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Title	Cross-lag analysis of early reading and spelling development for bilinguals learning English and Asian scripts
Author(s)	Beth A. O'Brien, Nicole Cybil Lim, Malikka Begum Habib Mohamed and Nur Artika Arshad
Source	<i>Reading and Writing</i> , 33, 1859–1891
Published by	Springer

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This is a post-peer-review, pre-copy/edit version of an article published in *Reading and Writing*. The final authenticated version is available online at: <https://doi.org/10.1007/s11145-019-09999-8>

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Cross-lag analysis of early reading and spelling development  
for bilinguals learning English and Asian scripts

Beth O'BRIEN, Nicole Cybil LIM, Malikka Begum HABIB MOHAMED, Nur Artika ARSHAD  
*Centre for Research in Child Development, National Institute of Education,  
Nanyang Technological University, Singapore*

Author Note:  
Centre for Research in Child Development, National Institute of Education,  
Nanyang Technological University, Singapore

Acknowledgement:  
This study was funded by the Education Research Funding Programme, National Institute of Education (NIE), Nanyang Technological University, Singapore, project no. OER 09/14RB. The views expressed in this paper are the author's and do not necessarily represent the views of NIE. The authors would like to thank the participating children, parents and schools. Portions of the paper were presented at the annual conference for ARWA, 2019, Goa, India.

Correspondence should be directed to Beth A. O'Brien, beth.obrien@nie.edu.sg, (ORCHID #0000-0002-1187-5908), 1 Nanyang Walk, National Institute of Education, Nanyang Technological University, Singapore, 637616

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4 The two components of literacy, reading and writing, would seem to go hand in hand. They often co-occur.  
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6 This is true of typical academic tasks, such as giving written responses after reading some material (Kim, Petscher,  
7  
8 Wanzek & Al Otaiba, 2018; Fitzgerald & Shanahan, 2000), as well as finer-scaled perception-action cycles, such as  
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10 spelling a word and then reading it to verify its correctness. Such co-occurrence suggests a close alignment of these  
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12 skills. Likewise, requisite skills for reading and writing largely overlap. From the simple view theories of reading  
13  
14 and writing, each includes oral language skills for listening comprehension and for composition planning,  
15  
16 respectively (Gough & Tunmer, 1986; Juel, Griffith & Gough, 1986; Kim, et al., 2018). Each also requires  
17  
18 knowledge of speech and print correspondence (GPC) to decode or encode words, respectively (e.g., Vaessen &  
19  
20 Blomert, 2013). Moreover, reading and writing seem to share neural systems: both involve activation of areas of the  
21  
22 left fusiform gyrus and the inferior frontal gyrus, and lesions of these same regions result in deficits for both reading  
23  
24 and writing (Rapp & Lipka, 2011). These are brain areas that are aligned to lexical orthography and visual word  
25  
26 recognition (the VWFA, Cohen & Dehaene, 2004). The focus of the current study is on the beginning stages of  
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28 literacy development and therefore the word level, which enables comprehension in developing readers (Perfetti,  
29  
30 Landi & Oakhill, 2005).

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33 Despite these commonalities, co-occurrences and shared skills, some theorists have suggested that the  
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35 development of reading and writing skills might not be entirely synchronous. In the current study, we focused at the  
36  
37 beginning of literacy acquisition and word spelling processes. According to Frith's (1985) three-phase model, in  
38  
39 which children progress through logographic, alphabetic and orthographic stages, the beginning of each phase  
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41 involves a period of divergence, then a period of convergence for the skills of reading and spelling. Others echo this  
42  
43 arrangement, whereby reading and spelling co-develop in a complex dynamic interactive relation over time  
44  
45 (Lerkkanen, Rasku-Puttonen, Aunola & Nurmi, 2004; Kim et al., 2018). This progression is borne out by  
46  
47 longitudinal evidence. Of the few longitudinal studies on reading plus spelling development, findings include an  
48  
49 early contribution of reading to later spelling at primary 1 (P1) to primary 2 (P2) (Caravolas, Hulme & Snowling,  
50  
51 2001) and across P1 to primary 4 (P4) (Ahmed, Wagner & Lopez, 2014), and a later stronger contribution of writing  
52  
53 to reading from primary 3 (P3) to primary 6 (P6) (Kim, Petscher & Al Otaiba, 2018). However, bidirectional  
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55 influences are also reported over a similar span of grades (Abbot, Berninger & Fayol, 2010), and alternative models  
56  
57 suggest an accumulation of spelling strategies rather than discrete developmental phases (e.g., Sharp, Sinatra &  
58  
59 Reynolds, 2008). Notwithstanding, Bosman and Van Orden (1997) considered the bidirectional relations between  
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grapheme-to-phoneme (reading direction) and phoneme-to-grapheme (spelling direction) in terms of the recurrent activation of phonology, graphemes<sup>1</sup> and semantic codes. In this case, spelling was considered the more difficult skill due to inconsistencies that have to be resolved through the semantic-graphemic relations for spelling versus the phonemic-semantic relations for reading.

These perspectives and longitudinal data were based on English, a relatively opaque orthography. Studies of more transparent languages with consistent grapheme and phoneme mappings, such as Finnish and Dutch, showed a different developmental pattern: a unidirectional early influence of spelling-to-reading (Leppanen, Nieme, Aunola & Nurmi, 2006) then a reading-to-spelling influence into P2 (Schaars, Segers & Verhoeven, 2017; Leppanen et al., 2006). Studies of non-alphabetic languages with extended graphemic inventories show dynamic patterns as well. A study of the non-alphabetic language of Chinese showed that initially in kindergarten (age 5) reading and writing were unrelated, but became moderately related a year later (age 6), although the directionality of this relationship was not reported (Wang, Lin & McBride, 2015). Nakamura, Joshi and Ji (2019) also reported that word decoding contributed to spelling for primary school (P1-P5) children using the akshara scripts of Kannada and Telugu, whereas the opposite spelling-to-reading relation was not reported. Therefore, the degree of consistency between the oral and written forms of a language may influence how reading and spelling skills co-develop.

For most alphabetic languages, there is an asymmetry in phoneme-to-grapheme consistency compared to grapheme-to-phoneme consistency, with greater regularity in one direction than the other (Schaars et al., 2017; Stone, Vanhoy & Van Orden, 1997). For English, the asymmetry is more consistent from grapheme-to-phoneme (0.72) than from phoneme-to-grapheme (0.62) (on a scale from 0 to 1, with 1 being more consistent; Caravolas, Lervag, Mousikou et al., 2012). Ziegler, Stone and Jacobs (1997) referred to these mappings as feedforward consistency, meaning similar spellings are pronounced the same way, and feedback consistency, meaning there is one way to spell a phonological pattern. English is both feedforward inconsistent (the spellings of ‘hint’ and ‘pint’ are pronounced differently and do not rhyme), and feedback inconsistent (the sound /-ip/ can be spelled as ‘-eep’ or ‘-eap’, as in ‘deep’ or ‘heap’). In various studies, feedforward inconsistency has been shown to affect reading performance and feedback inconsistency to affect spelling performance (Content & Peerean, 1992; Ziegler et al., 1997; Stone et al., 1997).

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<sup>1</sup> We use the term grapheme inclusively to include any printed symbolic representations of language units like sounds or words (e.g., letter, groups of letters (gh and ph), aksharas, and characters) throughout the paper.

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4 Furthermore, consistency varies at different grain sizes, and this may influence the unit of lexical processing.  
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6 For English reading, consistency can be found at larger grain sizes such as word rimes (vowel and ending  
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8 consonants; Treiman, Kessler & Bick, 2002), while spelling still requires access to the phoneme level (Ziegler &  
9  
10 Goswami, 2005). Over time, children seem to first use a coarse grain size for orthographic processing, and  
11  
12 subsequently a finer grain size to access letter ordering and position, which allows them to build up frequently  
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14 occurring sublexical orthographic combinations to speed word recognition (Grainger & Ziegler, 2011). Across  
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16 languages, readers tend to seek the relevant units of print-sound-meaning that make word reading most efficient  
17  
18 (Perfetti, Liu & Tan, 2005). This would be the letter-phoneme level for transparent languages, larger units of sound  
19  
20 for opaque languages, and still larger units of syllables or words for akshara languages, such as Tamil, and non-  
21  
22 alphabetic languages, such as Chinese where prevalent homophones are best disambiguated by accessing meaning  
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24 (Perfetti, Cao & Booth, 2013). Thus, for transparent languages, processing at the sublexical phoneme level would be  
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26 most efficient, and should progress evenly for reading and spelling. For opaque languages, processing at larger grain  
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28 sizes would be most efficient, such as subsyllable for English or syllable/word for Chinese, and reading may be  
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30 more easily acquired than spelling, since spelling favors smaller, less complex orthographic units (Ziegler &  
31  
32 Goswami, 2005).  
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35 In highlighting these aspects of spelling-sound consistency and grain size we follow the principle that writing  
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37 systems universally encode spoken language (the ‘Language Constraint on Writing Systems’, Perfetti, 2003, p. 3).  
38  
39 Naturally, print encodes other aspects of language besides phonemes (e.g., stress, morphemes, morphosyntax, etc.),  
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41 and we consider these additional aspects where appropriate, but our overall focus is on the mapping conventions for  
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43 oral to written language across orthographies. We also note that current theories of reading development, including  
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45 the psycholinguistic grain size theory, have not proposed how reading develops when children must learn two  
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47 orthographic systems, especially ones that differ in their consistency or granularity.  
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50 In this study, we examine the early co-development of reading and spelling in a longitudinal design  
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52 comparing groups of children in Singapore who are acquiring literacy in the opaque language of English, plus  
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54 another Asian language that is either a more transparent alphabetic system (Malay), an akshara system (Tamil), or a  
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56 non-alphabetic system (Chinese). Of interest is whether all these bilingual groups show similar patterns of literacy  
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58 skill relations when they read and spell English. We also examine patterns of reading and spelling development in  
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60 the children’s Asian language to see whether the bilingual groups will differ according to expectations, as outlined  
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4 above with regard to transparency and grain-size. Finally, we consider whether each bilingual group may show  
5 cross-language influence between English and the other language, for reading and for spelling, separately. In the  
6 next sections, we give brief overviews of the nature of the scripts for these three Asian languages. The contrast  
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8 across these languages provides a novel opportunity to tease out language universal and language-specific processes  
9  
10 in the co-development of the two literacy components of reading and spelling.  
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### 13 14 *Malay orthography*

