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Off to a good start: Early Spanish-language processing efficiency supports Spanish- and English-language outcomes at 4½ years in sequential bilinguals

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Abstract

Many Latino children in the U.S. speak primarily Spanish at home with few opportunities for exposure to English before entering school. For monolingual children, the strongest early predictor of later school success is oral language skill developed before kindergarten. Less is known about how early oral language skills support later learning in sequential bilingual children. A question with wide-reaching significance is whether skill in a child's first language (L1) supports later learning in a second language (L2). In this longitudinal study of sequential Spanish-English bilinguals, we assessed oral language skills in Spanish at 2 years through parent reports of vocabulary size and children's real-time language processing efficiency (Accuracy, RT) in the 'looking-while-listening' (LWL) task. At 4½ years, we assessed language outcomes in both Spanish and English using standardized tests. Reported relative exposure to each language was significantly correlated with language outcomes in Spanish and English. Within-language relations were observed between Spanish vocabulary size and processing efficiency at 2 years and later Spanish-language outcomes. Critically, across-language relations were also observed: Children with stronger Spanish-language processing efficiency at 2 years had stronger English-language skills at 4½ years, controlling for socioeconomic status and exposure to English. Children's early language processing efficiency in Spanish is associated with stronger real-time information processing skills that support maintenance of Spanish and learning in English when these children enter school. These results support the recommendation that primarily Spanish-speaking families should engage in activities that promote children's Spanish-language skills while also seeking opportunities for children to be exposed to English.

Keywords

language processing efficiency; pre-kindergarten outcomes; sequential bilinguals; Spanish-English bilinguals; vocabulary size

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CONFLICTS OF INTEREST
The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT
The data presented here are openly available at https://github.com/vmarchman/biltransfer.

1 | INTRODUCTION

Children's early ability to communicate effectively through language has cascading consequences for school success and achievements later in life (Bornstein, Hahn, & Putnick, 2016; Dickinson, Golinkoff, & Hirsh-Pasek, 2010; Morgan, Farkas, Hillemeier, Hammer, & Maczuga, 2015). Oral vocabulary is vital for constructing linguistic and conceptual networks, expanding world knowledge, strengthening problem solving and reasoning skills (Neuman, 2007), and is fundamental for later literacy development (August, Carlo, Dressler, & Snow, 2005; Carlo et al., 2004; Hulme & Snowling, 2014; Lervåg, Hulme, & Melby-Lervåg, 2018). While these links are well-established for monolingual children, the role of early oral language skill in building a foundation for later learning in bilingual children is less well understood. Some bilingual children learn two languages at the same time from birth (i.e. *simultaneous bilingualism*). However, others primarily speak a first language at home and have limited opportunities for exposure to the majority language until they reach school (i.e. *sequential bilingualism*). For sequential bilinguals, an open question is the extent to which a child's level of language skill in their first language (L1) transfers to later learning in a second language (L2). Here, we examined transfer effects in sequential bilingual children in the U.S. who were primarily learning Spanish at 2 years, but who had varying amounts of exposure to English at time of school entry. We asked whether early vocabulary knowledge and real-time language processing efficiency in Spanish was linked to their later language outcomes not only in Spanish but in English as well. Does children's skill in Spanish at 2 years predict language outcomes at 4½ years in both Spanish and English, above and beyond socioeconomic status (SES) and the extent of their exposure to each language?

1.1 | Language development in latino children

More than 12 million children in the U.S. speak a language other than English at home, with Spanish the most common non-English language (Kidscount, 2018). Because many of these children live in primarily Spanish-speaking homes with native Spanish-speaking caregivers, they may be exposed to English only after a substantial period in a Spanish-language environment. It is well established that children's level of exposure to a language is a strong predictor of development in that language (Cattani et al., 2014; Hurtado, Grüter, Marchman, & Fernald, 2014; Marchman, Martínez, Hurtado, Grüter, & Fernald, 2017; Place & Hoff, 2011). Indeed, Latino children with higher levels of English proficiency at kindergarten entry have been shown to make academic progress comparable to their monolingual English peers (Halle, Hair, Wandner, McNamara, & Chien, 2012). In contrast, Latino children with weaker English-language skills are significantly more likely to struggle in literacy and math (Reardon & Galindo, 2009). Although children who have had some exposure to English at home may enter school with modest English-language skills that are useful in social contexts, they may lack the language proficiency required to support higher-order learning in English (Hindman & Wasik, 2015).

1.2 | The importance of L1 proficiency

Research in several different languages has shown that a strong foundation in a child's L1 can support the learning of English as L2, as well as bolster academic accomplishments more generally (Cha & Goldenberg, 2015; Hammer, Jia, & Uchikoshi, 2011; Kim, Curby, & Winsler, 2014; Melby-Lervåg & Lervåg, 2011; Prevoo, Malda, Mesman, & Van Ijzendoorn, 2016; Takanishi & Le Menestrel, 2017; Winsler, Burchinal, et al., 2014; Winsler, Kim, Kim, & Richard, 2014). For example, according to Cummins (1979, 2008), bilinguals develop and operate on information in their two languages within a common processing system. Thus, proficiency in L1 may provide conceptual and linguistic frameworks for learning in L2 (August et al., 2005; August & Shanahan, 2006; Goodrich, Lonigan, Kleuver, & Farver, 2016). In studies of bilingual adults, there is considerable evidence that both languages are activated during real-time language production and comprehension, observed at all levels of the linguistic system, including phonological, semantic, and syntactic (Kroll, Bobb, & Hoshino, 2014; MacWhinney, 2012). Moreover, models of bilingual language development propose that both languages are co-activated within a dynamic system and influence each other over development (De Anda, Poulin-Dubois, Poulin-Dubois, Zesiger, & Friend, 2016).

However, the degree to which skills or knowledge in L1 will influence or 'transfer' to L2 depends on a variety of factors, including the level of proficiency achieved in L1, the particular domain assessed, and the degree of similarity across the two languages (Proctor, August, Carlo, & Snow, 2006). For example, scores on tests of language-specific vocabulary knowledge are generally uncorrelated across languages (Goodrich et al., 2016); however, children who score higher on language-general knowledge or metalinguistic skills, such as phonological awareness, in their native L1 are more likely to perform better on literacy-related tasks when tested in L2 (Dickinson, McCabe, Clark-Chiarelli, & Wolf, 2004; Verhoeven, 2007). Similarly, based on data from the Early Childhood Longitudinal Study-Kindergarten (ECLS-K), Relyea and Amendum (2019) report that stronger early Spanish reading skills were associated with greater growth in English reading skills. Studies have suggested that across-language transfer is more likely in bilinguals who are learning languages which are structurally similar and share many cognates, such as Spanish and English, compared to typologically or orthographically dissimilar languages, such as English and Chinese (Bialystok, Luk, & Kwan, 2005).

