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Bilingualism and Phonological Awareness: Re-examining Theories of Cross-Language Transfer and Structural Sensitivity

Li-Jen Kuo¹, Yuuko Uchikoshi², Tae-Jin Kim³, and Xinyuan Yang¹

¹Texas A&M University, USA

²University of California-Davis, USA

³Independent Researcher, Taiwan

Abstract

The purpose of this study was to examine the relationship between bilingualism and phonological awareness by re-evaluating *structural sensitivity theory* and expanding *cross-language transfer theory*. The study was conducted with three groups of 1st and 2nd graders matched in age, SES and non-verbal IQ: a) monolingual English-speaking children from a general education program, b) native Japanese-speaking children from a Japanese-English two-way immersion bilingual program and c) native English-speaking children from the same bilingual program. An odd-man-out task that took into account the phonological and orthographical contrasts between English and Japanese was developed to assess onset awareness. The results showed that the bilingual children outperformed their monolingual peers in processing onsets that are shared between the two languages, which provided empirical support for the first hypothesis derived from *structural sensitivity theory* and highlighted the importance of contextual variability in bilingual metalinguistic processing. The second hypothesis derived from *structural sensitivity theory*, which predicated that bilingual advantage would be more evident in processing novel stimuli, was not confirmed in the present study. The absence of the predicted group difference may be attributed to the disparity in the extent of novelty of the stimuli and the difference in the comparability of participants' degrees of bilingualism between the present study and previous research. Finally, expanding existing research, results from this study showed that cross-language transfer can occur at a phonetic featural level. Future research and theoretical implications were discussed.

1. Introduction

The past two decades have witnessed a dramatic worldwide growth in the number of young children developing language and literacy skills in two languages. In the United States alone, the number of two-way immersion bilingual programs has increased by 25% in the past decade (Center for Applied Linguistics, 2014). In many East Asian countries, English has become a required subject in the early elementary grades or even in kindergarten (Butler, 2005). In light of the increasing awareness of maintaining a heritage language and acquiring a foreign language in early childhood, a series of scientific investigations has been conducted on how early bilingual experience would affect children's development of metalinguistic awareness, that is, their ability to manipulate linguistic units and to reflect upon structural properties of language (Kuo & Anderson, 2008).

While various aspects of metalinguistic awareness have been investigated among second language learners (e.g., Kieffer, Biancarosa, & Mancilla-Martinez, 2013; Kieffer & Lesaux, 2012; Kim et al., 2015; Kuo & Kim, 2014), *phonological awareness*, the ability to manipulate and reflect upon the units and structures of a language's sounds, has received the most attention in bilingual cognition and literacy research (Bialystok, 2001, 2002; Kuo & Anderson, 2010; 2012). This unique attention is attributed to the role of phonological awareness as a precursor to reading. It has been well-established in the literature that beginning readers who are more capable of attending to subsyllabic sound units can more rapidly map written symbols onto sound units and, therefore, are more likely to be successful in decoding and reading. The relationship between phonological awareness and decoding has been documented in research with learners of alphabetic languages (e.g., Bradley & Bryant, 1983; Nithart & Demont, 2011; Schneider & Naslund, 1999; Soltani & Roslan, 2013; Wagner et al., 1994, 1997; Wimmer, 1994), as well as learners of logographic languages (Ho & Bryant, 1997), and among first language learners (e.g., Bradley & Bryant, 1983; van de Sande, Segers, & Verhoeven, 2013) as well as second language learners (e.g., Dixon, 2010; Geva & Ryan, 1993; Gottardo & Mueller, 2009; Uchikoshi, 2013).

1.1. Cross-Language Transfer Theory

Most of the observed bilingual advantage in phonological awareness has been construed in terms of cross-language transfer. Following the classical theory of transfer (e.g., Osgood, 1949), cross-language transfer can be defined based on specific common elements. At the most fundamental level, the theory predicts that the learning of language A facilitates the learning of language B if: a) the two languages share a linguistic feature, such as a particular phoneme or a particular phonological structure, and b) that particular linguistic feature is more prominent or complicated in language A than in language B. Positive transfer is unlikely to occur if neither or only one of the conditions are met; instead, negative transfer would occur, especially in the assessment of the less-dominant language, when the dominant language has a simpler or less salient linguistic feature (e.g., Bialystok et al., 2003; Dupeau et al., 1999).

Positive bilingual effect on phonological awareness has been documented among bilinguals who speak pairs of languages varying in phonological complexity, orthographic depth and typological affinity. In one of the pioneering studies in the field, Campbell and Sais (1995) showed that Italian-English bilingual kindergartners, despite being slightly younger, outperformed their English-speaking monolingual peers on a phonemic odd-man-out task and on a syllable deletion task. The bilingual advantage was attributed to the more regular syllable structure of Italian versus English, which may make it easier for the Italian-English bilingual children to attend to syllables and phonemes. Similar bilingual advantage was also reported in a study by Bruck and Genesee (1995) with English-speaking first-graders who attended either an English-speaking school or a French immersion school. The children in the French immersion program outperformed their monolingual peers in measures of syllable awareness. The authors argued that the bilingual advantage may have stemmed from the saliency of syllables in French compared to English.

Research has demonstrated that bilingual advantage in phonological processing is not limited to the awareness of segmental units, such as onset, rimes or syllables, and can be extended to awareness of suprasegmental features. In a study with Mandarin-speaking monolingual children and Cantonese-Mandarin speaking children, Chen et al. (2004) showed that bilingual children outperformed their monolingual peers on tone awareness. These bilingual children spoke Cantonese at home and learned to speak and read in Mandarin at school. Their advantage in tone awareness was credited to the richness of tones in Cantonese over Mandarin.

The aforementioned findings on bilingual advantage have been observed among young children who were literate in only one of their two languages. Similar bilingual advantage among children who are literate in both languages have also been documented. Bialystok, Majumder and Martin (2003) showed that Spanish-English and Hebrew-English bilingual children outperformed their English-speaking monolingual peers on phoneme awareness assessed in English, the weaker language of the bilinguals. The observed bilingual advantage was ascribed to the greater transparency of Spanish and Hebrew over English. Spanish and Hebrew (i.e., the Ktic menuqad script) have much more consistent grapheme-to-phoneme correspondences than English. Such bilingual advantage may be moderated by the amount of exposure to the more transparent script. In a cross-sectional and longitudinal study with French monolingual and French-Occitan bilingual 3rd, 4th and 5th graders, Laurent and Martinot (2010) revealed that the bilingual advantage in phoneme segmentation and phoneme permutation was only found among the 4th and 5th graders but not the 3rd graders.

With a push for the early introduction of English in schools in many different parts of the world (Butler, 2003), the effect of bilingual experience on phonological awareness has been studied in groups of children with different amounts of instruction in the second language as well. Chen et al. (2010) conducted a study with Chinese-speaking children in three different programs: the *non-English* (NE) program, where English instruction was not provided; the *regular English* (RE) program, where English instruction was provided twice a week for 40 minutes each time, and the *intensive English* (IE) program, where English instruction was offered for a total of 10 hours every week. Through their longitudinal data, Chen et al. (2010) demonstrated that English instruction expedited the development of phonological awareness in Chinese, and this effect derived from the relative greater transparency of English over Chinese.