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16 Malay belongs to the Austronesian language family and is the national language and traditional lingua franca  
17 of Singapore. The standard form of Malay, *Sebutan Baku*, is used for literacy and instruction. It features the same  
18 Latin alphabetic script (Rumi) with 26 letters as in English, while the letter ‘x’ is only found in loan words. It is a  
19 transparent, shallow alphabet characterized by highly regular letter-to-phoneme mappings. Only the letter ‘e’ carries  
20 two phonemic forms (/e/ or /ə/). Phonology includes three types of sounds– vowels, diphthongs and consonants.  
21 There are 6 vowel phonemes (a, e, /ə/, i, o, u), 3 diphthongs (<ai>, <au> and <oi>) and 21 consonant phonemes.  
22 Syllable structure in Malay is typically short but variable (V=vowel, C=consonant: VCC, CCV, CV, CVC, CVCC,  
23 CCVC) with CV and CVC being the most common structure (Lee et al., 2011). Morphology includes three main  
24 processes: affixation, reduplication and compounding (Karim, Onn, Haji Musa, & Mahmood, 2008), with  
25 derivational affixation the most common process (Prentice, 1987).  
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36 In contrast to English, Malay words are feedforward consistent, meaning similar spellings are pronounced the  
37 same way, and feedback consistent, meaning similar sounds are spelled the same way. As such, both reading and  
38 spelling in Malay are deemed more easily acquired than English (Rickard Liow & Lee, 2004; Seymour, Aro, &  
39 Erskine, 2003; Deacon, Chen, Luo & Ramirez, 2013). Following the psycholinguistic grain size theory (Ziegler &  
40 Goswami, 2006), Malay learners are expected to rely on smaller grain sizes, where Malay allows for easier  
41 acquisition of phoneme level coding of letter units. However, some inconsistencies occur when affixes are added to  
42 words. The prefixes *me-* (active verbs) and *pe-* (deriving agents), or suffixes such as */-an/* change the derived form  
43 by breaking the stem word (e.g., /ma/ /kan/ (to eat) becomes /ma/ /ka/ /nan/ (food), Koh, 1978). Most affixes in  
44 Malay also interact with reduplication to produce very complex word forms (Tadmor, 2009). This makes syllabic  
45 boundaries more salient and phonology less accessible, which could impact reading more so than spelling.  
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### 56 57 *Tamil Orthography*

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In contrast to the morphographic (e.g., Chinese) and the alphabetic (e.g., Malay) systems, the Tamil writing system has been described as an alphasyllabary because it represents sounds at the level of the syllable and also contains features that indicate phonetic information (Bright, 1996; Daniels, 1996). The Tamil script is made up of 1 special character ஃ /akh<sup>2</sup>, 12 vowels and 18 consonants (Aaron & Joshi, 2013). The vowels can be further divided into 5 short vowels, 5 long vowels and 2 diphthongs (ஐ /aj/, ஒள/av/). The five short vowels are (அ /a/, இ /i/, உ /u/, எ /e/, ஒ /o/)<sup>3</sup>. The five long vowels are (ஆ /a:/, ஈ /i:/, உள் /u:/, ஏ/e:/, ஔ /o:/) and they can be formed with the addition of diacritical marks (Aaron & Joshi, 2013). For instance, a small curved diacritic mark is included to the short vowel அ to form the long vowel ஆ and the same goes for the other four vowels where a small change in the writing of the symbol using diacritic marks can denote a different sound. As for the consonants, they are represented by an akshara symbol that has an inherent vowel (Aaron & Joshi, 2013). For example, the consonant ச /ca/ is formed with a muted stop consonant ச̣ /tʃ/ and a short vowel அ /a/ (Aaron & Joshi, 2013).

On the transparency-opacity continuum, Tamil is considered very transparent (Padakannaya & Mohanty, 2004). The relationship between the aksharas and the sounds they represent are highly consistent. This consistency makes it easier for beginning readers to make the connection between sounds and aksharas and akshara combinations, thus allowing for effective reading acquisition (Padakannaya & Mohanty, 2004). However, there are several instances of opacity in the Tamil orthography at the vowel and consonant levels that could pose potential problems when it comes to spelling Tamil words. Firstly, at the vowel level there are inconsistencies in the location and shape of vowel markers for the vowels உ /u/ and உள் /u:/ within an akshara symbol block (Nag & Narayanan, 2019). For both the short and long vowel, the shape and location of the diacritical mark is solely dependent upon the base consonant (Nag & Narayanan, 2019) (e.g. ச̣ /tʃ/ + உ /u/ = சு /cu/ or ப̣ /p/ + உள் /u:/ = /pu:/). Secondly, at least 50% of vowel diacritics are written in a non-linear manner before the base consonant (VC) while the spoken stream is in the CV form (Nag & Narayanan, 2019). This mis-sequencing between the written and spoken forms can be tricky for early spellers. In fact, Nag and Narayanan (2019) found that 93% of the participants in their study

<sup>2</sup> The phoneme symbols used are from the ISO 15919 "Transliteration of Devanagari and related Indic scripts into Latin characters, 2001. The // symbols indicate the speech sounds of one or a set of aksharas.

<sup>3</sup> The phoneme symbols used are International Phonetic Association, 1999. The // symbols indicate the speech sounds of one or a set of aksharas.

committed CV-VC errors. Third, stress plays an important role at the consonant level especially in the presence of retroflex sounds. For example, the aksharas ட் /ṅ/, ண் /n/ and ண் /ṇ/ sound very similar but are written differently.

It is probable that children may get confused when spelling these retroflex consonants (Aaron & Joshi, 2013).

Lastly, some consonants can be graphically confusable with other consonants and vowels too. For example, consonants க் /ka/, ச் /ca/ and ல் /pa/, ட் /ma/ are written in a similar manner with the exception of one minor curve in க் /ka/ and ட் /ma/. Children may also make consonant-vowel errors when spelling the vowel ஐ /aj/ and the consonant ஜ் /ja/ (Nag & Narayanan, 2019). Taken together, these linguistic features of the Tamil orthography make spelling more demanding than reading Tamil words (Nag, Treiman, & Snowling, 2010). However, the interplay between beginning reading and spelling in Tamil children has rarely been subjected to systematic study.

### *Chinese Orthography*

Unlike alphabetic languages, in which children can apply the alphabetic principle to sound out words by mapping letters to sounds (Hung, Hung, Tzeng, & Wu, 2014), the Chinese script is based on logograms or characters made up of strokes and radicals which do not consistently mark phonology (Ho & Bryant, 1997; Perfetti & Tan, 1998; Shen & Bear, 2000). Hence, even though phonological awareness skills play a role in reading Chinese, its function holds less importance as compared to reading alphabetic languages (McBride-Chang & Ho, 2005; Yeung et al., 2011). In Chinese, words are mostly composed of two or more individual characters, with each character representing a morpheme. The majority of characters in the Chinese language consist of a semantic and a phonetic radical that each give a clue to the character's meaning on one hand and pronunciation on the other hand (Ellis et al., 2004; Ho & Bryant, 1997; Hsiao & Shillcock, 2006). These clues are generally more stable for indicating the script-meaning relationship in the case of the semantic radical within the character, as compared with the less consistent script-sound relationship indicated by the phonetic radical. This is because there are many homophones in the Chinese language, wherein there are different ways to write a single syllable with a given tone. Thus, different characters may sound the same, but the orthographic rendition gives the unique meaning of each. In comparison to English, the homophone density is higher in Chinese where, on average, a tone syllable can be represented by five different characters, whereas a syllable in English may be represented in less than two ways on average (1.4 to be precise) (Chen & Pasquarella, 2017). Following from the premise of the psycholinguistic grain size theory, and given the imprecision of the phonetic component of Chinese characters, children learning Chinese do not readily benefit from mappings between phonology and orthography. Gradually over several stages, children come to



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4 understand that the phonetic component of the Chinese character may provide partial clues to its sound, without  
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6 indicating the full pronunciation of the character. According to the “phonetic principle” described by Anderson, Li,  
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8 Ku, Shu and Wu (2003), children start by reading the phonetic components in the same way as their phonetics, and  
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10 then over time, learn that the phonetic component provides incomplete information on pronunciation.  
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12 Because the script-sound relationship is more inconsistent and arbitrary in the Chinese language (Ho &  
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14 Bryant, 1987; Shu, Chen, Anderson, Wu, & Xuan, 2003) reading and spelling necessitates grasping grapheme-  
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16 morpheme correspondences and a reliance on morphological awareness skills (Kalindi & Chung, 2018; Li,  
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18 Anderson, Nagy, & Zhang, 2002; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Pan et al, 2016; Perfetti,  
19  
20 2007; Zhang, 2017). This skill describes the ability to identify and utilize the smallest unit of meaning and the  
21  
22 morphological structure of words in a language (Carlisle, 1995; Li, et al. 2017; Yeung et al., 2011). Morphological  
23  
24 awareness skills are essential in helping the reader determine the meaning of words from the morphemes (Carlisle,  
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26 2003), and to discern the meaning of homophones when reading Chinese. Learners of Chinese develop  
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28 morphological awareness skills progressively in the early years of formal education (Li, et al., 2017). As the link  
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30 between grapheme to meaning is more efficient (Yang, Shu, McCandliss, & Zevin, 2006; Tong, & McBride-Chang;  
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32 2010), children steadily become more dependent on morphological skills for reading Chinese (Li, et al., 2017; Zhou,  
33  
34 Shu, Miller, & Yan, 2018). Even with the increased reliance on morphological awareness skills, the mutually  
35  
36 influential relationship between phonology, morphology, and orthography still persists when reading Chinese. Tong  
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38 and McBride (2010) illustrated the evolving patterns of interconnection between these skills, where children  
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40 gradually become more adept over the course of early primary school at using the semantic and phonetic  
41  
42 components of the Chinese characters for reading.  
43

44 As compared to reading, spelling in Chinese is thought to be more difficult, because Chinese characters have  
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46 a complex structure that can involve many strokes. Furthermore, the characters may be very visually similar to one  
47  
48 another (Liu, Chen, X & Wang, 2016; Shen & Bear, 2000). Thus, recognizing a character may be easier than  
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50 spelling as the latter involves having to produce the precise form and structure of the character, which has been  
51  
52 shown to rely on knowledge about the function of radicals (Lo, Yeung, Ho, Chan, & Chung, 2015). Additionally,  
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54 unlike reading, spelling demands the additional skill of stroke knowledge (Lo et al., 2016). Yet, the relationship  
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56 between reading and spelling may be mutually influential as both activities enable children to familiarize themselves  
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58 with Chinese characters.  
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In sum, across these three scripts there are variations in transparency or consistency in the feedforward (reading) direction and feedback (spelling) direction, in addition to other varying features. For Malay, both directions are consistent, while for Tamil there is feedforward consistency and feedback inconsistency. Chinese, on the other hand, has little consistency in either direction. Given these differences, we may expect a closer alignment of reading and spelling in the transparent orthography of Malay, weaker relations across these domains for Tamil with reading leading spelling, and weakest relations across domains for Chinese, where alternate strategies may be used for reading and spelling compared with learning the alphabetic languages.

