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Does Writing System Influence the Associations Between Phonological Awareness, Morphological Awareness, and Reading? A Meta-Analysis

Yufang Ruan
Beijing Normal University

George K. Georgiou
University of Alberta

Shuang Song, Yixun Li, and Hua Shu
Beijing Normal University

Differences in how writing systems represent language raise important questions about the extent to which the role of linguistic skills such as phonological awareness (PA) and morphological awareness (MA) in reading is universal. In this meta-analysis, the authors examined the relationship between PA, MA, and reading (accuracy, fluency, and comprehension) in 2 languages (English and Chinese) representing different writing systems (alphabetic and logographic). A random-effects model analysis of data from 64 studies with native speakers of each language revealed significant correlations between PA, MA, and all reading outcomes in both languages. The correlations remained significant even after controlling for each other's effect on reading. However, PA was a stronger correlate of reading in English than in Chinese. MA was as good a correlate of reading in English as in Chinese (except for comprehension, where it was better). In addition, complex PA tasks in English and production/compounding MA tasks in Chinese produced significantly larger correlations with reading accuracy. Taken together, the findings of this meta-analysis suggest that PA and MA are significant correlates of reading, but their role is influenced by the writing system, the type of reading outcome, and the type of task used to operationalize PA and MA. The implications of these findings are discussed.

Educational Impact and Implications Statement

The authors examined the role of writing system in the relationship between phonological awareness, morphological awareness, and reading. The results of the meta-analysis revealed significant relationships between these linguistic skills and reading in each language, but the strength of the relationships was influenced by the writing system, the type of reading outcome, and the type of task used to operationalize phonological awareness and morphological awareness. These findings help us better understand the linguistic skills that are most important for reading acquisition in different writing systems.

Keywords: phonological awareness, morphological awareness, reading, meta-analysis

Phonology, orthography, and semantics are three of the major lexical constituents that contribute to reading development (e.g., Kamhi & Catts, 2012; Perfetti, Liu, & Tan, 2005). Connectionist models of reading (see e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989) have used these language parameters and proposed that word identification involves making connections between orthography and phonology, and between orthography and semantics. Nevertheless, different writing systems differ in the way they represent language in written form (whereas alphabetic systems such as English use a small set of letters to represent sounds, logographic systems such as Chinese use logograms to represent meaning) and in the statistical properties of the orthography-to-phonology and orthography-to-meaning mappings (e.g., Yang, Shu, McCandliss, & Zevin, 2013). This implies that the role of processing skills that represent phonology (e.g., phonological awareness [PA]) and semantics (e.g., morphological awareness [MA]) in reading may also differ across writing systems. Although a few studies have examined this hypothesis (Cho, Chiu, & McBride-Chang, 2011; McBride-

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Yufang Ruan, State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University; George K. Georgiou, Department of Educational Psychology, University of Alberta; Shuang Song, State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University; Yixun Li, Beijing Key Laboratory of Applied Experimental Psychology, School of Psychology, Beijing Normal University; Hua Shu, State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University.

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Correspondence concerning this article should be addressed to George K. Georgiou, Department of Educational Psychology, 6-102 Education North, University of Alberta, Edmonton-AB, Canada T6G2G5. E-mail: georgiou@ualberta.ca

Chang, Cho, et al., 2005, 2012), to date, no systematic reviews have been conducted. Thus, the purpose of this meta-analysis was to examine if the size of the relationship between PA (the ability to access and manipulate speech sounds in a language), MA (the awareness of morphemic structures of words and the ability to reflect on them), and reading differs between English and Chinese, two languages with distinct linguistic features.

English has been described as a morphophonemic language (Chomsky, 1970; Venezky, 1967). Because it uses an alphabetic script, to read a given word one would need to know how symbols (i.e., graphemes) relate to sounds (i.e., phonemes). However, in English, these grapheme-phoneme correspondences are highly inconsistent: a letter can be pronounced in different ways and a phoneme can be spelled in various ways. To resolve this problem, when two words are pronounced the same but have different meanings (e.g., *to*, *two*, *too*), spelling has evolved, where possible, to separate those meanings with different spellings. As stated by Venezky (1967) five decades ago, "the simple fact is that the present orthography [English] is not merely a letter-to-sound system riddled with imperfections, but instead, a more complex and more regular relationship wherein phoneme and morpheme share leading roles" (p. 77).

These features of English are in contrast to those of Chinese, which has been described as a morphosyllabic language that uses a logographic script (Hanley, 2005; Shu, 2003). The basic graphic unit in Chinese is the character, which corresponds to a monosyllabic morpheme. Characters are made up of a number of strokes that are packed into a square configuration and usually consist of two components: a phonetic radical that gives some clues to the character's pronunciation and a semantic radical that provides information about the meaning of the character. The Chinese characters map onto phonology at the syllabic level, with no parts in a character corresponding to phonological segments like phonemes. Although about 80% of modern Chinese are compound characters containing a phonetic radical, only one fourth of them can be read accurately using the phonetic radical (Chung & Leung, 2008; however, see Shu, Chen, Anderson, Wu, & Xuan, 2003, for a higher estimate).

Because the phonetic information in Chinese characters is encoded at the syllabic level, researchers have argued that the ability to dissect syllables into onsets and rimes should be a significant correlate of Chinese word reading, a hypothesis that has been confirmed in several previous studies (e.g., Ho & Bryant, 1997; McBride-Chang & Ho, 2000; Pan et al., 2011; Shu, Peng, & McBride-Chang, 2008; Zhang et al., 2013). An important role of syllabic awareness or onset/rime awareness in character recognition would also be expected given that Chinese children are introduced to a phonetic alphabet called *Pinyin* (in mainland China) or *Zhuyin Fuhao* (in Taiwan) that is used to assist them in learning new characters. However, Newman, Tardif, Huang, and Shu (2011) showed that phonemic awareness (operationalized with initial, middle, and final phoneme deletion tasks) also predicts Chinese reading, even after controlling for the effects of pinyin knowledge, vocabulary, and syllabic awareness. Taken together, these findings suggest that PA underlies successful reading acquisition in all languages, but the linguistic level that drives its relationship with reading may be the one with the greatest variability at the time of testing (see Siok & Fletcher, 2001, for a similar conclusion).

In contrast to the orthography-to-phonology mapping, the orthography-to-semantics mapping is more reliable in Chinese than in alphabetic orthographies. The semantic radical in Chinese characters provides useful cues to the meaning of a character (e.g., Hanley, 2005). However, because there are about 7,000 morphemes, but only 1,300 syllables in Mandarin Chinese (Chao, 1976), more than five morphemes share the same syllable (Packard, 2000). Hence, a reader must be able to distinguish between homophone characters that share the same syllable (e.g., /yi4/), but with different morphemes (e.g., 义 'meaning,' 易'easy,' 亿 'a hundred million,' 异 'difference,' 益 'benefit,' 艺 'art,' 议 'discuss'). This renders MA (often operationalized in Chinese with homophone awareness tasks) a crucial skill in learning to read Chinese (e.g., Kuo & Anderson, 2006; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Shu, McBride-Chang, Wu, & Liu, 2006; Tong et al., 2011).

Researchers have further argued that because Chinese is a morphosyllabic language, to read, an individual should map the character to a morpheme (Shu, 2003). This should also draw upon one's awareness of morphemes within a word. For example, the meaning of the compound word 大人/da4ren2/adult can be derived from its constituent morphemes, 大/da4/grown and 人/ren2/person. Furthermore, because about 70% of Chinese words are polymorphemic compounds made up of two or more morphemes (Institute of Language Teaching and Research of China, 1986), understanding how morphemes can be legally combined to form a word should play an important role in learning to read Chinese words. Awareness of compound word construction and production in Chinese is also important for vocabulary development, because it helps children to access the meaning of new words based on morphemes they are familiar with (e.g., McBride-Chang et al., 2011; McBride-Chang, Shu, Ng, Meng, & Penney, 2007; Tong, Tong, & McBride, 2017). Given that MA contributes to the learning of new vocabulary (this also applies to other languages and not just Chinese) and that vocabulary and word reading are independent predictors of reading comprehension (e.g., Kendeou, van den Broek, White, & Lynch, 2009; Li, Dronjic, Chen, Li, Cheng, & Wu, in press), we would expect MA to be a particularly strong correlate of reading comprehension. In addition, because MA involves the integration of semantic, phonological, and syntactic information, it mirrors many of the integrative processes involved in reading comprehension (e.g., Kuo & Anderson, 2006; Perfetti, Landi, & Oakhill, 2005). In line with this argument, Chik and colleagues (2012) have shown that MA and morphosyntactic awareness were significant predictors of reading comprehension, even after controlling for the effects of word reading.

There are three levels of MA in Chinese (Li, Anderson, Nagy, & Zhang, 2002; Liu & McBride-Chang, 2010; Shu et al., 2006). The first relates to homophone awareness that has been described above. The second relates to homograph awareness, which requires children to be aware that a single written character (e.g., 草) may represent different morphemes (grass or hasty). Different morphemes contribute to the word's meaning when they are in different compound words (e.g., grass in 草地 lawn or hasty in 草率 cursory). The third relates to the knowledge of the morphemic structure of compound words, which requires awareness of the contribution of the individual morpheme (e.g., 飞 fly and 机 machine) to the meaning of the whole word (e.g., 飞机, airplane). Although several studies have established that MA is a strong concurrent and longitudinal predictor of Chinese reading (e.g., Liu & McBride-Chang, 2010; McBride-Chang, Cho et al., 2005; Xue, Shu, Li, Li, & Tian, 2013; Yeung et al., 2011), it remains unknown if different levels of MA relate to Chinese reading the same way.