Cross-language transfer theory has also explained null and negative effects among bilinguals who speak different pairs of languages. For example, in a study with English-speaking monolingual children and Punjabi-English bilingual children in first grade, Chiappe and Siegel (1999) did not find any bilingual advantages in phonological awareness, as measured with phoneme recognition, location identification, phoneme deletion, and substitution. Additionally, in a series of studies by Bialystok and her colleagues, it was found that Mandarin-English bilingual children in kindergarten through second grade either scored the same as or more poorly than their English-speaking monolingual peers on phonological awareness measures, depending on the tasks being used, which included phoneme substitution, syllable deletion, phoneme onset deletion, and phoneme counting tasks (Bialystok, Majumder, & Martin, 2003; Bialystok, Luk, & Kwan, 2005; Bialystok, McBride,

& Luk, 2005). In these studies, the two languages of the bilingual children either shared fewer linguistic features or the particular shared linguistic features were less prominent or complicated in the additional language than the language shared with the monolingual children.

In summation, in most of the studies that have reported bilingual advantage in phonological awareness, the bilingual participants had experience in an additional language with one of the following features: a) simpler or more regular phonological structures (e.g., Campbell & Sais, 1995); b) more salient segmental units (e.g., Bruck & Genessee, 1995); or c) an alphabetic writing system (e.g., Bialystok et al., 2003, 2005; Kang, 2012). The presence and absence of a bilingual advantage revealed in the above-mentioned research are consistent with the predictions made by cross-language transfer theory. However, cross-language transfer theory alone cannot account for observed bilingual advantage where a) the additional language has less prominent linguistic features (e.g., Marinova-Todd, Zhao and Bernhardt, 2010); or b) the assessment involved phonological units that do not exist in the bilingual's dominant language (e.g., Chen et al., 2004) or in either of their two languages (e.g., Kuo & Anderson, 2012). These empirical studies will be described in more detail in the next section.

1.2. Structural Sensitivity Theory

To complement the *cross-language transfer theory*, Kuo and Anderson (2012) proposed *structural sensitivity theory*. The theory postulates that children with regular exposure to more than one language may have “greater readiness to reorganize linguistic input and impute linguistics structure” (Kuo & Anderson, 2012, p.457). The theory argues that bilingual facilitation, characterized by a heightened sensitivity to structural aspects of language, stems from several sources. First, bilingual children constantly need to overcome interlingual interferences, which provide them an opportunity to focus their attention on the structural features of language. Second, with access to more than one linguistic system, bilingual children have the advantage over their monolingual peers in noticing the structural similarities and differences between languages and thus form representations of language structure at a more abstract level. Finally, drawing upon psycholinguistic research on the facilitation of contextual variability in the acquisition of phonology (Gomez, 2002), Kuo and Anderson (2012) also argued that bilingual children may benefit from the opportunity to experience certain phonological segments in richer and more variable contexts, which may allow them to more readily dissociate a phonological segment from its context and thus enhance their development of phonological awareness. It should be noted that structural sensitivity is framed in a unified language processing system (Kroll & DeGroot, 2005). While the theory suggests that the degree of bilingual effect can be contingent, in part, upon the amount of overlapping linguistic structures and units between the two languages, it is distinctive from cross language theory in that it is the “*joint* experience in the two languages, rather than the carry-over of processing skills developed in one language to the processing of another language” (Kuo & Anderson, 2010, p.370), that forms the underpinning for bilingual metalinguistic advantage.

Several studies have provided empirical support for the *structural sensitivity theory*. Extending research by Bialystok et al. (2003) and Chen et al. (2010), Kang (2012) showed that Korean-English bilingual kindergarteners, who attended an English immersion program with about five hours of instructions in English daily, outperformed their Korean monolingual peers, who attended Korean-speaking schools with only 15 minutes of English daily lessons, in phoneme awareness in Korean. Korean, an alphabetic language with highly consistent grapheme-to-phoneme correspondences, has greater transparency than English. Yet, the bilinguals, despite having less exposure to Korean and having more exposure to English, outperformed their Korean monolingual peers, suggesting that it was the bilingual experience, where the bilinguals were able to process the same phonological segment in more variable acoustic, articulatory and orthographic contexts, that promoted the advantage.

Furthermore, Marinova-Todd, Zhao and Bernhardt (2010) conducted a study with three groups of four to five-year olds: a) Mandarin-English bilinguals in Canada; b) English monolinguals in Canada; and c) Mandarin monolinguals in China. All three groups of children had limited literacy skills. The bilingual group outperformed the monolingual counterparts on most of the phonological awareness measures in *both* languages. The authors argued that the observed bilingual advantage cannot be explained by any unique linguistic characteristics of Mandarin or Chinese and thus is more likely to be ascribed to bilingualism *per se*.

Kuo and Anderson (2010, 2012) considered the similarities and differences in the phoneme inventory or syllable structures of the two languages in their design of research measures on bilingual phonemic awareness. The study was conducted with Mandarin-speaking monolingual and Mandarin-Southern-min bilingual children in kindergarten as well as first and second grade. Southern-min, a dialect spoken in Taiwan, does not have its own writing system and is mutually unintelligible when compared with Mandarin. Kuo and Anderson's (2010) measure of onset awareness in Mandarin contained two conditions: *Shared*, which contained syllables with onsets that exist in both languages; and *Mandarin-only*, which contained syllables with onsets that exist in Mandarin but not Southern-min. The study did not reveal any group differences in the *Mandarin-only* condition across any of the grade levels. However, in the *shared* condition, the bilingual children performed significantly better than their monolingual peers in kindergarten and grade 1, although the advantage did not maintain in grade two.

The results echo findings from Chen et al. (2004). Chen et al. (2004), as mentioned earlier, involved Mandarin-speaking monolingual and Cantonese-Mandarin bilingual first, second and fourth graders. In the phonological awareness assessment, a distinction was made between *shared words*, which contained syllables that exist in both Mandarin and Cantonese, and *Mandarin-only words*, which contained syllables consisting of an onset or rime that exists in Mandarin but not in Cantonese. It was found that in the *shared words* condition, the two groups performed similarly in grades one and four, but at grade two, the bilingual group outperformed the monolingual group. Taken together, these advantages can be attributed to bilinguals' unique experience in processing the shared phonological segments in richer and more variable contexts, which leads to enhanced ability in dissociating these phonological segments from the context.

It should be noted that somewhat surprisingly, while a significant body of acoustic linguistics research has demonstrated that speech perception can be shaped by linguistic input, and thus varies across speakers of different languages (e.g., Dupoux, Kakehi, Hirose, Pallier, & Mehler, 1999), the similarities and differences in the phoneme inventory or syllable structures of the two languages have been rarely considered in research on bilingual phonemic awareness. Chen et al. (2004) and Kuo and Anderson (2010) were the only two exceptions.

