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Home Language Environment and Executive Functions in Mexican American and Chinese American Preschoolers in Head Start

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Abstract

Research Findings: Using two groups of dual language learners (DLLs), the current study examined links between two developmental constructs closely linked to school readiness: the home language environment (HLE) and executive function (EF). In a sample of 90 children (age range = 38-70 months, 59% girls) from either Mexican American (MA, $N = 46$) or Chinese American (CA, $N = 44$) low-income families enrolled in Head Start preschool programs, parents reported on their HLE (home language balance, home English/heritage language activities) and children's EF (inhibitory control and attention shifting) was measured by cognitive tasks. Findings showed preschool-aged DLLs in low-income immigrant families received more heritage language exposure relative to English language exposure at home. Several demographic variables (parental education, per capita income, DLL group, child age of English acquisition, child generation, child English receptive vocabulary) were related to various aspects of HLE. Controlling for covariates, the amount of heritage language activities at home was uniquely and positively related to children's attention shifting.

Practice or Policy: The findings underscore the importance of incorporating language background considerations when designing intervention programs that target HLE and EF in low-income DLLs.

The U.S. population of dual language learners (DLLs), or children who are exposed to and learning through two languages, has grown rapidly in the last decade (National Center for Education Statistics, 2020). DLLs from low-income families lagged significantly behind their monolingual English-speaking peers on school readiness measures at kindergarten entry, and the achievement gap continued to widen with age (Ansari & Crosnoe, 2018). To close these gaps, intervention programs such as Head Start, a federally funded program for children from low-income homes, have focused on supporting outcomes critical to school readiness in low-income or DLL children.

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Two key factors commonly targeted by school readiness interventions are children's home language environments (Durán et al., 2016; Larson et al., 2020) and executive functions (Bierman, Nix, et al., 2008). Aspects of the home language environment (HLE) – such as home activities taxing one or both languages, as well as the balance of language use in the home – are predictive of children's academic and cognitive outcomes (Leung et al., 2020; Weisleder & Fernald, 2013). Interventions intended to enhance HLE in DLL samples showed promising effects on language skills and quality of interactive home book reading (Larson et al., 2020). Executive functions (EFs), a set of goal-oriented cognitive processes, have also been consistently linked to children's school readiness and academic achievement (Blair & Razza, 2007; Bull et al., 2008). Children's EFs have been shown to mediate socio-economic and cultural group differences in early achievement (Nesbitt et al., 2013), and consequently have been a target for many early intervention programs (Diamond & Lee, 2011).

Past studies generally found that children from low-income families scored lower on measurements of both HLE (indexed by quality and quantity of language inputs) and EF when compared to their middle- or high-income counterparts (Lawson et al., 2018; Schwab & Lew-Williams, 2016). However, these studies usually compared low-income, DLL or immigrant groups with middle-income, White or nonimmigrant groups (e.g. Raver, McCoy, Lowenstein, & Pess, 2013; McClelland et al., 2007; Mezzacappa, 2004). Because socioeconomic status (SES) and language background, culture, or immigrant status are often correlated with each other in the U. S. (Reeves et al., 2016), it is difficult to tease out the unique relations of language background to children's school readiness. Multilingualism is a common feature of the HLE of DLLs, and past research has revealed considerable heterogeneity in the quantity and quality of heritage and English language inputs in the homes of DLLs (Lewis et al., 2016; Luo et al., 2020). Thus, studying within-group differences in HLE among DLLs with similar socioeconomic backgrounds is needed to characterize the complexity of language inputs in these populations. Further, while several studies have reported relations between children's dual language proficiency and children's EF (Barac et al., 2014; S. M. Carlson & Meltzoff, 2008), relatively fewer studies examined the links between dual language *inputs* at home and children's EF.

The present study addresses these gaps by sampling two low-income DLL groups: Mexican American and Chinese American families living at or below the poverty line with children enrolled in Head Start. Children's HLE (home heritage language activities, home English language activities, and home language balance) was assessed using parent report and EF (inhibitory control and attention shifting) was assessed using cognitive tasks. The goals were to descriptively characterize children's HLE, as well as to examine the relations between each aspect of HLE and EF. Understanding key characteristics of the HLE and its connections to EF in DLLs can inform the development and adaptation of culturally competent early childhood intervention programs that capitalize on family resources in fostering DLL children's school readiness.

Home Language Environment in Mexican American and Chinese American Families

Defining and Measuring the Home Language Environment

Early language input is consistently implicated in children's developmental and academic outcomes (d'Apice & von Stumm, 2020; Hoff, 2003; Rowe, 2012; Weisleder & Fernald, 2013). Recognizing this, research efforts have focused on characterizing the quality and quantity of language inputs that children receive at home, often labeled as the *home language environment (HLE*). HLE is a multifaceted construct that entails language directed to children by parents and other adults (Scheele et al., 2010). HLE also includes speech between adults in the home that may be overheard by children (Akhtar et al., 2001), as well as language heard from media sources such as TV or audiobooks (Place & Hoff, 2011). The multiple aspects of language input reflect considerable variation in HLE that exists between families. Although some conceptualizations of HLE also include children's language output and use (e.g. Scheele et al., 2010), the present investigation focuses on language inputs and activities in the home.

HLE has another layer of complexity in families with DLL children, who receive language input in both their heritage language and host culture language. Language input sources in empirical studies on DLLs mirror those conducted in monolingual environments, including parents' or other adults' speech to the child (De Houwer et al., 2014), conversations between adults (Duursma et al., 2007), and media and language activities the child engages with (Brenneman et al., 2007). Past research highlights that both quantity and balance of dual language input comprise distinct and complementary facets of HLE for DLLs (Unsworth, 2019). Some empirical studies have operationalized dual language balance using a categorical or group approach, such as dividing relative language exposure into two (more heritage language or more English; Hammer et al., 2007) or three (including a balanced bilingual option; Hoff et al., 2012) groups. However, measuring home language balance continuously, such as by the relative amounts of language spoken (e.g. ranging from *only heritage language* to *only English*; Reese & Goldenberg, 2008), may reveal informative within-group heterogeneity among DLL families. Researchers have employed a variety of methods to capture the heterogeneity encountered in bilingual environments, such as parent reports (Marchman et al., 2010), diary records (Place & Hoff, 2011), and naturalistic audio recordings (Xu et al., 2009). Though advanced recording instruments such as LENA™ (Xu et al., 2009) may minimize reporter error, research suggests that parent-report measures of HLE moderately align with naturalistic recordings and illustrate the language input variance across a wider timeframe (Marchman et al., 2017).

Home Language Environment of Spanish-Speaking DLLs

Extant studies of HLE of Spanish-speaking DLLs suggest that the degree of balance of English and Spanish use at home may depend on several demographic factors. A study of Spanish-speaking DLLs enrolled in Head Start showed that longer residence in the U.S. is associated with greater home English usage (Hammer et al., 2011), and another study found that foreign-born Latino parents were less likely to speak English to their children than U.S.-born Latino parents (Fry & Gonzales, 2008). In another sample of 2 year-old Spanish-

speaking DLLs, the relative amounts of Spanish and English input at home depended upon whether one or both parents were native Spanish speakers (Place & Hoff, 2011). Specifically, children with two Spanish-speaking parents were exposed to more Spanish and less English at home than those children with only one Spanish-speaking parent. In studies of monolingual children, maternal education was generally positively associated with children's overall language input (Branum-Martin et al., 2014; Dollaghan et al., 1999; Rowe et al., 2005; Vernon-Feagans et al., 2019). However, studies with DLLs did not consistently show this association (Hammer et al., 2012; Place & Hoff, 2016), potentially because relations between maternal education and child language input may depend on the language in which mothers were educated (Hoff et al., 2018). Thus, the association between parental education and children's home language input in DLL families is unclear, and few studies consider both maternal and paternal education. Home language balance may also depend upon child gender. Indeed, a study of preschool and kindergarten Spanish-speaking DLLs found that mothers used more English with their sons and more Spanish with their daughters (Hammer et al., 2009). In summary, the language balance of English and Spanish in the homes of Spanish-speaking DLLs may depend on several factors including residence in the U.S., generation status, parental language proficiency, parental education, and child gender.