A strong foundation in L1 is also important for achieving and maintaining proficiency in both L1 and L2, which may itself confer additional social and cognitive advantages for learning (e.g. Cha & Goldenberg, 2015). Spanish-speaking children who attend bilingual preschool programs that offer continued support for the home language tend to be more successful in school than Latino children attending English-only preschools (Lindholm-Leary, 2012, 2014). Using data from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), Winsler, Burchinal, et al. (2014) report that children who were reported to use only their native L1 at home made stronger gains in English literacy skills than children living in families where a mix of languages were spoken. Moreover, children who maintain their Spanish while learning English are more successful at bridging the cultural gaps between home and school, and more likely to preserve connections to the values that are relevant to their home community (Oh & Fuligni, 2010; Tseng & Fuligni, 2000). In the long term, bilingualism may also enable future economic opportunities, as the demand for individuals who are proficient in both English and Spanish continues to increase in the U.S. in both low- and high-skilled positions (New American Economy, 2015). Finally, bilingualism has been linked to advantages in aspects of executive function, such as attention shifting and inhibitory control (Barac, Bialystok, Castro, & Sanchez, 2014; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008; Kroll et al., 2014; Thomas-Sunesson, Hakuta, & Bialystok, 2018). Executive function skills are considered beneficial for learning (e.g. McClelland et al., 2014; Morgan et al., 2019), although there is controversy over the extent of this advantage in bilinguals (de Bruin, Treccani, & Della Sala, 2015; Donnelly, Brooks, & Homer, 2019).

Just as monolingual children who enter school with strong oral language abilities are also stronger in school achievement (Morgan et al., 2015), sequential bilingual children who enter school with a solid foundation in L1 are more successful than those who enter school with weaker L1 language skills (August & Shanahan, 2006; Kim et al., 2014). In the words of Winsler, Burchinal, et al. (2014), ‘perhaps what is most important to general language development is not a particular language that is spoken at home, but that children receive rich exposure to at least one language at home, enabling them to build a strong linguistic foundation upon which other languages can be learned’ (p. 762). However, there is variation in how well native Spanish-speaking children perform on language assessments. For example, many Latino children from lower-SES Spanish-speaking communities score significantly lower on tests of native Spanish abilities than their higher-SES Spanish-speaking peers (Davison, Hammer, & Lawrence, 2011). More research is needed exploring the extent to which variation in early Spanish-language proficiency shapes trajectories of later language development in sequential bilingual children. Moreover, only a few studies have examined language abilities in toddlerhood at the early phases of language development in relation to later outcomes (Hoff, 2013; Morgan et al., 2015). Here, we assess early Spanish-language native proficiency at 2 years using both parent reports of vocabulary knowledge and an experimental measure of children’s efficiency in real-time lexical comprehension. We then explore links between these early Spanish-language skills and within-language outcomes in Spanish and across-language relations in English at 4½ years in sequential bilingual children.

1.3 | Assessing L1 Spanish-language abilities in toddlerhood

Around 18 months of age, children typically begin to produce recognizable words, although there are individual differences in how many words children can say and how quickly children build their productive vocabularies (Frank, Braginsky, Yurovsky, & Marchman, 2017). Estimates of children’s accumulated vocabulary knowledge, that is, vocabulary size, are often derived from parent report checklists, such as the English-language MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007) and its Spanish-language adaptation (Jackson-Maldonado et al., 2003). While parent reports of vocabulary size are widely used and predictive of later outcomes (Morgan et al., 2015), they capture estimates of the products of learning, and thereby, may only indirectly index the dynamic mechanisms involved in the process of early learning (Loi, Marchman, Fernald, & Feldman, 2017). Measures of online language comprehension, in contrast, capture children’s proficiency in processing the incoming speech signal and linking speech to referents in the world around them in real time. The ‘looking-while-listening’ (LWL) task (Fernald, Zangl, Portillo, & Marchman, 2008) is a well-established test of real-time spoken language comprehension. In this task, children look at pictures of objects (e.g. a baby and a dog) and speech directs their attention to one of the pictures (e.g. 'Where's the doggy?'). Language processing efficiency is reflected in two measures, accuracy (overall looking to the target picture) and speed (RT to shift from the distracter to the target picture).

Individual differences in monolingual children's spoken language processing efficiency have been linked to vocabulary development in children learning English (Fernald & Marchman, 2012; Fernald, Perfors, & Marchman, 2006; Law & Edwards, 2014) and Spanish (Hurtado, Marchman, & Fernald, 2007; Weisleder & Fernald, 2013), suggesting that efficiency in language processing may support word learning. More direct tests of this link have demonstrated that children who are more efficient in spoken language processing are better at anticipating a referent based on semantic information (Mani & Huettig, 2012), using knowledge of familiar words to learn novel words (Bion, Borovsky, & Fernald, 2013; Lany, 2018), and demonstrating sensitivities to mispronunciations of familiar words (Law & Edwards, 2014). However, a recent study found that these relations are more robust early in development and in children who have smaller productive vocabularies (Peter et al., 2019), suggesting that measures of vocabulary knowledge and real-time lexical processing may be capturing related, but distinct, learning mechanisms.

Moreover, several studies have demonstrated that early language processing efficiency also correlates with later non-verbal skills, such as problem-solving and working memory, in both typically developing (Marchman & Fernald, 2008) and clinical (Marchman et al., 2018) populations. While the precise mechanisms and direction of these effects are not well understood (Peter et al., 2019), these findings suggest that children's skill in early real-time spoken language processing is linked to many different processes, including language, attention, and working memory that are likely to support speed of information processing and knowledge development more generally.

A few studies have explored relations between language processing efficiency and vocabulary knowledge in children learning two languages at the same time. Using the LWL task, one study with Spanish-English simultaneous-bilingual 30-month-olds found that early processing efficiency in Spanish and in English were concurrently related to vocabulary size within each language, with little evidence for cross-language relations (Marchman, Fernald, & Hurtado, 2010). These findings were interpreted to suggest that efficiency in language processing was tightly linked to a child's vocabulary knowledge in a particular language, rather than reflecting language learning skill more generally. Similar findings were observed in somewhat younger French-English simultaneous bilinguals using a touch-based measure of comprehension (Legacy, Zesiger, Friend, & Poulin-Dubois, 2016). At the same time, there is substantial experimental evidence that lexical-semantic and phonological representations are shared across languages during real-time language comprehension, even at early ages (e.g. Singh, 2014; Von Holzen & Mani, 2012; see De Anda, Poulin-Dubois, et al., 2016, for review). Thus, in young simultaneous bilingual children who frequently use two languages at the same time, real-time access to multiple languages may support conceptual and linguistic development both within and across languages from early in development.

However, much less is known about the extent to which languages interact in children who begin to learn L2 after they have been immersed in L1 for several years. In sequential bilinguals, the relations across languages might show a different pattern than those seen in simultaneous bilinguals given differences in the timing of exposure to L2 and in potentially asymmetrical proficiency in the two languages. Moreover, while there is evidence to suggest that L1 proficiency assessed by standardized tests during the preschool years is related to later L2 learning (e.g. Winsler, Kim, et al., 2014), less is known about potential links between proficiency in L1 and later language outcomes when assessed in toddlerhood. Moreover, no studies to date have explored within- versus across-language relations between L1 proficiency as measured by both accumulated language knowledge (i.e. vocabulary size) and language processing efficiency. Evidence for transfer effects in vocabulary size would suggest that the products of early word learning in L1 have implications for later language learning in L2. Transfer effects in processing efficiency would suggest that the learning processes involved in building a foundation in real-time language comprehension support later language learning. Language processing efficiency has also been linked to later non-verbal skills, such as working memory and attention. Thus, accuracy and speed of processing may be capturing a host of general information processing skills that may support real-time language use.

