The Effect of Second-Language Experience on Native-Language Processing

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Abstract

Previous work on bilingual language processing indicates that native-language skills can influence second-language acquisition. The goal of the present work was to examine the influence of second-language experiences on native-language vocabulary and reading skills in two groups of bilingual speakers. English-Spanish and English-Mandarin bilingual adults were tested on vocabulary knowledge and reading fluency in English, their native language. Participants also provided detailed information regarding their history of second-language acquisition, including age of L2 acquisition, degree of L2 exposure, L2 proficiency, and preference of L2 use. Comparisons across the two bilingual groups revealed that both groups performed similarly on native-language vocabulary and reading measures. However, in English-Spanish bilinguals, higher self-reported reading skills in Spanish were associated with *higher* English reading-fluency scores, while in English-Mandarin bilinguals, higher self-reported reading skills in Mandarin were associated with *lower* English reading-fluency scores. These findings suggest that second-language experiences influence native-language performance, and can facilitate or reduce it depending on the properties of the second-language writing system.

Key words: L2 experience, vocabulary, reading fluency, bilingualism, transfer

Resumen

Trabajos anteriores en el procesamiento del lenguaje de los bilingües indican que las habilidades de la lengua materna pueden incidir en la adquisición de la segunda lengua. El presente trabajo examina la influencia de experiencias en la segunda lengua

sobre el vocabulario y las habilidades de lectura en dos grupos de hablantes bilingües. Adultos bilingües inglés-español e inglés-mandarín fueron sometidos a pruebas de conocimientos de vocabulario y facilidad de lectura en inglés, en ambos casos su lengua materna. Los participantes también suministraron información detallada con respecto a su historia de adquisición de la segunda lengua, incluyendo la edad de adquisición de la L2, el grado de exposición a la L2, dominio de la L2 y preferencia de uso de la L2. Las comparaciones entre los dos grupos bilingües mostraron que ambos grupos tuvieron resultados similares en el vocabulario de la lengua materna y mediciones de lectura. Sin embargo, en los bilingües inglés-español, la facilidad de lectura, según ellos mismos, se asociaba con resultados más altos de facilidad de lectura en inglés, mientras que en los bilingües inglés-mandarín, la facilidad de lectura en mandarín se asociaba con resultados más bajos de facilidad de lectura en inglés. Estos resultados sugieren que la experiencia en la segunda lengua tiene influencias sobre el dominio de la lengua nativa, y que puede facilitarlo o reducirlo según las propiedades del sistema de escritura de la segunda lengua.

Palabras clave: Experiencia en la L2, vocabulario, fluidez en la lectura, bilingüismo, transferencia.

1. Introduction

Acquisition of a second language is often viewed as a process that differs from native-language acquisition (e.g., Bley-Vroman, 1990), and it is frequently assumed that factors influencing one's ability to acquire a second language (e.g., motivation) do not play a role in native-language development (e.g., Dörnyei, 2001). However, it is also well-established that knowledge of a second language impacts the ability to manage information in the native language (e.g., Marian & Spivey, 2003), and current cognitive and psycholinguistic models of bilingualism explicitly posit that the two languages interact, even during language-specific processing (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra & Van Heuven, 2002). Yet, the degree to which acquisition of a second language influences native-language function remains underspecified, and thus, knowledge regarding the interactivity of two languages within a single cognitive system remains incomplete. The broad goal of the present study was to explore the role of factors that have traditionally been linked to second-language acquisition (i.e., age of L2 acquisition; length of immersion in L2; etc.) in native-language functioning. This work was motivated by two parallel lines of research: First, we considered the literature on environmental factors in L2 acquisition. This literature generally indicates that variability in age of L2 acquisition, extent of L2 immersion, and degree of L2 exposure has a significant effect on attained L2 proficiency. Second, we considered the literature on cross-linguistic influences

(or transfer). This work suggests that native-language skills play a significant role in second-language acquisition, and that different combinations of L1 and L2 yield distinct transfer patterns. By integrating these two lines of research, the current study tested whether factors that have been linked to successful L2 acquisition influence native-language vocabulary and reading performance in two groups of bilingual speakers: English-Spanish bilinguals and English-Mandarin bilinguals.