Research that takes into account the phonological inventory and structure of bilinguals' two languages also reported bilingual advantage that goes beyond the shared phonological features. In Chen et al. (2004), it was revealed that the Cantonese-Mandarin bilinguals outperformed their monolingual Mandarin peers on test items containing Mandarin syllables that were acoustically distinctive from Cantonese syllables. In Kuo and Anderson (2010), bilinguals' advantage over monolinguals in phonological awareness development was particularly pronounced in tasks requiring the children to segment and compare onsets and rimes or attend to tones in syllables that were composed of existing Mandarin phonemes but violated the phonotactics of both languages spoken by the bilingual children. These studies have suggested that bilingual children may be more superior than their monolingual peer in extracting segmental or suprasegmental features from syllables that they are equally unfamiliar with their monolingual peers or less familiar with than their monolingual peers.

1.3. The Present Research

Both the cross-language theory and the structural sensitivity theory (Kuo & Anderson, 2012) provide theoretical explanations for bilingual advantages in the development of phonological awareness. However, to our knowledge, the structural sensitivity theory has not been systematically validated in research on the development of phonological awareness among bilingual children. The more widely studied cross-language transfer theory, on the other hand, has focused on transfer only at the segmental level, such as phonemes (e.g., Bialystok et al., 2003) or syllables (e.g., Campbell & Sais 1995), or at the suprasegmental level, such as tones (e.g., Chen et al., 2004), but not at the featural level, such as voicing, which is an important but overlooked area of phonological awareness (Treiman, Broderick, Tincoff & Rodriguez, 1998). Research has shown that young children tend to have more difficulty recognizing phonemes that differ only in voicing. Similar difficulties were observed in studies on children's short-term memory errors (Eimas, 1975), spelling (Treiman, 1993) and reading (Read, 1975). The present study aims to a) re-evaluate *structural sensitivity theory*, and b) extend the scope of *cross-language transfer theory* (Osgood, 1949; Chen et al., 2004) by using the contrastive features in Japanese and English with three groups of children: monolingual English-speaking children, native Japanese-speaking children in a Japanese-English two-way immersion bilingual program, and native English-speaking children in the same Japanese-English two-way immersion bilingual program. The following three hypotheses will be examined. First, following *structural sensitivity theory* (Kuo & Anderson, 2010; Kuo & Kim, 2014), we hypothesized that bilingual advantage would manifest itself in the abstracting phonological segments that are shared between two languages as the bilingual experience allows children to process these segments in richer contexts. The second hypothesis, also derived from *structural sensitivity theory* (Kuo & Anderson, 2010;

Kuo & Kim, 2014), predicted that bilingual advantage would be more evident in the abstraction of phonological segments from novel rather than extant linguistic input. The third hypothesis extended the scope of *cross-language transfer theory* and predicted that children with exposure to Japanese, which marks the voicing feature in the writing system, would outperform their peers in detecting voiced from voiceless sounds.

It should be noted that the term bilingual experience is broadly construed in this context and does not refer to equal mastery in or equal amount of exposure to two languages. In fact, research has shown that individuals who are equally fluent in two languages are rare (Barac et al., 2014). Furthermore, it has been documented that those who have limited but regular exposure to a second language may enjoy a bilingual advantage in some domains. For example, in a pioneering study, Yelland, Pollard & Mercuri (1993) showed that children with one hour of instruction in a second language per week for six months outperformed their monolingual peers in several metalinguistic awareness measures.

1.3.1 Differences in Japanese and English—Japanese and English differ in phoneme inventory. English has 25 different single-consonant onsets, six of which do not exist in Japanese (i.e., /l/, /r/, /v/, /tʃ/, /dʒ/, /θ/, /ð/) (Thompson, 2001). The two languages also differ in syllable structure. An English syllable can take up to three consonants in the onset position (e.g., *spring*) and up to four consonants in the coda position (e.g., *adjuncts*) (Giegerich, 1992). In contrast, consonant clusters are extremely limited in Japanese (Thompson, 2001). An onset contains typically a single consonant with an optional glide. Most Japanese syllables are open syllables that end without a coda. The only consonants allowed in the coda position are nasals (e.g., /n/). By considering the contrast in phoneme inventory and syllable structure in designing the measures for phonological awareness, the study re-evaluated structural sensitivity theory (Kuo & Anderson, 2010, 2012) with bilinguals who speak a different pair of languages.

The Japanese writing system consists of two character types: logographic *kanji*, which were adopted from Chinese characters, and syllabic *kana*. *Kana* includes parallel syllabaries: *hiragana*, which are used for native or naturalized Japanese words and grammatical markers, and *katakana*, which are used for foreign names, loan words or onomatopoeia. The majority of Japanese texts contain a mixture of both *kanji* and *hiragana*. Most of the *kanji* characters used in Japanese have more than one pronunciation, depending on the context. *Hiragana* characters are syllabic, and each represents a syllable. Unlike English, phonemes are not represented in the Japanese writing system. However, about one third of the *hiragana* characters (25 out of 71) contain diacritics that mark the voicing feature of the syllable's onset. For example, the hiragana character, き, /ki/ contains a voiceless onset. By adding the diacritic dakuten, ぎ, to き, the character becomes /gi/ with a voiced onset. Similar principles apply to the diacritic hadakuten っ. The character ぱ /pa/ contains a voiced onset. By replacing the dakuten with the hadakuten, the character becomes ぱ /pa/, which contains a voiceless onset. Most of the existing research on cross-language transfer theory has focused on transfer at the segmental level, such as phonemes (e.g., Bialystok et al., 2003) or syllables (e.g., Campbell & Sais 1995), or at the suprasegmental level, such as tones (e.g., Chen et al., 2004). The unique contrast in the way voicing is marked in the writing system allows for a critical extension of cross-language transfer theory to the featural level.

2. Method

2. 1. Participants

The study was conducted at an elementary school in a Midwestern suburb in the U.S. The school offered general education and Japanese-English two-way immersion dual-language programs. The General Education program consisted of only English-speaking students; the only language of instruction was English. The Japanese-English Dual Language Program consisted of two groups of students, native speakers of English and native speakers of Japanese. Students received approximately 15 hours of instruction in English and 15 hours of instruction in Japanese per week. Math instruction was in English, but students who met the grade-level standard were enriched through Japanese math instruction. Music and physical education were exclusively taught in English while art was always taught in Japanese. The content areas of science and social studies alternated between Japanese and English depending upon the grade level; at the first grade level, both subjects were taught in English. The teachers from the general education and dual language programs met weekly to ensure consistency of the curriculum across the programs.