In addition, it remains unclear if the relationship between MA and reading changes over time. Based on phase theories of reading development (e.g., Ehri, 2005; Seymour, 2005) as well as on current practices of teaching reading (e.g., Grade 1–2 teachers in North America put heavy emphasis on phonics that relies on PA; Grade 1–2 teachers in mainland China use Pinyin to introduce new characters with little reference to morphemes), one would expect PA to be more important during the early phases of reading development and MA to be more important during the later phases of reading development.[1] Kuo and Anderson (2006) pointed out that "morphological awareness becomes an increasingly important predictor of measures of reading as children grow older" (p. 161).

Although the few cross-sectional studies in Chinese have confirmed the increasing role of MA in reading over time (e.g., Hu, 2013; Li et al., 2002; Wei et al., 2014; Xue et al., 2013), the few cross-sectional studies in English have either covered the early elementary grades (e.g., Deacon, 2012) or the upper elementary grades (e.g., Nagy, Berninger, & Abbott, 2006; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009), and have provided mixed findings. For example, whereas Nagy et al. (2006) found MA to be a stronger predictor of reading comprehension in older children, Roman et al. (2009) found no age differences when predicting word and nonword reading. Nevertheless, studies with young children in Chinese (e.g., Li, Shu, McBride-Chang, Liu, & Peng, 2012; McBride-Chang et al., 2003; Tong et al., 2011) and English (e.g., Carlisle, 1995; Kirby et al., 2012) have shown that MA is a unique predictor of word reading, even after controlling for the effects of PA. Thus, a meta-analysis is needed to examine if grade level influences the role of MA in reading.

Finally, we do not know if the relationship between MA and reading varies as a function of reading ability status. Despite the findings of studies in both English and Chinese showing that children with dyslexia or specific poor comprehension perform worse than chronological-age controls in different MA tasks (Shu et al., 2006; Siegel, 2008; Tong et al., 2011; Zhang, in press) to our knowledge, no studies have examined the role of reading ability status in the relationship between MA and reading. At the same time, the few studies that examined the role of reading ability status in the relationship between PA and reading have provided mixed findings. For example, McBride-Chang and Manis (1996) reported significantly lower correlations between PA and word reading in the group of poor readers than in the group of good readers, Katzir, Kim, Wolf, Kennedy, Lovett, and Morris (2006) reported no differences between groups, and Savage, Frederickson, Goodwin, Patni, Smith, and Tuersley (2005) reported stronger associations in the group of poor readers.

The Present Study

The purpose of this meta-analysis was to examine if the relationship between PA, MA, and reading (accuracy, fluency, and comprehension) differs between English and Chinese. If the role of PA or MA in reading depends on the linguistic properties of a language, we should observe a stronger relationship between PA and reading in English than in Chinese, and a stronger relationship between MA and reading in Chinese than in English.

The findings of this meta-analysis are expected to make two important contributions to the literature: First, although there are two meta-analyses examining the relationship between PA and reading in English (Scarborough, 1998; Swanson, Trainin, Necoechea, & Hammill, 2003),[2] none of them has examined the relationship between PA and reading fluency. Swanson et al. (2003) further showed that there were no significant differences in the correlations with word reading (r = .51) and reading comprehension (r = .49). Likewise, Song et al.'s (2016) meta-analysis in Chinese did not examine the association between PA and reading comprehension. No significant differences in the relationship of PA with reading accuracy (r = .36) and reading fluency (r = .39) were reported. Second, to our knowledge, this is the first meta-analysis of correlational studies examining the relationship of MA with reading in any language.[3] This is important in light of the increased use of MA tasks in research across languages. In their review paper, Nunes and Hatano (2004) suggested that despite the differences between writing systems, MA is important for reading acquisition across languages.

Method

Data Collection and Inclusionary Criteria

The data collection, coding, and inclusionary criteria are summarized in Figure 1. To select the studies for our meta-analysis, we first searched in computerized databases (ERIC, Medline, PsychAPA, PsychInfo, ProQuest, and Google Scholar) for studies published in English from January 1975 to July 2015 using the following descriptors: English, Chinese, China, Hong Kong, Taiwan paired with phon* awareness, phonological processing, MA, reading, and character recognition. Abstracts of peer-reviewed studies, dissertations, and book chapters were subsequently scrutinized. Similar to previous meta-analyses (see Song et al., 2016; Swanson et al., 2003), only studies including both PA and MA measures were considered. This was done to increase our control over possible confounding variables (e.g., age of participants, sampling procedures) associated with different studies and for practical reasons since there are hundreds of studies on PA in English alone.

[1] Had we adopted a different theoretical framework (e.g., overlapping waves; see also Treiman & Kessler, 2014, for integration of multiple patterns framework for spelling development), we should find no developmental differences in the relationship of phonological awareness and morphological awareness with reading. This is because children in kindergarten or Grade 1 have some morphological awareness (e.g., Grigorakis, 2014; Kirby et al., 2012; Li et al., 2012) and can use it together with phonological awareness in word recognition.

[2] Melby-Lervåg, Lyster, and Hulme (2012) also performed a meta-analysis on the relationship between phonemic awareness and word reading but included studies across several languages. The average correlation in their meta-analysis was .57 (95% CI: .54, .59).

[3] However, there are two meta-analyses on the role of morphological awareness instruction in reading ability (see Bowers, Kirby, & Deacon, 2010; Goodwin & Ahn, 2010). Reed (2008) and Carlisle, McBride-Chang, Nagy, and Nunes (2010) also reported significant effects of morphological awareness instruction (particularly for the less able and younger children) in their systematic reviews.

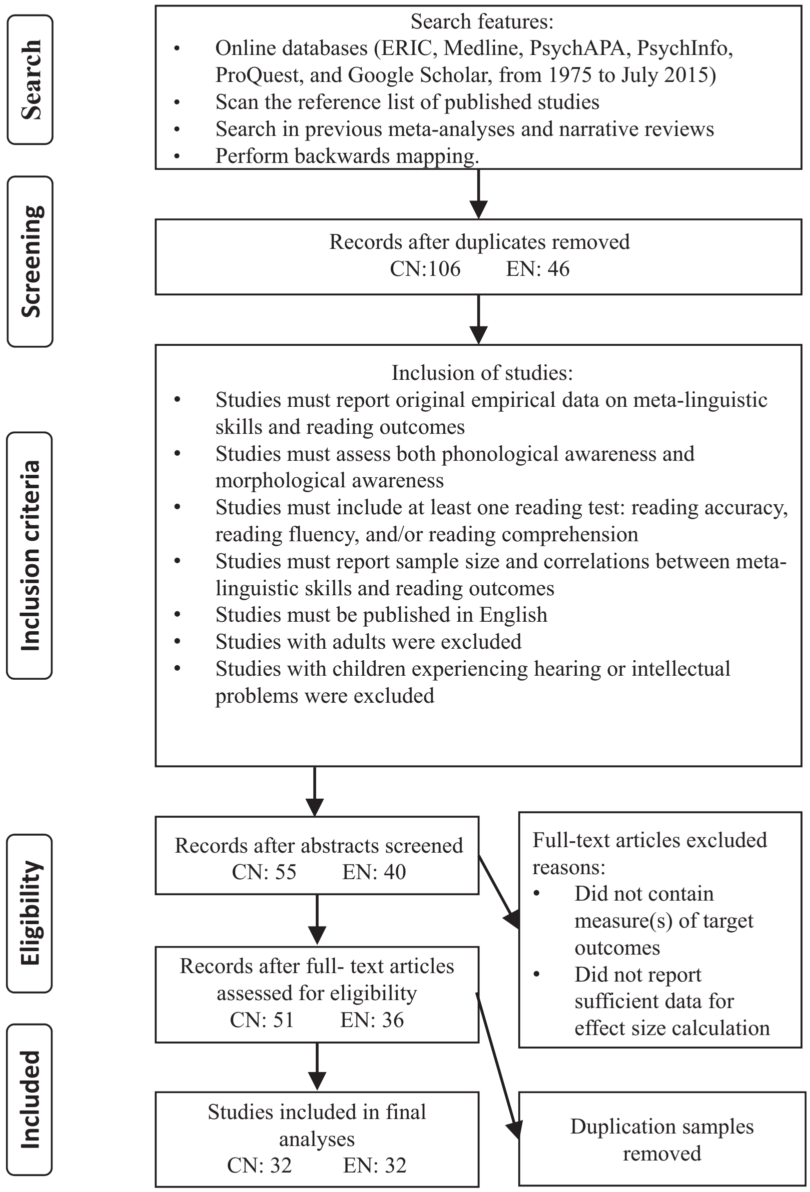

Figure 1. Flow diagram for the search and inclusion of studies. CN = Chinese; EN = English.