#### *Cross-language shared knowledge*

The children in the current study are simultaneous bilinguals, learning English plus one of these three scripts at the same time. Children take part in literacy lessons within mixed classrooms (i.e., consisting of multiple ethnic, bilingual groups) for English instruction. Their classrooms use a consistent curriculum based on guidelines from the Ministry of Education's Nurturing Early Learners (NEL, MOE, 2013a) framework, including language experiences with songs, rhymes, dialogic shared book reading, and synthetic phonics. Similar methods are used for learning their Asian language, with shared book reading, songs, pictures and object naming, where the whole class is split into separate groups that learn either Chinese, Malay or Tamil (NEL, MOE, 2013b). These lessons last 30-45 minutes daily<sup>4</sup> within the 3-4 hour school day. Each Asian language may involve a slightly different emphasis, due to the nature of the orthography (refer to Author, 2019, for more details). For example, for Malay lessons, reading and spelling are taught with an emphasis on syllable-by-syllable pronunciation. For Tamil lessons, the akshara chart introduces printed vowels and consonants, while akshara and word cards are used for teaching reading, whereby words are blended phoneme-by-phoneme by the teacher to model vowel and consonant sounds. Children also practice tracing aksharas. Chinese lessons involve familiarization with whole characters that are introduced in themes such as animals, occupations and food, they practice tracing strokes, radicals and whole characters. It is not until primary school entry (first grade, P1) that children are introduced to the Han Yu Pin Yin system (a Romanization of the Chinese language based on the pronunciation of the Chinese characters), and so Singaporean kindergarteners do not demonstrate an understanding of the Pin Yin system (Chin, 2016).

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<sup>4</sup> For about half of the Chinese/English children (N=143), they were enrolled in schools that advertised use of a 'bilingual approach' curriculum, meaning both English and Chinese languages were used throughout the school day, and outside the block of Chinese language instruction.

Therefore, transfer or shared knowledge between scripts may vary due to linguistic and typological distance between their learned script sets (Koda, 2008). Current research also suggests that such cross-linguistic influence impacts readers' grain size, where the cognitive-neural system for reading accommodates preferred grain sizes across languages (Lallier & Carreiras, 2017). The cross-language transfer between English and Malay has been fairly well documented (Rickard Liow & Poon, 1998; Dixon, Zhao & Joshi, 2010; Zhang, Chin & Li, 2016). Comparing the same three bilingual groups in Singapore, Dixon, Chuang and Quinoz (2011) found that only Malay correlated with English for both phonological awareness and vocabulary. Morphological awareness also transferred, but only from the English to Malay direction (Zhang, Chin and Li, 2016). In spite of this, children's early spellings of Malay may be based on their knowledge of larger grain-sized syllables and morphemes, the units that are reinforced in the classroom, such that their early literacy skills are founded on dissimilar grain sizes for Malay and English (Mann, 1986). This is in line with findings comparing the skills needed in English and Malay (Lee and Wheldall, 2010). While phonemic awareness and grapheme-phoneme knowledge were found to be necessary for word recognition in both languages, the skill of syllable segmentation was vital in the development of Malay literacy.

Unlike English which has a contained orthography of only 26 letters, Tamil has extensive orthographic register of more than 200 symbols, hence confusion is minimized (Nag, 2011). Thus, following the psycholinguistic grain-size theory, we would expect cross-language influence for English-Tamil bilinguals, particularly for the transparent orthography of Tamil which may draw English reading to a smaller grain-size at the phoneme level. Further, Tamil literacy instruction in Singapore highlights phoneme-grapheme correspondence, phonemic segmenting and blending, which children may apply to English reading and spelling. However, for spelling a positive effect of transferrable skills may be more muted. The confusing retroflex consonants of Tamil potentially impact children's ability to pick up the rules that link spoken and written words in English.

The Chinese/English children from Singapore commonly use English as the main language at home (Vaish, Jamaludeen, & Roslan, 2009), and consequently they would be familiar with the phonemic sounds of English and may more easily acquire letter-sound correspondences. Research has shown that children learning two languages may generalize metalinguistic awareness and linguistic strategies from their dominant language and apply this to the less dominant language (Perfetti & Dunlap, 2008). Hence, for these children it means that employing the skills acquired in English may be used to learn Chinese. The possibility of transfer of skills between these two languages

with different scripts is supported by findings of moderate to strong relationships for reading and spelling as well as reading comprehension at later ages (e.g., 8-10 years, Tong, McBride-Chang, Wong, & Shu, 2012). With younger bilingual children, Pasquarella and colleagues (2015) proposed that the script differences between English and Chinese restrict the extent of transfer for reading accuracy, while they still reported that reading fluency can benefit from a positive transfer (Pasquarella, Chen, Gottardo, & Geva, 2015). These research findings together support the likelihood of transfer, as individuals are able to assimilate and utilize the information from the different languages. Yet, due to the dissimilarities between English and Chinese scripts, younger bilingual children may not be able to tap onto this strategy as efficiently.

Examining simultaneously bilingual groups of children at the first phase of literacy acquisition in this longitudinal study, we address the following research questions:

- I. Is the relation of English reading and spelling similar for different groups of bilinguals?
- II. What is the nature of the relation of reading and spelling in different orthographies varying in transparency?
- III. Do different bilingual groups vary in cross-language relations for reading and for spelling?

## Method

### Participants

Six-hundred forty-five children (337 male, 308 female) from 80 preschools in geographically dispersed locations across Singapore were included in this study. The sample was drawn from a larger longitudinal project on school readiness and kindergarten outcomes (Author, 2014). Data from a subset of this sample collected in kindergarten (K1 and K2) were reported in Author ((2019). That report focused on the development of phonological awareness and the relation to early reading skills for English. The current study examines both reading and spelling skills for children's English plus Asian language skills, with a specific focus on cross-domain and cross-linguistic relations for literacy over three years.

The language groups were comprised of the following: 321 Chinese/English, 138 Malay/English and 186 Tamil/English. Children were evaluated on their reading and spelling skills at K1 (Mean age = 63.67 mos, SD = 3.76), at their second year of kindergarten (K2, Mean age = 70.17 mos, SD = 3.68), and their first year of primary school (P1, Mean age = 80.12 mos, SD = 3.79). Parental consent and report on family language history was obtained for all preschoolers. In addition, information on socio-economic status was gathered, including mother's education,

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4 family housing type and household income (Table 1). All children were simultaneous bilinguals based on relative  
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6 language onset, input and proficiency (English minus Asian Language): relative age of language acquisition Mean =  
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8 -0.24 years (SD = 1.35); relative proportion of home language input Mean = 0.29 (SD = 0.53); and relative receptive  
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10 vocabulary raw score Mean = 7.38 (SD = 10.12). Most children learned both languages at nearly the same age (or  
11  
12 only 1 year apart), English was used at home about 25% more often on average (although there was a range), and  
13  
14 children's proficiency was relatively similar between their two languages. Means across the different bilingual  
15  
16 language groups are presented in Table 1, along with media viewing time in the Asian language. Viewing patterns  
17  
18 did not differ between the groups, whereas the Chinese group had relatively more English language input at home  
19  
20 and started using English slightly earlier than Chinese, while the Malay group showed more balanced proficiency  
21  
22 (vocabulary) compared to the other groups. Also, only a small number of children had home and media input from  
23  
24 additional languages, meaning most children were bilingual rather than multilingual.

## 26 Measures

28 **Nonverbal Reasoning.** Raven's Coloured Progressive Matrices (CPM) was administered at K1 as a measure  
29  
30 of children's non-verbal intelligence (Raven, 1947). There are three sets of 12 items (Sets A, AB, and B), with items  
31  
32 arranged in order of increasing difficulty within each set. Each item includes a pattern with a missing element  
33  
34 presented in matrix format (either 2x2, 3x3, 4x4 or 6x6). Children were asked to select the element that completed  
35  
36 the pattern from a set of alternatives. Administration of each set was terminated when four consecutive incorrect  
37  
38 responses were made. The dependent measure was the total number of correct responses across all three sets.  
39  
40 Internal consistency is reported as Cronbach's alpha = .83, (Bildiren, 2017). A between-groups analysis of variance  
41  
42 showed a main effect,  $F(2,614) = 31.38, p < .01$ , where the Chinese group showed slightly higher scores than the  
43  
44 other two groups, which did not differ from each other (see Table 1).

46 **English Reading.** Children's reading ability was measured using the Wide Range Abilities Test, 4<sup>th</sup> Edition  
47  
48 (WRAT-4, Wilkinson & Robertson, 2006). Subtests included letter naming (11 items), word reading (55 items), and  
49  
50 sentence comprehension for those who read at least 5 words in the word reading subtest. All *letter* items from the  
51  
52 Green form were administered. The *word reading* subtest was terminated after 10 consecutive errors. Both Green  
53  
54 and Blue forms were administered at K1 (with scores averaged), and the Blue form was administered at K2 and P1.  
55  
56 A total reading score was summed across the three subtests. Spearman-Brown split half reliabilities across subtests  
57  
58 ranged from 0.96 to 0.95.  
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4       **English Spelling.** Children's spelling ability was measured using the WRAT-4 (Wilkinson & Robertson,  
5  
6 2006). The Blue form was administered at K1, K2 and P1, and included *name* and *letter writing* (15 items) and *word*  
7  
8 *spelling* (42 items). Letters and words were dictated, and words were presented in a sentence for this task. Word  
9  
10 spelling was terminated after 10 consecutive errors. Total number of correctly written letters and words were scored  
11  
12 and summed. Split half reliability was 0.99.