1.4 | The current study

This longitudinal study of sequential Spanish-English bilinguals explores within- and across-language links between Spanish-language vocabulary size and language processing efficiency at 2 years and a composite of receptive and expressive language skills both in Spanish and in English at 4½ years. The participants were Latino children in the U.S. who were primarily Spanish-speaking at 2 years but who had varying degrees of exposure to English just prior to entering school. We addressed two major research questions:

- First, are there *within-language* relations between early vocabulary size and language processing efficiency (accuracy and RT) assessed at 2 years and language outcomes at 4½ years in the children's native Spanish, after controlling for SES and degree of exposure to Spanish? If so, do vocabulary size and language processing efficiency make independent or overlapping contributions to outcomes?
- Second, are there *across-language* relations between early vocabulary size and language processing efficiency (accuracy and RT) in Spanish at 2 years and children's language skill in English at 4½ years? That is, does individual variation in vocabulary knowledge and processing skill in Spanish at 2 years predict children's ability in English at pre-kindergarten, after controlling for SES and degree of exposure to English? If so, do these factors each contribute uniquely to English-language outcomes at 4½ years?

2 | METHOD

2.1 | Participants

Participants were children from Spanish-speaking families (n = 95, 41 males; 54 females) who participated in an ongoing longitudinal study exploring the influence of parental engagement on language outcomes. Data analyzed in the current study were collected between 2014 and 2018. Families were recruited through birth records or community contacts. A brochure in Spanish was sent to families in which the mother identified as Hispanic or Latino or reported being born in a Spanish-speaking country. A bilingual Spanish-English research assistant conducted a screening phone call to determine eligibility. Inclusionary criteria were that the child's primary caregiver was a native Spanish speaker and that the child regularly heard Spanish at home from others as well. Exclusionary criteria were known diagnoses of neurodevelopmental disorders and hearing or vision loss. As shown in Table 1, at the 2-year time point, children ranged in age from 24 to 28 months. All children who returned for testing at the 4½-year time point were included in the current analyses. At 4½ years, five children were reported to have some parental concerns about speech or language delays with two of these children having a diagnosis of speech delay. An additional 33 children were tested at 2 years but were excluded from the current analyses due to missing data at the 2-year ($n = 3$) or 4½-year ($n = 4$) time point or because they did not return for testing at the 4½-year time point ($n = 26$).

At both time points, basic demographic information was collected, including maternal and paternal years of education, occupation, country of birth, native language, and the primary language spoken at home. Given inclusionary criteria at the 2-year time point, all families in the current study spoke primarily Spanish at home and all maternal caregivers were native Spanish speakers. As shown in Table 1, the participants were from families in which mean maternal education was less than high school, although there was some range. We also computed scores on an updated version of the Hollingshead Index of Socioeconomic Status (HI, Hollingshead, 1975), a comprehensive measure of socioeconomic status (SES) which reflects a composite of both parents' occupation and education (possible range = 8–66). The mean score at 4½ years indicated that these families were generally from lower SES backgrounds. In addition, a total of 64.8% of the families reported an annual household income of <$40 K/year, which is approximately a third of the median family income in the local area. Those children who were excluded did not differ, as a group, from the analyzed sample in either maternal education ($M = 11.1$ years, $SD = 3.5$), $t(126) = 0.5$, $p = .51$, $d = 0.14$, or HI reported at induction ($M = 24.8$, $SD = 10.7$), $t(126) = 0.3$, $p = .79$, $d = 0.04$. Most of the maternal caregivers in the final sample were born in Mexico (83.2%, $n = 79$), with others born in Central America (7.4%, $n = 7$) or South America (2.0%, $n = 2$), and the remainder born in the U.S. (7.4%, $n = 7$). As for birth order, 24.2% ($n = 23$) of the children were first-born, 36.8% ($n = 35$) were second-born, and 39.0% ($n = 37$) were later-born (3rd to 6th).

2.2 | Measures and procedures

2.2.1 | Language background—To derive estimates of a child's relative exposure to Spanish and English, a bilingual research assistant conducted a language background interview at both time points in the language preferred by the caregiver, which was typically Spanish (Marchman et al., 2017; Marchman & Martínez-Sussmann, 2002). The interviewer asked the caregiver, usually the mother, to describe their child's typical weekday and weekend, including wake-up, night-time, and nap times, and then to list the people with whom their child comes into regular contact, when that contact occurred, and the proportion of Spanish versus English that person uses when speaking with the child. The overall proportion of Spanish to the target child was computed as the proportion of Spanish-language exposure hours out of total exposure hours in Spanish and English. Hours of exposure to television or other electronic media were not included. To capture the degree of Spanish exposure specifically from primary caregivers, an analogous proportion exposure score was computed including only those adults at home who were active caregivers of the child, most typically mother and father, but in a few cases a grandparent. Estimates based on similar measures have been shown to have good criterion validity regarding children's relative language exposure (De Anda, Bosch, Bosch, Poulin-Dubois, Zesiger, & Friend, 2016; Orena, Byers-Heinlein, & Polka, 2019).

2.2.2 | Spanish vocabulary size at 2 years—Spanish vocabulary size was estimated based on caregivers' reports on the MacArthur-Bates *Inventario del Desarrollo de Habilidades Communicativas: Palabras y Enunciados* (Jackson-Maldonado et al., 2003). At the 2-year time point, parents indicated on a vocabulary checklist the number of words that their child 'comprende y dice' ('understands and says'). Parents were told that childlike forms and words specific to the family or dialect are acceptable (e.g. 'ota' for 'pelota'). Vocabulary size was computed as the sum of all words selected out of a maximum of 680 words. Validity and reliability of the *Inventarios* are well-established (see Jackson-Maldonado et al., 2003, Chapter 4, pp. 80–87).

2.2.3 | Spanish language processing efficiency at 2 years—Children and their caregivers visited a community-based laboratory for two testing sessions, typically 1 week apart. Children's efficiency in online language comprehension in Spanish was assessed using the LWL procedure (Fernald et al., 2008). In this task, the child sits on their parent's lap while viewing pictures of two familiar objects; recorded speech directs the child's attention to the target picture. Speech stimuli were simple sentences spoken in Spanish by a female, native Spanish speaker with the target noun in sentence-final position (e.g. *¿Dónde está el perro?* 'Where's the doggy?'). The 12 target nouns were likely to be familiar to children in this age range: *el perro* 'doggie,' *el libro* 'book,' *el jugo* 'juice,' *el globo* 'balloon,' *el zapato* 'shoe,' *el plátano* 'banana,' *la pelota* 'ball,' *la galleta* 'cookie,' *el caballo* 'horse,' *el pájaro* 'bird,' *la cuchara* 'spoon,' *la manzana* 'apple' (Frank et al., 2017; Jackson-Maldonado et al., 2003). Across the two sessions, each target noun was presented six times (72 test trials). Visual stimuli were presented in fixed pairs, matched for salience and grammatical gender of object name. Side of target picture was counter-balanced across trials. Children's gaze patterns were videotaped and later hand-coded to yield a high-resolution record of eye movements aligned with target noun onset. Following standard procedures (Fernald et al., 2008), all sessions were pre-screened to remove trials on which the child was inattentive or the parent distracted the child. To ensure that each child was familiar with all target words, trials with target words which the parent reported their child did not understand were eliminated on a child-by-child basis.