Studies of HLE in Spanish-speaking homes have indicated that Spanish and English usage occurs along a continuum, and may vary across interpersonal contexts. For example, a study of Spanish-speaking DLLs in kindergarten and their families showed divergence between mothers and fathers in the balance of languages spoken to children, and the direction of this language balance among mothers and fathers was not consistent across families (Branum-Martin et al., 2014). The balance of home language usage may also be deliberate, with research suggesting that parents may speak more Spanish at home as a way to counterbalance the amount of exposure to English that Spanish-speaking DLLs receive in their classrooms (Duursma et al., 2007). However, other studies suggest that parents may actually speak *more* English to their children as they progress through school (Hammer et al., 2009). These language usage patterns may be further related to cultural values. Qualitative studies have found that Spanish-speaking parents may use more Spanish in speaking to their children as a form of heritage culture maintenance (Farruggio, 2010; Schecter et al., 1996). Parents may also provide materials such as books and media to their children in Spanish as a way of maintaining their heritage culture (Rios & Gaines, 1998). These materials may provide the basis for shared language activities and language use in the home (Lewis et al., 2016). However, the relative amount of Spanish and English language materials available in the homes of Spanish-speaking DLLs has not been the focus of prior studies, despite findings that Spanish-speaking DLL children spend a significant portion of their time at home interacting with such materials (Place & Hoff, 2011). Overall, research suggests that there is rich within-group heterogeneity in HLE of Spanish-speaking families, which may be due to a number of demographic, interpersonal, and cultural factors.

Home Language Environment of Chinese-Speaking DLLs

Compared to research on HLE of Spanish-speaking DLLs, much less is known about home language usage in families with Chinese-speaking DLL children. A study of Chinese-speaking immigrant families in New York City showed that parents predominantly spoke

Chinese to their infants (Jia, 2008), either because of limited English proficiency or because of a desire to maintain the language aspect of their heritage culture. Another study of 52 Chinese-speaking parents of Chinese-English preschool DLLs showed that home language usage was quite heterogeneous, with 28.8% speaking exclusively Chinese to their children, 13.5% speaking exclusively English, and the remainder using a mix of Chinese and English (Lao, 2004). In terms of demographic variables influencing home language balance, a study of low-income Chinese-speaking preschool DLLs found that the length of residence in the U.S. was not associated with patterns of parental language usage (J. J. Chen & Ren, 2019). However, this study included a mix of Chinese-dominant and English-dominant parents, which may confound this association. Overall, more research is needed investigating links between demographic factors and Chinese-English language balance in the homes of Chinese-speaking DLLs.

The characteristics of HLE in Chinese-speaking families may be shaped by the complexity of the Chinese language. While Spanish has a transparent, alphabetic orthography with most graphemes representing a unique sound (Jiménez et al., 2009), Chinese is logographic with a large number of characters corresponding to the same syllable (Tan et al., 2005). The visual-orthographic demands of the Chinese language render it more difficult for children to acquire than languages such as Spanish or English (Li & Rao, 2000). There is evidence that bilingual mothers may alter the language they use to speak to their child if they perceive that the child has challenges communicating in that language (De Houwer & Bornstein, 2016). According to this pattern, parents may choose to speak relatively less Chinese to their children given the difficulty of mastering Chinese language. The relative availability of language materials in Chinese may also influence how much language exposure children receive in Chinese at home. The study of Chinese-English preschool DLLs showed that families possessed more English language materials than Chinese language materials, which may be attributed to limited availability of Chinese materials at homes (Lao, 2004).

In summary, there may be variability in aspects of HLE both within and between DLL groups, although to date research has not studied HLE in DLLs from different language groups in the same study. This gap in the literature limits knowledge on what is common across DLLs or unique to certain DLL groups (Hammer et al., 2011).

Executive Function and its Development in Mexican American and Chinese American Children

Defining Executive Functions in Early Childhood

Executive functions (EFs) are a collection of goal-oriented cognitive processes generally consisting of working memory, cognitive flexibility, and inhibitory control (A Miyake et al., 2000). Children's EFs undergo rapid development between ages 3 and 5 years, and play a central role in fostering school readiness in children (McClelland & Cameron, 2011). Specifically, EF-related processes can promote children's school readiness and success in multiple mechanisms, including supporting children's effortful attention in classroom, promoting their engagement in and persistence on learning-related activities, reducing externalizing problems that might interfere with learning, as well as promoting positive

relationships with peers and teachers (Brock et al., 2009; Eisenberg et al., 2010; Valiente et al., 2011). Consistent with the theory, studies have shown that EF differences in early childhood are associated with later academic achievement (Bull, Espy, & Wiebe, 2008) and social-emotional competence (Riggs et al., 2006).

A large body of literature suggests that low socioeconomic status has detrimental influences on children's EFs (Lawson et al., 2018). However, fewer studies have examined EFs among low-income DLLs. DLLs have cultural backgrounds that may be relevant to the development of EF – specifically, language is one salient aspect of culture that may relate to EF. Research has shown that even among groups of low-income DLLs, there is still considerable variability in children's EFs (Farver et al., 2013; Lewis et al., 2016). This variability may be related to differences in children's home language exposure.

Links between Home Language Environment and Executive Functions

Theoretical Links between Home Language Environment and Executive Functions

Although HLE has been largely studied in relation to language outcomes, theoretical accounts suggest HLE may also be related to children's EFs. These theories suggest that overall language exposure and aspects of HLE specific to DLLs such as language balance may be linked to children's EFs. According to information processing theory, children deploy a variety of EFs in organizing, manipulating, and storing the language inputs they receive at home (Munakata, 2007; White et al., 2017). The consistent recruitment of the cognitive processing system that underlies EF when children are exposed to language may therefore enhance EF over time. Relatedly, the hierarchical competing systems model (Marcovitch & Zelazo, 2009) proposes that reflective cognition is activated by language exposure and is crucial for EF development. In other words, when presented with language, children are given the opportunity to engage in the skills of reflecting, reasoning, and inferring, and these same skills are tapped when using EFs (Daneri et al., 2019; Marcovitch & Zelazo, 2009). Some researchers have hypothesized that children's EF development may be specifically shaped by exposure to syntax and grammar, which represent rule-based systems that can shift under certain conditions (Daneri et al., 2019; Kuhn et al., 2016). Over time, exposure to the type of conditional thinking that is necessitated by syntax and grammar can aid in EF tasks that require cognitive flexibility and set shifting. HLE could also directly facilitate children's expressive and receptive verbal language, and enhanced self-verbalizations could in turn promote EF development by facilitating planning and self-monitoring (Emerson & Miyake, 2003; Muller, Jacques, Brocki, & Zelazo, 2009). In summary, regardless of dual language background, the absolute amount of language inputs may be positively related to children's EF.

For DLL samples, the unique experience of being exposed to two languages may also have implications for EFs (Barac & Bialystok, 2012). According to the adaptive control hypothesis (Green & Abutalebi, 2013), there are several aspects involved in the dual language experience that may bolster EF – specifically inhibitory control – over time. Multilingual children must deploy EF in inhibiting activation of the nontarget language so as to avoid cross-linguistic contamination that would interfere with communication. The repeated practice of inhibiting the nontarget language is theorized to enhance children's

capacity to suppress irrelevant information in favor of relevant information over time (i.e. inhibitory control; Bialystok et al., 2005).

This "bilingual advantage" in EF is also proposed to occur in the domain of attention shifting, given that bilingual children must decide when and how to shift languages between different contexts, speakers, or even within a single conversation (Prior & MacWhinney, 2010). Given that these theories emphasize the role of using and switching between both languages actively, some researchers purport that EF benefits may only be observed among those who hear and/or use both languages equally ("balanced" bilinguals; Thomas-Sunesson et al., 2018; Weber et al., 2016; Yow & Li, 2015). In other words, greater balance in the relative usage of two languages in the home may relate to greater EF performance among DLL children.