Pre-established criteria were used to evaluate the appropriateness of the measures used to assess reading, PA, and MA. Reading accuracy included measures requiring accurate word/character recognition without imposing any time limits. To be considered a measure of reading fluency, the task should require children to read as many words/characters or sentences as possible within a specified time limit. Text reading accuracy or speed was assessed in only two studies in English (no studies in Chinese) and was not considered further. Reading comprehension included measures requiring children to answer questions about a story they read as well as measures requiring children to either provide a missing word that completes the meaning of a sentence/short passage or select the right word among options. For PA, acceptable measures were considered those that involved manipulation of syllables or phonemes of real words/nonwords as in syllable/phoneme deletion/detection test, phoneme blending test, rhyme detection/production test, syllable counting test, and tone detection test (used only in Chinese). Finally, acceptable measures for MA were considered those that involved manipulation (identification, generation) of morphemes in real words or nonwords (found only in English) as in judgment of word relation tests, production of word form tests, and compound structure tests.

To avoid including data from the same study more than once, studies conducted by the same author were further scrutinized. In longitudinal studies, data from the first measurement of each processing skill were coded. In addition, although our studies included native speakers of Chinese and English, for three studies with bilingual children (one with English-Arabic, two with Chinese-English), we only coded data from the children's native language (L1) and ran the analyses with and without these three studies. Finally, for studies using multiple measures of PA or MA, a set of rules was further established to assist us in coding. For PA, phoneme deletion or tone detection tasks were coded before other types of PA measures because of their complexity as well as predictive value (e.g., Shu et al., 2008). An arithmetic mean of reported r values was coded for each sample when more than one test was used to operationalize a type of PA measure (see below for a description of the two types of PA measures). For MA, production tasks were coded before judgment tasks because they are generally more difficult and guessing rates are much lower in them (Deacon, Parrila, & Kirby, 2008; Kirby et al., 2012). Again, an arithmetic mean of reported r values was coded, when there were more than one tests used to operationalize a type of MA measure (see below for details).

Moderator Variables

For each study, we coded the following moderators: task type, grade level, and reading ability status. Studies that reported combined scores (e.g., correlations derived from a pooled sample of poor readers and controls) or had limited/no information on the measures they used that prohibited us from obtaining a clear picture of the group in which a certain task could be classified were excluded.

Task type. For PA, phoneme deletion, phoneme blending, phoneme segmentation, phoneme isolation, spoonerism, and tone detection tasks were coded as "complex" and the rest (e.g., syllable deletion/detection task, rhyme detection/production task, onset/rime awareness, and syllable counting) were coded as "simple" PA tasks. For MA, we used three types of classifications: First, we grouped the tasks into two categories, production and judgment. The analysis using this grouping was carried out in both Chinese and English. Second, we grouped the tasks into oral and written groups based on how the morphological tasks were presented to the children. However, because no studies in Chinese had used a written presentation of the MA tasks, this analysis was conducted only with the English studies. Finally, following previous categorizations of MA tasks in Chinese (e.g., Li et al., 2002; Liu & McBride-Chang, 2010; Shu et al., 2006; Tong et al., 2017), we grouped the Chinese tests into three categories: compounding (e.g., "when we see the sun rising in the morning, we call it "sunrise", what would we then call the moon rising in the evening?"); homophone (e.g., 时光 (shi2 guang1, time), 食品 (shi2 pin3, food), 识别 (shi2 bie2, recognize), and 石块 (shi2 kuai4, stone), select which one corresponds to the meaning of (shi 2 bie2, recognize), and homograph (e.g., 草地 (cao3di4, lawn), the children were asked using the target morpheme 草(cao3) to produce two more words, one sharing the same meaning with the target word and one having a different meaning from the target word).

Grade level. Grade level was coded to differentiate between reading development phases. Samples consisting of kindergarten children were coded as "preschooler;" Grade 1 and 2 were coded as "beginning;" Grade 3 and 4 were coded as "intermediate;" and Grade 5 and above (to high school) were coded as "advanced." Studies with adults were excluded from this meta-analysis.

Reading ability status. More than half of the studies in each language used unselected samples of children, which we coded here as "unselected." Control groups in comparison studies or samples clearly described as having no reading problems (or learning disabilities, educational difficulties, developmental disorders) were coded as "normal." Samples including children with dyslexia, poor readers, or at-risk children were coded as "poor." One study with participants experiencing speech disorders and one study with participants who were identified as having a specific language impairment were excluded.

Coder Reliability

All studies were coded twice by the first and the fourth author who received specialized training in meta-analysis. Interrater reliability was calculated for the whole sample of studies. The interrater correlation (Pearson's) for the r values (the correlation between PA tasks or MA tasks and reading) was .998 ($p < .001$, agreement rate $= 99.3\%$, $N = 611$). The interrater correlation for the sample size was .999 ($p < .001$, agreement rate $= 91.1\%$, $N = 89$). Finally, Cohen's kappa for categorical moderator variables (task type, grade level, and reading level) was .903 ($p < .001$, agreement rate $= 93.6\%$, $N = 421$). Any discrepancies in the ratings were resolved by revisiting the articles and after discussing the coding with the corresponding author.

Meta-Analytic Procedures

The analyses were conducted with the Comprehensive Meta-Analysis program (CMA, Borenstein, Hedges, Higgins, & Rothstein, 2005). The correlations between our predictor variables (PA and MA) and the reading outcomes (reading accuracy, reading fluency, and reading comprehension), as well as information pertinent to task type, grade level, and reading status were coded.

The effect sizes for the studies were displayed by the Pearson's r correlation coefficient. A 95% confidence interval (CI) was calculated for each effect size to examine whether the correlation was significantly different from zero. The overall correlation was estimated by calculating a weighted average of the correlations from each study. We used a random-effects model, which rests on the assumption that variation between studies can be systematic and not only due to random error. A sensitivity analysis was also conducted to examine the impact on the overall range of correlations, when studies were removed. Studies were removed one at-a-time to calculate a new overall correlation and the range of this new overall correlation was checked again to make sure the overall correlation was stable (Borenstein et al., 2005). To further examine if the variation in the effect sizes between studies was significant, we performed the Q test of homogeneity (Hedges & Olkin, 2014). A significant value on this test indicates a reliable variability between the correlations in the sample of studies. I^2 was used to determine the magnitude of heterogeneity. I^2 is the proportion of total variation between the effect sizes that is caused by real heterogeneity rather than chance.

For the categorical moderator variables (task type, grade level, and reading ability status), the studies were separated in subsets based on the categories of the moderator variable. The analysis was not conducted when there were fewer than three studies in a category. The degree of differences between the subsets of studies was tested with a Q test and by comparing the correlation magnitude with CIs between the study subsets. Similar to an analysis of variance F test, a Q test would be significant when between-groups difference is statistically larger than within-group difference.

A funnel plot for random-effects models was used to determine the presence of retrieval bias. In the funnel plot, sample size is plotted on the *y*-axis and effect size on the *x*-axis. In the absence of retrieval bias, this plot should be expected to form an inverted funnel. In the presence of bias, the funnel will be asymmetric. To detect retrieval bias, funnel plots are examined for all analyses presented. The trim and fill for random-effects models (Duval & Tweedie, 2000) was used to examine the impact from possible missing studies. The trim-and-fill method imputes values in the funnel plot to make it symmetrical and calculate an estimated overall effect size on this basis.

Results

The literature search and screening process resulted in 64 studies: 32 studies in Chinese and 32 studies in English (see Appendix A, for a list of the studies). Three hundred and 81 separate effect sizes were reported, based on 85 independent samples. In total, 11,138 subjects participated in these studies. The mean age of the participants in Chinese (based on 43 samples that reported the exact age of the participants) was 92.80 months (SD = 23.24 months, range = 52.00–145.72). In turn, the mean age of the participants in English (based on 33 samples that reported the exact age of the participants) was 95.42 months (SD = 19.28 months, range = 57.00–138.30).

Before calculating the average effect size of the correlations between PA, MA, and three reading outcomes, we calculated the correlation between PA and MA, separately for each language. In Chinese, 29 studies and 36 effect sizes described the relationship between PA and MA. The weighted mean correlation was moderate and significant, r = .34 (95% CI: .28, .40), z (35) = 10.62, p < .001. In turn, 30 studies and 36 effect sizes described the relationship between PA and MA in English. The weighted mean correlation was moderate and significant, r = .43 (95% CI: .36, .49), z (35) = 10.98, p < .001. The difference across languages was not significant, Q (1) = 3.47, p = .062. Because PA correlated significantly with MA in each language, we calculated both the mean effect size of zero-order correlations (see Tables 1–3) as well as the mean effect size of partial correlations (after controlling for each other's effect; see Appendix B).

Mean Effect Size Analyses for Reading Accuracy

PA. Forty-one effect sizes, comprising 5,437 subjects (M sample size = 132.61; SD = 107.95; range = 34–496), described the relationship between PA and reading accuracy in Chinese. The weighted mean correlation was moderate and significant, r = .30 (95% CI: .27, .34), z (40) = 16.92, p < .001 (see Table 1). The variation in the effect sizes between studies was significant, Q (40) = 63.76, p = .010 and I^2 = 37.27%. A sensitivity analysis showed that the overall effect size ranged from .30 (95% CI: .26, .33) to .31 (95% CI: .28, .34). The funnel plot indicated that no studies were missing on either side of the mean. In turn, 41 effect sizes, comprising 5,286 subjects (M sample size = 128.93; SD = 190.06; range = 26–1238), described the relationship between PA and reading accuracy in English. The weighted mean correlation was large and significant, r = .55 (95% CI: .50, .59), z (40) = 17.75, p < .001 (see Table 1). The variation in the effect sizes between studies was significant, Q (40) = 209.40, p < .001 and I^2 = 80.90%. A sensitivity analysis showed that the overall effect size ranged from .54 (95% CI: .49, .58) to .55 (95% CI: .51, .60). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis (Duval & Tweedie, 2000), six studies were imputed and the adjusted overall mean was .58 (95% CI: .53, .62). A comparison of the correlation coefficients in Chinese and English (see Table 4, top half) revealed that PA had a stronger effect on reading accuracy in English than in Chinese, Q (1) = 58.58, p < .001. The difference between languages remained significant, even when partial correlations were considered, Q(1) = 40.23, p < .001 (see Appendix B, top half).