2. Environmental Factors in L2 Acquisition

Variability in second-language acquisition has been linked to a number of factors, including Age of L2 acquisition (AoA, e.g., Hyltenstam & Abramsson, 2003), modes of L2 acquisition (immersion vs. classroom, e.g., Carroll, 1967), length of L2 immersion (e.g., Flege, Frieda, & Nozawa, 1997), and extent of daily L2 vs. L1 usage (e.g., Jia et al., 2002). For instance, a robust relationship exists between the age at which a learner was exposed to L2 and the ultimate L2 attainment level (e.g., Birdsong, 2005; Birdsong & Molis, 2001; Johnson & Newport, 1989). Although the precise nature of this relationship is still debated (e.g., Bialystok & Miller, 1999) and there is evidence for critical-period effects in L2 acquisition (e.g., Johnson & Newport, 1989) as well as evidence against them (e.g., Bialystok & Hakuta, 1999), the link between AoA and proficiency in L2 is no longer a matter of controversy (e.g., Birdsong, 2005). Certainly, for phonological (e.g., Flege, Yeni-Komishian, & Liu, 1999) and morphosyntactic domains (e.g., Johnson & Newport, 1989), earlier exposure to the L2 yields higher L2 proficiency. While other environmental factors in L2 acquisition have received less attention than age-of-acquisition, there is clear evidence that the degree to which a learner is immersed in L2 (e.g., Carroll, 1967; Flege et al., 1999), the extent of L2 exposure (e.g., Birdsong, 2005; Genesee, 1985; Kohnert, Bates, & Hernandez, 1999; Weber-Fox & Neville, 1999), and extent of on-going L2 use (e.g., Flege, MacKay, & Piske, 2002; Jia et al., 2002) all influence attained L2 proficiency.

Cognitive models of L2 acquisition therefore must be able to accommodate the role of these environmental variables in order to yield coherent mechanistic accounts of second language development. Yet, models of native-language acquisition and processing do not incorporate these factors, since there is little variability in L1 development that can be linked to the timing and extent of L1 immersion. For example, while age-of-acquisition effects in L2 have been examined from the perspective of when the learner became exposed to L2, research on age-of-acquisition effects in L1 focuses on the age at which a learner was exposed to a particular word (e.g., Brysbaert, Van Wijnendaele, & De Deyne, 2000; Carroll & White, 1973; Ellis & Morrison, 1998; Gillhooly & Watson, 1981). This poses problems to theoretical models of bilingualism that attempt to reconcile native-language acquisition

and second-language acquisition within a single bilingual cognitive system. In the current study, we aimed to explore the relationship between native-language function and second-language acquisition by examining the effects of L2 acquisition variables (including age of L2 acquisition, degree of L2 immersion in various learning environments, and extent of L2 exposure) on native-language functioning. We also explored the relationship between L2 proficiency and native-language functioning. This approach allowed us to begin integrating L2 acquisition and native-language processing into a single cognitive framework. Examining the relationship between factors associated with L2 acquisition and native-language function also allowed us to explore whether different combinations of L1 and L2 yield distinct patterns of cross-linguistic influences. In order to delineate specific hypotheses with regards to how different combinations of L1 and L2 may influence the degree to which L2 acquisition can impact L1 function, we turned to the literature on cross-linguistic transfer.

3. Native-Language Influences on L2 Acquisition and Processing

The role of native-language (L1) knowledge in second language (L2) acquisition is well-established, and development of second-language phonological inventory (e.g., Durgunoglu, Nagy, & Nancin-Bhatt, 1993; Harrison & Kroll, 2007), lexical skills (e.g., Ordonez et al., 2002; Proctor et al., 2006), grammatical competence (e.g., MacWhinney, 1997; 2002), and literacy abilities (e.g., Gottardo & Mueller, 2009) has been linked to native-language skills. The literature is especially robust for the transfer of L1 literacy skills to the acquisition of reading in the L2 (e.g., Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Lindsay, Manis & Bailey, 2003; Nakamoto, Lindsey & Manis, 2008), although evidence for transfer of oral language skills from L1 to L2 also exists (e.g., Ordonez et al., 2002; Proctor et al., 2006).

Acquisition of L2 vocabulary can pose challenges for language learners, both with regards to the sheer number of words that must be acquired, and with regards to the depth of lexical representations that must be developed. Prior studies have shown that L2 learners differ from native speakers in both the size of their lexicon and in the richness of semantic representations associated with the lexical items (e.g., Meara, 1982; Verhallen & Schoonen, 1998). For example, bilinguals performing word-association tasks in their second language often produce less mature responses than monolingual participants (e.g., Meara, 1982) and have less robust semantic representations for words than do monolinguals (e.g., Verhallen & Schoonen, 1998). Further, vocabulary skills in bilinguals' native language have been found to be lagging compared to monolinguals (e.g., Bialystok, Craik, & Luk, 2008; Gollan, Montoya, & Werner, 2002; Ivanova & Costa, 2008; Portocarrero, Burright, & Donovick, 2007).

For example, bilinguals have been shown to be slower at naming pictures in their native language (Ivanova & Costa, 2008) and have more tip-of-the-tongue states (Michael & Gollan, 2004) compared to monolingual speakers. However, while it is known that bilingualism impacts L1 vocabulary skills, relatively little work has been conducted on the relationship between L1 and L2 vocabulary skills in bilinguals.