The school had multi-age classes at the first and second grade levels. Participants for this study included a total of 129 first and second graders: 48 were monolingual English-speaking children enrolled in the General Education program; 41 were English-speaking children enrolled in the Japanese-English Dual Language program (English-Japanese bilingual); and 40 were Japanese-speaking children enrolled in the Japanese-English Dual Language program (Japanese-English bilingual). None of the participating students had a documented learning disability. All of the participants from the general education program were native speakers of English and none of them had regular exposure to or were learning another language. The parents of all English-speaking participants in the dual language program, including one who was born in Japan, reported English as their children's dominant language. 55 % of the Japanese-speaking participants ($n = 22$) were born in Japan; the rest were born in the US. Parents of 80% the Japanese-speaking participants ($n=32$) reported Japanese as their child's dominant language; the remaining 20% ($n=8$) reported that their children were equally proficient in English and Japanese; none reported English as their children's dominant language.

The school principal indicated that the community valued bilingualism and viewed the dual language program as an enrichment program. Except for the parents of children with learning disabilities, most parents, English-speaking as well as Japanese-speaking, preferred their children to be enrolled in the dual language program. Admission was determined through a lottery system. The school usually maintained a long wait list for the dual language program, which suggests that most of the parents in the community, regardless of whether their children were admitted to the dual language program, viewed bilingualism positively. Information about how bilingualism was viewed by the community is important because it helped establish comparability of students from different programs with respect to parental perception of bilingualism.

The dual language program used a 50/50 model where Japanese and English were used for equal amount of instructional time. The teachers in the dual language program participated

fully in grade-level collaborative meetings team meetings with teachers from the general education program to ensure the alignment of the curriculum across programs.

Results from a home language use survey revealed that the three groups were comparable in age ($M = 92$ months; $SD = 7$, $F(2, 128) = .25$, $n.s.$). Parents' educational levels were collected as well. Chi-square analysis revealed that the three groups were comparable on the educational levels of the mothers, $\chi^2(8) = 6.29$, $n.s.$, and the fathers, $\chi^2(8) = 7.92$, $n.s.$ The majority of the mothers completed a two-year associate degree (36%, $n = 47$) or a four-year college degree (36%, $n = 47$); the majority of the fathers completed a four-year college degree (61%, $n = 79$). Following existing research (e.g., Kuo & Anderson, 2010; Laurent & Martinot, 2010), comparability of non-verbal IQ across the groups was also examined. Results from the non-verbal reasoning section of the Wide Range Achievement Test, expanded edition, level 1 (Wide Range, 2001) showed that the three groups were also comparable in non-verbal IQ, $F(2, 128) = 1.75$, $n.s.$

2.2. Instruments

The following assessments were administered by graduate research assistants with the assistance from the homeroom teachers at the end of the academic year. Oral vocabulary was measured in both languages to measure language proficiency among the three groups. Phonological awareness was measured with an onset-awareness task. While phonological awareness is multi-faceted and can be assessed in multiple ways, we chose to focus on onset-awareness using an odd-man-out task because this assessment allowed us to manipulate the phonological segments and features that are shared between English and Japanese or unique in English in the test items, which was critical for the purpose of our study. The odd-man-out was also the primary phonological awareness task used in previous research that took into consideration the similarities and differences in the phonological segments and features between bilingual children's two languages (e.g., Chen et al. 2004; Kuo & Anderson, 2010).

2.2.1. English oral receptive vocabulary—Because of time-constraints, a group assessment of selected items from the Peabody Picture Vocabulary Test (4th edition) (PPVT) (Dunn & Dunn 2007) was administered. The test contained 36 items that were identified by the teachers as within and slightly above the age level of the participants. The reliability for the measure is .89.

2.2.2. Japanese oral receptive vocabulary—Because of time-constraints, a group assessment of selected items from the Japanese Picture Vocabulary Test – Revised (Ueno, Nagoshi, & Konuki, 2008) was administered. The test contained 36 items and was piloted with a separate group of eight Japanese-English bilinguals in the U.S. This test was the only one administered only to the participants from the Japanese-English dual-language program. The reliability for the measure is .94.

2.2.3. Onset-awareness—Onset awareness was assessed in an odd-man-out task. For each trial of the task, participants listened to three single-syllable words and were asked to indicate on an answer sheet which of the three contained a different onset. The phonological

task was prerecorded by a native-speaker of English with a digital audio recorder at a phonetic lab.

All items used in the assessments were either real English words or non-words that conformed to the syllable structure of English (Giegerich, 1992). Following Kuo and Anderson (2010), items in this measure varied along Word Type (Real words versus Non-words) and Onset Overlap (Shared versus English-only). To examine whether children with exposure to the Japanese writing system would be more sensitive to the voicing contrast, a third factor, Voicing (Voicing vs. Non-Voicing), was also considered in the design. Together these conditions yielded a total of eight types of items (see Table 2).

Shared items contained syllables with onsets that exist in both English and Japanese. English-only items contained syllables with onsets that exist only in English but not in Japanese. English has 25 different single-consonant onsets, six of which do not exist in Japanese (i.e., /l/, /r/, /v/, /tʃ/, /dʒ/, /θ/, /ð/). In addition, the English-only items also contained syllables with consonant clusters, which do not exist in Japanese. For the voicing factor, the odd-man and the non-odd-man were either contrasted in a voicing (e.g., /b/ vs. /p/) or a non-voicing feature. There were 12 items in each condition. All items were screened by two native speakers of Japanese to ensure that none of them sounded the same as or similar to existing words in Japanese.

Items with real-word syllables were combined into one test, and items with non-word syllables were combined into another. Participants were assessed on the test with real-word syllables first, and then with the non-word syllables test. The reliabilities of the subtests (Cronbach's alpha) ranged from .91 to .94. The two assessments were given separately about a week apart.

3. Results and Discussion

3.1. Vocabulary

Means and standard deviations for proportions of correct answers for the vocabulary measures are presented in Table 1. On the English vocabulary measure, the monolingual group outperformed the Japanese-English bilingual children, $F(2, 126) = 8.79, p < .001, \eta^2 = .121$. Multiple comparison analysis showed that neither the difference between the monolingual and the English-Japanese bilingual group, $p = .132$, nor the difference between the English-Japanese and Japanese-English bilingual group, $p = .157$, were significant. As for Japanese oral vocabulary, the Japanese-English bilinguals performed significantly better than the English-Japanese bilinguals, $F(1, 73) = 22.44, p < .001, \eta^2 = .235$. Because the societal language was English, and the English-Japanese bilinguals did not have as much exposure to Japanese as their Japanese-English bilingual peers, these differences in vocabulary across groups were expected.

3.2. Onset awareness

Table 3 presents the means and standard deviations of proportions correct for participants from the general education and the dual-language programs. Data was first analyzed in a 2×3 (Word Type [Real Word and Non-Word] $\times$ Participant Profile [Monolingual English-

speaking children, English-Japanese bilingual and Japanese-English bilingual)) mixed-design ANCOVA. Word Type was the within-participant variables; Participant Profile was the between-participant variable; English vocabulary was the covariate. A significant effect of Word Type was revealed, $F(1, 125) = 37.42, p < .001, \eta^2 = .230$. Participants performed significantly better in the Real Word condition than in the Non-Word condition. Neither the effect of Participant Profile, $p = .615$, nor the interaction between Word Type and Participant Profile, $p = .738$, was significant.