Empirical Links between Home Language Environment and Executive Functions in DLLs

Supporting theoretical accounts, empirical studies report associations between aspects of the HLE and children's EFs in DLL samples. In a study of kindergarten children, children who were exposed to both Spanish and English at home – but not children enrolled in Spanish immersion programs who only received English input at home – outperformed monolingual children on a task of cognitive flexibility (Carlson & Meltzoff, 2008). Similarly, a study of 7-15 year old Welsh children found that bilingual children exposed to both Welsh and English at home outperformed monolinguals as well as bilinguals who were exposed to only Welsh at home and English at school on a task of inhibitory control (Gathercole et al., 2010). These studies suggest that EF enhancement may be conferred by the specific experience of being exposed to two languages in the same context. In a closer examination of the home context, an investigation of 3-year-old Dutch bilinguals categorized children based on whether parents always or mostly addressed them in the same language or two different languages (Verhagen et al., 2017). Results showed that while "different language" bilinguals evidenced greater performance than monolinguals on a task of inhibitory control, "same language" bilinguals did not, again suggesting that the bilingual advantage may result from more balanced exposure to two languages. Recently, a study of 5 to 11-year-old Spanish bilingual children quantified balanced dual language exposure as the amount of time per day children spent in an environment with simultaneous exposure to both English and Spanish (Crespo et al., 2019). These authors did not observe direct relations between their measure of dual language exposure and children's EFs in the overall sample, although they did observe associations with attention shifting for those children with high language proficiency. These authors suggested that direct effects of dual language exposure on EFs might be observed at younger ages when EFs are more unitary.

Taken together, extant theoretical work and empirical studies suggest relations between a more balanced language exposure at home and children's inhibitory control and attention shifting, although findings are heterogeneous in terms of the EF outcomes studied and the operationalization of home language exposure. According to the adaptive control hypothesis whereby dual language experience bolsters conflict resolution abilities (Green & Abutalebi, 2013), associations with home language variables may be specifically expected for EF tasks that tap inhibitory control. However, a recent meta-analysis reviewing links between dual

language experience and EF in children showed greater and more significant effect sizes for attention shifting as compared to inhibitory control (Gunnerud et al., 2020). Several studies examined dual language experience with single measures of EF, and thus, could not identify which EF abilities might be related to HLE (Arizmendi et al., 2018; Friedman, 2016). Observing significant links between the HLE and specific EF components within a single study might help illuminate the aspect of HLE that is related to EF for that sample (e.g., inhibiting the nontarget language or switching between languages), which has implications for understanding the potential mechanisms through which home language exposure relates to children's particular EFs during the preschool period.

Indirect evidence for a link between home language input and children's EFs also comes from the multitude of studies showing links between children's language proficiency in both languages and their EF performance (Iluz-Cohen & Armon-Lotem, 2013; Kalia et al., 2019; Rosselli et al., 2016). For example, using data from the same sample as the present study, children's English and heritage language vocabulary were each uniquely associated with attention shifting when controlling for English language proficiency, age of English acquisition, and other demographic covariates (Williams et al., 2018). The present study seeks to extend this investigation of dual language output to investigate whether similar links to EF are observed when examining dual language inputs at home. However, there is currently a lack of consensus on the proposed "bilingual advantage" in EF, which is subject to mixed findings and methodological criticisms (Antoniou, 2018; Barac et al., 2014; Laine & Lehtonen, 2018; Paap & Greenberg, 2013; Samuel et al., 2018). The majority of studies on the bilingual advantage used a categorical approach in comparing DLLs to their monolingual peers, which may overlook the heterogeneity in HLE and EF within DLLs. Further, while several studies have considered home language balance in connection with children's EFs, few researchers have considered other aspects of HLE such as exposure to language activities and materials in each language. Given the importance of children's EFs to a variety of developmental outcomes (Robson et al., 2020) as well as the focus on HLE in many intervention programs for DLLs (Larson et al., 2020), further investigations of connections between HLE and EF in DLL families is informative for efforts to promote positive outcomes for DLL children.

Socio-cultural Factors That Might Confound Associations between DLL Group, Home Language Environment, and Executive Functions

When examining the associations among HLE and EF, it is important to consider other theoretically supported child and family variables that might confound these relations. Therefore, we considered variables that may relate to both HLE and EF based on prior research as potential covariates when examining the HLE-EF associations. Demographic characteristics such as child age and gender have been associated with both EF (Grissom & Reyes, 2018; Huizinga et al., 2006) and HLE (Rodriguez et al., 2009), so have the length of preschool attendance (Duncan & Magnuson, 2013) and the child's age when first exposed to a second language (Luk et al., 2011). Child generational status, an indicator of acculturation, can shape both EF and HLE (S. H. Chen et al., 2015; Farver et al., 2013). Children's receptive language abilities may influence comprehension of the EF tasks (Booth et al.,

2010), and may shape or be shaped by the HLE (Scheele et al., 2010). Thus, in addition to family SES, children's age, gender, age of English acquisition, generation status, length of schooling in Head Start, and receptive vocabulary in both languages were examined as covariates.

The Present Study

In a sample of Mexican American (MA) and Chinese American (CA) preschool-age children enrolled in Head Start, we assessed children's EF (inhibitory control and attention shifting) using behavioral tasks and children's HLE (home language balance, home heritage language activities, home English language activities) using parent report. The study had two aims. First, we examined descriptive characteristics of HLE dimensions in DLLs from low-income CA and MA families (Aim 1). This aim included characterizing the demographic variables that showed unique relations with HLE dimensions. Second, we tested whether the three features of HLE were uniquely associated with EF above and beyond covariates (Aim 2). Based on previous research showing significant associations between levels of language exposure and EF (Bosma et al., 2017; S. M. Carlson & Meltzoff, 2008), we hypothesized that greater amounts of home English and heritage language activities would each be associated with greater EF above and beyond covariates. We also expected greater language balance in the home to be uniquely associated with greater EF in light of studies showing similar findings (Crespo et al., 2019; Gathercole et al., 2010; Verhagen et al., 2017). We expected these associations to emerge for both inhibitory control and attention shifting, given that theoretical and empirical work has supported connections between dual language experience and both EF components (Gunnerud et al., 2020).

Methods

Participants

Participants consisted of 90 children (59% girls, age range = 38-68 months, M_{age} = 54.4 months, *SD*=7.06) and their parents from Spanish-speaking Mexican American families (MA; *N* = 46) and Chinese-speaking Chinese American families (CA; *N* = 44), who participated in a cross-sectional study on language and socioemotional development of dual language learners in Head Start preschool programs in the San Francisco Bay Area (Williams et al., 2018). Although Spanish speakers are the largest immigrant group in the U.S., the Chinese population has increased by over 40% from 2000 to 2015 (Pew Research Center, 2017), and both groups were equally represented in the Bay Area. The children had on average 14.4 months of Head Start attendance (*SD* =8.0, range=1-32 months). Of the participating children, 18% were first-generation (born outside of the United States), 77% were second-generation (born in the United States with at least one foreign-born parent), and 5% were third-generation or above (born in the United States and had two U.S.-born parents). The participating parents were on average 34.6 years of age (range = 21 – 46 years, *SD* = 6.38) and had on average 10.9 years of education (range = 5-17 years, *SD* = 3.40). The parents had lived in the United States for 9.2 years on average (*SD* = 6.2, range = 0-28 years), and had an average annual per capita income (total estimated income divided by household size) of $5,167 (*SD* = $3,655, range = $1,000 to $24,167). The parents were born

in the United States (9%), China (46%), Mexico (43%), and other parts of the world (2%). Full sample characteristics are detailed in Table 1.

Independent samples *t*-tests were used to compare language groups (Spanish-speaking MA families vs. Chinese-speaking CA families) on continuous demographic variables. MA and CA families were matched on child age, child age of English acquisition, child's length of schooling in Head Start, parental education, and per capita income. Pearson chi-square tests of independence were used to compare cultural groups on categorical variables. There was no language group difference in child gender, but there was a significant difference in distributions of child generation status by language groups ($\chi^2(2)=23.4$, $p<.001$). Specifically, the CA group was comprised of 36.4% first-generation and 63.6% second-generation children, while the MA children were 89.1% second-generation and 10.9% third-generation. This aligns with U.S. population trends showing that Asian-Americans are more likely to have immigrated recently (Pew Research Center, 2012).

Procedures

The sample was recruited from Head Start preschool centers serving high concentrations of CA or MA families using study flyers (available in Chinese, Spanish, and English) given to parents at monthly parent meetings or during the pick-up or drop-off time. The project was described as a research study to understand language and emotional development of children in Chinese American and Mexican American families. To be eligible for the study, the child must: (a) be between 36 and 71 months of age; (b) be currently enrolled at a Head Start center for a minimum of three days per week; (c) understand and speak some English and Spanish, Cantonese, or Mandarin; (d) have at least one biological parent that self-identified as ethnically Chinese or Mexican. Children who were diagnosed with a speech or language disorder or receiving speech or language services were excluded from the study. After screening a total of 194 families (106 CA, 88 MA), 132 were deemed eligible and of these 90 (44 CA, 46 MA) families completed the assessment.