The majority of studies that have examined the transfer of oral language skills in bilinguals have focused on the relationship between oral language skills in the L1 and literacy skills in the L2, and generally showed that strong native-language vocabulary skills were associated with better second-language performance (e.g., Atwill, Blanchard, Gorin & Burstein, 2007; Mumtaz & Humphreys, 2002; Nagy et al., 1993; Proctor, August, Carlo, & Snow, 2006). However, the relationship between oral language skills in L1 and oral language skills in L2 has been left relatively unexplored, and the small number of studies that examined the relationship between L1 and L2 vocabulary skills have been inconclusive. In one study of how oral language skills may transfer across bilinguals' two languages, Ordonez, Carlo, Snow, and McLaughlin (2002) examined the depth of bilinguals' word knowledge through analyzing children's performance on word-description and definition tasks. The results suggested that vocabulary skills transferred from children's L1 (Spanish) to L2 (English), with children's knowledge of super-ordinate information in English and Spanish correlating highly. However, the breadth of vocabulary knowledge in one language (i.e., the number of words known in a language) was inversely related to breadth of vocabulary knowledge in another language. Other studies, however, did not find significant relationships between L1 and L2 vocabulary knowledge (e.g., Gottardo & Mueller, 2009).

Thus, the work on the relationship between L1 and L2 oral language skills is quite sparse, and it remains unknown whether L2 acquisition can influence L1 vocabulary skills. Moreover, it is unknown whether the relationship between L1 vocabulary skills and L2 experiences remains stable independent of the specific combination of languages known to bilinguals. The *first goal* of the present study was to examine the influence of L2-acquisition-related factors on native-language vocabulary functioning. We were especially interested in whether different combinations of L1 and L2 would yield similar patterns of relationships between L2 acquisition history and L1 vocabulary skills. Examining two distinct groups of bilinguals allowed us to test the degree to which patterns of L1/L2 relationships generalize across different groups of speakers. In formulating this aim, we relied on evidence suggesting that there are differences in cross-linguistic transfer patterns for literacy-related skills depending on the specific combination of languages known to a bilingual.

Reading acquisition is a complex process that relies on orthographic, phonological,

and semantic knowledge. Acquisition of literacy in the second language is known to depend on native-language knowledge (e.g., Sparks et al., 2008), and previous work indicates that word decoding, phonological awareness and word recognition in L1 are all predictive of reading outcomes in L2 (e.g., Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Lindsay, Manis & Bailey, 2003; Nakamoto, Lindsey & Manis, 2008). The work on transfer of literacy skills has focused extensively on cross-linguistic similarity as the key variable that may mediate the relationship between L1 and L2 reading. In particular, a number of studies has contrasted the relationship between L1 and L2 literacy in bilinguals who speak two languages that share the writing system (e.g., English and Hebrew) and/or the alphabet (e.g., English and Spanish) and languages that do not share the writing system (e.g., English-alphabetic and Mandarin Chinese-logographic).

Reading an alphabetic language may rely on a somewhat different set of skills than reading a logographic language, and reading Chinese appears to be a process that is distinct from reading English, both with regards to how visual word information is processed (e.g., Akamatsu, 2003; Zhou & Marslen-Wilson, 1999; 2000), and in the degree to which visual word recognition relies on phonological processing (e.g., Perfetti, et al., 2002; Perfetti & Liu, 2005). For example, while reading Chinese and reading English both involve activation of phonological information, the timing of activation and the size of the activation unit differ (e.g., Perfetti & Liu, 2005). Moreover, it appears that bilinguals who read both an alphabetic and a logographic language apply different strategies for reading each language (e.g., Chen & Tsoi, 1990; Green et al., 1996).

Given the distinct sets of skills associated with reading alphabetic and logographic languages, it is not surprising that different transfer patterns have been observed for bilinguals who speak two alphabetic languages vs. bilinguals who speak an alphabetic and a logographic language. In general, studies on literacy transfer in bilinguals suggest a robust positive relationship between L1 and L2 skills when the two languages overlap in terms of their writing systems. A number of literacy-related skills can transfer across languages that share orthography, including phonological awareness (e.g., Dickinson et al., 2004), decoding abilities (e.g., Sparks et al., 2008), and word identification (e.g., Abu-Rabia, 2001). As a result of such positive transfer, bilingual children who speak two languages that overlap in their writing systems often outperform monolingual children on literacy-related tasks (Abu-Rabia & Siegel, 2002; Bialystok, Luk, & Kwan, 2005; Da Fontoura & Seigel, 1995; Friedenberg, 1984).

The transfer patterns for bilinguals whose two languages do *not* share the writing system are more complex. It appears that phonologically-based processes show positive transfer between bilinguals' two languages, even when the languages do not

share the writing system (e.g., Harrison & Kroll, 2007; Luk & Bialystok, 2008; Wang, Perfetti, & Liu, 2005). However, a lack of relationships between L1 and L2 reading skills (e.g., Wang et al., 2005) and instances of negative transfer (e.g., Bialystok, 1997; Holm & Dodd, 1996; Liow & Poon, 1998) have also been noted in bilinguals who speak languages that differ in their writing systems. For example, Liow and Poon (1998) showed that children who read a logographic script had lower scores on phonological awareness measures compared to children who read alphabetic scripts. Similarly, Holm and Dodd (1996) found that Chinese-speaking students had difficulty with reading English, and attributed this difficulty to the fact that reading Chinese recruits visual processing skills, while reading English recruits phonological processing skills.