In the LWL task, language processing efficiency is reflected in two measures (Fernald et al., 2008). First, mean *accuracy* is the proportion fixations to the named target picture versus the distracter picture from 300 to 1800 ms from target noun onset. The mean number of trials contributing to accuracy scores was 47.8 (*SD* = 11.1, range = 16–66). Second, language processing speed is reflected in reaction time (RT), the mean latency in milliseconds to shift from the distracter to the target picture on those trials on which the child was fixated on the distracter picture at target noun onset. Trials on which the child is oriented to the target picture or away from both pictures at noun onset are not included in the computation of RT. Shifts that occurred prior to 300 ms and after 1,800 ms from target-word onset were excluded since these shifts were not likely to be in response to the target word. The mean number of trials per child that contributed to the computation of mean RT was 19.4 (*SD* = 6.2, range = 3–34). Reliability in inter-observer agreement was computed by double-coding approximately 20% of the sessions. The proportion of trials on which accuracy scores were comparable within 5% was 98%. The proportion of distracter-initial trials on which there was agreement for RT within one frame (33 ms) was 99%.

2.2.4 | Spanish- and English-language measures at 4½ years—At 4½ years, native Spanish-English bilingual researchers administered language assessments in both Spanish and English, as part of a comprehensive battery. Children were tested at a community laboratory in two sessions, typically about 1 week apart. Children's receptive vocabulary ability in Spanish was assessed using the *Test de Vocabulario en Imágenes Peabody* (TVIP; Dunn, Lugo, Padilla, & Dunn, 1997). Spanish expressive language was assessed using the *Clinical Evaluation of Language Fundamentals-Preschool, Spanish Edition* (CELF-P, Wiig, Secord, & Semel, 2009). Children's receptive vocabulary in English was assessed using the *Peabody Picture Vocabulary Test-4* (PPVT-4; Dunn & Dunn, 2012). English expressive language was assessed using *Preschool Language Scales, 5th Edition* (PLS-5; Zimmerman, Steiner, & Pond, 2011). For each language, standard scores were averaged to derive a composite language score reflecting both receptive and expressive skills in that language.

3 | RESULTS

We first present descriptive statistics on the language backgrounds of the children, documenting change in the language exposure landscape from toddlerhood to pre-kindergarten. We then provide descriptives for the child language measures in Spanish at 2 years and in both Spanish and English at 4½ years. To address our main questions, a series of multiple regression analyses explored the within- and across-language relations between early measures of Spanish-language learning at 2 years (vocabulary size, language processing accuracy and speed [RT]) and later language outcomes at 4½ years in Spanish and English, controlling for SES and reported exposure to each language. These models allowed us to examine the unique and overlapping contributions of vocabulary size and each measure of processing efficiency (accuracy and RT) to later outcomes in both Spanish and English. We chose not to evaluate accuracy and RT in a single model given that we expected a high level of collinearity in these measures (Fernald & Marchman, 2012). In addition, we conducted analogous analyses using the full sample and with children with reported language delays at 4½ years removed. Since the pattern of results was identical in both cases, we report the findings only for the full sample here.

3.1 | Language background at 2 and 4½ years

As shown in Table 1, based on inclusionary criteria at 2 years, the children were reported to be exposed primarily to Spanish, with reported Spanish-language exposure proportion averaging >85%. The mean reported Spanish-language exposure from primary caregivers was more than 95%, and more than 85% of the children heard ≥90% Spanish from caregivers. Across all caregivers, two children heard more English than Spanish, but both mothers reported they were native Spanish speakers who used primarily Spanish when interacting with their child. Thus, overall these children are best described as being primarily exposed to Spanish at age 2 years.

Table 1 shows that by the age of 4½ years, many children were hearing some English, but to varying degrees. The relative proportion of Spanish exposure overall decreased significantly to about 68%, on average, $t(94) = 9.4$, $p < .001$, $d = 0.9$, although there was still some variability. Thus, as they approached the age of school entry, some children remained primarily exposed to Spanish, whereas, other children were exposed to more English. Children's relative proportion exposure to Spanish from caregivers also decreased significantly between 2 to 4½ years, $t(94) = 6.3$, $p < .001$, $d = 0.7$, although this proportion remained high, about 85%, on average. At both time points, children's relative Spanish exposure from caregivers was significantly correlated with degree of exposure overall (2 years: $r(94) = .52$, $p < .001$; 4½ years: $r(94) = .68$, $p < .001$), suggesting that children who were exposed to relatively more Spanish from caregivers were also more likely to be exposed to relatively more Spanish overall.

3.2 | Child language measures at 2 years

At 2 years, Table 2 shows that mean vocabulary size was just under 300 words, on average, placing the sample near the 50th percentile based on the norms for this instrument (Jackson-Maldonado et al., 2003). But there was also considerable range, as expected. Table 2 also shows that children were accurate at recognizing familiar Spanish words in the LWL task, performing significantly above chance as a group, $t(94) = 18.3$, $p < .0001$, $d = 1.9$. On average, children responded to a familiar word within about 725 ms from target noun onset. There was considerable variability across children in both language processing measures. The two measures were significantly correlated, $r(94) = -.63$, $p < .001$, as expected, justifying our decision to evaluate these measures independently. As found earlier (Hurtado et al., 2007), children who were reported to say more words in Spanish were also more accurate, $r(94) = .27$, $p = .008$, and faster to respond, $r(94) = -.26$, $p = .009$, in the LWL task, than children who were reported to say fewer words. This suggests that vocabulary size and the measures of early language processing efficiency are indeed associated, as seen in earlier studies (e.g. Fernald et al., 2006), although these weak effects leave open the possibility for unique contributions to later language outcomes.

3.3 | Child language measures at 4½ years

Table 2 also presents mean standard scores on the language assessments at 4½ years. Since these children were from primarily Spanish-speaking homes, standard scores were significantly higher on the Spanish- than on the English-language composite measures, $t(94) = 2.3$, $p = .03$, $d = 0.3$, as expected. At the same time, scores were significantly below expected normative levels both in Spanish, $t(94) = 4.2$, $p < .001$, $d = 0.4$, and in English, $t(94) = 9.2$, $p < .001$, $d = 0.9$. Spanish-language scores were uncorrelated with English-language scores ($r = .08$, $p = .47$), indicating that those children who were performing better in Spanish at 4½ years were not necessarily performing better in English.

3.4 | Predictors of language outcomes at 4½ years

Our main focus was to explore early contributors to later language outcomes at 4½ years in both Spanish and English in these sequential bilingual children. In a series of multiple regression models, we assessed the additional contribution of Spanish-language vocabulary size and the two measures from the LWL task, language processing accuracy and speed (RT), each measured at 2 years, to Spanish- and English-language outcomes at 4½ years, beyond SES and overall exposure to each language. All predictors were converted to *z*-scores, to allow comparisons using standard deviation units across measures.