Eligible families were given the option to complete assessment procedures at home or at university lab given the limited transportation options for low-income families. Of the 90 participating families, 29 (32%) chose a home assessment and 61 (68%) chose a lab assessment. The primary caretaker participating in the study with the child consisted of 98% mothers and 2% fathers. Before beginning the assessment, all parents provided informed consent for all aspects of the study in their preferred language. After obtaining consent, a 10-minute observation was conducted to confirm the child's dominant language with the parent's report during the phone screening, whereby two trained research assistants presented the child with a set of toys (coloring kit and play-doh). One research assistant asked the child questions in English, while the other asked questions in the child's heritage language – the dominant language was confirmed to be the language that elicited the most responses from the child. Child assessments consisted of EF and language tasks counterbalanced for each participant. Children were administered the EF tasks in their dominant language (18% English and 82% heritage language – Spanish or Chinese). In a separate area and concurrent with the child assessment, parents completed surveys in their preferred language (10% English and 90% heritage language). Upon completion of all of the

assessments (approximately 2.5 hours), children received a small prize and parents received $70 for participation.

Measures

Home language environment (parent report)—HLE was assessed with parent questionnaire items. Research suggests that home language balance and language activities are important components of the HLE. We measured three components of HLE: home language balance, home heritage language activities, and home English language activities.

Home language balance.: Home language balance was measured by questions asking about the language spoken most frequently between various dyads in the home (among adults, mother to child, father to child, and other adult to child). Using a scale similar to other studies on the HLE in DLL children (Collins, 2014; Lewis et al., 2016), language use among each dyad was rated on a 1 to 5 scale as *Only Chinese/Spanish* (1), *Chinese/Spanish and English but More Chinese/Spanish* (2), *Chinese/Spanish and English equally* (3), *Chinese/Spanish and English but more English* (4), and *Only English* (5). Cronbach's alpha indicated language use was moderately consistent across the different dyads (α = 0.76). Scores were averaged to yield one home language use variable with a minimum score of 1 (only heritage language) and a maximum score of 5 (only English). To index degree of language balance, the absolute value of the difference of this average score from 3 (equal use of heritage language and English) was computed, and numbers were multiplied by negative one so that more positive values approaching 0 indicate greater language balance, while more negative values represent more dominant use of one language at home.

Home English and heritage language activities.: Home English and heritage language activities were measured using items asking about home language use from the Cultural and Social Acculturation Scale (X. Chen & Tse, 2010). Parents indicated the frequency that their child heard English or their heritage language as a result of 5 sources (books, movies, radio, TV, music) on a scale of 1 (*almost never*) to 6 (*almost every day*). In line with Paradis and Jia's (2017) approach, language activity scores were calculated by summing item responses in the given language and dividing that by the maximum number of points possible to yield a score between 0 and 1, with higher scores indicating more frequent language activities. Because English and heritage language activities are conceptualized and measured as separate dimensions, scores are not inverses of each other (i.e., an English language activity score of .4 does not indicate a Spanish language activity score of .6). Cronbach's alphas indicated relatively modest internal consistency for the 5 items asking about English language activities (α = 0.68) and the 5 items on heritage language activities (α = 0.59).

Executive functions (cognitive tasks).—Two tasks from the Preschool Executive Functions Assessment (M. T. Willoughby et al., 2010) were individually administered to the child: Silly Sounds Stroop (SSS) and Something's the Same (STS). The SSS task measures inhibitory control, the child's ability to inhibit a dominant response. The STS task measures attention shifting, the ability to flexibly shift between distinct but related dimensions of a given task. Inhibitory control and attention shifting were chosen as EF constructs as these

dimensions have shown particular relevance and developmental sensitivity for preschool children (S. Carlson, 2005). These tasks have also shown reliability and validity in previous studies of Chinese-speaking and Spanish-speaking preschoolers (White & Greenfield, 2017; Xing et al., 2019). Each task lasted approximately 5 minutes and was performed in the child's dominant language.

The SSS task is based on the Day-Night task developed by Gerstadt, Hong, and Diamond (1994). Children were presented with pictures of a cat and a dog and asked to produce what sounds they make. The assessor then introduced to the child that in this game, dogs make the sounds of cats ("meow") and cats make the sounds of dogs ("woof"). Next, the assessor presented 36 side-by-side illustrations of a cat and dog and, pointing to each picture, asked the child what sound this animal made. Responses were marked either correct (i.e. dogs "meow" and cats "woof") or incorrect (other responses including self-corrections). The final score represented the number of times children paired the sound and picture correctly. When used with preschool-aged children, this task has shown adequate test-retest reliability (r=.52; Willoughby & Blair, 2011) and criterion validity with other EF and academic achievement tasks (Willoughby, Blair, Wirth, & Greenberg, 2012). In the present study, the split-half reliability of SSS items was estimated to be .85 for the full sample using the Spearman-Brown coefficient (CA=.88, MA=.76). Of the full sample of 84 children that completed this task, 6 (6.7%) performed at ceiling (100% accuracy).

The STS task is derived from Jacques & Zelazo's (2001) flexible item selection task. Children were shown a page containing two pictures that matched along one dimension (i.e. color, size, or content). The assessor explicitly stated the dimension of similarity, and then presented a page with the same two pictures plus a novel third picture. The third picture was similar to one of the first two pictures in a dimension that was not stated by the experimenter (e.g. if the stated dimension was shape, the third picture might match one of the first two in color). Children were asked to identify which of the two original pictures the new picture was similar to (using the unstated dimension of similarity). Thus, the task requires children to shift between dimensions of similarity. Responses were marked either correct or incorrect, and 20 total trials were presented. Using the Spearman-Brown coefficient, the split-half reliability of STS items was .70 for the full sample (CA=.75, MA=.65). Of the full sample of 89 children that completed this task, 10 (11.1%) performed at ceiling. Importantly, both the SSS and STS tasks have shown equivalent item functioning for children in low and middle-to-high income homes (Willoughby et al., 2012). In other words, each item in the task relates to overall task performance in a similar manner for children regardless of family income, rendering the task appropriate for use with children from low-income backgrounds. There was no significant difference between children who performed the tasks in English (N=16) compared to those who completed tasks in their heritage language (N=74; p>.05).

Family socio-cultural characteristics (parent report).—The Family Demographics and Migration History Questionnaire was adapted for use in the present study, and has been used in prior studies involving Chinese American and Mexican American immigrant families (S. H. Chen et al., 2014; Roosa et al., 2008). For each family, one parent (the primary caregiver) completed the questions. The questionnaire included items indexing the child's age, child's gender, child's age of English acquisition, parent's age, parent's country

of birth and length of stay in the United States, and race/ethnicity of parents and children. A question was added to also ask about the child's length of schooling in Head Start.

Socio-economic status was measured by questions asking about parents' education, family annual income, and household size. Parents' education was obtained by asking about each parent's highest level of education (number of years) they had completed. A single parental education variable was used in analysis, computed by averaging maternal and paternal education for each child. Annual per capita income was calculated by dividing the estimated total household income over the past year by the household size.

Receptive vocabulary (direct assessment).—Children's receptive vocabulary in English was measured using the Peabody Picture Vocabulary Test 3rd edition (PPVT-III; Dunn & Dunn, 1997). In this task, children nonverbally selected a picture from an array of four pictures that matched a word verbally presented by the research assistant. Raw scores from this task were used in analyses. Children's receptive vocabulary in their heritage language was measured by equivalent assessments in either Spanish for the MA children (*Test de Vocabulario en Imágenes-Peabody*; Dunn et al., 1986) or Cantonese or Mandarin for the CA children (Peabody Picture Vocabulary Test-Revised; Lu & Liu, 1998). Raw scores representing the sum of correct items were used in analyses.