Together, the work on the relationship between L1 and L2 vocabulary and reading skills strongly indicates that native-language abilities can influence second-language vocabulary and reading performance. However, these studies are limited in that they only examine the effects of L1 on L2, thus ignoring the possibility that acquisition of a second language may impact the ability to function in the native language, and in that they only examine the relationships between bilinguals' L1 and L2 performance on highly-constrained tasks (e.g., word association). Therefore, while current cognitive models of bilingualism incorporate the notions of interactivity between bilinguals' two languages (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra & Van Heuven, 2002), and while it is well-known that aspects of L2 acquisition (including age of L2 acquisition; extent of L2 exposure; etc.) have a strong impact on L2 proficiency, it remains unknown whether experiences associated with second-language acquisition have an effect on native-language abilities. In the current study, we rely on theories of bilingualism that construe bilinguals' two languages as constantly engaging in dynamic interactions (sometimes, competitive and sometimes, mutually-reinforcing; e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra & Van Heuven, 2002) to hypothesize that experiences associated with L2 acquisition would influence L1 functioning.

4. Current Study

While the transfer of native-language abilities to second-language skills in bilinguals has been a focus of many studies, significantly less is known about the inverse relationship between bilinguals' second language and their native-language skills. Only a few studies have examined the transfer of language skills from bilinguals' L2 to their L1, and these have been largely limited by their focus on literacy. Relying on cognitive models of bilingualism that incorporate the notions of interactivity between bilinguals' two languages and on the cross-linguistic transfer literature,

the goal of the current study was to examine the effects of knowing two different second languages on bilinguals' native language performance. Specifically, we tested whether factors that influence second language acquisition also bear a relationship to native-language vocabulary and reading skills in two groups of bilingual speakers: An English-Spanish bilingual group and an English-Mandarin bilingual group. Since English and Spanish share the writing system (both are alphabetic), we expected positive relationships between knowledge of Spanish and performance on the English reading task. Conversely, since English and Mandarin do not share the writing system (English is alphabetic, while Mandarin is logographic), we expected a negative relationship between knowledge of Mandarin and performance on the English reading task. However, we expected similar relationships between L2 experiences and bilinguals' native-language vocabulary performance in the two groups of bilinguals.

In order to index bilinguals' L2 acquisition history, we collected extensive questionnaire data from bilinguals regarding the specifics of their second-language acquisition experiences. The L2 experiences that were of most interest were: (1) L2 acquisition age; (2) extent of prior L2 exposure; (3) extent of current L2 exposure; and (4) self-reported L2 proficiency levels for speaking, understanding, and reading. Since it is well known that earlier L2 acquisition age and increased exposure to the second language lead to improvements in L2 processing abilities (e.g., Flege et al., 1999), the same variables should also be related to L1 processing abilities, if knowledge of L2 can influence L1 performance. By considering the role of L2 acquisition, the extent of L2 exposure, and L2 proficiency in native-language functioning, the current study provides a new direction in the work on the relationship between L1 and L2, and the ability of the cognitive system to adapt to the presence of a second language.

5. Method

Participants

Fifty-three participants were recruited for the experiment, including 29 English-Spanish bilinguals and 24 English-Mandarin bilinguals. All participants spoke English as their first language, and acquired either Spanish or Mandarin as a second language early in life, with a mean acquisition age of 7.3 years (*SE* = 1.03) for Spanish speakers, and a mean acquisition age of 2.4 years (*SE* = 0.79) for Mandarin speakers. Second-language speaking proficiency levels were similar for the two groups, with a mean of 7.3 (*SE* = 0.26) for Spanish and 6.5 (*SE* = 0.43) for Mandarin on a scale from zero (no knowledge) to ten (native-speaker knowledge). Moreover, both groups had

similar levels of L2 exposure on a daily basis, with an average 12.2 % of the time (*SE* = 2.62) for English-Spanish bilinguals and an average 11.9 % of the time (*SE* = 3.14) for English-Mandarin bilinguals. See Table 1 for participant characteristics in the two bilingual groups.

Procedure

Both groups of bilingual participants filled out the *Language Experience and Proficiency Questionnaire* (Marian, Blumenfeld, & Kaushanskaya, 2007). Data from this questionnaire were used to determine participants' self-reported levels of L2 proficiency, L2 exposure, and L2 experience. All participants were also administered standardized tests of receptive vocabulary, expressive vocabulary, and reading fluency in English.

Language Experience and Proficiency Questionnaire (LEAP-Q). The *LEAP-Q* is a reliable questionnaire that elicits internally consistent self-reported data regarding bilinguals' language proficiency, age of acquisition, and history of prior and current language exposure across all languages. The questionnaire was validated in a large sample of bilingual speakers against standardized measures of language ability across various domains (phonology, vocabulary, and morphosyntax), and was shown to be highly predictive of bilinguals' actual linguistic performance in both the L1 and the L2.

Peabody Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997). The *PPVT-III* measures receptive vocabulary ability by requiring a participant to listen to a stimulus word and to choose the picture that best represents a stimulus word given four options. The difficulty level of the words increases incrementally with less frequent and later-acquired words appearing later in the test.