13  
14       **Asian Language Reading.** Measures of children's reading ability in their other learned language followed a  
15  
16 similar format to the WRAT-4, but certain subtasks differed for each language: Children's reading ability was  
17  
18 measured in two parts for Malay and three parts for Chinese and Tamil. For Chinese and Tamil scripts, a recognition  
19  
20 sub-test was added (for characters and aksharas) because the younger children were not as familiar with this script  
21  
22 and many could not perform the naming sub-tests during piloting. Spearman-Brown split half reliabilities were 0.95  
23  
24 (Chinese), 0.98 (Malay) and 0.98 (Tamil).

25  
26       Malay reading was measured through *letter naming* (11 letters) and *word reading* (100 words). All letter  
27  
28 items were administered. Three practice items were followed by test items on the word reading subtest. This was  
29  
30 given in 4 blocks of 25 words and was terminated after 0 correct responses in a block. The word reading list was  
31  
32 based on word frequencies derived from the word corpus by Lay and Low (2011), and syllable number and  
33  
34 complexity increased within blocks.

35  
36       Chinese reading was measured through *character recognition* (19 characters), *simple character reading* (15  
37  
38 characters) and *character reading* (100 words) subtests. In *character recognition*, the child pointed to one of four  
39  
40 characters that matched a dictated word (which was read in a sentence). This sub-test was taken from the Preschool  
41  
42 and Primary Chinese Literacy Scale (PPCLS, Li, 2014). *Simple character reading* involved 3 practice trials then all  
43  
44 test items where the child named aloud the printed characters. *Character reading* was presented in 4 blocks of 25  
45  
46 single character words and was terminated after 0 correct responses in a block. Items were presented in order of  
47  
48 character frequency based on Loo (1989).

49  
50       Tamil reading was measured through *akshara recognition* (18 aksharas), *akshara naming* (12 aksharas) and  
51  
52 *word reading* (100 words) subtests. In *akshara recognition*, the child pointed to one of four aksharas that matched a  
53  
54 dictated akshara sound. The akshara recognition task was developed in house and the format was based on that of  
55  
56 the Preschool and Primary Chinese Literacy Scale (PPCLS, Li, 2014). *Akshara naming* involved naming aloud all  
57  
58 aksharas presented. Following 3 practice trials, *word reading* consisted of 5 blocks of 20 words and was terminated  
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4 after 0 correct response in a block. Items were presented in order determined by curriculum materials to include  
5  
6 words learned from early to later primary 1 and they increased in syllable number.  
7

8         **Asian Language Spelling**<sup>5</sup>. Children's spelling ability was measured in two parts for all Asian languages. In  
9  
10 K1, K2 and P1, the first sub-test consisted of *letter writing* (10 letters) for Malay, *stroke/radicals writing* (10 items)  
11  
12 for Chinese, and *akshara writing* (10 aksharas) for Tamil. All letter or stroke/radicals items were dictated and  
13  
14 selected based on curriculum materials from the curriculum content from grade 1 (P1) and from piloting. The second  
15  
16 sub-test consisted of a *word writing vocabulary* task (free response) in K1 and K2 for all languages. Based on Clay  
17  
18 (2002), the child was instructed to write down all the words they knew how to write. A maximum time of 5 minutes  
19  
20 and a structured set of prompts were given as needed per child following Clay (2002). The task was terminated  
21  
22 before 5 minutes if the child had exhausted their vocabulary of known words. Correctly spelled words were given a  
23  
24 score of 1 and partially correct words a score of 0.5. Partially correct words included spellings with 1 letter/stroke  
25  
26 missing or added or transposed in position, while a score of 0 was given for any drawings or scribbles or words  
27  
28 written in English. Total scores of correctly spelled words and partially correct words were summed. In P1, *word*  
29  
30 *writing vocabulary* was replaced with a *dictated spelling* task (10 items). The words were derived from curriculum  
31  
32 materials across the full year of grade 1 materials. Words in the list progressed in complexity with regard to the  
33  
34 number of syllables and multi-letter graphemes, and multiple character words for Chinese. Each word was dictated  
35  
36 and presented in a sentence and all items were administered. Total number of correctly spelled words were scored  
37  
38 and summed. Overall, scores from the two sub-tests were summed and taken as the total score for spelling at each  
39  
40 time point. Spearman-Brown split half reliabilities were 0.78 (Chinese), 0.86 (Malay) and 0.88 (Tamil).  
41

#### 42 **Data Analysis**

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45 To determine the longitudinal relationships between reading and spelling skills in bilingual children from  
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47 kindergarten to the first year of primary school, several three-wave cross-lagged panel analyses were conducted.  
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49 Cross-lagged analyses demonstrate the reciprocal relationship between variables across time, and enables  
50  
51 examination of predictions and potential causal relationships between variables. Cross-lagged models also provide  
52  
53 details on the auto-regressive relations within a construct, enabling examination of the construct's development  
54  
55 overtime. The models were assessed using Mplus 7.4 (Muthén & Muthén, 1998–2011) using the maximum  
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58  
59 <sup>5</sup> The term spelling is used throughout for consistency, even though for the Chinese tasks it is more accurately  
60 considered as writing tasks.  
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likelihood procedure (MLR) which accounts for non-normally distributed data. In this study, each cross-lagged model independently examined the:

- (a) Relationship between reading and spelling skills within the English language for children from different Asian groups, i.e., Chinese, Malay and Tamil (Figure 1).
- (b) Relationship between reading and spelling skills within each Asian language (e.g., the relationship between Malay reading and Malay spelling skills) (Figure 1).
- (c) Association between English reading skills and reading skills in the children's Asian language (e.g., the relationship between English reading and Chinese reading skills) (Figure 2).
- (d) Association between English spelling skills and spelling skills in the children's Asian language (e.g., the relationship between English spelling and Tamil spelling skills) (Figure 2).

Each of the models examined included a total of 2 variables, e.g., English reading and English spelling in (a), over three waves at Kindergarten 1 (K1), Kindergarten 2 (K2), and Primary 1 (P1), respectively. The models examined are represented in Figures 1 to 2. In every model, paths were included across each set of adjacent grades (K1 → K2, K2 → P1). For instance, English reading at K1 predicts English spelling at K2, while English reading at K2 predicts English spelling at P1. The model also examines prediction from English spelling at an earlier time point, and predicting English reading at a later time point, e.g. English spelling at K1 predicts English reading at K2, while English spelling at K2 predicts English reading at P1.

The goodness of fit criteria utilized to assess the fit of each of the models included attaining a non-significant Chi-Square statistic ( $\chi^2$ ; Barrett, 2007); Root Mean Square Residual (RMSEA) value of  $\leq .08$  (the Comparative Fit Index (CFI) value of  $\geq .90$ ; and the Standardised Root Mean Square Residual (SRMR) value of  $\leq .08$  for good fit (Hu & Bentler, 1999). All of the models were tested with and without constrains, independently. Specifically, the fit of unconstrained models were compared to time-constrained and construct-constrained models. The results indicated that freely estimated, unconstrained models resulted in better model fit for the following cross-lagged models: English reading and English spelling for Chinese children; reading and spelling in the Asian language for Malay children; English reading and reading in the Asian language for Malay children; and English spelling and spelling in the Asian language for Malay children. These models were determined to be of better fit based on lower AIC values. Chi-square difference significance testing was examined between constrained models of lower AIC values and freely estimated models. For all models tested, the chi-squares were not significantly different, hence, the freely



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4 estimated models were used and reported for all of the subsequent analyses. Standardized coefficients are given in  
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6 the results section. It is also notable that models including only the autocorrelation paths (e.g., for reading and  
7  
8 spelling) with no cross-domain or cross-linguistic paths, yielded unsuitable fits to the data (with the exception of  
9  
10 cross-linguistic models for Tamil reading and spelling).

## 11 **Results**

### 12 **Descriptive statistics and bivariate correlations**

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15 The means and standard deviations of all of the measures utilized in this study are shown in Table 2.  
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17 Skewness and kurtosis values indicate that the distribution across most measures are normally distributed (Byrne,  
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19 2010; George & Mallery, 2016). The Pearson correlations of the reading skills and spelling skills (in English and the  
20  
21 Asian languages) in K1, K2, and P1, nonverbal reasoning measure (CPM at K1), and socioeconomic status (SES)  
22  
23 are shown in Table 3. All of the correlations amongst the English and Asian languages' reading skills from K1 to P1  
24  
25 were significant and moderately to highly correlated (correlations ranged from  $r = .30$  to  $r = .77$ ,  $p < .01$ ). All of the  
26  
27 correlations among spelling skills for the English and Asian languages from K1 to P1 were significant and in the  
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29 expected direction (correlations ranged from  $r = .11$  to  $r = .78$ ,  $p < .05$ ). Nonverbal reasoning scores were  
30  
31 significantly correlated with English reading and spelling (correlations ranged from  $r = .13$  to  $r = .43$ ,  $p < .05$ ), and  
32  
33 were significantly correlated with reading and spelling for the Chinese and Malay language from K1 to P1,  
34  
35 (correlations ranged from  $r = .20$  to  $r = .41$ ,  $p < .001$ , with the exception of the relationship between nonverbal  
36  
37 reasoning and Chinese spelling at P1,  $r = .10$ ,  $p = n.s.$  The relationship between nonverbal reasoning and Tamil  
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39 reading and spelling skills were not significant,  $r = .003$  to  $r = .15$ ,  $p = n.s.$ ).

### 40 **Fit of cross-lagged models**

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43 Fit indices for all of the reported models are indicated in Table 4. The coefficients of the models indicating the  
44  
45 relationship between the variables at each time point are shown in Table 5. Within each of the following sections,  
46  
47 the model correlation coefficients at each time point are reported first, then the cross-lagged coefficients are reported  
48  
49 and the relationship between the variables are then described.

