations for productive responses. Thus, an understanding of metalinguistic awareness for college-age bilinguals can provide evidenced-based inroads to language services and supports in higher education.

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CHAPTER 6: GENERAL DISCUSSION

The overarching goal of the current dissertation was to investigate word representation and processing in bilinguals with a history of DLD. Specifically, the dissertation sought to explain whether and how crosslinguistic interaction supports word recognition for bilinguals who may struggle with language through an analysis of participant-internal factors, including language experience and history of DLD, as well as task-internal factors, including word type (cognate, noncognate) and word difficulty (frequency). **Chapter 1** of the dissertation began with an overview of bilingual word recognition dynamics and established a groundwork to make word recognition and processing predictions.

Broadly, the overview provided in Chapter 1 yielded the following set of predictions, which were presented in each subsequent chapter. It was predicted that bilinguals with a history of DLD would demonstrate less accurate word recognition on receptive vocabulary tasks, with slower response times and smaller proportion of looks to target images in the early processing time window for eye-tracking. It was also predicted that crosslexical interaction, indexed by cognate effects, would benefit recognition accuracy and processing speed for participants, with more accurate recognition of cognate targets, as well as faster button-press responses and greater proportion of looks across the early timecourse of word recognition. Furthermore, an exploration of metalinguistic awareness was predicted to elucidate strategies used across groups to accomplish form to meaning mapping goals, with an open hypothesis that group differences would emerge based on history of DLD.

Chapter 2 established that typical college age bilinguals recognize cognates more accurately than noncognates. The cognate effect observed in this chapter was mediated by participants’ language experience, indexed by a multifaceted and continuous language dominance variable that included self-reported proficiency, exposure, and word production accuracy across English and Spanish. Cognate effects were larger in participants’ less dominant language, either English or Spanish, suggesting that crosslexical interaction supported word recognition for typical bilinguals with a predictable pattern.

In **Chapter 3**, cognate effects were replicated in groups of college age, Spanish-English bilinguals with and without a history of DLD. First, group differences were noted in total words recognized across groups, with young adults with a history of DLD recognizing fewer words overall and likely driven by smaller Spanish vocabularies. Indeed, a breakdown of total vocabulary into English only and Spanish only suggests that the participants of this study were similar in the proportion of English words recognized and differed on the Spanish task. One explanation was that English was the majority language of education, and all participants were academically successful college students (e.g., enrolled in a 4-year university). Conversely, participants differed in their daily experiences with Spanish (e.g., home language), and it was expected that there would be greater variability in Spanish vocabulary. However, both groups with and without a history of DLD reported comparable self-reported proficiency, language learning history, and exposure across languages. Thus, differences in total vocabulary are not supported by purely language experience variables. Instead, participant reports of speech-language services and ongoing language concern corresponded with the observed group differences in total language and Spanish performance. These results suggest that a history of DLD may indeed impact long-term vocabulary development in some, but not all, linguistic contexts.

Second, word difficulty effects in Chapter 3 suggested that lower frequency words in English and Spanish were less recognizable for bilinguals. When separated by word type, it was further suggested that cognate effects in English were evident only on the most difficult (hard, low frequency) word types, while cognate effects in Spanish were observed across the task and most evidently in medium and hard levels of difficulty. Both groups of participants recognized fewer words across tasks as difficulty increased from easy to medium to hard, though participants with a history of DLD recognized fewer Spanish noncognates especially at the hard (lower word frequency) level. These results added that participant-internal factors, such as a history of DLD, and task-internal factors, such as word difficulty, influence word recognition outcomes. There were no significant interactions between group and word difficulty in these data, and bilinguals with and without a history of DLD recognized and/or were exposed to a similar ratio of words of varying difficulty. Again, these results are aligned with participant reports of similar proficiency and exposure across languages, as well as years of education and ages of acquisition.

Chapter 4 of the dissertation shifted from a focus on word representation accuracy to processing. First, results indicated that cognate effects for speed of recognition were minimal, as there were no differences between how fast participants responded to cognate versus noncognate targets on the English task. This finding in addition to the word recognition accuracy data suggested that bilinguals with and without a history of DLD similarly recognized and processed words in the majority language. For Spanish, cognates were recognized more quickly than noncognates, elaborating processing speed differences by language context.

Second, Chapter 4 results suggested that bilinguals with a history of DLD may have a subtle lexical access delay, with slightly slower responses and less target word activation, albeit only in Spanish. Participants with a history of DLD were equally as accurate in their response to their typical peers, though they were slower in making button-press decisions. These overt responses were complemented by eye-gaze data in Spanish, whereby typical participants gave more attention to target words (e.g., looked more to target images) in early time windows. In English however, while participants with a history of DLD made faster overt responses, a speed-accuracy trade-off on button presses between groups complicated interpretation of lexical assess delay overall. If participants with a history of DLD were to demonstrate less efficient processing, differences would be observed across languages. Instead, the corroboration of button-press and eye-tracking data in Spanish may highlight that lexical access differences, if they are present, are most evident in the language of less exposure.