Expressive Vocabulary Test (EVT; William, 1997). The *EVT* measures expressive vocabulary ability by requiring a participant to produce a synonym to a target word. For example, an experimenter reads a target word "walk" while showing the picture of a person walking, and the participant produces a synonym to a target word. The correct responses would be "stroll," "stride," "pace," etc.

Reading Fluency. Participants' reading skills in English were indexed by the *Reading Fluency* sub-test of the *Woodcock Johnson III - Tests of Achievement* (Woodcock, McGrew, & Mather, 2001). This test measures how quickly and accurately people read English sentences. Participants are presented with 98 sentences and are given three minutes to read as many of them as they can. After reading each sentence,

the participant needs to judge the truth value of the sentence by circling a *Yes* or *No* response provided on the answer sheet. The difficulty level of sentences gradually increases.

4.1. Analyses

To examine whether there were differences between English-Spanish and English-Mandarin bilinguals on measures of native-language vocabulary and reading knowledge, independent samples *t*-tests were conducted that compared bilinguals' performance on the *PPVT-III*, the *EVT*, and the *Reading Fluency* sub-test of the *WJ-II*. To examine where there were differences between the two bilingual groups in their L2 acquisition history, independent samples *t*-tests were conducted that compared bilinguals' responses on the LEAP-Q that indexed age of L2 acquisition, degree of L2 immersion, extent of on-going L2 exposure, and L2 proficiency. Finally, to examine whether L2 acquisition history was related to native-language vocabulary and reading skills, correlations analyses were performed for each bilingual group, where L2 experiences were correlated with bilinguals' native-language vocabulary skills and reading knowledge.

5. Results

5.1. Comparing English-Spanish and English-Mandarin Bilinguals

Native-Language Vocabulary and Reading Fluency Performance: Independent-samples *t*-tests showed that there were no significant differences in bilinguals' performances on standardized measures of native-language vocabulary and reading. This was true for the *PPVT-III* (t (50) = 0.26, p = 0.98), the *EVT* (t (49) = -0.998, p = 0.32), and Reading Fluency (t (38) = - 0.40, p = 0.69) (see Table 2).

L2 Acquisition History. Independent-samples *t*-tests were used to compare the two bilingual groups to each other with regards to proficiency, exposure, and experience with the second language (Spanish vs. Mandarin). There were differences between groups in the timing of L2 acquisition, including the age of L2 acquisition and the age at which both speaking and reading fluency in L2 were attained. While English-Spanish and English-Mandarin bilinguals acquired reading skills in English at comparable ages, English-Spanish bilinguals acquired reading skills in their L2 later (M = 10.46, *SE* = 0.8) than English-Mandarin bilinguals (M = 7.46, *SE* = 1.1), t (50) = 2.28, p = 0.027. The L2 acquisition age of English-Spanish bilinguals (M = 7.39, *SE* = 1.0) was significantly later than that of English-Mandarin (M = 2.41, *SE*

= 0.8), t (50) = 3.72, p = 0.01. Similarly, English-Spanish bilinguals attained fluency in speaking (M = 13.32, SE = 1.5) and reading (M = 13.96, SE = 1.3) in their L2 later than English-Mandarin bilinguals (speaking: M = 7.14, SE = 0.98; reading: M = 10.19, SE = 1.2), $t_{speaking}$ (44) = 3.23, p = 0.02; $t_{reading}$ (39) = 2.04, p = 0.049. In general, English-Spanish bilinguals acquired their L2 (Spanish) later than English-Mandarin bilinguals acquired their L2 (Mandarin).

There were also differences between the two bilingual groups with regards to self-rated L2 reading proficiency. English-Mandarin bilinguals reported lower levels of L2 reading than English-Spanish bilinguals, t (50) = 3.67, $p < 0.01$, although both groups reported similar levels of L2 speaking and understanding (all p values > 0.1).

5.2. Relating L1 Performance to L2 Acquisition History

Correlation analyses were conducted within each group to examine the relationship between bilinguals' second language experience and native-language receptive and expressive vocabulary; similarly, correlation analyses were conducted to examine the relationship between bilinguals' second-language experience and reading fluency in the native language.

Relating L1 Vocabulary Skills and L2 Acquisition Age

For English-Spanish bilinguals, age of L2 acquisition generally correlated positively with L1 vocabulary knowledge, indicating that later ages of L2 acquisition were associated with better L1 vocabulary knowledge. Specifically, L2 acquisition age correlated positively with L1 expressive vocabulary skills (r = 0.37, p = 0.05); age at which L2 speaking fluency was attained correlated with both receptive vocabulary skills (r = 0.47, p = 0.02) and expressive vocabulary skills (r = 0.72, p = 0.000) in the L1; lastly, age at which L2 reading fluency was attained correlated positively with both receptive vocabulary skills (r = 0.53, p = 0.006) and expressive vocabulary skills (r = 0.64, p = 0.001) in the L1.