#### 50 **(a) English reading skills and English spelling skills**

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53 **Chinese bilingual group.** English reading and English spelling were significantly correlated at K1, K2, and P1,  
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55 with  $r = .72$ ,  $r = .41$ , and  $r = .35$ , respectively, all  $p$ 's  $< .001$ . Cross-lagged coefficients demonstrated a stronger  
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57 cross-domain relation of K1 reading on K2 spelling,  $\beta = .51$ ,  $p < .001$  than K2 reading on P1 spelling,  $\beta = .19$ ,  $p =$   
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.003, but both effects were none-the-less significant. Results also showed that the spelling to reading cross-lag coefficient was not significant from K1 spelling to K2 reading,  $\beta = .03, p = .672$ , but was significant from K2 spelling to P1 reading in English,  $\beta = .19, p = .003$ .

**Malay bilingual group.** English reading and English spelling were significantly correlated for this group at K1, K2, and P1,  $r = .70, p < .001$ ,  $r = .36, p = .001$ , and  $r = .67, p < .001$ , respectively. Cross-lagged coefficients demonstrated that English reading and English spelling skills in Malay children generally had little influence on each other, with coefficients ranging from  $\beta = .08$  to  $\beta = .11, p = n.s.$  The only exception was for English K2 reading skills to contribute a small influence on P1 spelling skills,  $\beta = .26, p < .001$ .

**Tamil bilingual group.** English reading and English spelling for this group were also significantly correlated at each point, from K1, K2, and P1,  $r = .72, r = .49$ , and  $r = .53$ , respectively, all  $p$ 's  $< .001$ . Cross-lagged coefficients showed a K1 to K2 reading to spelling influence from,  $\beta = .55, p < .001$ , but no spelling to reading influence,  $\beta = .09, p = .147$ . From K2 to P1, however, there was a bidirectional influence across domains, with K2 reading to P1 spelling  $\beta = .32, p = .001$ , and K2 spelling to P1 reading,  $\beta = .19, p = .035$ .

#### (b) Reading skills and spelling skills in Asian languages

**Chinese bilingual group.** Chinese reading and Chinese spelling were significantly correlated at K1, K2, and P1,  $r = .62, p < .001, r = .42, p < .001$ , and  $r = .15, p = .011$  respectively. Cross-lagged coefficients showed a bidirectional relationship across domains at an earlier age, but not at the later time point. K1 reading contributed moderately to K2 spelling,  $\beta = .43, p < .001$ , and K1 spelling showed a small effect on K2 reading,  $\beta = .07, p = .029$ . From K2 to P1 neither reading to spelling, nor spelling to reading contributions were significant  $\beta = .12, p = .149, \beta = .06, p = .154$ .

**Malay bilingual group.** Malay reading and Malay spelling were correlated K1, K2, and P1 were,  $r = .43, r = .33$ , and  $r = .66$ , respectively, all  $p$ 's  $< .001$ . Cross-lagged coefficients showed small but significant effects of K1 to K2 reading to spelling,  $\beta = .13, p = .048$ , and spelling to reading,  $\beta = .14, p = .003$ . From K2 to P1, the spelling to reading influence remained,  $\beta = .41, p < .001$ , but the reading to spelling influence was no longer significant,  $\beta = .14, p = .055$ .

**Tamil bilingual group.** Tamil reading and Tamil spelling were correlated at K1, K2, and P1,  $r = .82, r = .61$ , and  $r = .78$ , respectively, all  $p$ 's  $< .001$ . Cross-lagged coefficients showed that Tamil reading and spelling were bidirectionally influential, from K1 reading to K2 spelling,  $\beta = .27, p = .001$ , and K1 spelling to K2 reading,  $\beta = .24, p$

< .001. From K2 to P1, these skills were unrelated,  $\beta = .16$ ,  $p = .207$  and  $\beta = .11$ ,  $p = .310$ , for reading to spelling, and spelling to reading, respectively.

### (c) English and Asian languages' reading skills

**Chinese bilingual group.** English and Chinese reading were only correlated at K1,  $r = .46$ ,  $p < .001$ , and not at K2 or P1,  $r = -.10$ ,  $p = .084$ , and  $r = -.04$ ,  $p = .485$ , respectively. Cross-lagged coefficients showed no influence between English and Chinese reading skills at any time point, ranging from  $\beta = -.02$  to  $\beta = .05$ , all  $p$ 's = n.s.

**Malay bilingual group.** English and Malay reading were significantly correlated at K1, and P1 with  $r = .75$ , and  $r = .57$ , respectively,  $p$ 's < .001, but not at K2,  $r = .26$ ,  $p = .086$ . Cross-lagged coefficients showed a bidirectional influence of English reading and Malay reading skills over time. Specifically, K1 English reading had a small influence on Malay reading at K2,  $\beta = .20$ ,  $p = .006$ , and there was a larger influence from K2 to P1,  $\beta = .44$ ,  $p < .001$ . The influence of K1 Malay reading on K2 English reading was also significant and similar to the opposite cross-language direction,  $\beta = .26$ ,  $p = .001$ , and this Malay to English influence remained steady from K2 to P1,  $\beta = .23$ ,  $p = .002$ .

**Tamil bilingual group.** English and Tamil reading were significantly correlated at K1, and P1,  $r = .50$ ,  $p < .001$ , and  $r = .23$ ,  $p = .006$ , respectively, but not at K2,  $r = -.003$ ,  $p = .962$ . Cross-lagged coefficients showed no cross-language influence of English and Tamil reading skills over time,  $\beta = -.02$  to  $\beta = .06$ , all  $p = n.s.$

### (d) English and Asian languages' spelling skills

**Chinese bilingual group**<sup>6</sup>. English spelling and Chinese spelling were related at K1 and K2,  $r = .43$ ,  $p < .001$ ,  $r = .14$ ,  $p = .027$ , respectively, but not at P1,  $r = .11$ ,  $p = .113$ . The cross-lagged coefficients showed bidirectional influence between English and Chinese spelling from K1 to K2,  $\beta = .16$ ,  $p = .003$ , and  $\beta = .12$ ,  $p = .014$ , respectively. From K2 to P1, English spelling did not impact on Chinese spelling,  $\beta = .02$ ,  $p = .734$ , and Chinese spelling did not impact English spelling,  $\beta = .04$ ,  $p = .579$ .

**Malay bilingual group.** English and Malay spelling were consistently but diminishingly related from K1, K2, to P1,  $r = .69$ ,  $r = .52$ , and  $r = .33$ , all  $p$ 's < .001. Cross-lagged coefficients showed a moderate effect of K1 English

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<sup>6</sup> As noted above, roughly half of the Chinese/English children were enrolled in traditional classrooms like the Tamil/English and Malay/English children, while the other half encountered 'bilingual approach' schools. To examine the comparability of those in different programs, we ran the same 4 cross-lag analyses (a-d) with only the subsample of Chinese/English children in traditional classrooms. The results demonstrated minimal differences in the fit indices of the models for this subgroup, and revealed the same patterns in the relationship between reading and spelling.

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4 spelling to K2 Malay spelling at K2,  $\beta = .43, p < .001$ , and a marginal effect from K2 English to P1 Malay spelling,  
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6  $\beta = .30, p = .051$ . From Malay to English spelling, there was no effect from K1 to K2,  $\beta = -.02, p = .836$ , but there  
7  
8 was a small effect from K2 to P1,  $\beta = .19, p = .009$ .

9  
10 **Tamil bilingual group.** English and Tamil spelling were only correlated with each other at K1,  $r = .47, p <$   
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12  $.001$ , but were unrelated at K2 and P1,  $r = .17, p = .065$  and  $r = .09, p = .352$ , respectively. Cross-lagged coefficients  
13  
14 revealed no cross-language influence for English and Tamil spelling at any point in their early development,  $\beta = -.01$   
15  
16 to  $\beta = .08$ , all  $p = n.s.$

## 17 18 **Discussion**

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20 We examined the relation of reading and spelling skills at the initial phase of literacy acquisition for children  
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22 who were learning two orthographies: English plus another alphabetic system (Malay), or an additional akshara  
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24 system (Tamil), or another orthographic system (Chinese). By comparing across these bilingual groups, we  
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26 considered language specific and language universal processes in terms of the co-development of reading and  
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28 spelling. We first considered cross-domain relations within all groups for reading and spelling in English, to  
29  
30 examine whether learning an Asian language affects English literacy development. Secondly, we examined the three  
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32 additional Asian languages with regard to cross-domain relations in reading and spelling, to see how different  
33  
34 orthographies may contribute to the co-development of these literacy skills. Finally, we examined cross-linguistic  
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36 effects for reading and for spelling, to see how closely aligned or shared these skills are for bilingual children  
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38 learning different script sets.

### 39 40 *English reading and spelling development*

41  
42 All three bilingual groups of children showed that these two skills for English were correlated at each time  
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44 point, across K1 to P1, with the strongest relations at the first time point. However, there were differences in the  
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46 direction of influence between reading and spelling skills over time per group, suggesting that the nature of the  
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48 additional language being learned affects performance in English (noting that all the children experienced the same  
49  
50 curriculum for English). The Chinese and Tamil bilingual groups were similar in that reading contributed to spelling  
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52 at each time, while spelling contributed only to reading at P1. From kindergarten into primary school entry, the  
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54 relations of reading and spelling became bidirectional for these two groups. This fits with Frith's (1985) model, such  
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56 that reading is the pacemaker at the point when children are still in the early logographic phase of reading, and then  
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58 their reading and spelling skills converge as they enter the later part of the phase, when they grasp print-sound  
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relationships and the alphabetic principle. On the other hand, for the Malay bilingual group, reading only contributed to P1 spelling, while spelling did not contribute to reading. This suggests that English reading and spelling were more independent skills for the young Malay bilingual children, as also indicated by stronger autoregressive relations within each domain ( $r$ 's from 0.78 to 0.71) compared with their cross-lag contribution from reading to spelling ( $r = 0.26$ ). These results could be accounted for based on differences between the orthographies that the children are learning simultaneously. Similar to other transparent languages, Malay may not require input from spelling to reading (e.g., Schaars et al., 2017), and so these children may approach English reading the same way – without input from their English spelling skills. For the other groups, if processing their akshara and morphosyllabary language at larger grain sizes is applied to English, this would make reading more easily acquired and support the initial influence of reading to spelling.