MA. Forty-one effect sizes, comprising 5,437 subjects (M sample size = 132.61; SD = 107.94; range = 35–496), described the relationship between MA and reading accuracy in Chinese. The weighted mean correlation was moderate and significant, r = .39 (95% CI: .36, .43), z (40) = 19.54, p < .001 (see Table 1). The variation in the effect sizes between studies was significant, Q (40) = 84.18, p < .001 and I^2 = 52.49%. A sensitivity analysis showed the overall effect size ranged from .37 (95% CI: .34, .39) to .38 (95% CI: .36, .41). The funnel plot indicated that no studies were missing on either side of the mean. In turn, 41 effect sizes, comprising 5,286 subjects (M sample size = 128.93; SD = 190.06; range = 26–1238), described the relationship between MA and reading accuracy in English. The weighted mean correlation was moderate and significant, r = .46 (95% CI: .40 to .51), z (40) = 14.06, p < .001 (see Table 1). The variation in the effect sizes between studies was significant, Q (40) = 223.81, p < .001 and I^2 = 82.13%. A sensitivity analysis showed that the overall effect size ranged from .45 (95% CI: .40, .50) to .47 (95% CI: .42, .52). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis, two studies were imputed and the adjusted overall mean was .48 (95% CI: .43, .53). A comparison of the effects of MA on reading accuracy across the two languages (see Table 4, top half) indicated that MA had a stronger effect on reading accuracy in English than in Chinese, Q (1) = 4.13, p = .042. However, the difference failed to reach significance when partial correlations were considered, Q (1) = 1.38, p = .239 (see Appendix B, top half).

Mean Effect Size Analyses for Reading Fluency

PA. Six effect sizes, comprising 803 subjects (M sample size = 133.83; SD = 74.69; range = 34–261), described the relationship between PA and reading fluency in Chinese. The weighted mean correlation was small and significant, r = .26 (95% CI: .18, .34), z (5) = 6.00, p < .001 (see Table 2). The variation in the effect sizes between studies was not significant, Q (5) = 7.30, p = .200, and I^2 = 31.46%. A sensitivity analysis showed that the overall effect size ranged from .24 (95% CI: .14, .34) to .30 (95% CI: .23, .37). The funnel plot indicated that studies were missing on the left side of the mean. In the trim-and-fill analysis, a study was imputed and the adjusted overall mean was .26 (95% CI: .18, .33). In turn, 11 effect sizes, comprising 2,462 subjects (M sample size = 223.82; SD = 341.08; range = 43–1238), described the relationship between PA and reading fluency in English. The weighted mean correlation was large and significant, r = .51 (95% CI: .44, .58), z (10) = 11.51, p < .001 (see Table 2). The variation in the effect sizes between studies was significant, Q (10) = 40.50, p < .001

Table 1
Number of Effect Sizes, Effect Size With 95% Confidence Interval, Heterogeneity Statistics, and Moderator Analysis of the Relationship Between Phonological Awareness, Morphological Awareness, and Reading Accuracy in Chinese and English

Moderator variables	n	k	Effect size r	95% CI	z	I^2 (%)	$Q_{between}$
Phonological awareness							58.579***
Chinese	31	41	.302	[.269, .335]	16.915***	37.267*	
Reading status							3.713
Normal		1	.460	[.263, .620]	4.278***	—	
Poor		5	.357	[.240, .463]	5.721***	33.493	
Unselected		35	.293	[.258, .327]	15.820***	36.073*	
Grade level							5.278
Advanced		3	.372	[.285, .454]	7.804***	17.055	
Intermediate		6	.320	[.259, .378]	9.810***	<.001	
Beginning		9	.263	[.211, .314]	9.523***	<.001	
Preschool		18	.317	[.252, .379]	9.124***	56.049**	
Task type							1.953
Complex		21	.256	[.204, .306]	9.398***	28.303	
Simple		31	.307	[.255, .358]	11.008***	61.883***	
English	31	41	.545	[.495, .590]	17.752***	80.898***	
Reading status							1.422
Normal		7	.492	[.407, .568]	9.909***	19.506	
Poor		5	.524	[.378, .645]	6.197***	80.518***	
Unselected		23	.555	[.486, .617]	12.897***	81.036***	
Grade level							2.667
Advanced		6	.495	[.393, .585]	8.355***	78.145***	
Intermediate		8	.470	[.337, .585]	6.278***	63.316***	
Beginning		15	.541	[.455, .617]	10.317***	78.429***	
Preschool		3	.575	[.489, .650]	10.696***	<.001	
Task type							8.576**
Complex		18	.572	[.506, .632]	13.629***	75.509***	
Simple		15	.424	[.343, .498]	9.359***	59.868**	
Morphological awareness							4.138*
Chinese	31	41	.393	[.357, .427]	19.540***	52.485***	
Reading status							8.975*
Normal		1	.640	[.486, .756]	6.522***	—	
Poor		5	.402	[.312, .485]	8.084***	<.001	
Unselected		35	.384	[.346, .420]	18.324***	51.888***	
Grade level							.715
Advanced		3	.436	[.176, .640]	3.163**	87.194***	
Intermediate		6	.413	[.318, .500]	7.826***	54.802	
Beginning		9	.370	[.288, .447]	8.277***	56.487*	
Preschool		18	.379	[.331, .425]	14.210***	28.703	
Task Type I							7.663**
Production		40	.388	[.351, .424]	18.731***	52.938***	
Judgment		19	.288	[.225, .349]	8.565***	63.163***	
Task Type III							4.937
Compounding		35	.376	[.336, .414]	17.164***	43.808**	
Homophone		10	.333	[.217, .439]	5.423***	81.179***	
Homograph		11	.307	[.259, .354]	11.916***	26.867	
English	31	41	.461	[.405, .514]	14.063***	82.128***	
Reading status							1.890
Normal		7	.371	[.211, .511]	4.357***	69.595**	
Poor		5	.467	[.219, .659]	3.501***	91.894***	
Unselected		23	.486	[.405, .559]	10.350***	83.122***	
Grade level							6.269
Advanced		6	.526	[.437, .605]	9.865***	73.393**	
Intermediate		8	.354	[.241, .457]	5.858***	42.859	
Beginning		15	.427	[.323, .520]	7.384***	80.557***	
Preschool		3	.440	[.338, .531]	7.711***	<.001	
Task Type I							5.993*
Production		34	.451	[.387, .511]	12.269***	77.371***	
Judgment		20	.346	[.288, .401]	11.064***	65.968***	
Task Type II							.411
Oral		33	.417	[.350, .481]	11.003***	79.536***	
Written		9	.447	[.383, .506]	12.296***	61.400**	

Note. n = number of studies; k = number of effect sizes; CI = confidence interval; I^2 = the proportion of total variation between the effect size caused by real heterogeneity rather than chance (when <.001 it means that almost all of the observed variance is spurious or there is nothing to explain); $Q_{between}$ = between-groups homogeneity of variance.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 2
Number of Effect Sizes, Effect Size With 95% Confidence Interval, Heterogeneity Statistics, and Moderator Analysis of the Relationship Between Phonological Awareness, Morphological Awareness, and Reading Fluency in Chinese and English