3.4.1 | Spanish-language outcomes—In Table 3, Model 1 introduces only the covariates, showing a significant contribution of concurrent Spanish-language exposure, but not SES, to Spanish-language outcomes. That is, children with better Spanish-language outcomes were those who were exposed to relatively more Spanish at 4½ years, compared to children who were hearing less Spanish. Model 2 added Spanish vocabulary size to the models. This model showed a significant 13% additional contribution in variance, indicating that early Spanish-language vocabulary size was associated with later Spanish-language outcomes, beyond the covariates. In Model 3, we explored the contribution of accuracy in the LWL task. Here, there was a significant gain of approximately 10% of variance accounted for, beyond SES and relative exposure. Model 4 directly compares the contribution of vocabulary size and accuracy, showing that both factors together nearly doubled the variance accounted for by each factor alone and each remained significant predictors in the model. This model can be interpreted as a 1 *SD* increase in Spanish vocabulary size is associated with, on average, a 5.4 point increase in Spanish-language standard scores at 4½ years and a 1 *SD* increase in accuracy in the LWL task is associated with, on average, a 4.3 point increase in Spanish outcomes. Similar findings were seen for Spanish-language processing speed (RT). Model 5 shows RT alone contributed nearly 10% additional variance beyond SES and exposure. Finally, Model 6 shows that Spanish-language vocabulary size and RT together contributed >18% additional variance, with all factors accounting for just under 55% of the variance in Spanish-language outcomes at 4½ years. The unique contribution of Spanish vocabulary size illustrated in Figure 1a. This effect can be interpreted as a 1 *SD* increase in vocabulary size at 2 years is associated with an average of a 5.5 point increase in standard scores on tests of Spanish-language outcomes at 4½ years. The unique contribution of RT is illustrated in Figure 1b. This effect can be interpreted as a 1 *SD* improvement in speed is associated with an average of a 4.3 point increase in Spanish-language standard scores. These analyses demonstrate significant within-language relations between early measures of Spanish-language vocabulary size and processing efficiency at 2 years and later Spanish-language skills at 4½ years, beyond SES and degree of exposure to Spanish.

3.4.2 | English-language outcomes—Table 4 shows the contributions of the same set of predictors to English-language proficiency at 4½ years. Model 7 shows that both variability in SES and relative Spanish exposure significantly uniquely predicted English-language outcomes, together accounting for about 30% of the variance. That is, those children who scored higher on tests of English language were those children who were from higher SES backgrounds and who were exposed relatively less to Spanish, and hence, relatively more to English. Model 8 shows that children's Spanish-language vocabulary size added just under 5% additional variance to children's English-language scores, beyond SES and degree of English exposure. This suggests a relatively small, albeit significant, contribution of early Spanish vocabulary knowledge to later English-language outcomes. When considering the LWL task, Model 9 shows that accuracy alone contributed over 7% additional variance beyond SES and relative exposure. Model 10 shows that accuracy remained a significant predictor when Spanish-language vocabulary size was also included in the model, however, the contribution of vocabulary size was reduced and became non-significant. This model can be interpreted as a 1 *SD* increase in overall accuracy in the LWL task is associated with an average of more than a 3 point increase in English-language standard scores at 4½ years. Model 11 shows that Spanish-language RT alone added more than 8% unique variance beyond SES and degree of English exposure. Finally, when both Spanish-language vocabulary and RT were added in Model 12, RT but not vocabulary size, remained a unique predictor, together accounting for more than 10% significant unique variance. The non-significant unique contribution of Spanish-language vocabulary size to English-language outcomes at 4½ years is illustrated in Figure 2a. The significant unique contribution of RT is illustrated in Figure 2b. This effect can be interpreted as showing that a 1 *SD* improvement in processing speed in Spanish at 2 years is associated with a 3.4 point gain in standard scores in English-language outcomes at 4½ years, on average. These analyses demonstrate significant across-language relations between early Spanish-language vocabulary size and language processing efficiency and later English-language outcomes when entered into the models individually. However, children's early Spanish language processing skills reflected in both accuracy and RT, but not Spanish vocabulary size, have unique consequences for later learning of English, beyond the contributions of SES and English-language exposure.

4 | DISCUSSION

This study explored how children's vocabulary knowledge and language processing efficiency in Spanish at 2 years are related, within-and across-languages, to children's language outcomes in both Spanish and English at pre-kindergarten. All children were primarily exposed to Spanish at the onset of the study, especially from caregivers. At 4½ years, many children continued to experience primary exposure to Spanish, whereas others had increased opportunities for exposure to English. Four main findings emerged from this study.

First, not surprisingly, the reported amounts of children's exposure to Spanish and English were significantly associated with their performance on standardized tests in each of those languages, even after controlling for SES. Those children with higher proportions of Spanish exposure at 4½ years were likely to score higher on standardized tests of Spanish-language abilities, while those children with more opportunities for exposure to English at that age were likely to score higher on comparable English-language tests. This result is consistent with many earlier findings showing that reports of relative exposure to a language through interactions with others are associated with the degree of learning in that language (Hammer et al., 2012; Hurtado et al., 2014; Marchman et al., 2017; Orena et al., 2019).

Second, we also identified within-language relations between children's early Spanish-language skill, reflected in both vocabulary size and processing efficiency, and their later Spanish-language accomplishments. Those children who knew more words in Spanish and who were more efficient at language processing at 2 years were likely to score higher on tests of Spanish-language skill at 4½ years, compared to children with weaker early language skills. These results suggest some stability in Spanish-language abilities within children from 2 to 4½ years, not attributable to language exposure or SES. These results are concordant with earlier findings showing stability in children's language abilities across development (Bornstein & Putnick, 2012; Hoff, Burridge, Ribot, & Giguere, 2018; Hurtado, Marchman, & Fernald, 2008). It is noteworthy that Spanish vocabulary size and language processing efficiency at 2 years each made a unique contribution to later outcomes, suggesting that these measures were tapping into correlated, though somewhat independent, aspects of early language skill that have consequences for later Spanish-language outcomes. Moreover, SES did not independently contribute to Spanish-language outcomes in any of the models.

We next explored across-language relations between early Spanish-language abilities at 2 years and later English-language outcomes at 4½ years. These series of models revealed that both SES and English-language exposure at 4½ years were significant predictors of English-language outcomes. In addition, our third major finding was that Spanish vocabulary size as reported by parents at 2 years was significantly related to later English-language scores, however, these effects were accounted for by both measures of processing efficiency. This finding is consistent with earlier studies showing relatively weak across-language correlations on tests of language-specific vocabulary knowledge in toddlerhood (e.g. Marchman et al., 2010) and school age (Goodrich et al., 2016). Possible explanations for weak links between early vocabulary in Spanish and later English-language skills could be that much of vocabulary learning relies on arbitrary sound-meaning correspondences that are not transparent when encountered in a different language. Another possibility is that vocabulary items learned in one language may be different from those learned in a second language because the two languages are typically learned in different contexts (e.g. home vs. school; Dickinson et al., 2004; Goodrich et al., 2016; Palermo, Mikulski, Fabes, Martin, & Hanish, 2017).