The framework for this dissertation was situated in bilingual word recognition models, and Chapters 2 through 4 focused on word knowledge and processes in the word identification system. **Chapter 5** investigated higher-order processes and explored metalinguistic awareness when evaluating form to meaning mappings for word recognition. Quantitative data demonstrated that bilinguals with and without a history of DLD thought about words in similar manners. Across seven themes for metalinguistic strategy, there were no differences across groups in the proportion of coded responses across themes, nor was there a difference in the variety of strategies reported across participants. This suggested that the impact of DLD observed in accuracy and lexical access may not extend to higher-order processes like metalinguistic awareness, at least in adulthood. Instead, bilinguals of varying ability may be equally capable of employing strategies towards a word comprehension goal.

Qualitative results highlighted individual experiences, cognates, and sound similarity as productive strategies for word recognition. A high proportion of idiosyncratic associations reported may suggest that bilinguals refer to context and experience when drawing the meaning of encountered words, at least more so than making morphological associations or word-form comparisons that are not translation equivalents across languages. Cognate awareness was also meaningful in making form to meaning mapping. In fact, when participants reported instances of word form similarities between translation equivalents across languages, they were likely to correctly draw the meaning of the targeted word. While participants additionally reported a high proportion of sound associations in making these mappings, there was less reliability in correctness of the association. Overall, these qualitative findings provided insight into effective strategies that bilinguals with and without a history of DLD used to accomplish language goals, while identifying strategies that were indeed used although not to a reliably productive degree.

In summary, individual factors and task factors contributed to word recognition success in the current sample of bilinguals. Importantly, while bilinguals with a history of DLD might present with vocabulary and processing differences, crosslexical influences had a positive impact on word recognition dynamics. First, these data and similar studies evidenced that a history of DLD implies lifelong differences with peers without DLD, although these differences may become nuanced in adulthood. While effects of DLD were not always obvious in English, investigations of language skills in Spanish revealed word recognition differences even when controlling for individual and task factors. Second, translation equivalents that were similar in form seemed to bridge knowledge and processing across languages and were a strong foundation for word recognition for bilinguals. With this, the current dissertation supports the increasingly accepted position that bilinguals who may struggle with language should not feel discouraged from engaging in language practices that bolster both language skills (e.g., Bird et al., 2016; Dai et al., 2018; de Valenzuela et al., 2016; Lim et al., 2019; Marinova-Todd et al., 2016; Yu, 2013). Indeed, these data may indicate that language services would benefit bilinguals beyond K-12 education, with considerations for a bilingual approach to further vocabulary-strengthening strategies for college age students. Future research based on these initial findings may include continued investigations of the stimulability for crosslexical influence to enhance vocabulary and word recognition.

It is important to note, one limitation here is that a childhood diagnosis of DLD in bilingual populations generally requires that language skills in *both* languages are impacted. However, the adult participants of the current study all have language skills within typical range for at least one of their languages. Of the 10 participants who report a history of DLD, eight were in average range for English and not Spanish, while only two of the 19 participants without DLD were in average range for only one of their languages. Therefore, contrasting language profiles could be noted for the two groups. Although others have found that monolingual adults with a history of DLD can test in the average range (e.g., McGregor et al., 2020), identification of DLD in the current dissertation did not align with traditional notions of language disorder. The participants of the current dissertation were recruited using language on materials that speak to language and literacy challenges, and participants were further required to report a history of speech-language services or current language concern. However, it was beyond the methodological scope of the current dissertation to formally diagnose DLD in adulthood. A future direction based on the current dissertation data is to more thoroughly evaluate the bilingual profile as it relates to DLD in adulthood. Understanding what measure or measures continue to predict DLD may be useful in future investigations to validate participant reported histories of language challenges.

In conclusion, as Francois Grosjean has stated, “bilinguals are not two monolinguals in one,” and an account of crosslexical interaction is required in any understanding of bilingual language processing. Furthermore, bilingualism is not a monolith. Language experiences, abilities, and even language context modulate how successful bilinguals are in efficiently mapping words to their meanings. This dissertation provides evidence that Spanish-English bilinguals with a history of DLD demonstrate a slight vocabulary gap and lexical access delay likely observed in Spanish, that Spanish language experience bolsters English word recognition and vice versa for the majority of bilinguals, and that language differences between bilinguals with and without a history of DLD may be limited to word identification systems, with similar higher-order processing strategies for word recognition. Still, open questions remain concerning the language profiles of bilingual adults with DLD, whether language skills for bilinguals appear typical in English after years of education in the majority language, and whether and how cognate effects may be targeted to boost word recognition performance or mitigate word recognition challenges when related to a history of disorder.

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