*Reading and spelling development in the bilinguals' other language*

Regarding the relationship of reading and spelling skills in the children's other languages, all bilingual groups again showed that these two literacy skills were correlated across each time point. For Chinese language, the relation diminished with time, whereas for Malay language it strengthened over time. In terms of the direction of influence between reading and spelling skills, each group showed a different pattern for their other, Asian language. The influence of reading to later spelling was significant in Chinese early on, and in Malay across both time points (K2 and P1), whereas in Tamil reading did not influence later spelling. The influence of spelling to later reading was evident early on for each of the groups, and this direction of spelling to reading influence continued into P1 for Malay and Tamil languages. This fits with the prediction of orthographic depth and consistency, that the transparent and symmetric language of Malay would show persistent bidirectional influence and equal progress for reading and spelling skills. The result differs from previous findings for other transparent languages, however, where a unidirectional reading to spelling influence was found and explained as the ease of reading the script that required no additional feedback information gained from spelling skills (e.g., Leppanen et al., 2006; Schaars et al., 2017). For Tamil, we expected weaker relations between reading and spelling overall, but also that reading would lead spelling due to the asymmetry in feedforward versus feedback consistency (Padakannaya & Mohanty, 2004). One reason this consistency asymmetry may not show up in the modelled results is that the first words learned for spelling and reading tend to have a simpler syllable structure and simple types of akshara (Nag, 2011), which makes the print-sound mapping easier than it is for more complex akshara and words learned later on. This, taken with the phonemic

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4 emphasis in pedagogy, may sway these children to take an analytic approach to encoding the script. Other aspects of  
5  
6 the Tamil script may affect these developmental patterns – namely that Tamil is not a constrained orthography but  
7  
8 an extensive one, with many glyphs to be learned (247). Thus, although the akshara languages require learning of  
9  
10 many more symbols than alphabetic languages, they tend to involve less confusion about mapping sounds with  
11  
12 letters and thus more automatized spelling (Nag, 2011). While this may explain the contribution of spelling to  
13  
14 reading, it does not explain the lack of reading to spelling influence in Tamil.

15  
16 For Chinese, the early bidirectional influence was actually stronger from reading to spelling than vice versa.  
17  
18 Producing all the necessary strokes of a Chinese character in spelling requires attention to detail and may be more  
19  
20 cognitively taxing for an early learner of Chinese as compared to reading. Children may be particularly prone to  
21  
22 errors when spelling in Chinese due to homophones, as well as having problems with accurately representing tone  
23  
24 through the strokes paired with the phonetic radical, thus introducing more inconsistency in phoneme to grapheme  
25  
26 mapping. Moreover, due to its extensive orthography, Chinese spelling requires knowledge of whole character  
27  
28 features, hence a larger known character repertoire learned from reading could aid spelling skills. As children get  
29  
30 older, this influence between reading and spelling appears to taper off. At this point whole word phonology and  
31  
32 semantic relations to the print become more prominent, and lexical vocabulary is necessary. The build-up of the  
33  
34 Chinese lexicon may be more protracted for these bilingual children compared with monolingual Chinese speakers,  
35  
36 especially for the children who are dominant in English. In this case, it appears a non-alphabetic script elicits less  
37  
38 shared processes for matching a character with its syllable or word level pronunciation (reading) versus graphically  
39  
40 representing the ensemble of strokes in the character related to a spoken word (spelling).

#### 41 42 43 *Cross-linguistic influence on reading and spelling*

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45 All bilingual groups showed an early correlation of reading concurrently for English and other language  
46  
47 skills, which was largest for the Malay group. At this earliest point in literacy development, the basic elements for  
48  
49 recognizing any print, either at the single letter or single stroke level, may be related to general experience and  
50  
51 readiness for kindergarten. After K1, Chinese and English reading were uncorrelated. At P1, Malay and English  
52  
53 reading as well as Tamil and English reading were significantly correlated, with Malay and English showing a  
54  
55 stronger relation again. In each case, these correlations may be due to the similarity of decoding methods via  
56  
57 grapheme to phoneme translation in each language. However, only the Malay bilingual group showed a cross-lag  
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59 relationship between reading in the two languages. These relations were bi-directional, with English influencing  
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4 Malay and Malay influencing English reading to a similar degree initially, and then more so from English to Malay  
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6 into P1. For the Tamil bilingual group, reading skills showed no cross-lag relations across languages. Since Malay  
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8 and English are both represented by the same alphabetic script and therefore share letter knowledge, it was expected  
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10 that reading will function similarly and be related in each language. This is consistent with research that has found  
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12 cross language transfer due to script similarity and it fits with the typological distance hypothesis (Koda, 2007). That  
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14 is, for bilinguals, structural similarities in the languages facilitate cross-language relationships for reading skills. In  
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16 contrast, children learning Tamil acquire a different script with a larger symbol set of dual-nature glyphs  
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18 representing phoneme and syllable levels of sound. For children learning Chinese, it appears that their reading skills  
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20 for their alphabetic and non-alphabetic scripts are unrelated over time. These findings differ from those with older  
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22 bilingual children, who may show more script-universal transfer of reading skills, due to reliance on additional skills  
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24 related to fluency or reading comprehension in addition to decoding (e.g., Inoue, Georgiou, Imanaka, Oshiro,  
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26 Kitamura, Maekawa, & Parrila, 2019; Pasquarella et al., 2015; Tong et al., 2012; Wang, Cheng, & Chen, 2006).

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28 With regard to cross-linguistic influences for spelling, all bilingual groups showed an early correlation of  
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30 concurrent English and other language skills, just as for reading. The correlation was strongest for the Malay group  
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32 which persisted over time. Similar to reading, at the earliest time point the basic elements for writing, such as  
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34 graphomotor skills and knowledge about the basic elements of print per language, may be related to general  
35  
36 experience and readiness for kindergarten. Since spelling favors small, less complex orthographic units (Ziegler &  
37  
38 Goswami, 2005), acquiring the basic elements per script is likely most similar at this early stage. Thereafter, there  
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40 were no relations or cross-language influences between English and Tamil spelling. Somewhat surprisingly, there  
41  
42 were small cross-lag effects from Chinese to English spelling and vice versa. Possibly, early spellers of English and  
43  
44 Chinese may be reliant on rote memorization of the orthographic representation of letters in English and strokes and  
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46 radicals in Chinese, and thus are able to spell accurately with the memorization of the basic units of scripts. Yet,  
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48 when the Chinese scripts become more visually complex as the children enter formalized education, reliance on rote  
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50 memorization to produce characters might not elicit accurate Chinese spellings. Following the typological distance  
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52 hypothesis noted above (e.g., Koda, 2007), there were expected cross-lag influences for spelling in the Malay  
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54 bilingual group that were bidirectional, but stronger in the English to Malay direction, perhaps due to more practice  
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56 with writing English words.  
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4 In sum, there was evidence that reading and spelling skills were related for all groups in both of their  
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6 languages, suggesting a language universal co-development of early literacy skills. The directionality of influence  
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8 between these skills varied within the preschool years to primary school entry, and differences across the groups  
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10 suggest language-specific dynamics in the co-development of early literacy skills. Orthographic depth explained  
11  
12 some of these differences, but other factors play a role in these complex relations, including cross-language  
13  
14 influences based on different preferred grain sizes and methods of instruction across the bilingual children's two  
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16 languages. For each group, the pattern of results is summarized as follows:  
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- 18 • The Tamil-English group showed cross-domain reading-to-spelling influence for English and a later  
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20 bidirectional influence; cross-domain spelling-to-reading influence for Tamil; and minimal cross-language  
21  
22 influence.  
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- 24 • The Malay-English group showed a later cross-domain reading-to-spelling influence for English;  
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26 bidirectional cross-domain reading and spelling influence for Malay; and significant cross-linguistic influence  
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28 for both reading and spelling over time.  
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- 30 • The Chinese-English group showed a cross-domain reading-to-spelling influence for English and later  
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32 bidirectional influence; an initial cross-domain reading and writing influence for Chinese; and cross-linguistic  
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34 influence only for spelling.  
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37 Cross-language influences are seen across the groups' English literacy development and in the direct  
38  
39 examination of the cross-language models. Yet these influences were not always aligned with predictions based on  
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41 the nature of the orthographies (transparent vs. opaque scripts) or the focus of the educational approach (phonemic  
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43 vs. syllabic level). For instance, while reading and spelling mutually influence one another for the transparent  
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45 orthography of Malay, this group's English reading showed a unidirectional contribution to English spelling that is  
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47 strengthened cross-linguistically. On the other hand, for Tamil there was minimal cross-linguistic influence on  
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49 reading or spelling, where the skills within each language appear more independent (as also supported by the  
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51 reduced models with only autocorrelational paths yielding better model fits than the model with full paths). As  
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53 Lallier and Carreiras (2017) demonstrated for bilinguals of alphabetic languages, script transparency and grain-size  
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55 result in accommodations of bilinguals' reading systems. Shallow, transparent languages, like Malay or Tamil, may  
56  
57 accommodate any grain size to support reading accuracy. At the first stages of literacy development, small grain size  
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59 is important for alphabetic languages (Ziegler, et al., 2013), but the extension to other systems, alpha- or morpho-  
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4 syllabaries, is not as clear. In addition to orthographic depth, biliteracy acquisition may differ for sets of constrained  
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6 and extensive orthographies. For example, decoding strategies may only transfer between alphabetic systems with  
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8 constrained sets of graphemes, via shared requisite component skills like phonological awareness, letter knowledge  
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10 and phonics (Pasquarella et al., 2015). On the other hand, while it may only take a few years to master an alphabet,  
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12 orthographies with more extensive elements, like Chinese and Tamil, require more years to learn the basic elements  
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14 of the script (Nag, 2007; Chang, Plaut, & Perfetti, 2016). Learning larger graphemic inventories with more visually  
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16 complex graphemes may preclude the ability to transfer word reading skills, because different sets of component  
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18 skills are required (e.g., RAN, visual-orthographic awareness, Wang, Lin, McBride, 2015; Shum, Ho, Siegel, & Au,  
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20 2016).