For English-Mandarin bilinguals, age of L2 acquisition correlated negatively with L1 vocabulary knowledge, indicating that earlier ages of L2 acquisition were associated with better L1 vocabulary knowledge. Specifically, English-Mandarin bilinguals' L1 expressive vocabulary skills negatively correlated with L2 Age of Acquisition (r = -0.48, p = 0.03), age at which L2 speaking fluency was attained (r = -0.49, p = 0.03), and age at which L2 reading fluency was attained (r = -0.57, p = 0.03).

Relating L1 Vocabulary Skills and L2 Experience

Extent of prior exposure to L2 correlated negatively with L1 vocabulary skills in both English-Spanish bilinguals and English-Mandarin bilinguals. Specifically, for English-Spanish bilinguals, the number of years spent with a Spanish-speaking family correlated negatively with both receptive vocabulary skills (r = -0.37, p = 0.05) and expressive vocabulary skills (r = -0.60, p = 0.001) in the L1. For English-Mandarin bilinguals, the number of years spent in a Mandarin-speaking country correlated negatively with receptive vocabulary skills in the L1 (r = -0.39, p = 0.07).

Extent of current L2 exposure correlated negatively with L1 vocabulary skills in both groups of bilingual speakers. For English-Spanish bilinguals, the extent of current L2 exposure in a family context correlated negatively with both receptive (r = -0.40, p = 0.04) and expressive vocabulary skills (r = -0.60, p = 0.001) in L1. For English-Mandarin bilinguals, the extent of current L2 exposure through friends correlated negatively with receptive vocabulary skills in the L1 (r = -0.37, p = 0.08), while the extent of current exposure to reading in their L2 correlated negatively with both receptive vocabulary skills (r = -0.36, p = 0.092) and expressive vocabulary skills (r = -0.37, p = 0.09) in the L1.

Self-rated L2 proficiency levels did not correlate with L1 vocabulary skills in English-Spanish bilinguals. However, English-Mandarin bilinguals demonstrated a negative correlation between self-rated L2 reading proficiency and receptive vocabulary skills in the L1 (r = -0.53, p = 0.01).

Relating L1 Reading Skills and L2 Acquisition Age

For English-Spanish bilinguals, age of L2 acquisition correlated positively with L1 reading fluency. Specifically, L1 reading fluency correlated positively with both the age at which L2 speaking fluency was attained (r = 0.64, p = 0.003) and the age at which L2 reading fluency was attained (r = 0.72, p = 0.0001). This suggests that later acquisition of Spanish was associated with higher reading fluency in English for this group of bilinguals. A similar relationship was noted between English-Spanish bilinguals' age of L2 acquisition and L1 vocabulary performance. However, there were no significant correlations observed between the age of L2 acquisition and reading fluency in L1 for English-Mandarin bilinguals.

Relating L1 Reading Skills and L2 Experience

For English-Spanish bilinguals, the *extent of prior L2 exposure* did not correlate with L1 reading fluency. However, for English-Mandarin bilinguals, L1 Reading Fluency was negatively correlated with the number of years spent in a Mandarin-speaking country (r = -0.50, p = 0.04).

For English-Spanish bilinguals, there was no correlation between the *extent of current L2 exposure* and L1 Reading Fluency. However, for English-Mandarin bilinguals, L1 Reading Fluency correlated negatively with the extent of current exposure in the context of L2-speaking friends (r = -0.44, p = 0.06), and correlated positively with the extent of current exposure in the context of L2-speaking family (r = 0.40, p = 0.09).

Generally, *L2 proficiency* correlated positively with L1 Reading Fluency in English-Spanish bilinguals, but negatively in English-Mandarin bilinguals. Specifically, for English-Spanish bilinguals, L1 Reading Fluency correlated positively with L2 speaking proficiency (r = 0.38, p = 0.08) and with L2 reading proficiency (r = 0.42, p = 0.06). However, for English-Mandarin bilinguals, L1 reading fluency correlated negatively with L2 reading proficiency (r = -0.61, p = 0.007).

6. Discussion

The role of native-language (L1) knowledge in second language (L2) acquisition is well-established (e.g., Durgunoglu, Nagy, & Nancin-Bhatt, 1993; Harrison & Krol, 2007; Ordonez et al., 2002; Proctor et al., 2006; MacWhinney, 1997; 2002) especially with regards to literacy skills (e.g., Gottardo & Mueller, 2009; Lindsay, Manis & Bailey, 2003; Nakamoto, Lindsey & Manis, 2008). However, less is known about the transferability of oral language skills, e.g., vocabulary knowledge, and about the effects L2 acquisition may have on native-language performance. The current study was designed to address two interrelated questions: First, we examined whether acquisition of a second language can influence native-language vocabulary and reading performance. Second, we examined whether acquisition of two different L2s – Spanish and Mandarin – may have distinct influences on bilinguals' native language skills (English). Our broad hypothesis was that knowledge of L2 would mediate L1 performance, but that distinct L2 experiences would have different influences on L1 performance. Specifically, we predicted that acquisition of Spanish vs. Mandarin as the second language would have distinct effects on native-language English reading skills in the two groups of bilinguals.