Our fourth major finding was that variation among children in early language processing efficiency in Spanish at 2 years accounted for significant additional variance in their English learning at 4½ years. That is, those children who were better at processing familiar words in real-time in Spanish as toddlers were more likely to perform better on a test of English-language skill at kindergarten entry, compared to children who had weaker Spanish-language processing skills. Critically, the contribution of early Spanish-language processing skill to English-language outcomes was significant even after accounting for relative amounts of English exposure at 4½ years. In other words, while amount of English exposure at 4½ years was a significant and strong predictor of children's concurrent skill in English, early language processing proficiency in Spanish conferred additional benefits for learning English. These results are consistent with those in older children which indicate that children's level of proficiency in their home language is associated with stronger learning in a second language (Winsler, Burchinal, et al., 2014). The fact that across-language associations were identified as young as 2 years of age suggest that the benefits of proficiency in L1 for learning in L2 are evident earlier in development than has been previously documented.

Why would early language processing in L1 relate to later learning in L2? Since early language processing efficiency reflects children's skill at integrating linguistic signals with visual information in real time, one possibility is that children who are more efficient at language processing in their first language are more effective in accessing conceptual and linguistic information that can provide a framework for learning an L2 (Cummins, 1979). A child who already has a rich conceptual basis for identifying and categorizing people or objects in their first language may be better prepared to map new phonetic forms onto an already established set of concepts or to associate relations among concepts in an L2, given sufficient opportunities for exposure to that language (Goodrich et al., 2016). In addition to advantages associated with world knowledge, across-language associations might reflect mechanisms that operate on a more general level. For example, those children who are more efficient at language processing in their L1 might be benefiting from more efficient and flexible information-processing skills, reflected in processing speed, attention or working memory processes, that are associated with strong oral language comprehension (Hurtado et al., 2008; Law & Edwards, 2014; McMurray, Horst, & Samuelson, 2012; Newman, Rowe, & Bernstein Ratner, 2016). Because the LWL task measures children's real-time interpretation of familiar words, stimuli must be presented in a language with which children is familiar. At the same time, this task may be indexing processes that are distributed across both linguistic and non-linguistic domains. For example, efficient language processing of a familiar word early in a sentence may free-up valuable cognitive resources to allow children to pay greater attention to auditory or visual cues to the meanings of less familiar words that come later (Fernald et al., 2006; McMurray et al., 2012). In the moment, the child is more likely to be 'in the right place at the right time' to maximize information uptake and take more efficient advantage of individual instances of cues to meaning or phonological or morphosyntactic structure.

The advantages of early skill in spoken language processing are likely to have cascading consequences over developmental time. As children gain more practice interpreting spoken words from moment to moment, they may also become more efficient at linking auditory and visual information, accelerating the gains in efficiency that have been reported to occur over the 2nd and 3rd years of life (e.g. Fernald & Marchman, 2012) and buttressing or fine-tuning the skills that support strong oral language skills. Even small advantages in processing efficiency can lead to meaningful gains in the ability to process increasingly longer sentences, to build up networks of conceptual organizations, and to link information together in causal or temporal orders. These influences might also operate in the opposite direction, with increased cognitive advantages feeding back into learning mechanisms such that children who are faster at processing information will have more efficient language comprehension skills. As noted by Law and Edwards (2014), children who have early advantages in real-time language processing provide yet another example of a ‘Matthew effect’ in which early processing speed continues to confer increasingly greater benefits over time in learning about the world and in applying knowledge flexibly. The child who struggles early on with processing spoken language in real-time will not be as effective in taking advantage of opportunities to learn about less familiar words, and will be increasingly at a disadvantage in using language to stretch thinking skills and to build densely connected conceptual or semantic networks. Unfortunately, for Latino children who are from lower-SES backgrounds, the consequences of missed opportunities for learning may be amplified by other factors associated with poverty in conjunction with limited exposure to English, all of which may place children at greater risk for poorer outcomes in school.

Why are some children faster in processing spoken language than others? Variation in real-time language processing skill is likely to be related to individual differences in a host of neurodevelopmental factors, for example, premature birth, that shape trajectories of learning (Loi et al., 2017). This variation might also be the result of genetic factors which contribute to more efficient learning (Tucker-Drob & Harden, 2012). Additionally, recent studies have shown that children who are exposed to richer and more complex language from caregivers are likely to score higher on language assessments (Gilkerson et al., 2018; Romeo, Leonard, et al., 2018; Romeo, Segaran, et al., 2018) and to be more efficient in processing language in real time (Adams et al., 2018; Hurtado et al., 2008; Weisleder & Fernald, 2013). We propose that a major contributor to facilitating language processing skill and language knowledge in sequential bilingual children is frequent and effective engagement with caregivers from early in life. For many sequential bilingual children, these interactions are most likely to occur in the child’s home language. Caregivers from primarily Spanish-speaking homes should be encouraged to engage with their children early and often in the language in which they feel most comfortable. Such rich interactions can provide opportunities for increasing efficiency in real-time language comprehension in their native language and can thus support vocabulary learning and provide a strong base of knowledge about the world that is beneficial for children’s later learning. Activities that provide rich vocabulary and more complex syntax, such as book sharing, are likely to be particularly valuable (Grimm, Solari, & Gerber, 2018; Logan, Justice, Yumuş, & Chaparro-Moreno, 2019; Montag, Jones, & Smith, 2015). At the same time, interactions with caregivers across many different activities in a child’s life may also be useful in providing rich and meaningful practice in real-time comprehension (Bang, Munevar, Marchman, & Fernald, 2019). Future studies should continue to explore the extent to which efficient language processing skills in toddlerhood are the consequence or the cause of associated processes, such as those involving working memory or attention. Interventions that explore ways to encourage effective caregiver-child engagement and that evaluate effectiveness in terms of both language knowledge and language processing efficiency are sorely needed to more fully explicate the mechanisms underlying the effects observed here. These results have important policy and early educational implications because they suggest that children’s skill in processing their native language as early as 2 years of age already reflects the strength of critical oral language skills that can support successful L1 and L2 language outcomes at school entry.