### 21 22 *Limitations*

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24 While this study makes a unique contribution by examining reading and spelling development for children  
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26 learning multiple languages with different types of script pairs, and sheds light on language-general and –specific  
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28 aspects of the interrelations of literacy skills during the earliest phases of development, there are some limitations to  
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30 note. First, comparison across studies is not straightforward because of differences in the types of tasks used to  
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32 measure literacy skills (e.g., Schaars et al., 2017). While we used a standardized measure of English literacy that has  
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34 been used previously in the Singapore context, we chose literacy tasks for the other languages that are relevant to the  
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36 current context of Singapore. For instance, a free writing task was used at kindergarten rather than a dictation task  
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38 because curricular content varies across kindergarten centres, and children are exposed to different sets of words.  
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40 This, however, introduced differences in the types of tasks for English and the other languages (dictation vs. non-  
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42 dictated spelling) that may have undermined the relationship between English and Chinese spelling, for example.  
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44 Another limitation is with the nature of the reading recognition subtest for Tamil, where children had to select  
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46 between options that were graphically similar looking and similar sounding to the correct akshara. This may  
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48 introduce a challenge to young learners by requiring fine visual and auditory recognition skills (Emam & Kazem,  
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50 2014), and may have underestimated their early reading skills. This could have contributed to the lack of reading to  
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52 spelling influence in Tamil in the present study. Further, the results discussed in this paper do not take into account  
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54 possible diglossic differences in the Malay and Tamil language. That is, spoken compared with literary registers of  
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56 Tamil may include additional or omitted consonants (e.g., ‘Enakku panam veentum’ versus ‘Enakku panam  
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58 veenum’, for “I want money”), and Malay standard compared with nonstandard registers may include grammatical  
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4 modifications (e.g., ‘Ayah tidak tahu’ versus ‘Ayah tak tau’ for “‘Dad does not know’”). Such diglossic differences  
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6 concerning the two registers can be potential sources of reading and spelling problems for children learning these  
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8 languages. This question is receiving increasing attention in the linguistics world on the effects of literacy skills  
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10 acquisition in bilingual children (Nag & Narayanan, 2019) and needs to be addressed in future studies. Additionally,  
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12 we utilized manifest rather than latent variables in the current study, and future work could include latent constructs  
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14 of literacy with more tasks for the different languages. Finally, we also note that the groups themselves differed in  
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16 terms of SES level and proportion of English used in the home, which may contribute to group differences and  
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18 renders the group comparisons more complex. Due to the limited size of the smaller bilingual groups, we were  
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20 unable to accommodate covariates or exogenous predictors in the models, which may help to explain some of the  
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22 variation across models. Overall, the findings from this study contribute to our growing understanding of early  
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24 bilingual and biliteracy development in children.  
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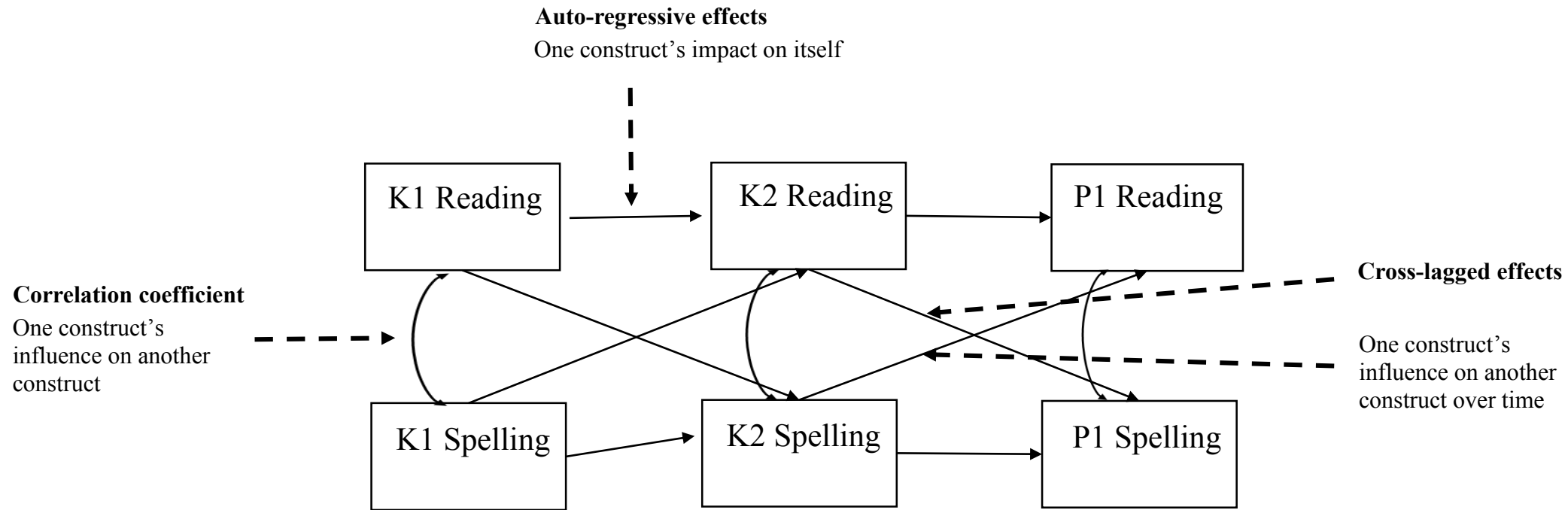
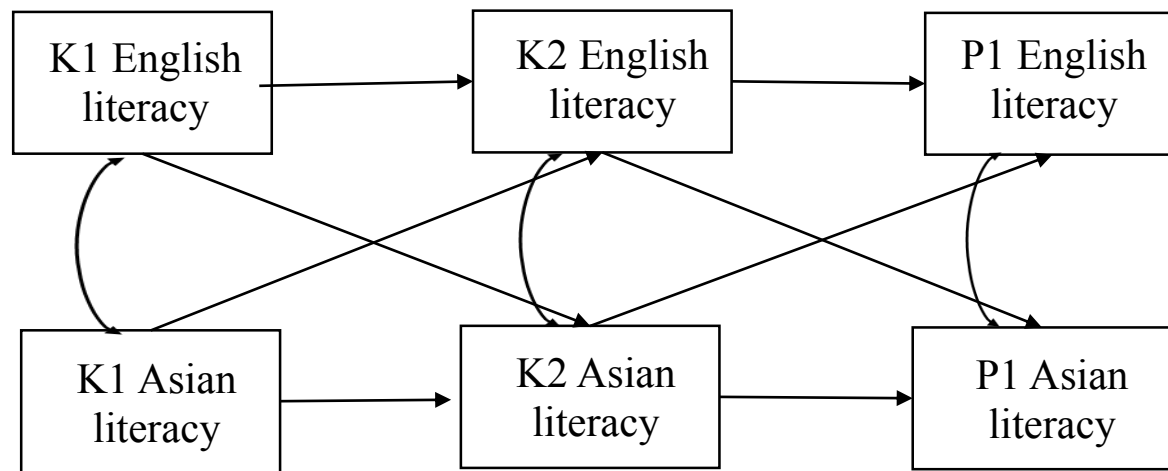


Figure 1.



*Figure 2*

Table 1

*Family socio-economic status and language input for groups of bilingual children*

<i>Variables</i>	<u>Chinese</u>		<u>Malay</u>		<u>Tamil</u>		<i>p</i>
	<i>N</i>	M(SD)	<i>N</i>	M(SD)	<i>N</i>	M(SD)	
Mother Education	305	9.22 (2.17) <sub>a</sub>	133	7.07 (2.75) <sub>b</sub>	174	9.82 (1.77) <sub>c</sub>	< 0.01
Income	301	15.62 (4.87) <sub>a</sub>	129	6.05 (4.45) <sub>b</sub>	170	12.05 (5.34) <sub>c</sub>	< 0.01
Housing Type	303	4.81 (1.99) <sub>a</sub>	134 <sub>a</sub>	3.07 (1.31) <sub>b</sub>	173	3.53 (1.43) <sub>c</sub>	< 0.01
Raven	307	16.96 (5.03) <sub>a</sub>	132	14.41 (5.05) <sub>b</sub>	178	13.53 (4.52) <sub>b</sub>	< 0.01
Relative AOA	247	-.56 (1.15) <sub>a</sub>	107	.27 (1.45) <sub>b</sub>	115	-.028 (1.49) <sub>b</sub>	< 0.01
Relative HLI	263	.46 (.45) <sub>a</sub>	113	.07 (.51) <sub>b</sub>	152	.18 (.59) <sub>b</sub>	< 0.01
Relative Vocab	265	8.60 (11.03) <sub>a</sub>	128	3.27 (8.52) <sub>b</sub>	167	8.58 (8.90) <sub>a</sub>	< 0.01
Media in AL	124	27.68 (21.43) <sub>a</sub>	81	29.84(16.30) <sub>a</sub>	72	30.08(16.88) <sub>a</sub>	0.60
Proportion of children with exposure to more than 2 languages at home and through media viewing	7	0.02	0	0	16	0.08	

*Note:* Mother Education is rated on an 11-point scale (with 7 = high school diploma, and 9 = post-secondary certificate); Income on a 20-point scale (where median monthly income in Singapore corresponds to a rating of 17 = 8800SGD); and Housing Type is rated on an 9-point scale (where ratings of 3-4 correspond to 4-5 room public housing, slightly above the average in Singapore). Significant group differences according to univariate ANOVA's are reported in final column (*p*-values). Means with different subscripts differ (*p* < .05) according to post-hoc Student-Newman-Kuels range tests. "Relative" measures indicate English minus Asian Language, for AOA (age of language acquisition), HLI (proportion of home language input and use), Vocab (receptive vocabulary score), and Media (percent of overall viewing time).