Moderator variables	n	k	Effect size r	95% CI	z	I^2 (%)	$Q_{between}$
Phonological awareness							19.511***
Chinese	4	6	.263	[.179, .343]	6.004***	31.457	
Reading status							1.938
Normal		3	.209	[.069, .340]	2.917**	53.362	
Unselected		3	.324	[.231, .411]	6.539***	<.001	
Grade level							1.524
Intermediate		2	.188	[−.044, .401]	1.589	74.524*	
Beginning		1	.250	[.085, .402]	2.934**	–	
Preschool		2	.323	[.226, .414]	6.248***	<.001	
Task type							.248
Complex		5	.232	[.121, .337]	4.050***	30.736	
Simple		6	.266	[.187, .342]	6.377***	32.326	
English	8	11	.509	[.435, .577]	11.512***	75.306***	
Reading status							21.164***
Normal		1	.290	[.079, .476]	2.670**	—	
Poor		3	.373	[.235, .496]	5.043***	45.841	
Unselected		5	.602	[.554, .646]	18.917***	<.001	
Grade level							2.514
Advanced		3	.564	[.437, .668]	7.377***	86.675**	
Intermediate		1	.413	[.233, .566]	4.262***	—	
Beginning		2	.409	[.043, .678]	2.178*	87.084**	
Task type							4.371*
Complex		4	.619	[.570, .663]	18.659***	<.001	
Simple		2	.483	[.344, .601]	6.137***	<.001	
Morphological awareness							.041
Chinese	4	6	.385	[.257, .500]	5.545***	73.556**	
Reading status							1.198
Normal		3	.318	[.139, .478]	3.396**	73.855*	
Unselected		3	.476	[.236, .661]	3.665***	80.623**	
Grade level							2.796
Intermediate		2	.249	[.048, .431]	2.411*	67.134	
Beginning		1	.448	[.302, .574]	5.544***	–	
Preschool		2	.378	[.173, .551]	3.495***	71.341	
Task Type I							.144
Production		12	.350	[.264, .430]	7.567***	71.944***	
Judgment		2	.297	[.019, .533]	2.089*	82.562*	
Task Type III							1.248
Compounding		7	.341	[.226, .446]	5.556***	73.956**	
Homophone		3	.265	[.058, .451]	2.491*	79.327**	
Homograph		4	.398	[.260, .520]	5.309***	67.469*	
English	8	11	.368	[.248, .476]	5.712***	87.650***	
Reading status							9.103*
Normal		1	.030	[−.187, .244]	.268	–	
Poor		3	.286	[−.010, .536]	1.893	86.440**	
Unselected		5	.459	[.279, .608]	4.648***	86.995***	
Grade level							39.065***
Advanced		3	.541	[.462, .612]	11.230***	66.014	
Intermediate		1	.191	[−.009, .376]	1.877	—	
Beginning		2	.074	[−.066, .211]	1.031	<.001	
Task Type I							.909
Production		2	.131	[−.042, .296]	1.484	23.008	
Judgment		10	.243	[.083, .390]	2.955**	88.184***	
Task Type II							3.056
Oral		4	.270	[−.010, .510]	1.890	80.695**	
Written		1	.491	[.447, .532]	18.862***	—	

Note. n = number of studies; k = number of effect sizes; CI = confidence interval; I^2 = the proportion of total variation between the effect size caused by real heterogeneity rather than chance (when <.001 it means that almost all of the observed variance is spurious or there is nothing to explain); $Q_{between}$ = between-groups homogeneity of variance.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3
Number of Effect Sizes, Effect Size With 95% Confidence Interval, Heterogeneity Statistics, and Moderator Analysis of the Relationship Between Phonological Awareness, Morphological Awareness, and Reading Comprehension

Moderator variables	n	k	Effect size r	Effect size 95% CI	Effect size z	I^2 (%)	$Q_{between}$
Phonological awareness							12.300***
Chinese	5	8	.225	[.160, .287]	6.704***	10.151	
Reading status							2.557
Normal		4	.275	[.168, .375]	4.932***	35.196	
Poor		1	.240	[.014, .443]	2.077*	–	
Unselected		3	.163	[.071, .253]	3.439**	<.001	
Grade level							1.349
Advanced		2	.318	[.164, .457]	3.945***	1.775	
Intermediate		3	.213	[.108, .314]	3.914***	9.602	
Beginning		2	.220	[.059, .370]	2.669**	61.461	
Task type							1.278
Complex		6	.258	[.180, .332]	6.338***	5.132	
Simple		6	.179	[.062, .290]	2.997**	62.531*	
English	15	20	.437	[.338, .526]	7.891***	89.569***	
Reading status							.699
Normal		2	.439	[.008, .733]	1.993*	87.407**	
Poor		3	.513	[.362, .638]	5.926***	64.281	
Unselected		11	.433	[.298, .552]	5.799***	86.942***	
Grade level							2.857
Advanced		5	.380	[.230, .513]	4.724***	86.993***	
Intermediate		5	.324	[.070, .539]	2.474*	79.816**	
Beginning		5	.555	[.356, .705]	4.851***	86.056***	
Task type							5.099*
Complex		8	.466	[.328, .585]	5.999***	87.790***	
Simple		4	.248	[.109, .377]	3.452**	<.001	
Morphological awareness							10.337**
Chinese	5	8	.360	[.304, .413]	11.835***	<.001	
Reading status							2.438
Normal		4	.380	[.301, .454]	8.760***	<.001	
Poor		1	.200	[−.028, .408]	1.720	—	
Unselected		3	.362	[.278, .441]	7.925***	<.001	
Grade level							.530
Advanced		2	.360	[.037, .615]	2.173*	77.186*	
Intermediate		3	.337	[.243, .425]	6.680***	<.001	
Beginning		2	.382	[.298, .461]	8.245***	<.001	
Task Type I							1.604
Production		13	.351	[.299, .402]	12.183***	26.189	
Judgment		5	.262	[.128, .388]	3.759***	56.600	
Task Type III							.064
Compounding		5	.324	[.248, .396]	7.924***	<.001	
Homophone		7	.333	[.253, .408]	7.757***	39.212	
Homograph	15	5	.343	[.198, .473]	4.475***	70.663**	
English		20	.534	[.444, .613]	9.893***	89.849***	
Reading status							.855
Normal		2	.432	[.142, .654]	2.841**	73.414	
Poor		3	.587	[.205, .814]	2.834**	94.197***	
Unselected		11	.552	[.420, .661]	7.039***	89.364***	
Grade level							3.231
Advanced		5	.536	[.418, .637]	7.639***	84.694***	
Intermediate		5	.386	[.250, .508]	5.264***	38.331	
Beginning		5	.522	[.266, .709]	3.707***	90.578***	
Task Type I							.365
Production		11	.490	[.334, .620]	5.563***	88.451***	
Judgment		14	.443	[.415, .471]	27.154***	2.395	
Task Type II							1.055
Oral		7	.530	[.358, .668]	5.362***	91.048***	
Written		8	.443	[.411, .474]	23.772***	4.465	

Note. n = number of studies; k = number of effect sizes; CI = confidence interval; I^2 = the proportion of total variation between the effect size caused by real heterogeneity rather than chance (when <.001 it means that almost all of the observed variance is spurious or there is nothing to explain); $Q_{between}$ = between-groups homogeneity of variance.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4
Language Comparisons Within Phonological Awareness and Morphological Awareness and Meta-Linguistic Awareness Comparisons Within English and Chinese

Awareness	*r*-values CH	EN	PA	MA	*r*-values defferences	$Q_{between}$	*p*
Phonological awareness							
Reading accuracy	.302	.545			EN > CH	58.579	<.001
Reading fluency	.263	.509			EN > CH	19.511	<.001
Reading Comprehension	.225	.437			EN > CH	12.300	<.001
Morphological awareness							
Reading accuracy	.393	.461			EN > CH	4.138	.042
Reading fluency	.385	.368			n.s.	.041	.840
Reading Comprehension	.360	.534			EN > CH	10.337	.001
Chinese							
Reading accuracy			.302	.393	PA < MA	13.396	<.001
Reading fluency			.263	.385	n.s.	2.533	.111
Reading Comprehension			.225	.360	PA < MA	10.059	.002
English							
Reading accuracy			.545	.461	PA > MA	5.107	.024
Reading fluency			.509	.368	PA > MA	4.478	.034
Reading Comprehension			.437	.534	n.s.	2.238	.135

Note. CH = Chinese; EN = English; PA = phonological awareness; MA = morphological awareness.

and I^2 = 75.31%. A sensitivity analysis showed that the overall effect size ranged from .49 (95% CI: .42, .56) to .53 (95% CI: .46, .59). The funnel plot indicated that no studies were missing on either side of the mean. A comparison of the correlation coefficients across the two languages (see Table 4, top half) revealed that PA had a stronger effect on reading fluency in English than in Chinese, Q (1) = 19.51, p < .001. A similar finding was obtained with partial correlations, Q (1) = 22.74, p < .001 (see Appendix B, top half).

MA. Six effect sizes, comprising 803 subjects (*M* sample size = 133.83; *SD* = 74.53; range = 35–261), described the relationship between MA and reading fluency in Chinese. The weighted mean correlation was moderate and significant, r = .39 (95% CI: .26, .50), z (5) = 5.55, p < .001 (see Table 2). The variation in the effect sizes between studies was significant, Q (5) = 18.91, p = .002 and I^2 = 73.56%. A sensitivity analysis showed that the overall effect size ranged from .34 (95% CI: .23, .44) to .43 (95% CI: .30, .53). The funnel plot indicated that studies were missing on the left side of the mean. In the trim-and-fill analysis, a study was imputed and the adjusted overall mean was .34 (95% CI: .20, .47). In turn, 11 effect sizes, comprising 2,462 subjects (*M* sample size = 223.82; *SD* = 341.08; range = 43–1238), described the relationship between MA and reading fluency in English. The weighted mean correlation was moderate and significant, r = .37 (95% CI: .25, .48), z (10) = 5.71, p < .001 (see Table 2). The variation in the effect sizes between studies was significant, Q (10) = 80.97, p < .001 and I^2 = 87.65%. A sensitivity analysis showed that the overall effect size ranged from .34 (95% CI: .21, .45) to .40 (95% CI: .28, .50). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis, two studies were imputed and the adjusted overall mean was .43 (95% CI: .32, .53). A comparison of the effects of MA on reading fluency across the two languages (see Table 4, top half) indicated no significant differences, Q (1) = 0.04, p = .840. A similar finding was obtained with partial correlations, Q (1) = 0.30, p = .583 (see Appendix B, top half).