Results

Missing data

Out of the 90 participants, complete data (N=90) were available for most of the demographic variables and all HLE variables. Data for some participants were missing for child length of schooling in Head Start (N=1, 1%), child receptive English vocabulary (N=3, 3%), child receptive heritage language vocabulary (N=8, 9%), per capita income (N=4, 4%), inhibitory control (N=6, 7%), and attention shifting (N=1, 1%). Evaluation of data collection procedures led us to conclude that the data were not missing completely at random (MCAR), and Little's MCAR test (Little, 1988) suggested the data did not violate the MCAR assumption ($\chi^2(33)=34.70$, p=.387). Thus, missing data were handled using the full information maximum likelihood (FIML) estimation in Mplus Version 8 (Muthén & Muthén, 2019). For descriptive statistics and independent samples t-tests, analyses were conducted in SPSS Version 25.

Descriptive statistics and language group comparison on demographic variables

Descriptive statistics and comparison of language groups on demographic and study variables are displayed in Table 1. All variables except per capita income were within acceptable values of skewness and kurtosis (Kline, 2015). The kurtosis of the per capita income represents a high concentration of low-income families, which was expected given the families' enrollment in Head Start. Per capita income was log-transformed for use in analysis, which reduced skewness to .037 and kurtosis to .282.

Relations between socio-demographic variables and HLE and EF

In order to select covariates for the analysis examining unique relations of HLE variables to EF variables (Aim 2), full information maximum likelihood (FIML) correlations were computed between study variables (HLE and EF) and socio-demographic variables (parental education, child age, child age of English acquisition, child's length of schooling in Head Start, child generation, child gender, and child vocabulary in English and heritage language). Independent samples t-tests and ANOVAs were used to examine relations between categorical variables (DLL group, child gender and child generation) and study variables. As indicated in Table 1, greater home language balance ($t(88)=2.17$, $p=.031$) and home heritage language activities ($t(88)=2.87$, $p=.005$) were observed in MA families as compared to CA families. In terms of EF, children from MA families showed greater performance on the inhibitory control task ($t(82)=3.33$, $p=.001$). Child generation was related to HLE and EF such that, as child generation in the U.S. increased from 1st to 3rd, home English activities ($F(89)=3.59$, $p=.032$), home language balance ($F(89)=4.20$, $p=.018$), and attention shifting ($F(88)=3.75$, $p=.028$) also increased. As displayed in Table 2, parental education was positively correlated with HLE (home English language activities), but not with EFs. Per capita income was positively correlated with all aspects of HLE. Child age was positively correlated with both inhibitory control and attention shifting. Age of child's English acquisition was correlated negatively with HLE (household language balance and home English language activities) and negatively with EF (attention shifting). Child English receptive vocabulary was positively correlated with HLE (home English language activities and home language balance) and EF (attention shifting).

Following the suggestion of Steiner, Cook, Shadish, and Clark (2010), and to preserve parsimony, we included variables from our list of hypothesized covariates as actual covariates in subsequent analyses if they were significantly correlated with both the predictor and the outcome. Therefore, age of child's English acquisition, child generation, child's English receptive vocabulary, and DLL group were included as covariates in analyses testing Aim 2.

Analyses for Aim 1: Descriptive Characteristics of HLE and Relations with Demographic Variables

Home Language Balance—Descriptive statistics, correlation analyses, and regressions were computed to examine characteristics of the HLE (the range of home language balance among families and the frequencies of home language activities) as well as demographic variables that might relate to the HLE. In terms of language balance, most of the language between adults in the home was only heritage language (Chinese or Spanish) (88.9%), with a few parents reporting that mostly heritage language (6.7%), heritage language and English equally (2.2%) and more English (2.2%) were used. Mothers indicated speaking to their child in only heritage language (61.1%), more heritage language (28.9%), heritage language and English equally (4.4%), more English (3.3%), and only English (1.1%). Fathers spoke to their child in only heritage language (58.9%), more heritage language (27.8%), heritage language and English equally (6.7%), more English (2.2%), and only English (1.1%). Families reporting language from another adult in the home to the child ($N=78$) indicated use of only heritage language (66.7%), more heritage language (6.7%),

heritage language and English equally (8.9%), more English (2.2%), and only English (2.2%). The language balance composite with 0 representing complete balance ranged from −2.00 to −0.25, indicating that no families reported an exactly equal balance between using their heritage language and English in the home. The indexes for language activities from media/activity sources were similar for English and heritage language (0.60 compared to 0.58, respectively). No families reported a complete lack of language activities in either language.

Home Language Activities—The average frequency of each of the types of language activities (music, TV, radio, movies, books) in English and the child's heritage language are displayed in Figure 1. The most common child language activity reported in both the heritage language and English is watching TV (Means = 4.20 and 4.70, respectively). The least common language activity in the heritage language reported is reading books (M=2.53), while the least common activity in English is listening to the radio (M=2.55). Overall, parents report a greater frequency of the child listening to music and the radio in the heritage language as compared to English, and a greater frequency of the child watching TV, movies, and reading books in English as compared to the heritage language.

Correlations Between Demographic Variables and HLE—As noted from the FIML correlations discussed above, greater parental education was correlated with greater home English language activities, but not with home heritage language activities or language balance. Per capita income was positively correlated to all HLE variables, with higher income families reporting greater English language activities, heritage language activities, and language balance at home. Age of English acquisition was associated with home English language activities and home language balance, such that the older children were when they learned English, the fewer home English language activities they participated in and the less balanced their home language exposure was. Children's receptive vocabulary in English was correlated with greater English language activities as well as greater household language balance – heritage receptive vocabulary was not correlated with any HLE variable. The child's length of schooling in Head Start was also not correlated with any HLE variable.

According to an independent samples t-test, gender differences were not observed in any aspect of the HLE. There were differences by DLL group, such that greater home language balance ($t(88)=2.17$, $p=.031$) and home heritage language activities ($t(88)=2.87$, $p=.005$) were observed in MA families as compared to CA families. Differences in home English activities ($F(89)=3.59$, $p=.032$) as well as home language balance ($F(89)=4.20$, $p=.018$) – but not home heritage language activities – were observed based on child generation according to a one-way ANOVA. Specifically, first generation children (children born outside of the U.S.) had fewer home English activities (M=0.50) than second generation children (M=0.62; children with parents born outside of the U.S.) and third generation children (M=0.74; children with grandparents born outside of the U.S.). The homes of third generation children were more language balanced (M=−0.97) than those of second (M=−1.64) or first (M=−1.67) generation children.

Unique Associations between Demographic Variables and HLE—To investigate the unique associations between demographic variables and HLE components, regression

models were conducted with all variables that correlated with HLE components as predictors. As displayed in Table 3, in the model predicting home language balance, child age of English acquisition and language group emerged as significant predictors beyond per capita income, child generation, and child English receptive vocabulary. In the model predicting home English activities, child English receptive vocabulary and parental education emerged as significant predictors beyond per capita income, child age of English acquisition, and child generation. Because language group was the only demographic variable that correlated with home heritage language activities, a regression predicting home heritage language activities was not conducted.

Analyses for Aim 2: Testing the unique relations of HLE components to EFs

To test the hypothesized positive relations between HLE variables and EFs, we examined correlations between HLE and EF variables and conducted a regression model to control for potential covariates. Correlational analyses revealed some associations between HLE and EFs in expected directions. As observed in Table 2, greater household language balance was correlated with higher inhibitory control, but it showed no significant correlations with attention shifting. Similarly, greater home heritage language activities were correlated with higher inhibitory control, but showed no significant correlations with attention shifting.

To test the unique relations of HLE components to EFs, two multiple regressions were conducted with inhibitory control and attention shifting as outcomes (Table 4). In both regressions, the predictors included all HLE variables (household language balance, home English language activities, and home heritage language activities) and covariates (child age of English acquisition, child generation, child English receptive vocabulary, and DLL group). Sensitivity analyses indicated no change in our results when we removed nonsignificant covariates from our models. In addition, results did not change when examining each of the HLE variables as separate predictors in three separate models. Therefore, to preserve statistical power, the most parsimonious models are reported as final models in Table 4. Regression outliers were examined with Cook's Distance and no outliers were found based on the cutoff value of 1. There was no evidence for multicollinearity, as indicated by tolerance values greater than 0.1 and VIF values lower than 10 (Hair et al., 2010). For the regression predicting inhibitory control, no HLE variable emerged as a significant predictor. In terms of covariates, DLL group emerged as a significant predictor of inhibitory control: Mexican American children scored higher than Chinese American children on the inhibitory control task. For the regression predicting attention shifting, home heritage language activities emerged as a positively significant predictor. In terms of covariates, child English receptive vocabulary positively predicted attention shifting.