In general, our findings suggest that acquisition of a second language is related to bilinguals' performance in the native language. The robustness of the correlation analyses attests to the relationships between factors associated with L2-acquisition and L1 skills, both in the vocabulary domain and the reading domain. Crucially, the effects were not limited to a single factor associated with L2 acquisition, and instead, Age of L2 acquisition, immersion- and experience-related measures associated with L2 acquisition and use, and L2 proficiency all entered into significant relationships

with L1 performance. This pattern of findings supports the interactive view of the bilingual cognitive system, and suggests that acquisition and processing of L1 and L2 are mutually-dependent processes. While prior work in this general theoretical framework only considered the effects of native-language knowledge on L2 processing, the current study indicates that similar effects are present when the effects of second-language knowledge on L1 processing are considered.

Distinct patterns of findings were observed for the relationship between L2-acquisition-history and L1 vocabulary skills in the two groups of bilinguals. While in English-Spanish bilinguals, later acquisition of L2 was associated with higher L1 vocabulary performance, in English-Mandarin bilinguals, later acquisition of L2 was associated with lower L1 vocabulary performance. The relationship between L2 acquisition age and L1 vocabulary in English-Spanish bilinguals can be easily interpreted, since later exposure to Spanish would have allowed English-Spanish bilinguals more time to be exposed to English, thus yielding higher English vocabulary scores later in life. However, the relationship between L2 acquisition age and L1 vocabulary in English-Mandarin bilinguals cannot be explained using the same logic, since earlier exposure to Mandarin should have reduced exposure to English, thus decreasing English vocabulary performance. One possible explanation for the inverse relationship between L2 acquisition age and L1 vocabulary skills in English-Mandarin bilinguals is that early exposure to two highly distinct languages like English and Mandarin may actually facilitate the ability to acquire vocabulary later in life. Evidence for such a mechanism was obtained by Bialystok (1997), who showed that while at 4 years of age, children exposed to both Chinese and English performed less successfully on literacy tasks than monolingual children or children, by 5 years of age, this disadvantage resolved, and English-Chinese children actually outperformed the monolingual group. Similarly, Kaushanskaya and Marian (2009) found that early exposure to English and Mandarin yielded enhanced word-learning skills in adult English-Mandarin bilinguals compared to monolingual speakers of English. Clearly, then, further studies are necessary to delineate the possible differences in how exposure to two different L2s early in life can impact on subsequent vocabulary development. However, the correlation patterns obtained in the current study indicate that differences in L2s acquired in childhood can yield distinct influences on native-language vocabulary performance in adulthood.

The differences in how the age of L2 acquisition influenced L1 vocabulary performance in the two groups of bilinguals are in stark contrast to the similarities in how the extent of L2 immersion (past and present) influenced L1 vocabulary performance in English-Spanish and English-Mandarin bilinguals. For both groups, longer immersion in L2 was associated with decreased L1 vocabulary performance. Since increased exposure to L2 throughout the lifespan necessarily reduces exposure

to L1, and since acquisition of vocabulary occurs through immersion (Gollan, Montoya, Cera, & Sandoval, 2008), this inverse relationship between L2 exposure and L1 vocabulary skills is inevitable. Interestingly, it does not appear to be modulated by the specifics of the L2 (Spanish vs. Mandarin), indicating that extended exposure to any L2 is likely to take a toll on native-language vocabulary skills. These findings are largely in line with prior literature on cross-linguistic transfer, where the breadth of vocabulary knowledge in bilinguals' L1 was found to be inversely related to the breadth of vocabulary knowledge in their L2 (e.g., Ordonez, Carlo, Snow, & Mclaughlin, 2002). These results also align with literature demonstrating that bilinguals perform less successfully than monolinguals on lexical retrieval tasks, even when these tasks are administered in their native language (e.g., Ivanova & Costa, 2008).

While we did not expect the typological distance between two languages to moderate the relationship between bilinguals' L2 and L1 vocabulary performance, we did expect it to influence bilinguals' literacy-related skills. The extensive literature on cross-linguistic transfer strongly suggests that (1) literacy-related skills in L1 are more likely to transfer to L2 when the two languages share the writing system (e.g., Abu-Rabia, 2001; Dickinson et al., 2004; Sparkes et al., 2008), and (2) that bilinguals' literacy skills are positively impacted by the knowledge of a language that shares the reading principles with the target language (and this appears to be especially true when the native language is more transparent than the second language, e.g., Bialystok, Luk, & Kwan, 2005; Da Fontoura & Seigel, 1995). In the current study, there were clear differences between how L2 acquisition history and L1 reading fluency were related in the two groups of bilingual speakers. In English-Spanish bilinguals, there was no relationship between L2-immersion-related variables and L1 reading fluency, but there was a positive relationship between bilinguals' ratings of their L2 proficiency and L1 reading fluency. This suggests that English-Spanish bilinguals who were more proficient in Spanish were more likely to be better readers in English. Conversely, there were consistent negative correlations between L2-immersion-related variables and L1 reading fluency in English-Mandarin bilinguals, and most notably, there was a robust inverse relationship between bilinguals' ratings of Mandarin proficiency and their performance on the English reading fluency task. This indicates that English-Mandarin bilinguals who were more proficient in Mandarin were less fluent readers of English.