4.1 | Limitations

The research reported here has several limitations. First, while the sample size was larger than in many studies of early language development, it was modest compared to studies which have explored school-age outcomes of bilingual children using national databases or large-scale evaluation studies (Kim et al., 2014; Mancilla-Martinez & Vagh, 2013; Winsler, Kim, et al., 2014). Second, this sample of children was from primarily Spanish-dominant homes with caregivers who were typically of Mexican heritage. Thus these children represent one particular sub-population of Spanish speakers in the U.S., and these results may not generalize to children who are learning Spanish and English simultaneously at home (Marchman et al., 2010) or to children in families from different Latino cultural backgrounds (Escobar & Tamis-LeMonda, 2017; Hoff, Welsh, Place, & Ribot, 2014). It is also not clear whether these results would generalize to other populations of bilingual children who are learning languages other than Spanish and English, which may be more dissimilar in linguistic structure. This population is different from those in many other studies of bilingual development because the children lived in households with caregivers who were more proficient in Spanish than English, and were therefore, more likely to be exposed to English from sources other than their primary caregivers. Further studies should continue to explore the characteristics of exposure sources in this population (Bermudez, Bang, Marchman, & Fernald, 2019). Another limitation is that these estimates were based on parent reports of relative exposure. While reported measures of relative language exposure are widely used in the literature for reasons of convenience (Byers-Heinlein et al., 2019; De Anda, Bosch, et al., 2016; Marchman & Martínez-Sussmann, 2002; Orena et al., 2019), they do not capture individual variation in the absolute amount of language that children experience which are likely to have significant impacts on outcomes (Marchman et al., 2017; Orena et al., 2019). Moreover, future studies should specifically explore the contributions of non-interactive sources of language exposure, for example, television and other electronic media. Finally, we cannot yet directly address the question of what features of early engagement support early processing efficiency. Future studies should continue to explore the quantity and quality of the interactions that these children engaged in with caregivers as a possible source of these individual differences in skill in early language comprehension (Hirsh-Pasek et al., 2015; Song, Tamis-LeMonda, Yoshikawa, Kahana-Kalman, & Wu, 2012; Tamis-LeMonda, Kuchirko, & Song, 2014).

4.2 | Conclusion

Sequential bilingual children learning Spanish as L1 and English as L2 represent an important segment of the Latino population in the U.S. Identifying evidence-based recommendations for supporting the academic success of these children is a critical imperative. This study demonstrated that early efficiency in spoken language processing by young Spanish-speaking children, assessed as early as 2 years of age, was associated with their later language competencies not only in Spanish but also in English at age 4½ years, before entering kindergarten. Thus, early skill in interpreting spoken words may reflect information processing abilities that build conceptual networks or fine-tune attention and memory processes. Strengthening these abilities early in life are associated with strong oral language abilities and support later learning, regardless of language. These results suggest that building a strong foundation in a child’s native language begins early in development and has significant benefits for maintaining proficiency in the native language as well as for later learning in a second language. The implications are that caregivers from primarily Spanish-speaking families should continue to engage in a range of activities in Spanish that can support their child's learning, as well as to seek opportunities for their children to be exposed to English.

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Research Highlights

- In sequential Spanish-English bilinguals, we explored relations between Spanish-language vocabulary size and processing efficiency at 2 years and Spanish- and English-language outcomes at 4½ years.
- Within-language associations were observed: both Spanish-language vocabulary size and processing efficiency at 2 years accounted for unique variance in Spanish-language outcomes at 4½ years.
- Across-language transfer effects were also observed: Spanish-language processing efficiency at 2 years was uniquely associated with English-language outcomes, beyond socioeconomic status and proportion exposure to English.
- Efficient Spanish-language processing reflects a solid foundation in linguistic, conceptual, and information-processing skills that benefits maintenance of Spanish as well as later learning of English.

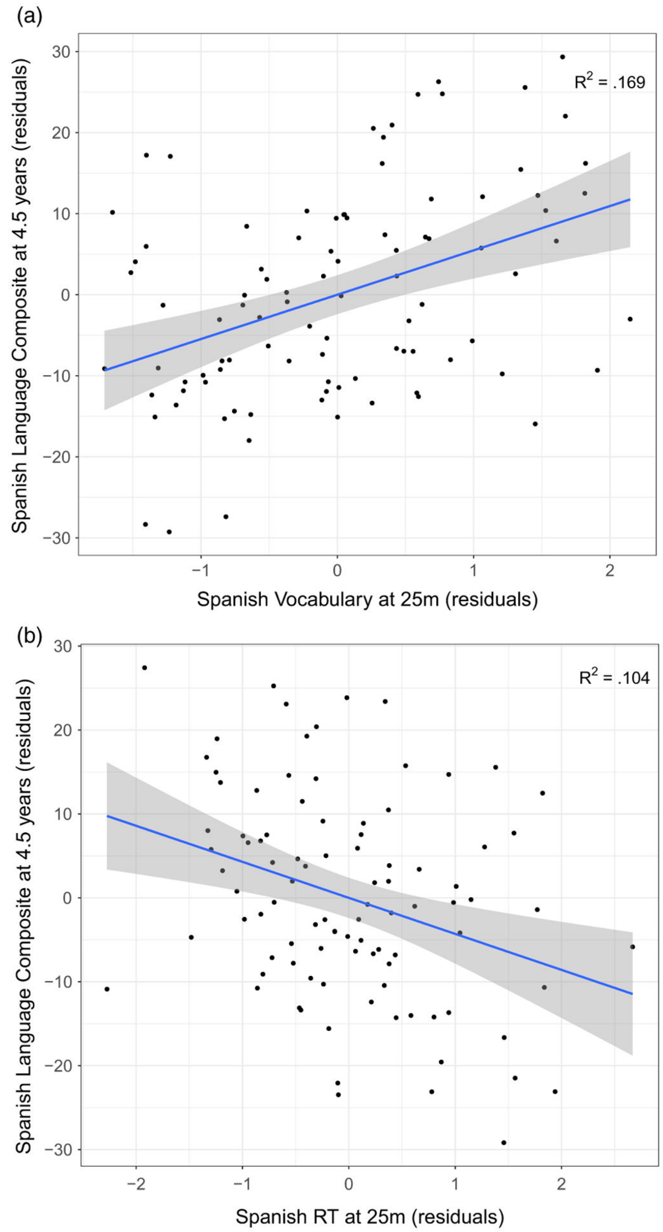

FIGURE 1.

Unique relations (standardized residuals) between (a) reported vocabulary size and (b) speed of processing in Spanish at 2 years and Spanish language outcomes at 4½ years (n = 95)

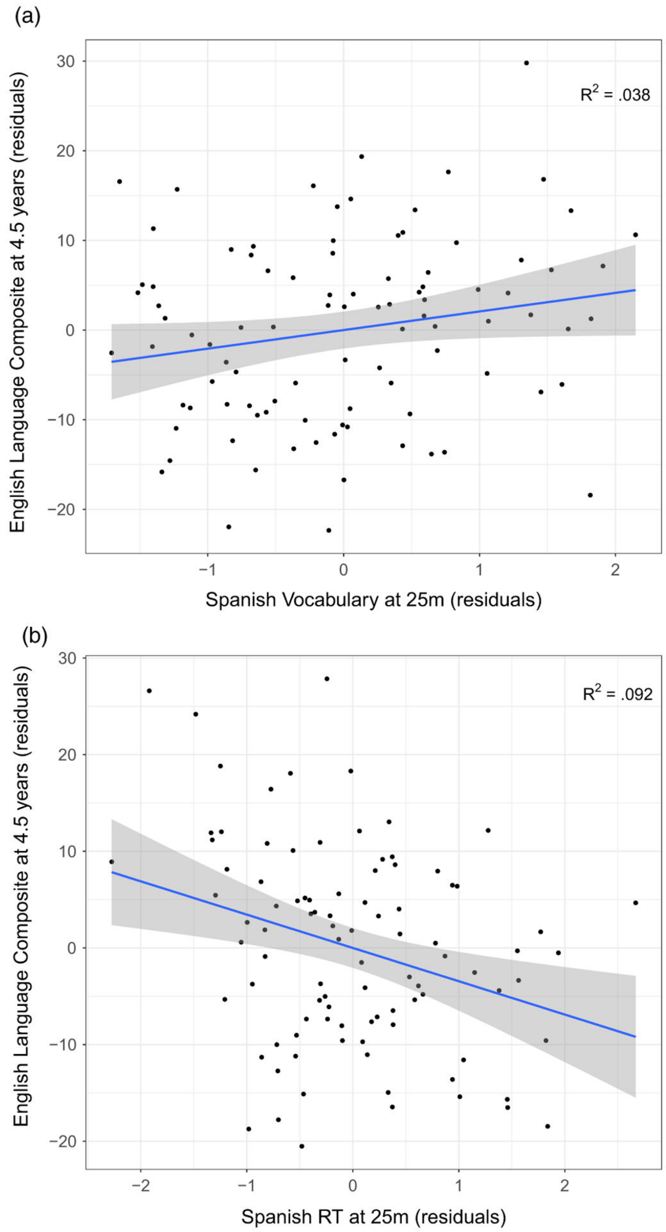

FIGURE 2.