Next, data from the real word conditions and the non-word conditions were analyzed separately with two $2 \times 2 \times 3$ (Contrast Type [Voicing and Others] $\times$ Onset Type [Shared and Unique in English] $\times$ Participant Profile [Monolingual English-speaking children, English-Japanese bilinguals and Japanese-English bilinguals]) mixed-design ANCOVAs. Contrast Type and Onset Type were the within-participant variables; Participant Profile was the between-participant variable; English vocabulary was the covariate. Table 3 presents the means and standard deviations of proportions correct for these measures. For the real-word version, the following two-way interactions were significant: a) the interaction between Participant Profile and Contrast Type, $F(2, 125) = 3.03, p < .05, \eta^2 = .046$; and b) the interaction between Participant Profile and Onset Type, $F(2, 125) = 4.50, p < .05, \eta^2 = .054$. The two-way interaction between Contrast Type and Onset Type was not significant, $p = .11$. Neither the three-way interaction, nor any of the between- or within-participant main effects were significant.

Further analyses of the two-way interaction between Onset Type and Participant Profile revealed that in the Unique onset condition, the three groups performed similarly, $p = .41$, but in the Shared onset condition, the differences among the groups were significant, $F(2, 125) = 15.74, p < .001, \eta^2 = .202$. Contrast analysis showed that the two bilingual groups outperformed the English-monolingual group, $p < .01$. The Japanese –English bilinguals also outperformed the English-Japanese bilinguals, $p < .05$.

Further analyses of the two-way interaction between Contrast Type and Participant Profile revealed that while the monolingual English-speaking children found the voicing condition significantly more challenging than the non-voicing condition, $F(1, 46) = 4.62, p < .05, \eta^2 = .10$, the English-Japanese bilingual children showed the opposite pattern and performed significantly better in the voicing condition than in the non-voicing condition, $F(1, 39) = 7.85, p < .001, \eta^2 = .17$. The difference between voicing and non-voicing conditions was not significant for the Japanese-English bilingual children, $p = .097$.

For the non-word version, the three-way interaction of Contrast Type, Onset Type and Participant Profile was significant, $F(2, 125) = 3.56, p < .05, \eta^2 = .054$. None of the two-way interactions or effects of other within- or between-participant variables were significant. Further analysis of the three-way interaction revealed that the two-way interaction between Contrast Type and Profile Group was significant only in the Shared Onset condition, $F(2, 125) = 4.44, p < .05, \eta^2 = .066$, but not in the English-only Onset condition, $p = .758$. In the Shared Onset condition, the effect of Participant Profile was significant for the Voicing Contrast, $F(2, 125) = 19.38, p < .001, \eta^2 = .237$, but not for the non-Voicing contrast. In the Shared Onset-Voicing Contrast condition, contrast analysis showed that the two bilingual

groups outperformed the English-monolingual group, $p < .01$. The Japanese–English bilinguals also outperformed the English-Japanese bilinguals, $p < .05$.

4. General Discussion

The present study set out with the aims of a) re-evaluating *structural sensitivity theory* (Kuo & Anderson, 2010, 2012; Kuo & Kim, 2014); and b) extending the scope of *cross-language transfer theory* (Osgood, 1949; Chen et al., 2004). Below we discuss how the findings addressed each of the three hypotheses posed at the beginning of the paper.

Hypothesis 1 *Following structural sensitivity theory, bilingual advantage would manifest itself in the abstraction of phonological segments that are shared between the two languages.*

Findings from the present study provide empirical support for the first hypothesis. In the Real Word condition, the three groups of participants performed similarly in questions containing syllables with onsets that only exist in English (Unique-in-English condition), but the two bilingual groups outperformed the monolingual group in questions containing syllables with onsets that are shared between the two languages (Shared condition). Similar patterns were also observed in the Non-Word condition, where the groups performed similarly the Unique-in-English condition, but the two bilingual groups outperformed the monolingual group in the Shared conditions, although only in questions containing syllables with onsets that are contrasted in voicing but not in non-voicing features.

The superior performance of the Japanese-English and English-Japanese bilinguals in the Shared onsets is unlikely to be explained by the *cross-language transfer theory*. A study conducted by Mann (1986) with Japanese-speaking children well before the prevalence of English education at the elementary school level in Japan showed that few Japanese-speaking children in early elementary grades were aware of phonemes. Mann (1984) also demonstrated Japanese children would only develop awareness of phonemes either by age, until they reach the later elementary grades, or through instruction of an alphabetic language. *Cross-language transfer theory* would thus predict that since the bilingual children in this study had less exposure to English, the alphabetic language that helps to promote phonemic awareness, they would perform more poorly or at best equally to their monolingual peers on the onset awareness measures. However, this was not the case in the present study and therefore the observed group difference in processing the Shared onsets cannot be attributed to cross-language transfer from Japanese to English.

Structural sensitivity theory, instead, provides a more plausible explanation for the observed bilingual advantage in the Shared onsets but not in Unique-in-English onsets. As argued by Kuo and Anderson (2012), bilingual children have the opportunity to be exposed to the shared phonetic units in more variable contexts than their monolingual peers. Such contextual variability allows them to more readily dissociate a phonological segment from its context, which enhances their development of phonological awareness. Kuo and Anderson (2012) highlighted that one of the central premises of structural sensitivity theory is that the *joint* experience of the two languages, in contrast with transfer of processing skills

from one language to another, may also contribute substantially to bilingual advantage in metalinguistic processing.

Findings from the present study are broadly consistent with existing research. In Kang (2012), the additional language of the Korean-English bilingual children was English. Because English is more opaque than Korean, any advantage in phonological awareness observed among the bilingual children would be unlikely to be attributed to cross-language transfer from English. Nonetheless, the bilingual children outperformed their monolingual Korean-speaking peers in phonological awareness assessed in Korean. The observed bilingual advantage may be more readily explained by the fact that the bilingual children had the opportunity to process the same phonological segment in more variable acoustic, articulatory and orthographic contexts. Likewise, in both Kuo and Anderson (2010) and Chen et al. (2004), bilingual children showed an advantage over their monolingual peers in phonemic awareness that focused on the shared syllables or onsets between the two languages, despite having less exposure to the tested language compared to their monolingual peers.

It should be noted that in the present study, the bilingual advantage in the shared condition for the non-words was only observed in items that were contrasted in voicing, which we will address further in the discussion of the third hypothesis.

Hypothesis 2 Following structural sensitivity theory (Kuo & Anderson, 2012; Kuo & Kim, 2014), it was hypothesized that bilingual advantage would be more pronounced in the abstraction of phonological segments from novel than extant linguistic input.