Mean Effect Size Analyses for Reading Comprehension

PA. Eight effect sizes, comprising 1,013 subjects (*M* sample size = 126.63; *SD* = 73.07; range = 64–290), described the relationship between PA and reading comprehension in Chinese. The weighted mean correlation was small and significant r = .23 (95% CI: .16, .29), z (7) = 6.70, p < .001 (see Table 3). The variation in the effect sizes between studies was not significant, Q (7) = 7.80, p = .351 and I^2 = 10.15%. A sensitivity analysis showed that the overall effect size was in the range of .21 (95% CI: .14, .27) to .25 (95% CI: .18, .32). The funnel plot indicated that studies were missing on the left side of the mean. In the trim-and-fill analysis, a study was imputed and the adjusted overall mean was .21 (95% CI: .14, .28). In turn, 20 effect sizes, comprising 3,419 subjects (*M* sample size = 170.95; *SD* = 262.90; range = 26–1238), described the relationship between PA and reading comprehension in English. The weighted mean correlation was moderate and significant, r = .44 (95% CI: .34, .53), z (19) = 7.89, p < .001 (see Table 3). The variation in the effect sizes between studies was significant, Q (19) = 182.14, p < .001 and I^2 = 89.57%. A sensitivity analysis showed that the overall effect size ranged from .42 (95% CI: .32, .51) to .45 (95% CI: .35, .54). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis, three studies were imputed and the adjusted overall mean was .48 (95% CI: .39, .56). A comparison of the correlation coefficients across the two languages (see Table 4, top half) revealed that PA had a stronger effect on reading comprehension in English than in Chinese, Q (1) = 12.30, p < .001) However, the difference failed to reach significance with partial correlations, Q (1) = 2.17, p = .140 (see Appendix B, top half).

MA. Eight effect sizes, comprising 1,013 subjects (*M* sample size = 126.63; *SD* = 73.07; range = 64–290), described the relationship between MA and reading comprehension in Chinese. The weighted mean correlation was moderate and significant, r =

.36 (95% CI: .30, .41), z (7) = 11.84, $p < .001$ (see Table 3). The variation in the effect sizes between studies was not significant, Q (7) = 5.59, p = .588 and $I^2 < .001\%$. A sensitivity analysis showed that the overall effect size ranged from .35 (95% CI: .28, .41) to .37 (95% CI: .31, .43). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis, two studies were imputed and the adjusted overall mean was .38 (95% CI: .33, .43). In turn, 20 effect sizes, comprising 3,419 subjects (M sample size = 170.95; SD = 262.90; range = 26–1238), described the relationship between MA and reading comprehension in English. The weighted mean correlation was large and significant, r = .53 (95% CI: .44, .61), z (19) = 9.89, $p < .001$ (see Table 3). The variation in the effect sizes between studies was significant, Q (19) = 187.17, $p < .001$ and I^2 = 89.85%. A sensitivity analysis showed that the overall effect size ranged from .51 (95% CI: .42, .59) to .55 (95% CI: .47, .63). The funnel plot indicated that studies were missing on the right side of the mean. In the trim-and-fill analysis, two studies were imputed, and the adjusted overall mean was .57 (95% CI: .48, .64). A comparison of the correlation coefficients across the two languages (see Table 4, top half) revealed that MA had a stronger effect on reading comprehension in English than in Chinese, Q (1) = 10.34, p = .001. However, the difference failed to reach significance with partial correlations, Q (1) = 2.18, p = .139 (see Appendix B, top half).

Comparing the Effects of PA and MA Across Reading Outcomes Within Each Language

To examine whether PA correlated more strongly with reading accuracy, fluency, and comprehension than MA (or vice versa), we performed a Q-test, separately for each language (see Table 4, bottom half). In Chinese, MA correlated more strongly with reading accuracy, Q (1) = 13.40, $p < .001$, and reading comprehension, Q (1) = 10.06, p = .002, than PA. No significant difference was observed for reading fluency, Q (1) = 2.53, p = .11). Similar findings were obtained with partial correlations (see Appendix B, bottom half). In contrast, in English, PA correlated more strongly with reading accuracy, Q (1) = 5.11, p = .024, and reading fluency, Q (1) = 4.48, p = .034, than MA. No significant difference was observed for reading comprehension, Q (1) = 2.24, p = .135. When we repeated the analyses with partial correlations, MA correlated more strongly with reading comprehension in English than PA, Q (1) = 6.01, p = .014 (see Appendix B, bottom half).

Moderator Analyses

The results of the moderator analyses are shown in Tables 1, 2, and 3.

Task type. For PA, only the difference in the relationship of simple and complex PA tasks with reading in English was significant. Complex PA tasks correlated more strongly with reading accuracy, Q (1) = 8.58, p = .003, reading fluency, Q (1) = 4.37, p = .037, and reading comprehension, Q (1) = 5.10, p = .024, than simple PA tasks. For MA, the only significant difference was found when comparing production and judgment tasks. The production tasks correlated more strongly with reading accuracy than the judgment tasks in both Chinese, Q (1) = 7.66, p = .006, and English, Q (1) = 5.99, p = .014.

Grade level. A significant difference was observed only in the relationship between MA and reading fluency in English, Q (2) = 39.07, $p < .001$. The correlation was significant among advanced readers (r = .54), but not among beginning (r = .07) or intermediate (r = .19) readers.

Reading ability status. In English, statistically significant differences between groups of readers were observed when reading fluency was the reading outcome, in the correlations with both PA, Q (2) = 21.16, $p < .001$, and MA, Q (2) = 9.10, p = .011. Studies with unselected samples produced the strongest correlations (PA: r = .60; MA: r = .46), followed by studies with poor readers (PA: r = .37; MA: r = .29), and finally by studies with normal readers (PA: r = .29; MA: r = .03). In Chinese, a significant difference was found in the relationship between MA and reading accuracy, Q (2) = 8.98, p = .011, with the strongest correlations obtained in studies with normal readers (r = .64), followed by studies with poor readers (r = .40), and finally by studies with unselected samples of readers (r = .38).

Discussion

The primary goal of this meta-analysis was to examine if the size of the relationship of PA and MA with different reading outcomes varies between English and Chinese. Given the linguistic features of each language, we hypothesized that a stronger relationship between PA and reading would be observed in English than in Chinese, and a stronger relationship between MA and reading would be observed in Chinese than in English. In line with our expectation and with the findings of previous studies (e.g., McBride-Chang, Bialystok, Chong, & Li, 2004; McBride-Chang, Cho et al., 2005, 2013; Tong & McBride-Chang, 2010), PA was more strongly related to all reading outcomes in English than in Chinese (however, the difference in reading comprehension disappeared when partial correlations were considered). This reinforces the argument put forward by several researchers that PA is fundamental to word reading in English (e.g., Bowey, 2005; Scarborough, 1998). In contrast, the low percentage of characters with a regular phonetic radical in Chinese (i.e., 23–26% when the tone is taken into account; Chung & Leung, 2008), renders the use of the phonetic radical to character reading inefficient, thus possibly downgrading the importance of PA in Chinese.

However, PA still produced significant correlations with reading in Chinese (the average correlations with reading accuracy and fluency are similar to those reported in Song et al.'s meta-analysis). A significant correlation would be expected based on the fact that 80% of Chinese characters contain a phonetic radical that provides some clues to character's pronunciation. Perhaps the percentage of these characters whose pronunciation is consistent with the phonetic radical (23–26%; Chung & Leung, 2008), albeit relatively low, is sufficient enough to produce a significant correlation. This is in line with the findings of some studies showing that the knowledge of phonetic radicals assists Chinese children in learning to read (e.g., Ho & Bryant, 1997; Wu, Zhou, & Shu, 1999).

A significant correlation would also be expected if we take into account how Chinese children in mainland China and Taiwan learn to read. Specifically, in mainland China, children are introduced to a phonetic alphabet called Pinyin to assist them in learning new characters. The Pinyin system borrows English letters to represent individual phonemes. In turn, in Taiwan, children are presented with a phonetic alphabet called Zhuyin Fuhao. Zhuyin Fuhao roughly transcribes spoken sounds at the onset-rime level and is printed alongside the new characters in the children's textbooks. Although children in Hong Kong are not exposed to a phonetic alphabet, they learn English from a very young age (at least those from relatively affluent families). Thus, exposure to and practice with PA tasks happens indirectly through learning to read English words.

Notice also that the correlations between PA and Chinese reading remained significant (albeit weak), after partialing out the effects of MA (see Appendix B). This suggests that PA plays an independent role in learning to read Chinese that is not completely overlapping with that of MA. This is important because the nonsignificant effects of PA on Chinese reading in previous studies (e.g., McBride-Chang, Cho et al., 2005; Yeung et al., 2011) were attributed to the inclusion of MA in the same models.

In contrast to our expectation, MA correlated more strongly with reading accuracy and comprehension in English than in Chinese (although none of these differences remained significant in the analyses with partial correlations). In addition, with one exception (the relationship of MA with reading fluency in English, which was stronger among advanced readers than among beginning or intermediate readers), grade level did not moderate the relationship between MA and reading. Taken together, these findings suggest that MA is equally important for reading in English (or even more important than Chinese when zero-order correlations are taken into account) and that the relationships can be found even among young children. This is in line with Nunes and Hatano's (2004) conclusion that irrespective of differences between writing systems, MA is important for learning to read.