Unique relations (standardized residuals) between (a) reported vocabulary size and (b) speed of processing in Spanish at 2 years and English language outcomes at 4½ years (*n* = 95)

TABLE 1

Demographic characteristics of the sample (*n* = 95)

	M (SD)	**Range**
Child age (months) at Time 1 (2 years)	25.6 (0.6)	24.6–28.1
Child age (months) at Time 2 (4½ years)	56.9 (1.4)	54.1–63.0
Maternal Education (years)[a]	11.8 (3.1)	3–18
SES[b]	26.6 (11.1)	10.5–64.5
Spanish exposure (%)[c]		
Time 1		
Overall	85.7 (13.9)	36–100
Caregivers only	95.8 (8.3)	47–100
Time 2		
Overall	67.5 (21.9)	12–100
Caregivers only	85.0 (18.7)	10–100

[a]Number of years of education: high school graduate = 12 years; college graduate = 16 years; post college degree = 18 years.

[b]Socioeconomic status (SES) at 4½ years based on an updated version of the Hollingshead Index of Socioeconomic Status (HI), derived from a composite of the education and occupation of both parents (Hollingshead, 1975).

[c]Mean proportion of hours child is reported to be exposed to Spanish (vs. English) from all sources (overall) and from primary caregivers based on a comprehensive language background interview.

TABLE 2

Descriptives of Spanish-language vocabulary and language processing measures at 2 years and Spanish and English language outcomes at 4½ years (n = 95)

	M **(*SD*)**	**Range**
2 years		
Spanish vocabulary size[a]	292.5 (184.2)	28–670
Spanish vocabulary percentile[a]	50.5 (29.2)	1–99
Spanish language processing (LWL)[b]		
Accuracy	0.66 (0.08)	0.45–0.86
RT (ms)	729 (146)	457–1,200
4½ years		
Spanish language (composite)[c]	92.5 (17.3)	61.5–128.5
English language (composite)[d]	87.7 (13.1)	65.5–126.5

[a]Number of words reported as ‘comprende y dice’ on the MacArthur-Bates Inventario: Palabras y Enunciados (Jackson-Maldonado et al., 2003).

[b]Accuracy and speed (RT) of processing familiar Spanish words in the looking-while-listening (LWL) procedure (Fernald et al., 2008) at 2 years.

[c]Composite standard scores in Spanish based on the TVIP (Dunn et al., 1997) and the expressive language sub-scale of the CELF-P (Wiig et al., 2009).

[d]Composite standard scores in English based on the PPVT-4 (Dunn & Dunn, 2012) and the expressive language sub-scale on the PLS-5 (Zimmerman et al., 2011).

TABLE 3

Multiple regression analyses examining predictors of Spanish-language outcomes at 4½ years, controlling for SES and exposure ($n = 95$)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
SES[a]	2.3 (1.5)	2.2 (1.3)	1.8 (1.4)	1.8 (1.2)	2.1 (1.3)	2.1 (1.2)
% Spanish exposure[b]	10.3 (1.5)***	9.3 (1.3)***	8.7 (1.4)***	8.3 (1.3)***	8.5 (1.4)***	8.2 (1.3)***
Spanish vocabulary size[c]	–	6.4 (1.3)***	–	5.4 (1.3)***	–	5.5 (1.3)***
Spanish accuracy[d]	–	–	5.7 (1.4)***	4.3 (1.3)**	–	–
Spanish RT[d]	–	–	–	–	−5.6 (1.4)***	−4.3 (1.3)**
Total R^2	35.8%***	49.3%***	45.6%***	54.6%***	45.3%***	54.6%***
r^2-change	–	13.5%***	9.8%***	18.8%***	9.5%***	18.8%***

Note: Unstandardized coefficients (SE); r^2-change values for Models 2–6 are in reference to Model 1.

[a] Socioeconomic status (SES) at 4½ years from an updated version of the Hollingshead Index of Social Status (Hollingshead, 1975).

[b] Reported relative exposure to Spanish versus English at 4½ years based on a comprehensive language background interview.

[c] Number of words reported as ‘comprende y dice’ on the Spanish-language Inventario: Palabras y Enunciados at 2 years (Jackson-Maldonado et al., 2003).

[d] Accuracy and speed (RT) of processing familiar Spanish words in the looking-while-listening (LWL) procedure at 2 years (Fernald et al., 2008).

* $p < .05$;

** $p < .01$;

*** $p < .001$.

TABLE 4

Multiple regression analyses examining predictors of English-language outcomes at 4½ years, controlling for SES and exposure ($n = 95$)

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
SES[a]	4.5 (1.1)***	4.4 (1.1)***	4.1 (1.1)***	4.1 (1.1)***	4.3 (1.1)***	4.3 (1.1)***
% Spanish exposure[b]	−5.3 (1.1)***	−5.7 (1.1)***	−6.3 (1.1)***	−6.5 (1.1)***	−6.5 (1.1)***	−6.7 (1.1)***
Spanish vocabulary Size[c]	–	2.8 (1.1)*	–	2.1 (1.1)	–	2.1 (1.1)
Spanish accuracy[d]	–	–	3.6 (1.1)**	3.1 (1.1)**	–	–
Spanish RT[d]	–	–	–	–	−4.0 (1.1)***	−3.4 (1.1)**
Total R^2	30.4%***	35.1%***	37.6%**	40.0%***	38.7%***	41.1%***
r^2-change	–	4.7%*	7.2%**	9.6%**	8.3%**	10.7%***

Note: Unstandardized coefficients (SE); r^2-change for Models 8–12 are in reference to Model 7.

[a] Socioeconomic status (SES) at 4½ years from an updated version of the Hollingshead Index of Social Status (Hollingshead, 1975).

[b] Reported relative exposure to Spanish versus English at 4½ years based on a comprehensive language background interview.

[c] Number of words reported as ‘comprende y dice’ on the Spanish-language Inventario: Palabras y Enunciados at 2 years (Jackson-Maldonado et al., 2003).

[d] Accuracy and speed (RT) of processing familiar Spanish words in the looking-while-listening (LWL) procedure at 2 years (Fernald et al., 2008).

* $p < .05$;

** $p < .01$;

*** $p < .001$.