The second hypothesis was not confirmed in our study. All three groups of children performed better in the Real Word condition (i.e., extant linguistic input) than in the Non-Word condition (i.e., novel linguistic input), but neither the effect of Participant Profile nor the interaction between Word Type and Participant Profile was significant. The findings might appear somewhat unexpected at first glance but may be attributed to two factors. First, the stimuli for the novel condition in this study were not as acoustically distant from the extant linguistic input as those used in relevant previous research. In Chen et al. (2004), the novel condition contained syllables that were acoustically distinct from the linguistic repertoire of the bilinguals' dominant language. In Kuo and Anderson (2012), the novel condition contained syllables that were composed of existing phonemes of Mandarin but did not conform the phonotactics of either of the two languages spoken by the bilingual children. In the present study, while the novel condition contained non-words, these syllables follow the phonotactics of English and the segments of these syllables may appear in existing words. For example, *roke* is a non-word in English, but the rime, /ok/, appears in words such as *coke*, *soak* and *woke*, and the body, /ro/, appears in *row*, *road* and *romance*. Therefore, while all three groups of participants in our study found the non-word version more challenging than on the real-word version, the contrast between the novel condition and the extant condition may not be sufficiently substantial to reveal bilingual advantage in processing novel linguistic input. Similar arguments regarding how task difficulty may contribute to the presence or absence of bilingual advantage has been made in previous research. For example, in Bialystok, Majumder & Martin (2003), different tasks to assess

phonological awareness were used, and group differences associated with bilingualism were only observed in the phonemic segmentation task, which involves moderate cognitive demand, but not in the simpler tasks, such as the sound-meaning problem. The authors argued that it is likely that simpler tasks may not be sufficiently challenging to detect metalinguistic differences between the groups.

The second possible factor contributing to the absence of more pronounced bilingual effect in the novel condition (i.e., non-word condition) than in the extant condition (i.e., real word condition) is concerned with the comparability of the backgrounds of the participants across the studies. In the present study, as revealed from the vocabulary assessments, the Japanese-English bilinguals had significantly lower proficiency in English than their monolingual peers, and the English-Japanese bilinguals had significantly lower proficiency in Japanese than the Japanese-English bilinguals. While neither Kuo and Anderson (2012) nor Chen et al. (2004) included a measure of vocabulary in their study, descriptions of the participants in the two studies suggested that their bilingual participants were likely to have a higher degree of bilingualism than the bilingual participants in the present study. In Kuo and Anderson (2012), the bilingual group was dominant in Mandarin, the language spoken by the monolingual and the language of which the phonemes were used to compose the novel syllables. Moreover, most of the bilinguals had exposure to the additional language from birth. In Chen et al. (2004), the Cantonese-Mandarin bilinguals attended Mandarin immersion schools where Mandarin was the only language of instruction, but Cantonese was their native language and the language they spoke primarily at home. Contrastively, in the present study, the bilingual participants spoke either English or Japanese at home, but attended two-way immersion program, where both languages were used for instruction at school. Therefore, participants in Kuo and Anderson (2012) and Chen et al. (2004) were likely to be more balanced in both languages than the bilingual participants in the present study. Previous research has shown that degree of bilingualism may be critical in determining its cognitive and linguistic consequences (Bialystok, McBride-Chang & Luk, 2005). Therefore, the disparity in the degree of bilingualism between participants in our study and those in previous relevant research may have also contributed to the absence of more prominent bilingual advantage in the novel conditions over the extant conditions in the present study.

Hypothesis 1b Following cross-language transfer theory, it was predicted that children with exposure to Japanese, which marks the voicing feature in the writing system, would outperform their peers on phonemic awareness measures that involved the detection of the voicing contrast.

Hypothesis 3 was partially supported by findings from the present study. The bilingual groups outperformed their monolingual peers on the onset awareness measure that involved the detection of the voicing contrast, but such superior performance was only present in the Shared Onset Non-words condition, but not in the other three conditions (i.e., Shared Onset-Real Words, English Only-Real Words, English Only-Non-Words). As noted earlier, experience with the Japanese language and writing system alone is unlikely to foster the development of phonemic awareness among children in early elementary grades (Mann, 1986). The fact that the superior performance by the bilinguals over the monolinguals in

detecting voicing contrast was only observed in the Shared Onset condition but not in the English-only conditions suggests that such bilingual advantage needs to be jointly explained by structural sensitivity theory and cross-language transfer theory. Contextual variability associated with shared onsets may have prompted the development of the ability to dissociate these phonological segments from the contexts. Voicing contrasts marked by the diacritics in the Japanese writing system is likely to have further enhanced the sensitivity to differentiate voiced sounds from voiceless sounds.

It may appear somewhat unexpected that the bilingual advantage was observed only in the Non-Words but not in the Real Words condition. One possible explanation is that while the magnitude of novelty in the non-word condition in our study was not sizable sufficient to produce consistent bilingual advantage in processing any novel linguistic stimuli, the combined effect of cross-language transfer, contextual variability and novelty allows the effect of bilingualism to manifest.

In addition, while group differences in attending to voicing did not show up in the real word condition, there is nonetheless indirect evidence showing that exposure to Japanese enhances children's sensitivity to voicing contrast. In the real word condition, the English monolingual children found it significantly more challenging to differentiate onsets differing in voicing than onsets differing in non-voicing features, which is consistent with prior research with English-speaking children (e.g., Treiman, Broderick, Tincoff & Rodriguez, 1998). Contrastively, the English-Japanese bilinguals, who also spoke English as their native language, showed a reverse pattern and found it significantly easier to recognize onset differences in the voicing feature than in the non-voicing feature.

Existing research has revealed cross-language transfer in phonological awareness at the segmental levels, such as syllables (e.g., Bruck & Genessee, 1995; Campbell & Sais, 1995) and phonemes (e.g., Bialystok, Majumder & Marin, 2003) and at the suprasegmental levels, such as tones (e.g., Chen et al., 2004). Findings from the present study extend the scope of existing research and demonstrate that cross-language transfer may also occur at a featural level.

5. Limitations and Future Research

This study has several limitations that warrant future research. First, only one type of phonological awareness task, odd-man out, was used. With this task, some - but not all - predicted group differences were detected. Odd-man out has been the primary task used to assess phonological awareness when the similarities and differences between the two languages were considered in designing the stimuli (Chen et al., 2004; Kuo and Anderson, 2012). Nonetheless, previous research has shown that task difficulty may contribute to the presence or absence of group differences in bilingual metalinguistic research (Bialystok, Majumder & Martin, 2003). Future research with a broader battery of phonological awareness assessments varying in cognitive demands may further elucidate the mechanism through which bilingual experience affects the development of phonological awareness.

Second, as noted earlier, the novel condition designed to evaluate one of the hypotheses derived from structural sensitivity theory in our study may not contain stimuli that are sufficiently distinctive from the existing phonological repertoire of the participants, and lack of distinctiveness may have contributed to the absence of predicted group difference. This speculation awaits further investigation using stimuli following the designs in Kuo and Anderson (2012) or Chen et al. (2004).