However, in Chinese, MA correlated more strongly with reading accuracy and comprehension than PA. This can be attributed to the richness of homophones in Chinese (Kuo & Anderson, 2006). It has been estimated that a spoken Mandarin syllable represents an average of five morphemes (Packard, 2000), whereas a spoken Cantonese syllable represents an average of three morphemes (Chow et al., 2008). Given the one-to-many relationship between a syllable and a morpheme in Mandarin and Cantonese, it is not always reliable to distinguish words with the same pronunciation by simply relying on PA. In addition, because the way morphemes are combined to form words in Chinese tends to be regular and informative (i.e., the meaning of most Chinese compound words is predictable from the meaning of their constituent morphemes), Chinese children rely on their MA skills to recognize words (e.g., Li et al., 2002; Liu & McBride-Chang, 2010; McBride-Chang, Cho et al., 2005; Shu et al., 2006; Tong et al., 2011; Wei et al., 2014). In contrast, in English, PA correlated more strongly with reading accuracy and fluency than did MA. This suggests that although English-speaking children may pay attention to the internal structure of words, they rely more heavily on PA to decode words and to read fluently. An alternative explanation may relate to the nature of the reading tasks.[4] Specifically, because most word reading tasks involve reading words in isolation, without meaningful context, this may have inflated the role of PA in word reading. In addition, in many English word reading tasks used in the studies incorporated in our meta-analysis, particularly those targeting younger children, the stimuli were one morpheme words. This may have also lessened the relationship of MA with word reading. Finally, although it is tempting to argue that the way reading is taught in English may have given an unfair advantage to PA (given that most teachers in North America teach PA explicitly; learning of morphology is achieved implicitly), the fact that MA in Chinese was a stronger correlate of reading accuracy and reading comprehension in the absence of any explicit teaching of morphology by Chinese teachers suggests that instructional practices are not likely the key factor determining the size of the relationship between these linguistic skills and reading.

From a theoretical point of view, our findings suggest that learning to read across different writing systems involves the same set of mappings between orthographic (written) and phonological (spoken)/semantic forms of words (e.g., Seidenberg, 2011). However, the "division of labor" between these processes differs by writing system. Both PA and MA correlated significantly with the reading outcomes in both languages. However, PA plays a stronger role than MA in word reading in English because the spelling-to-sound mappings are relatively systematic (or at least not as ambiguous as in Chinese). In Chinese, MA is a stronger correlate of reading accuracy and comprehension than PA, because the basic graphic unit, the character, represents a morpheme (not a phoneme).

Some limitations of the present study are worth mentioning. First, we ran our analyses using studies conducted only in Chinese and English. This was done not only because English and Chinese represent different writing systems, but also because they differ on important linguistic characteristics that have direct implications for the role of PA or MA in reading. However, we acknowledge that English is an atypical alphabetic orthography and our results may not generalize to other alphabetic languages with a more transparent orthography. Second, we considered studies in our meta-analysis that assessed both PA and MA in the same study. Although the issue of including studies examining both skills or studies examining either skill in a meta-analysis is still a matter of debate (e.g., Kulinskaya, Morgenthaler, & Staudte, 2008), we made this decision to gain a better control over the possible effects of confounding variables (e.g., sample characteristics) in the size of the correlations and to be able to compare our findings to those of previous meta-analyses that used a similar approach (e.g., Song et al., 2016; Swanson et al., 2003). However, we acknowledge that this has reduced the number of studies that were considered in the meta-analysis. Third, we did not examine the role of dialect (Mandarin vs. Cantonese) or script (simplified vs. traditional) in the relationship between PA, MA, and reading in Chinese. Had we examined their role, we would not be able to run some of the analyses because of the small number of studies conducted in either dialect or script. Fourth, we did not include any control variables (e.g., socioeconomic status, IQ, vocabulary) in our study. This was done for a methodological reason since there could be several potential control variables and not all studies incorporated in our meta-analysis assessed the same control variables. Fifth, information on how the children were taught to read was missing from most studies and for this reason we refrained from making any generalizations about reading instruction. Whether the observed differences in the size of the correlations between PA, MA and reading in English reflect the way children are taught how to read is a question that remains to be answered in a future study. Sixth, although grade level and reading ability status may be somewhat confounded, we could not test the interaction between the two because we had a very small number of effect sizes in the poor and normal readers' groups. Finally, we

[4] We thank the anonymous reviewer for this explanation.

acknowledge that our classification of the MA tasks is not the only one. Deacon et al. (2008), for example, proposed a taxonomy of MA tasks that takes into account not only the format of presentation (oral vs. written), but also the content (e.g., whether phonological or orthographic shifts happen when morphemes are added to a base or stem) and process (e.g., whether the task requires explicit or only implicit knowledge).

Psychoeducational Implications

The findings of this meta-analysis have some important psychoeducational implications. First, given that both PA and MA were found to be significant correlates of reading in both languages, tasks of both skills may be used to screen for reading difficulties. Currently, most screening batteries in English and Chinese include measures of PA, but not measures of MA. Second, given that PA and MA correlated significantly with each other in both languages, instruction in either skill may facilitate the learning of the other. This further suggests that some children with weak PA may be taught MA to compensate (e.g., Deacon et al., 2008).

Conclusion

To conclude, our meta-analysis is the first one to document the differential relationship of PA and MA with different reading outcomes across two writing systems (alphabetic and logographic). The results suggest that significant differences across the two languages included in this meta-analysis could only be detected in the role of PA (based on the results with partial correlations). Specifically, PA was a stronger correlate of reading accuracy and fluency in English than in Chinese. However, when we look at each language separately, variation is rather predictable. Because in Chinese the mapping from spelling to sound is syllable-based with no constituent parts of a character corresponding to phonemes, MA plays a more important role in reading than PA. In contrast, because in English letters correspond to sounds, PA plays a more important role in word reading than MA.

References

*An asterisk is put in front of studies that have been used in the meta-analysis.

*Apel, K., & Lawrence, J. (2011). Contributions of morphological awareness skills to word-level reading and spelling in first-grade children with and without speech sound disorder. *Journal of Speech, Language, and Hearing Research, 54,* 1312–1327. http://dx.doi.org/10.1044/1092-4388(2011/10-0115)

*Apel, K., & Thomas-Tate, S. (2009). Morphological awareness skills of fourth-grade African American students. *Language, Speech, and Hearing Services in Schools, 40,* 312–324. http://dx.doi.org/10.1044/0161-1461(2009/08-0015)

*Apel, K., Wilson-Fowler, E. B., Brimo, D., & Perrin, N. A. (2012). Metalinguistic contributions to reading and spelling in second and third grade students. *Reading and Writing, 25,* 1283–1305. http://dx.doi.org/10.1007/s11145-011-9317-8

*Berninger, V. W., Abbott, R. D., Thomson, J., Wagner, R., Swanson, H. L., Wijsman, E. M., & Raskind, W. (2006). Modeling phonological core deficits within a working memory architecture in children and adults with developmental dyslexia. *Scientific Studies of Reading, 10,* 165–198. http://dx.doi.org/10.1207/s1532799xssr1002_3

*Berninger, V. W., Raskind, W., Richards, T., Abbott, R., & Stock, P. (2008). A multidisciplinary approach to understanding developmental dyslexia within working-memory architecture: Genotypes, phenotypes, brain, and instruction. *Developmental Neuropsychology, 33,* 707–744. http://dx.doi.org/10.1080/87565640802418662

Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2005). Comprehensive meta-analysis (Version 2) [Computer software]. Englewood, NJ: Biostat.

Bowers, P. N., Kirby, J. R., & Deacon, S. H. (2010). The effects of morphological instruction on literacy skills: A systematic review of the literature. *Review of Educational Research, 80,* 144–179. http://dx.doi.org/10.3102/0034654309359353

Bowey, J. A. (2005). Predicting individual differences in learning to read. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 155–172). Oxford, UK: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch9

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Erlbaum.

Carlisle, J. F., McBride-Chang, C., Nagy, W., & Nunes, T. (2010). Effects of instruction in morphological awareness on literacy achievement: An integrative review. *Reading Research Quarterly, 45,* 464–487. http://dx.doi.org/10.1598/RRQ.45.4.5

*Carlisle, J. F., & Nomanbhoy, D. M. (1993). Phonological and morphological awareness in first graders. *Applied Psycholinguistics, 14,* 177–195. http://dx.doi.org/10.1017/S0142716400009541

Chao, Y. R. (1976). *Aspects of Chinese sociolinguistics: Essays* (Vol. 9). Palo Alto, CA: Stanford University Press.