The interpretation of correlational data must necessarily be cautious. Although it is difficult to construe the findings as suggesting that native-language performance can influence the patterns of L2 acquisition (especially those associated with L2 acquisition age), it is impossible to attribute directionality to the observed effects. Therefore, it is necessary that this work be followed-up with empirical manipulations

of bilingual groups. Specifically, it would be worthwhile to recruit larger samples of bilinguals, and split each group into an early-acquisition vs. a late-acquisition sub-groups. Similarly, future work must attempt to equate bilingual groups with distinct language histories (Spanish vs. Mandarin) on L2 acquisition history, in order to more precisely delineate the effect of different L2s on native-language performance. In the current study, the two groups of bilinguals (English-Spanish vs. English-Mandarin) differed not only with respect to the identity of the second language, but also with respect to the L2 acquisition history. Thus, although the two groups were matched in L2 speaking and understanding proficiency and L1 performance, as a group, English-Mandarin bilinguals acquired their L2 earlier than English-Spanish bilinguals, and reported lower levels of L2 reading than English-Spanish bilinguals. It is possible, therefore, that the differences observed between the two bilingual groups are due not to specifics of the L2 (Spanish vs. Mandarin), but to the age at which L2 was acquired (early vs. late). For instance, it is feasible that there is a cut-off age after which exposure to the L2 can lead to lower word-learning ability (akin to the critical-period hypothesis for syntax; Johnson & Newport, 1989), so that for bilinguals exposed to their L2 prior to this cut-off, earlier exposure to the L2 may lead to enhancements of the vocabulary-learning mechanisms, while for bilinguals exposed to their L2 after this cut-off, earlier exposure to the L2 may lead to the weakening of the vocabulary-learning mechanism. This would explain the findings in the current data, where earlier exposure to Spanish yielded lower English vocabulary performance, while earlier exposure to Mandarin yielded higher English vocabulary performance. However, this interpretation appears less likely in light of the fact that despite differences in the average ages of L2 acquisition, the ranges for the L2 acquisition age were quite similar across the two groups, and a number of English-Spanish bilinguals reported acquiring Spanish prior to three years of age. Therefore, to fully examine the effects of acquisition history and identity of L2 on native-language performance, experiments that orthogonally manipulate both variables are necessary.

In conclusion, the current study indicates that knowledge of a second language can influence bilinguals' performance on native-language vocabulary and reading tasks. Moreover, different L2 experiences (i.e., acquisition of Spanish vs. Mandarin as the L2), yield distinct influences on bilinguals' vocabulary and reading performance. These differences between English-Spanish and English-Mandarin bilinguals in the relationships between the history of L2 acquisition and native-language skills are all the more notable, since the two groups were in fact matched on their English vocabulary and literacy performance. Therefore, the distinct relationships that were observed between L2 acquisition and L1 function in the two groups of bilinguals indicate that seemingly comparable patterns of performance in bilinguals may obscure differences in the mechanisms that underlie L1 and L2 performance. In general,

observing L2 influences on L1 suggests bi-directionality of connections between the native language system acquired at birth, and a second language acquired later in life, and the permeability of native-language abilities to influences associated with acquisition of a new linguistic system.

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Table 1. English-Spanish Bilingual and English-Mandarin Bilingual Participant Characteristics (Means and SE values)

	English-Spanish Bilinguals	English-Mandarin Bilinguals	*t* and *p* value
Age	22.12 (0.65)	20.88 (0.57)	t (51) = 1.41, p = 0.16
Years of Education	15.43 (0.38)	14.62 (0.60)	t (47) = 1.18, p = 0.24
L2 Acquisition Age	7.39 (1.04)	2.42 (0.79)	t (50) = 3.72, p < 0.01
Percent of Daily Exposure to L2 (out of 100%)	12.21 (2.62)	11.88 (3.14)	t (51) = 0.08, p = 0.94
Self-Rated L2 Speaking Proficiency (zero-to-ten scale)	7.29 (0.26)	6.58 (0.43)	t (50) = 1.46, p = 0.15
Self-Rated L2 Understanding Proficiency (zero-to-ten scale)	7.82 (1.19)	7.25 (0.44)	t (50) = 1.22, p = 0.23
Self-Rated L2 Reading Proficiency (zero-to-ten scale)	7.29 (0.29)	4.71 (0.64)	t (50) = 3.67, p < 0.01

Table 2. Between-Group Comparison for Native-Language Vocabulary and Reading Fluency Performance of English-Spanish Bilingual and English-Mandarin Bilingual Participants

	English-Spanish Bilinguals	English-Mandarin Bilinguals	*t* and *p* value
Receptive Vocabulary	83.08 (3.6)	82.93 (4.8)	t (50) = 0.26, p = 0.98
Expressive Vocabulary	82.90 (4.6)	89.18 (3.9)	t (49) = -0.998, p = 0.32
Reading Fluency	77.52 (5.8)	80.69 (5.1)	t (38) = - 0.40, p = 0.69