Third, the participants' comparability could have been more comprehensively established in the present study. Previous research has identified participant comparability as a potential factor contributing to the presence or absence of bilingual effect (e.g., Barac et al., 2014; Kuo & Kim, 2014). In the present study, comparability of the groups was established in two ways. First, following existing research, it was ensured that the three groups of participants were comparable in SES and non-verbal IQ. Second, the principal of the school also indicated that the bilingual program was viewed positively as an enrichment program by the community, and there had always been a long waitlist for the English-speaking children to enroll in the dual language program. Nonetheless, because we did not ask the parents of the English-speaking participants in the general education program whether they intended to enroll their children in the dual language program, we were unable to rule out the potential effect of parents' views on bilingualism on the observed group differences. Future research should include parental survey questions regarding parents' perceptions of bilingualism and their intent to enroll their children in the bilingual programs.

Finally, further longitudinal research should be undertaken to examine the long-term impact of bilingualism on phonological awareness and reading among Japanese-English and English-Japanese bilinguals. Existing research has shown that the impact of bilingualism as well as their impact on reading may vary as a function of participants' age (Chen et al., 2004; Kuo and Anderson, 2012; Yeong, and Liow, 2012). While there is limited research on the role of phonological awareness in Japanese reading, preliminary findings suggest that a relation between phonological awareness and the reading of *kana*, the syllabic script in Japanese (Seki et al., 2008). As phonological awareness and reading may exert influence over each other, a longitudinal design will allow researchers to more systematically capture the dynamic relationship.

6. Conclusion

The present study set out with the aims of a) re-evaluating *structural sensitivity theory* (Kuo & Anderson, 2010, 2012; Kuo & Kim, 2014); and b) extending the scope of cross-language transfer theory (Osgood, 1949). Despite the limitations noted in the previous section, findings from the present study yield several important theoretical implications. First, the present study provided empirical support for *structural sensitivity theory* and demonstrated how contextual variability may contribute to bilingual advantage in phonological processing. Second, while bilingual advantage in processing novel phonological stimuli was not observed in the present study, the finding calls for a need to vary the cognitive demand and the degree of novelty in stimuli in future research. Third, expanding existing research, the present study demonstrated that that cross-language transfer in phonological awareness may extend beyond segmental or supersegmental levels and occur at a phonetic feature level,

such as voicing. Finally, we argue that the effect of bilingualism on metalinguistic awareness involves complex and multi-faceted processes. While some observed bilingual advantages may be fully explained by one theory, others may be more comprehensively captured using multiple theories.

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References

- Barac R, Bialystok E, Castro DC, Sanchez M. The cognitive development of young dual language learners: A critical review. *Early Childhood Research Quarterly*. 2014; 29(4):699–714. [PubMed: 25284958]
- Bialystok, E. *Bilingualism in development: Language, literacy and cognition*. New York: Cambridge University Press; 2001.
- Bialystok E. Acquisition of literacy in bilingual children: A framework for research. *Language Learning*. 2002; 52(1):159–199.
- Bialystok E, Luk G, Kwan E. Bilingualism, biliteracy, and learning to read: Interactions among languages and writing systems. *Scientific Studies of Reading*. 2005; 9:43–61.
- Bialystok E, Majumder S, Martin MM. Developing phonological awareness: Is there a bilingual advantage? *Applied Psycholinguistics*. 2003; 24:27–44.
- Bialystok E, McBride-Chang C, Luk G. Bilingualism, language proficiency, and learning to read in two writing systems. *Journal of Educational Research*. 2005; 97:580–590.
- Bradley L, Bryant PE. Categorizing sounds and learning to read: a causal connection. *Nature*. 1983; 310:419–21.
- Bruck M, Genesee F. Phonological awareness in young second language learners. *Journal of Child Language*. 1995; 22:307–324. [PubMed: 8550725]
- Butler YG, Iino M. Current Japanese reforms in English language education: The 2003 “action plan”. *Language Policy*. 2005; 4(1):25–45.
- Campbell R, Sais E. Accelerated metalinguistic (phonological) awareness in bilingual children. *British Journal of Developmental Psychology*. 1995; 13:61–68.
- Center for Applied Linguistics. Directory of two-way bilingual immersion programs in the US. 2014. Retrieved from <http://www2.cal.org/jsp/TWI/SchoolListings.jsp>
- Chen X, et al. Phonological awareness of bilingual and monolingual Chinese children. *Journal of Educational Psychology*. 2004; 96:142–151.
- Chen X, Xu F, Nguyen TK, Hong G, Wang Y. Effects of cross-language transfer on first-language phonological awareness and literacy skills in Chinese children receiving English instruction. *Journal of Educational Psychology*. 2010; 102(3):712–728.
- Chiappe P, Siegel LS. Phonological awareness and reading acquisition in English-and Punjabi-speaking Canadian children. *Journal of Educational Psychology*. 1999; 91(1):20–28.
- Dixon LQ, Zhao J, Joshi RM. Influence of L1 orthography on spelling English words by bilingual children: A natural experiment comparing syllabic, phonological, and morphosyllabic first languages. *Learning Disability Quarterly*. 2010; 33(3):211–221.
- Dupoux E, Kakehi K, Hirose Y, Pallier C, Mehler J. Epenthetic vowels in Japanese: A perceptual illusion? *Journal of experimental psychology: human perception and performance*. 1999; 25(6): 1568–1578.
- Eimas PD. Distinctive feature codes in the short-term memory of children. *Journal of Experimental Child Psychology*. 1975; 19:241–251.