Discussion

The goals of the present study were to characterize the HLE in Mexican American (MA) and Chinese American (CA) children enrolled in Head Start and examine the associations between HLE and children's EF. Results revealed that relatively more heritage language was used in the home, and that several demographic variables (parental education, per capita income, DLL group, child age of English acquisition, child generation, child English

receptive vocabulary) were related to various aspects of the HLE. Greater household language balance and home heritage language activities were correlated with higher inhibitory control. However, after controlling for covariates, the only unique significant link between HLE and EF was between home heritage language activities and attention shifting.

Characterizing the Home Language Environments of Mexican American and Chinese American Dual Language Learners

Home Language Balance—The descriptive analyses of the HLE showed that no families reported a completely equal balance of English and heritage language use among dyads in the home. Most (97.8%) families reported using more heritage language at home on average, with the remaining using more English. When examining language use patterns by speaker (mother, father, other adult), the relative proportion of language used was similar but not identical. Of note, a large proportion (87%) of families in the present study reported language use by another adult in the home, and for many families this adult was a grandparent. Although much attention has been paid to parental usage of language in the home influencing children's outcomes, future work should further investigate the influence of grandparent language use in the HLE and children's EFs. Some research suggested that the presence of grandparents may be more common in MA and CA families (Kataoka-Yahiro et al., 2004), and that grandparents may promote the use of heritage language in the home (Ishizawa, 2004).

In terms of language group and home language balance, MA families reported a relatively greater balance of English and heritage language use than CA families. This result could be partially due to differences in immigration history between MA and CA immigrants as a whole – CA immigrants are more likely to be recent immigrants than MA immigrants (Pew Research Center, 2012). Indeed, these population-level differences in immigration background are observed in our sample, whereby MA children were either 2nd generation (89.1%) or 3rd generation (10.9%), and CA children were either 1st generation (36.4%) or 2nd generation (63.6%). Studies have found that longer residence in the U.S. and being U.S.-born rather than foreign-born are associated with greater home English usage (Fry & Gonzales, 2008; Hammer, Jia, et al., 2011). The younger the child was first exposed to English, the greater balance (between English and heritage language) was observed in the HLE during preschool period. Therefore, the longer migration history of the MA families to the U.S. and a younger age of child's first exposure to English could parallel greater usage of English in the home, which might contribute to a more balanced home language usage.

Home Language Activities—Interestingly, although language usage in the home among adults primarily consisted of the heritage language, the relative amounts of home language activities in English and the heritage language were almost identical. These results suggest that home language activities do not precisely reflect the language balance within the home. One reason for this may be the availability of home language materials, which previous studies found to be connected to greater opportunities for children to engage in home language activities (Burgess, 2005; Farver et al., 2013; Frijters et al., 2000; Lewis et al., 2016), regardless of home language use. Another reason for this is that all children in the sample were enrolled in Head Start, which promotes parental awareness of the importance

of home language activities as part of its preschool curriculum (Bierman, Domitrovich, et al., 2008). In other words, regardless of the language primarily used in the home, parents could have supplemented their child's language learning through various activities in both languages. Research has also shown that engagement in home language activities is influenced by child interest in that language (Farver et al., 2006), or by parental beliefs regarding the importance of heritage language learning (King & Fogle, 2006). Our finding suggests that in addition to speech between household members, language activities provide an avenue to support DLL children's language development.

The present study aligned with prior work (Branum-Martin et al., 2014; Dollaghan et al., 1999; Rowe et al., 2005; Vernon-Feagans et al., 2019) in showing that greater parental education was uniquely associated with more overall language activities in English. However, this relation was not observed with activities in the heritage language, suggesting that heritage language usage may be less influenced by socioeconomic factors within the restricted range of a low-income sample. Children's receptive English vocabulary was also uniquely and positively associated with greater home English language activities. One explanation for this pattern is that parents calibrated the level of home English language activities based on the child's perceived English proficiency. This speculation is supported by empirical work suggesting that parents adapt the HLE to their child's language proficiency (De Houwer & Bornstein, 2016). Parental English proficiency – which was not measured in the present study – is another variable that could influence both home English language activities and children's English proficiency. Parents' English proficiency influences both the child's English proficiency (Hoff & Ribot, 2017) and the parents ability to provide quality interactions in language activities in English (Hammer et al., 2009). Future studies of the home language environment in DLLs should incorporate measures of parental English proficiency to investigate its relation to child English acquisition and activities.

MA families also reported more heritage language activities in the home as compared to CA families. It is important to note that the heritage language activity measure in the present study referred to language input received from sources other than routine daily speech from adults in the home, such as through language-rich interactions around book reading, TV, movies, and music. Previous research suggests that sources outside of routine adult speech are a significant source of language exposure for young DLLs (Place & Hoff, 2011). One possible reason why MA families reported more heritage language activities in the home could be because of greater availability of language materials, either due to the larger population of Spanish speakers (compared to Chinese speakers) or due to the longer migration history of MAs to the U.S. (compared to CAs). Researchers have found that there are more children's books in Spanish than in Chinese in the U.S. (Lambson, 2002). While the number of foreign language television shows in the U.S. has grown over the past two decades, the availability of Chinese television is estimated to be about a quarter of the amount of television available in Spanish (Coffey, 2008). These findings suggest that CA children in the present study may have been exposed to fewer heritage language activities than MA children because of limited availabilities of books and media in Chinese. The greater language balance observed in the homes of MA families as compared to CA families is an interesting area for future research. One possibility is that these differences

could be due to the greater complexity of the Chinese language. Spanish and English are more similar languages than Chinese and English (Liu et al., 2007), which may render using both languages in the household context easier. The present study did not focus on examining DLL group differences in HLE due to sample size limitations. However, in post hoc exploratory analyses, correlations between HLE variables and heritage language proficiency were stronger for the MA sample as compared to the CA sample. Future studies focusing on the mediating mechanisms of DLL group differences in HLE will be valuable for programs that serve DLLs from a range of language backgrounds.

Links Between Home Language Environment and Executive Functions

Inhibitory Control—Contrary to our hypothesis, none of the HLE variables were significant predictors of inhibitory control when controlling for language group. Research has observed connections between language exposure and composite measures of EF in preschool (Bindman et al., 2013; Daneri et al., 2019), suggesting that processing language recruits some of the same cognitive abilities as EF tasks (hierarchical competing systems model; Marcovitch & Zelazo, 2009). While these findings led us to hypothesize that language exposure through activities in either language would relate to inhibitory control, it is possible that our measurement of language activities was not sensitive enough. Specifically, prior studies have shown that the complexity of language exposure (as measured by utterance length, number of word types, etc.) relates to child EF (Hughes & Ensor, 2009; Sheridan et al., 2012), yet our study focused on a self-report measure of *quantity* of language activities. In addition, most studies on language exposure and EF in preschool have used composite measures of EF, precluding an understanding of whether and how language exposure relates to inhibitory control specifically. It is possible that some of the theorized mechanisms underlying how language exposure bolsters EF (opportunities for reflection, navigating a set of conditional grammatical and syntactical rules) relate more to EF outcomes such as working memory and shifting. Future studies will need to include measures of language complexity during various language activities, as well as multiple components of EF outcomes in order to address these possibilities.

Language group was a significant predictor of inhibitory control, with MA children outperforming CA children. The increased verbal demands may have rendered the inhibitory control task more difficult for Chinese American children, although because the task involved only two words this is not likely. Another possibility is that because the MA children had been in the U.S. longer on average, they may have been more accustomed to measures of performance that were developed in Western samples. Although the authors of the inhibitory control task validated it across children from different racial and ethnic groups (Willoughby et al., 2010), studies with larger sample sizes should consider testing for measurement equivalence across different immigrant and language backgrounds.

Our results also contrast with studies that have found links between more balanced dual language exposure and inhibitory control (Carlson & Meltzoff, 2008; Crespo et al., 2019; Verhagen et al., 2017). According to the adaptive control hypothesis (Green & Abutalebi, 2013), the experience of suppressing the nontarget language strengthens response inhibition abilities. Perhaps because our sample primarily used the heritage language at home, children

may have been accustomed to a primary home language and thus were not frequently required to inhibit a nontarget language. In other words, the restricted range of home language balance in our sample may have attenuated any relations with inhibitory control.