Table 2

*English and Asian language reading and spelling scores across bilingual language groups and time*

Measure	<u>Chinese</u>				<u>Malay</u>				<u>Tamil</u>			
	Mean (SD)	Min-Max	Skewness (SE)	Kurtosis (SE)	Mean (SD)	Min-Max	Skewness (SE)	Kurtosis (SE)	Mean (SD)	Min-Max	Skewness (SE)	Kurtosis (SE)
ER at K1	19.41 (6.11)	1-48.5	.97 (.14)	2.54 (.28)	14.30(5.62)	0-33.5	.11(.21)	1.64(.416)	19.53 (5.83)	3-38.5	.85 (.19)	2.03 (.37)
ER at K2	24.07 (7.25)	8-50	1.01 (.14)	.74 (.28)	17.94(6.42)	0-43	.65(.21)	2.67(.417)	24.36 (7.35)	13-56	1.15 (.19)	1.91 (.37)
ER at P1	31.23 (7.91)	15-53	.33 (.15)	-.38 (.29)	25.45(7.45)	15-50	.93(.21)	.43(.43)	32.66 (7.69)	16-53	.37 (.19)	-.09 (.39)
ES at K1	15.12 (3.29)	3-24	-.67 (.16)	2.23 (.31)	12.10(3.83)	3-22	-.54(.24)	-.16(.47)	15.39 (3.68)	0-29	-.50 (.19)	4.08 (.38)
ES at K2	17.55 (3.13)	7-28	.61 (.14)	.93 (.28)	14.59(3.43)	0-26	-.99(.21)	4.29(.42)	18.08 (3.73)	6-33	.65 (.19)	2.02 (.37)
ES at P1	21.12 (4.16)	8-34	.13 (.16)	.18 (.31)	18.13(4.90)	0-33	-.49(.23)	2.38(.45)	22.22 (4.36)	7-32	-.20 (.20)	.49 (.41)
ALR at K1	28.64 (17.67)	0-96	.73 (.14)	.30 (.28)	11.64(12.8 9)	0-80	3.44(.24)	13.16(.47)	20.41 (19.43)	1-88	1.60 (.20)	2.21 (.41)
ALR at K2	35.64 (19.68)	0-100	.470 (.14)	-.06 (.28)	19.87(23.3 14)	0-108	2.39(.21)	4.76(.42)	45.89 (32.22)	4-138	.79 (.20)	-.20 (.40)
ALR at P1	44.02 (21.40)	0-111	.30 (.15)	-.16 (.30)	57.61(33.6 5)	0-111	-.086(.21)	-1.41(.43)	60.69 (32.01)	1-122	.01 (.22)	-.86 (.43)
ALS at K1	23.51 (9.74)	0-52.5	-.19 (.14)	.13 (.28)	33.81(10.2 4)	0-52	-1.61(.24)	2.52(.47)	17.29 (14.82)	0-58	.47 (.20)	-.91 (.40)
ALS at K2	32.21 (11.79)	0-73.5	-.19 (.14)	.38 (.28)	38.71(7.73)	1-55.5	-2.04(.21)	6.68(.42)	26.16 (17.02)	0-64	.15 (.20)	-1.00 (.40)
ALS at P1	20.02 (11.10)	41	-.50 (.14)	-.94 (.27)	44.36(3.91)	26-50	-1.07(.21)	2.69(.43)	38.34 (12.20)	2-58	-1.01 (.22)	.66 (.43)

*Note. ER = English Reading Skills; ES = English Spelling Skills; ALR = Asian Language Reading Skills; ALS = Asian Language Spelling Skills, Nonverbal = Nonverbal reasoning; SES = Socioeconomic Status; K1= Kindergarten 1, K2 = Kindergarten 2, P1 = Primary 1.*

Table 3

*Correlations among reading, spelling, nonverbal reasoning, and SES*

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<b>Chinese</b>														
1. ER at K1	1													
2. ER at K2	.82**	1												
3. ER at P1	.70**	.81**	1											
4. ES at K1	.74**	.63**	.59**	1										
5. ES at K2	.75**	.77**	.71**	.72**	1									
6. ES at P1	.64**	.64**	.70**	.55**	.72**	1								
7. ALR at K1	.46**	.37**	.37**	.45**	.48**	.37**	1							
8. ALR at K2	.44**	.32**	.30**	.44*	.47**	.35**	.90**	1						
9. ALR at P1	.42**	.31**	.30**	.38**	.45**	.37**	.81**	.90**	1					
10. ALS at K1	.34**	.27**	.25**	.39**	.39**	.30**	.63**	.59**	.55**	1				
11. ALS at K2	.38**	.27**	.23**	.36**	.42**	.31**	.67**	.75**	.69**	.66**	1			
12. ALS at P1	.13**	.12*	0.09	.15*	.11*	.18**	.19**	.22**	.27**	.15**	.20**	1		
13. Nonverbal	.17**	.15*	.18**	.26**	.18**	.13*	.20**	.23**	.22**	.25**	.22**	0.1	1	
14. SES	.26**	.26**	.25**	0.1	.26**	.17**	.21**	.19**	.19**	.16**	.20**	0.1	0.07	1
<b>Malay</b>														
1. ER at K1	1													
2. ER at K2	.86**	1												
3. ER at P1	.64**	.77**	1											
4. ES at K1	.74**	.72**	.56**	1										
5. ES at K2	.62**	.68**	.57**	.81**	1									
6. ES at P1	.72**	.84**	.82**	.72**	.89**	1								
7. ALR at K1	.74**	.74**	.59**	.45**	.39**	.48**	1							
8. ALR at K2	.61**	.68**	.64**	.52**	.48**	.59**	.71**	1						
9. ALR at P1	.61**	.60**	.77**	.54**	.51**	.72**	.42**	.53**	1					
10. ALS at K1	.68**	.56**	.42**	.72**	.52**	.56**	.44**	.43**	.39**	1				
11. ALS at K2	.72**	.70**	.57**	.75**	.77**	.78**	.45**	.53**	.55**	.73**	1			
12. ALS at P1	.60**	.66**	.71**	.58**	.65**	.76**	.45**	.47**	.78**	.57**	.69**	1		
13. Nonverbal	.34**	.38**	.43**	.31**	.26**	.32**	.31**	.36**	.41**	.23*	.26**	.38**	1	
14. SES	.19*	.28**	.30**	.29**	.27**	.20*	.24*	.21*	.25**	.26*	.21*	.25**	0.18	1
<b>Tamil</b>														
1. ER at K1	1													
2. ER at K2	.85**	1												
3. ER at P1	.69**	.76**	1											
4. ES at K1	.74**	.67**	.49**	1										
5. ES at K2	.79**	.83**	.68**	.73**	1									
6. ES at P1	.68**	.75**	.79**	.60**	.78**	1								
7. ALR at K1	.47**	.39**	.31**	.52**	.44**	.28**	1							
8. ALR at K2	.50**	.44**	.44**	.54**	.50**	.43**	.89**	1						
9. ALR at P1	.56**	.51**	.50**	.60**	.56**	.50**	.68**	.83**	1					
10. ALS at K1	.26**	.19**	.23*	.43**	.29**	.21**	.81**	.81**	.64**	1				
11. ALS at K2	.33**	.30**	.35**	.44**	.39**	.39**	.75**	.87**	.76**	.81**	1			
12. ALS at P1	.38**	.34**	.34**	.46**	.40**	.35**	.51**	.64**	.86**	.56**	.69**	1		
13. Nonverbal	.31**	.28**	.41**	.17**	.32**	.32**	0.09	0.1	0.15	0.003	0.01	0.1	1	
14. SES	.27**	.29**	.32**	.19*	.26**	.26**	.24**	.29**	.26**	.20*	.30**	.28**	0.1	1

*Note.* ER = English Reading Skills; ES = English Spelling Skills; ALR = Asian Language Reading Skills; ALS = Asian Language Spelling Skills, Nonverbal = Nonverbal reasoning; SES = Socioeconomic Status (calculated as a latent factor of mother education, income and housing type); K1= Kindergarten 1, K2 = Kindergarten 2, P1 = Primary 1, \* =  $p < .05$ ; \*\* =  $p < .01$ .



Table 4

*Model Fit Indices*

	Chinese				Malay				Tamil			
	English Reading - English Spelling	AL Reading - AL Spelling	English Reading - AL Reading	English Spelling - AL Spelling	English Reading - English Spelling	AL Reading - AL Spelling	English Reading - AL Reading	English Spelling - AL Spelling	English Reading - English Spelling	AL Reading - AL Spelling	English Reading - AL Reading	English Spelling - AL Spelling
AIC	8852.4	13290.44	12014.71	10668.35	3841.92	5286.74	5280.68	3792.23	4509.25	6313.06	6107.58	5267.92
BIC	8939.14	13377.18	12101.45	10755.09	3909.25	5354.07	5348.01	3859.56	4579.98	6383.94	6178.45	5338.79
Chi-Square	4.44	2.27	3.75	3.71	1.43	12.31	8.58	6.42	4.37	8.53	15.71	12.17
p-value	0.35	0.69	0.44	0.45	0.84	0.02	0.07	0.17	0.36	0.07	0	0.02
RMSEA	0.02	0	0	0	0	0.12	0.09	0.07	0.02	0.08	0.14	0.11
CFI	1	1	1	1	1	0.97	0.99	0.99	1	0.99	0.98	0.98
SRMR	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01	0.01	0.02	0.03

*Note.* AL refers to the Asian Language of the group.

Table 5

*Cross-lag coefficients for the reading and spelling models across English and Asian languages across three time-points (K1, K2 and P1)*

	Chinese	Malay	Tamil
<b>English Reading – English Spelling</b>			
English Reading at K1 □ English Spelling at K2	.51**	0.11	.55**
English Reading at K2 □ English Spelling at P1	.19**	.26**	.33**
English Spelling at K1 □ English Reading at K2	0.03	0.12	0.09
English Spelling at K2 □ English Reading at P1	.19**	0.08	.21*
<b>AL Reading – AL Spelling</b>			
AL Reading at K1 □ AL Spelling at K2	.43**	.13*	0.27**
AL Reading at K2 □ AL Spelling at P1	0.12	.14 <sup>+</sup>	0.16
AL Spelling at K1 □ AL Reading at K2	.07*	.14**	.24**
AL Spelling at K2 □ AL Reading at P1	0.06	.41**	0.11
<b>English Reading – MT Reading</b>			
English Reading at K1 □ AL Reading at K2	0.04	.20**	0.06
English Reading at K2 □ AL Reading at P1	0.03	.44**	0.02
AL Reading at K1 □ English Reading at K2	-0.02	.26**	-0.02
AL Reading at K2 □ English Reading at P1	0.05	.23**	0.05
<b>English Spelling – AL Spelling</b>			
English Spelling at K1 □ AL Spelling at K2	.16**	.43**	0.08
English Spelling at K2 □ AL Spelling at P1	0.02	.30 <sup>+</sup>	0.02
AL Spelling at K1 □ English Spelling at K2	.12**	-0.02	-0.01
AL Spelling at K2 □ English Spelling at P2	0.04	.19**	-0.01

*Note: \*\* $p < .01$ , \* $p < .05$ , + $p < .06$ . K1, K2, and P1 represent Kindergarten 1, Kindergarten 2, and Primary 1, respectively. AL represents Asian Language.*

[Click here to view linked References](#)

Figure Captions.

Figure 1. Example of cross-lagged model for cross-domain literacy skills

Figure 2. Example of cross-Lagged model for cross-language skills in reading or spelling