- Geva E, Ryan EB. Linguistic and cognitive correlates of academic skills in first and second languages. *Language learning*. 1993; 43(1):5–42.
- Giegerich, HJ. *English phonology: An introduction*. Cambridge, UK: Cambridge University Press; 1992.
- Gomez RL. Variability and detection of invariant structure. *Psychological Science*. 2002; 13:431–436. [PubMed: 12219809]
- Gottardo A, Mueller J. Are first- and second-language factors related in predicting second language reading comprehension? A Study of Spanish-speaking children acquiring English as a second language from first to second grade. *Journal of Educational Psychology*. 2009; 101(2):330–344.
- Ho CSH, Bryant P. Phonological skills are important in learning to read Chinese. *Developmental psychology*. 1997; 33(6):946–951. [PubMed: 9383617]
- Howard, ER.; Sugarman, J.; Christian, D. Trends in two-way immersion education: A review of the research. 2003 Aug. Retrieved from <http://www.csos.jhu.edu/crespar/techReports/report63.pdf>
- Kang JY. Do bilingual children possess better phonological awareness? Investigation of Korean monolingual and Korean-English bilingual children. *Reading and Writing*. 2012; 25(2):411–431.
- Kieffer MJ, Biancarosa G, Mancilla-Martinez J. Roles of morphological awareness in the reading comprehension of Spanish-speaking language minority learners: Exploring partial mediation by vocabulary and reading fluency. *Applied Psycholinguistics*. 2013; 34(04):697–725.
- Kieffer MJ, Lesaux NK. Effects of academic language instruction on relational and syntactic aspects of morphological awareness for sixth graders from linguistically diverse backgrounds. *The Elementary School Journal*. 2012; 112(3):519–545.
- Kim TJ, Kuo LJ, Ramirez G, Wu S, Ku YM, de Marin S, Ball A, Eslami Z. The relationship between bilingual experience and the development of morphological and morpho-syntactic awareness: A cross-linguistic study of classroom discourse. *Language Awareness*. 2015; 24(4):332–354.
- Kroll, JF.; De Groot, A. *Handbook of bilingualism: Psycholinguistic approaches*. Oxford, UK: Oxford University Press; 2005.
- Kuo, L-J.; Anderson, RC. Conceptual and methodological issues in comparing metalinguistic awareness across languages. In: Koda, K.; Zehler, A., editors. *Learning to read across languages*. New York, NY: Routledge; 2008. p. 39–67.
- Kuo LJ, Anderson RC. Beyond cross-language transfer: Reconceptualizing the impact of early bilingualism on phonological awareness. *Scientific Studies of Reading*. 2010; 14:365–385.
- Kuo LJ, Anderson RC. Effects of early bilingualism on learning phonological regularities in a new language. *Journal of Experimental Child Psychology*. 2012; 111:455–467. [PubMed: 22169351]
- Kuo, L-J.; Kim, T-J. Effect of early bilingualism on metalinguistic development and language processing: Evidence from Chinese-speaking bilingual children. In: Chen, X.; Wang, Q.; Luo, Y., editors. *Reading development and difficulties in monolingual and bilingual Chinese children*. New York, NY: Springer; 2014. p. 171–190.
- Laurent A, Martinot C. Bilingualism and phonological awareness: the case of bilingual (French–Occitan) children. *Reading and Writing*. 2010; 23(3–4):435–452.
- Mann VA. Distinguishing universal and language-dependent levels of speech perception: Evidence from Japanese listeners' perception of English "l" and "r". *Cognition*. 1986; 24(3):169–196. [PubMed: 3816123]
- Marinova-Todd S, Zhao J, Bernhardt M. Phonological awareness skills in the two languages of Mandarin-English bilingual children. *Clinical Linguistics & Phonetics*. 2010; 24(4–5):387–400. [PubMed: 20345266]
- Nithart C, Demont E, Metz-Lutz MN, Majerus S, Poncelet M, Leybaert J. Early contribution of phonological awareness and later influence of phonological memory throughout reading acquisition. *Journal of Research in Reading*. 2011; 34(3):346–363.
- Osgood CE. The similarity paradox in human learning: A resolution. *Psychological Review*. 1949; 56(3):132–143. [PubMed: 18139121]
- Read, C. *Children's categorization of speech sounds in English* (NCTE Research Report No. 17). Urbana, IL: National Council of Teachers of English; 1975.
- Schneider, W.; Naslund, JC. The impact of early phonological processing skills on reading and spelling in school: Evidence from the Munich Longitudinal Study. In: Weindert, FE.; Schneider, W.,

editors. *Individual Development from 3 to 12: Findings from the Munich Longitudinal Study*. Cambridge: Cambridge University Press; 1999.

- Seki A, et al. Reading ability and phonological awareness in Japanese children with dyslexia. *Brain and Development*. 2008; 30(3):179–188. [PubMed: 17720344]
- Soltani A, Roslan S. Contributions of phonological awareness, phonological short-term memory, and rapid automated naming, toward decoding ability in students with mild intellectual disability. *Research in Developmental Disabilities*. 2013; 34(3):1090–1099. [PubMed: 23314249]
- Treiman, R. *Beginning to spell: A study of first-grade children*. New York: Oxford Univ. Press; 1993.
- Treiman R, Broderick V, Tincoff R, Rodriguez K. Children's phonological awareness: Confusions between phonemes that differ only in voicing. *Journal of Experimental Child Psychology*. 1998; 68(1):3–21. [PubMed: 9473312]
- Uchikoshi Y. Predictors of English reading comprehension: Cantonese-speaking English language learners in the U.S. *Reading and Writing: An Interdisciplinary Journal*. 2013; 26(6):913–939.
- Ueno, K.; Nagoshi, N.; Konuki, S. [Picture vocabulary test – Revised]. Tokyo: Nihon Bunka Kagakusha; 2008. (in Japanese)
- van de Sande E, Segers E, Verhoeven L. How phonological awareness mediates the relation between children's self-control and word decoding. *Learning and Individual Differences*. 2013; 26:112–118.
- Wagner RK, Torgesen JK, Rashotte CA. Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology*. 1994; 30(1):73–87.
- Wagner RK, et al. Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: a 5-year longitudinal study. *Developmental Psychology*. 1997; 33(3):468–479. [PubMed: 9149925]
- Wide Range, Inc. *Wide Range Achievement Test - Expanded Edition Group Assessment*. Lutz, FL: PAR; 2001. Level 1
- Wimmer H, Landerl K, Schneider W. The role of rhyme awareness in learning to read a regular orthography. *British Journal of Developmental Psychology*. 1994; 12(4):469–484.
- Yeong SH, Liow SJR. Development of phonological awareness in English–Mandarin bilinguals: A comparison of English–L1 and Mandarin–L1 kindergarten children. *Journal of Experimental Child Psychology*. 2012; 112(2):111–126. [PubMed: 22382048]

Table 1
Means and Standard Deviations of Age (month) and Proportion Correct on Non-verbal IQ and Vocabulary Measures

	Monolingual N=48		English-Japanese Bilingual N=41		Japanese-English Bilingual N=40	
	M	SD	M	SD	M	SD
Age (month)	92.25	6.36	91.73	7.42	91.20	7.22
Non-verbal IQ	0.78	0.19	0.70	0.16	0.73	0.20
Vocabulary						
English	0.96	0.07	0.91	0.17	0.85	0.13
Japanese			0.54	0.15	0.70	0.14

Table 2

Experimental Conditions

Onset Type	Word Type	
	Real Word	Non-Word
Shared		
Voicing	goat, goose, cat	goge, goon, cas
Non-Voicing	neck, hand, nose	nech, han, noke
Unique		
Voicing	jail, juice, chalk	jote, joof, chack
Non-Voicing	road, rug, light	raub, ruv, lige

Table 3
Means and Standard Deviations of Proportion Correct on Onset Awareness Measures

Stimuli Type	Monolingual <i>N</i> = 48		English-Japanese Bilingual <i>N</i> = 41		Japanese-English Bilingual <i>N</i> = 40	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Real Word						
Voicing						
Shared	0.74	0.25	0.82	0.15	0.81	0.18
Unique	0.82	0.17	0.86	0.14	0.85	0.15
Non-Voicing						
Shared	0.82	0.13	0.80	0.20	0.92	0.12
Unique	0.79	0.18	0.83	0.21	0.84	0.17
Non-Word						
Voicing						
Shared	0.73	0.23	0.83	0.20	0.84	0.20
Unique	0.81	0.19	0.82	0.20	0.82	0.18
Non-Voicing						
Shared	0.75	0.19	0.73	0.20	0.74	0.23
Unique	0.75	0.23	0.78	0.24	0.78	0.15