Attention Shifting—Consistent with our hypothesis, home heritage language activities emerged as a significant, unique predictor of attention shifting, controlling for household language balance, home English language activities, and child English receptive vocabulary. This relation may reflect the connection between absolute levels of language exposure and EF that has been observed in other studies of both monolingual and DLL samples (Bosma et al., 2017; Daneri et al., 2019; Hughes & Ensor, 2009; Sarsour et al., 2011). However, home English language activities was not a unique predictor of attention shifting. One possibility why home heritage language – but not English – activities related to attention shifting is that our sample was mainly comprised of sequential bilinguals who learned their heritage language first and English second. For these children, the home is the major context in which they are exposed to their heritage language, while Head Start is the context in which they are exposed to English. Thus, it is possible that these children were exposed to a higher quality of heritage language activities than English language activities at home, which was driving the significant relation between heritage language activities and children's attention shifting.

The finding that home heritage language activities related to attention shifting, but not to inhibitory control, warrants discussion. In theoretical and empirical studies linking language exposure to EF, one mechanism appears to be practice with the conditional "if then" thinking that language necessitates (Daneri et al., 2019; Kuhn et al., 2016). In processing language, children learn that syntax and grammar are governed by rules that shift under certain conditions. This rule-based shifting is similar to what is required of children in attention shifting tasks such as the one used in the present study, where children must adapt their responses to rules of color, shape, and size. Therefore, perhaps heritage language exposure at the preschool age taps into cognitive processes that are more related to attention shifting than inhibitory control.

The differential findings between the inhibitory control and attention shifting tasks could also be due to the fact that the inhibitory control task required a verbal response from children. This may have rendered the inhibitory control task a more difficult and less pure EF measure than the attention shifting task, in which no verbal response was required. Indeed, in our sample children performed less well on the inhibitory control task compared to the attention shifting task on average. Overall, our results concur with the notion that EF in children shows both unity (our EF measures are correlated) and separability (our EF measures show different relations with our variables of interest; Akira Miyake & Friedman, 2012). Other studies have also found different relations between measures of HLE and separate EF components in preschool children (Gunnerud et al., 2020; Verhagen et al., 2017), suggesting that there is utility in measuring multiple EF components within the same study.

Similar to the results with inhibitory control, we did not find the expected association between home language balance and attention shifting. We initially hypothesized this

relationship given theoretical and empirical evidence that switching between two languages confers general advantages in flexibly shifting between different sets of rules (Prior & MacWhinney, 2010). Importantly, however, connections between the dual language experience and attention shifting are stronger for children who switch between languages within the same context (Carlson & Meltzoff, 2008). The characteristics of the HLE in our sample indicate that families primarily used the heritage language at home, and children were likely exposed to primarily English at school. Thus, perhaps because children were not extensively switching between languages in the same context, associations between home language balance and attention shifting did not emerge.

Limitations and Implications

The present study has several limitations. First, the study was cross-sectional, so developmental changes in examined relationships cannot be determined. Although the directionality of HLE predicting EF makes theoretical sense, we acknowledge that these predictors may not be static. There may be a bidirectional relationship between EF and HLE, as some studies have suggested that EF can predict child language skills (Bohlmann et al., 2015; Slot & Von Suchodoletz, 2018). Second, the study's statistical power is limited by its small sample size, and does not allow us to conduct mediation analyses to determine which processes (e.g., language, cultural beliefs, measurement issues) are driving group differences in HLE and EF. Third, only two behavioral tasks were used to measure children's EF. Although this concurs with the unitary view of EF among young children (Hughes, Ensor, Wilson, & Graham, 2009), using a larger battery of EF tasks can help reduce measurement error. Another issue related to measurement of EF in our study is the relatively wide age range of our sample (36-68 months). This period is a time of rapid EF development, and reflecting this, age was correlated with EF performance in our sample. However, because age was not significantly correlated with HLE, the wide age range of the study is unlikely to significantly influence study results. Fourth, although not a main focus of the present study, our measurement of children's heritage language receptive vocabulary in Chinese has not been formally validated for use with a Chinese American sample. Instead, this task (the Chinese PPVT; Lu & Liu, 1998) was validated and normed on Chinese-speaking participants in Taiwan. Although the study authors consulted with Chinese language experts to check if adaptations were needed, we acknowledge that the task was likely still difficult for our Chinese American participants. Thus, the lack of correlations between heritage language receptive vocabulary and our HLE variables may be due to the lack of equivalence between the Spanish and Chinese versions of the PPVT. Finally, our measurement of HLE was based on parental report of the relative amount of each language used by adults in the home, as well as language children hear from other sources. This approach may be subject to reporting biases, and provides a less nuanced understanding of home language environment compared to approaches that objectively measure the number of words children hear in the home (e.g. Brushe et al., 2020).

Despite these limitations, our study has notable strengths and implications for research and policy. First, our sample included two DLL, ethnic-minority groups matched on SES. This design offers an advantage over studies comparing low-income, DLL, ethnic-minorities to middle-income, monolingual, majority groups, which makes it difficult to examine the

unique effects of language exposure. Our approach of including two DLL groups aligns with calls for research examining commonalities across DLLs and factors unique to certain DLL groups (Hammer, Jia, et al., 2011). Second, although our conceptualization of HLE was limited, we included measurement of language activities in both English and heritage languages as well as household language balance. Research on the HLE of ethnic-minority and DLL children lags behind that of monolingual children (Lewis et al., 2016), and the present study is a step in the direction of better understanding the DLL home context.

This study has implications for programs such as Head Start that serve families in poverty – over a quarter of whom raise DLL children from a range of cultural backgrounds (Child Trends Databank, 2017). Our findings show that among preschoolers from low-income families, there is still considerable variability in school readiness indicators (HLE and EF). Among DLLs, families who have more recently immigrated have lower home English activities, perhaps indicating that these children may need more English language supports. Socioeconomic factors were also only related to English language activities. Families' abilities to provide heritage language exposure regardless of socioeconomic factors is a strength that can be leveraged when working with low-income families – for example, by suggesting learning activities that parents can complete with their children in their heritage language, as well as providing workshops to parents about the significance of engaging with children in heritage language activities. Heritage language activities were uniquely related to children's attention shifting, suggesting the potential benefit of quality heritage language exposure for DLLs' EF development. The finding that DLLs in Chinese-speaking homes were exposed to fewer heritage language activities than those in Spanish-speaking homes suggest that Chinese-English DLLs might need greater support in heritage language development (e.g., accessibility to Chinese learning materials at home). Thus, home language interventions should be tailored to address language-unique challenges of diverse DLL families. Overall, findings highlight rich heterogeneity within and between DLL groups, and suggest that interventions for DLLs are likely to be more effective when they build on families' specific language backgrounds.

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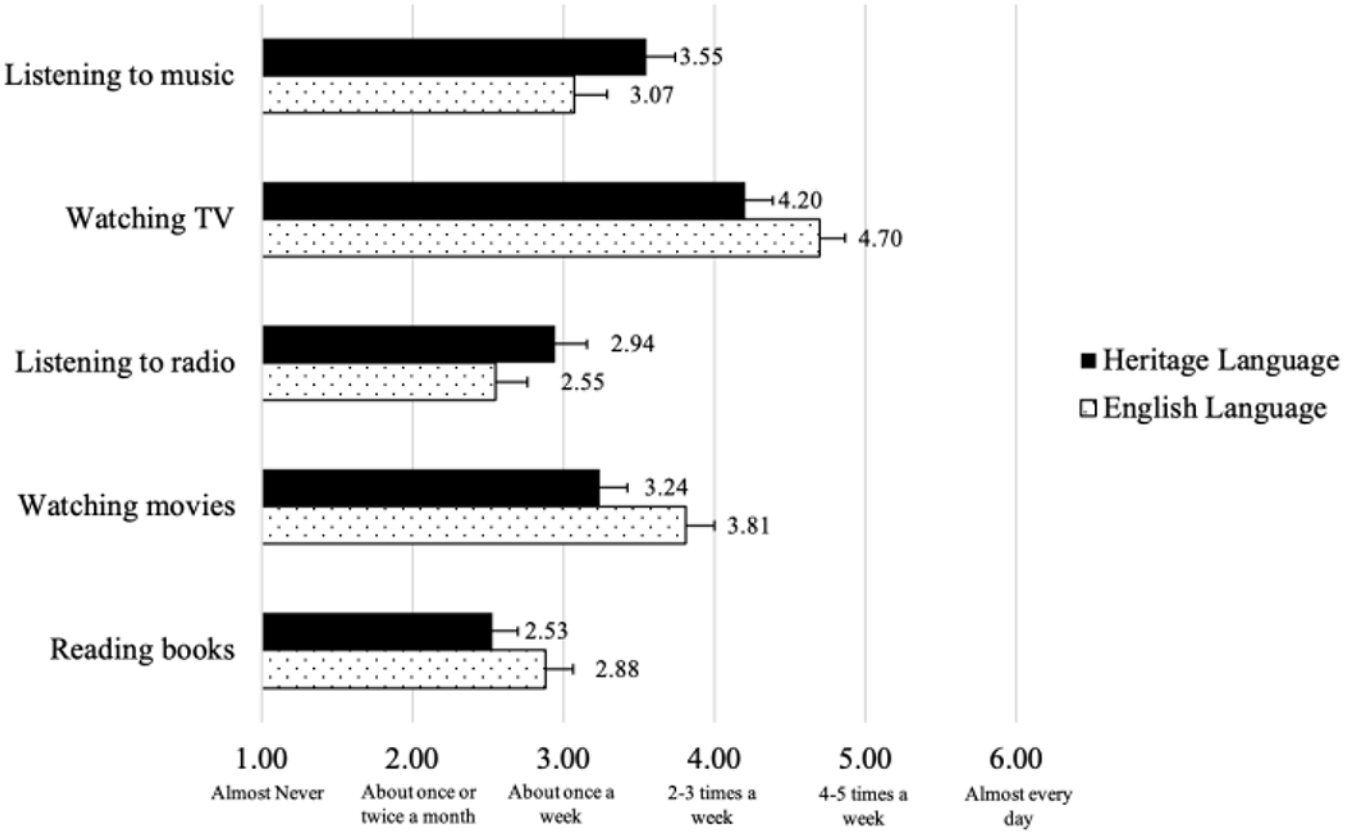

Figure 1.

The frequency of each of the home heritage language (black) and English language (dotted) activities that children engage in as reported by parents. Means of the sample for each item are displayed, with error bars representing standard error.

Table 1.

Descriptive statistics of demographics, covariates, and study variables for full sample and by cultural group.

	Full Sample						Mexican American		Chinese American	
	Min	**Max**	**Mean**	***SD***	**Skewness**	**Kurtosis**	**Mean**	***SD***	**Mean**	***SD***
Demographics & Covariates										
Child's age (months)	38	70	54.37	7.11	−0.09	−0.94	55.22	6.96	53.48	7.23
Child's age of English acquisition (months)	0	60	24.69	15.04	−0.21	0.25	25.70	15.93	23.64	2.14
Child's length of schooling in Head Start (months)	1	38	14.96	8.60	0.49	0.26	14.60	7.20	14.27	8.76
Child's English receptive vocabulary (raw)	1	80	34.07	19.03	0.10	−0.93	34.73	19.03	33.40	19.24
Child's heritage language receptive vocabulary (raw)	3	88	26.38	14.78	1.28	2.78	26.36	14.15	26.41	15.72
Socio-economic Status										
Parental education (years)	2.50	17	10.31	3.74	−0.42	−0.75	10.28	0.48	10.34	3.43
Per capita income (dollars)	1,000	22,500	5,118	3,457	2.37	8.30	4,624	598	5,590	514
Home Language Environment										
Home English Language Activities	0.20	1.00	0.60	0.21	0.22	−0.78	0.62	0.21	0.59	0.20
Home Heritage Language Activities **	0.23	1.00	0.58	0.18	0.21	−0.71	0.63	0.18	0.53	0.17
Home Language Balance [a] *	−2.00	−0.25	−1.60	0.53	1.34	0.81	−1.49	0.61	−1.73	0.41
Executive Function										
Inhibitory control (% accuracy) **	0.03	1.00	0.64	0.28	−0.54	−0.72	0.73	0.21	0.54	0.31
Attention shifting (% accuracy)	0.30	1.00	0.77	0.16	−0.56	−0.15	0.79	0.02	0.74	0.18

Notes.

[a]Household language balance: a higher score means more balanced in heritage and English language exposure; variables with star(s) indicate significant mean differences between the two cultural groups based on independent samples *t*-tests:

*$p<.05$;

**$p<.01$;

***$p<.005$

Table 2.

Full information maximum likelihood (FIML) correlations between demographics, covariates, and study variables.

	1	2	3	4	5	6	7	8
Socio-economic Status								
1. Parental education (years)	-							
2. Per capita income (dollars)	.24*	-						
Cultural Group								
3. Language Group (0=Spanish, 1=Chinese)	.18	.18	-					
Home Language Environment								
4. Home Language Balance [a]	.08	.25*	−.23*	-				
5. Home English Language Activities	.27*	.28*	−.01	.40***	-			
6. Home Heritage Language Activities	.11	.20†	−.29*	.22†	.31**	-		
Executive Function								
7. Inhibitory control (% accuracy)	−.01	−.03	−.36**	.27*	.12	.24*	-	
8. Attention shifting (% accuracy)	−.02	.21†	−.14	.10	.20†	.16	.28*	-
Demographics & Covariates								
10. Child's age (months)	−.00	.09	−.11	.22†	.12	−.05	.23*	.45**
11. Child's age of English acquisition (months)	−.21†	−.21†	−.15	−.27*	−.39***	−.02	.01	−.21†
12. Child's length of schooling in Head Start (months)	.12	.04	−.04	.01	.13	−.01	.18	.17
13. Child's gender (0=Female, 1=Male)	.05	−.11	.10	−.04	−.03	−.03	−.24*	−.27*
14. Child's generation (1=1st, 2=2nd, 3=3rd)	−.10	.24*	−.50***	.32**	.29*	.16	.17	.32**
15. Child's English receptive vocabulary (raw)	−.02	.15	−.03	.26*	.45***	−.10	.12	.47***
16. Child's heritage language receptive vocabulary (raw)	.07	−.03	.03	−.12	−.11	.15	.01	.19

[a]Household language balance: a higher score means more balanced in heritage and English language exposure;

†=$p<.10$;

*=$p<.05$;

** $=p<.01$;

*** $=p<.005$

Table 3.

Multiple regression predicting HLE from all correlated sociodemographic variables.

	DV: Home Language Balance [a]		DV: Home English Activities	
Predictors	***B* (*SE*$_B$)**	**β**	***B* (*SE*$_B$)**	**β**
Per Capita Income	0.27 (0.16)	0.19	0.06 (0.06)	0.10
Child Age of English Acquisition	−0.00 (0.00)	−0.23 *	−0.00 (0.00)	−0.18
Child Generation	−0.09 (0.14)	−0.09	0.06 (0.04)	0.14
Child English Receptive Vocabulary	0.00 (0.00)	0.10	0.00 (0.00)	0.35 ***
Language Group (0 = Spanish, 1 = Chinese)	−0.28 (0.13)	−0.29 *	--	--
Parental Education	--	--	0.01 (0.01)	0.24 *
Adjusted R^2	0.15 *		0.36 ***	

[a] Household language balance: a higher score means more balanced in heritage and English language exposure; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficient;

† = p<.10

* p < 0.05

** p < 0.01

*** p<.001.

Table 4.

Multiple regression predicting EF from all HLE variables and covariates.

	DV: Inhibitory Control		DV: Attention Shifting	
Predictors	***B (SE$_B$)***	**β**	***B (SE$_B$)***	**β**
Household Language Balance [a]	0.09 (0.06)	0.17	−0.02 (0.03)	−0.07
Home English Language Activities	−0.04 (0.16)	−0.03	−0.08 (0.10)	−0.10
Home Heritage Language Activities	0.16 (0.17)	0.11	0.22 (0.09)	0.25*
Language Group (0 = Spanish, 1 = Chinese)	−0.16 (0.06)	−0.28**	--	--
Child English Receptive Vocabulary	--	--	0.01 (0.00)	0.57***
Adjusted R^2	0.16*		0.30***	

[a]Household language balance: a higher score means more balanced in heritage and English language exposure; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficient;

†=p<.10

*p < 0.05

**p < 0.01

***p<.001.