*Chen, X., Hao, M. L., Geva, E., Zhu, J., & Shu, H. (2009). The role of compound awareness in Chinese children's vocabulary acquisition and character reading. *Reading and Writing, 22,* 615–631. http://dx.doi.org/10.1007/s11145-008-9127-9

*Cheung, H., Wong, S. W. L., Penney, T. B., Chung, K. K. H., McBride-Chang, C., & Ho, C. S. H. (2010). Speech perception, metalinguistic awareness, reading, and vocabulary in Chinese-English bilingual children. *Journal of Educational Psychology, 102,* 367–380. http://dx.doi.org/10.1037/a0017850

*Chik, P. P. M., Ho, C. S. H., Yeung, P. S., Chan, D. W. O., Chung, K. K. H., Luan, H., . . . Lau, W. S. Y. (2012). Syntactic skills in sentence reading comprehension among Chinese elementary school children. *Reading and Writing, 25,* 679–699. http://dx.doi.org/10.1007/s11145-010-9293-4

Cho, J.-R., Chiu, M. M., & McBride-Chang, C. (2011). Morphological awareness, phonological awareness, and literacy development in Korean and English: A 2-year longitudinal study. *Scientific Studies of Reading, 15,* 383–408. http://dx.doi.org/10.1080/10888438.2010.487143

Chomsky, C. (1970). Reading, writing, and phonology. *Harvard Educational Review, 40,* 287–309. http://dx.doi.org/10.17763/haer.40.2.y7u0242x76w05624

*Chow, B. W. Y., Ho, C. S. H., Wong, S. W. L., Waye, M. M. Y., & Bishop, D. V. M. (2011). Genetic and environmental influences on Chinese language and reading abilities. *PLoS ONE, 6,* e16640. http://dx.doi.org/10.1371/journal.pone.0016640

Chow, B. W., McBride-Chang, C., Cheung, H., & Chow, C. S. (2008). Dialogic reading and morphology training in Chinese children: Effects on language and literacy. *Developmental Psychology, 44,* 233–244. http://dx.doi.org/10.1037/0012-1649.44.1.233

Chung, F. H., & Leung, M. T. (2008). Data analysis of Chinese characters in primary school corpora of Hong Kong and mainland China: Preliminary theoretical interpretations. *Clinical Linguistics & Phonetics, 22,* 379–389. http://dx.doi.org/10.1080/02699200701776757

*Chung, K. K., & Ho, C. S. (2010). Second language learning difficulties in Chinese children with dyslexia: What are the reading-related cognitive skills that contribute to English and Chinese word reading? *Journal* *of Learning Disabilities, 43,* 195–211. http://dx.doi.org/10.1177/0022219409345018

*Chung, K. K. H., & McBride-Chang, C. (2011). Executive functioning skills uniquely predict Chinese word reading. *Journal of Educational Psychology, 103,* 909–921. http://dx.doi.org/10.1037/a0024744

*Chung, K. K. H., McBride-Chang, C., Wong, S. W., Cheung, H., Penney, T. B., & Ho, C. S. H. (2008). The role of visual and auditory temporal processing for Chinese children with developmental dyslexia. *Annals of Dyslexia, 58,* 15–35. http://dx.doi.org/10.1007/s11881-008-0015-4

*Cunningham, A. J., & Carroll, J. M. (2015). Early predictors of phonological and morphological awareness and the link with reading: Evidence from children with different patterns of early deficit. *Applied Psycholinguistics, 36,* 509–531. http://dx.doi.org/10.1017/S0142716413000295

*Deacon, S. H. (2012). Sounds, letters and meanings: The independent influences of phonological, morphological and orthographic skills on early word reading accuracy. *Journal of Research in Reading, 35,* 456–475. http://dx.doi.org/10.1111/j.1467-9817.2010.01496.x

*Deacon, S. H., Benere, J., & Pasquarella, A. (2013). Reciprocal relationship: Children's morphological awareness and their reading accuracy across grades 2 to 3. *Developmental Psychology, 49,* 1113–1126. http://dx.doi.org/10.1037/a0029474

*Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics, 25,* 223–238. http://dx.doi.org/10.1017/S0142716404001110

Deacon, S. H., Parrila, R., & Kirby, J. R. (2008). A review of the evidence on morphological processing in dyslexics and poor readers: A strength or weakness? In F. Manis, A. Fawcett, G. Reid, & L. Siegel (Eds.), *Sage handbook of dyslexia* (pp. 212–238). London, UK: Sage. http://dx.doi.org/10.4135/9780857020987.n11

*Deacon, S. H., Wade-Woolley, L., & Kirby, J. (2007). Crossover: The role of morphological awareness in French immersion children's reading. *Developmental Psychology, 43,* 732–746. http://dx.doi.org/10.1037/0012-1649.43.3.732

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics, 56,* 455–463. http://dx.doi.org/10.1111/j.0006-341X.2000.00455.x

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading, 9,* 167–188. http://dx.doi.org/10.1207/s1532799xssr0902_4

Ehri, L. C., Nunes, S. R., Willows, D. M., Schuster, B. V., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36,* 250–287. http://dx.doi.org/10.1598/RRQ.36.3.2

*Farran, L. K., Bingham, G. E., & Matthews, M. W. (2012). The relationship between language and reading in bilingual English-Arabic children. *Reading and Writing, 25,* 2153–2181. http://dx.doi.org/10.1007/s11145-011-9352-5

*Fraser, J., & Conti-Ramsden, G. (2008). Contribution of phonological and broader language skills to literacy. *International Journal of Language & Communication Disorders, 43,* 552–569. http://dx.doi.org/10.1080/13682820701778069

Goodwin, A. P., & Ahn, S. (2010). A meta-analysis of morphological interventions: Effects on literacy achievement of children with literacy difficulties. *Annals of Dyslexia, 60,* 183–208. http://dx.doi.org/10.1007/s11881-010-0041-x

Grigorakis, I. (2014). *The development of children's metamorphological abilities from Kindergarten to Grade 2 and its relationship with reading and spelling acquisition* (Unpublished doctoral dissertation). University of Crete, Rethymno, Greece.

Hanley, J. R. (2005). Learning to read in Chinese. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 316–335). Oxford, UK: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch17

Hedges, L. V., & Olkin, I. (2014). *Statistical methods for meta-analysis*. Orlando, FL: Academic Press.

*Ho, C. S.-H. (2014). Preschool predictors of dyslexia status in Chinese first graders with high or low familial risk. *Reading and Writing, 27,* 1673–1701. http://dx.doi.org/10.1007/s11145-014-9515-2

Ho, C. S.-H., & Bryant, P. (1997). Phonological skills are important in learning to read Chinese. *Developmental Psychology, 33,* 946–951. http://dx.doi.org/10.1037/0012-1649.33.6.946

*Ho, C. S.-H., Leung, M. T., & Cheung, H. (2011). Early difficulties of Chinese preschoolers at familial risk for dyslexia: Deficits in oral language, phonological processing skills, and print-related skills. *Dyslexia: An International Journal of Research and Practice, 17,* 143–164. http://dx.doi.org/10.1002/dys.429

*Hu, C. F. (2013). Predictors of reading in children with Chinese as a first language: A developmental and cross-linguistic perspective. *Reading and Writing, 26,* 163–187. http://dx.doi.org/10.1007/s11145-012-9360-0

Institute of Language Teaching and Research of China. (Ed.) (1986). *A frequency dictionary of modern Chinese*. Beijing, China: Beijing Language Institute Press.

*Jarmulowicz, L., Hay, S. E., Taran, V. L., & Ethington, C. A. (2008). Fitting derivational morphophonology into a developmental model of reading. *Reading and Writing, 21,* 275–297. http://dx.doi.org/10.1007/s11145-007-9073-y

*Jarmulowicz, L., Taran, V. L., & Hay, S. E. (2007). Third graders' metalinguistic skills, reading skills, and stress production in derived English words. *Journal of Speech, Language, and Hearing Research, 50,* 1593–1605. http://dx.doi.org/10.1044/1092-4388(2007/107)

*Joanisse, M. F., Manis, F. R., Keating, P., & Seidenberg, M. S. (2000). Language deficits in dyslexic children: Speech perception, phonology, and morphology. *Journal of Experimental Child Psychology, 77,* 30–60. http://dx.doi.org/10.1006/jecp.1999.2553

Kamhi, A., & Catts, H. W. (2012). *Language and reading disabilities* (3rd ed.). Boston, MA: Pearson.

Katzir, T., Kim, Y.-S., Wolf, M., Kennedy, B., Lovett, M., & Morris, R. (2006). The relationship of spelling recognition, RAN, and phonological awareness to reading skills in older poor readers and younger reading-matched controls. *Reading and Writing, 19,* 845–872. http://dx.doi.org/10.1007/s11145-006-9013-2

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology, 101,* 765–778. http://dx.doi.org/10.1037/a0015956

*Kim, Y.-S., Apel, K., & Al Otaiba, S. (2013). The relation of linguistic awareness and vocabulary to word reading and spelling for first-grade students participating in response to intervention. *Language, Speech, and Hearing Services in Schools, 44,* 337–347. http://dx.doi.org/10.1044/0161-1461(2013/12-0013)

*Kirby, J. R., Deacon, S. H., Bowers, P. N., Izenberg, L., Wade-Woolley, L., & Parrila, R. (2012). Children's morphological awareness and reading ability. *Reading and Writing, 25,* 389–410. http://dx.doi.org/10.1007/s11145-010-9276-5

*Kruk, R. S., & Bergman, K. (2013). The reciprocal relations between morphological processes and reading. *Journal of Experimental Child Psychology, 114,* 10–34. http://dx.doi.org/10.1016/j.jecp.2012.09.014

Kulinskaya, E., Morgenthaler, S., & Staudte, R. G. (2008). *Meta analysis: A guide to calibrating and combining statistical evidence* (Vol. 756). West Sussex, England: Wiley.

Kuo, K.-J., & Anderson, R. C. (2006). Morpholgical awareness and learning to read: A cross-language perspective. *Educational Psychologist, 41,* 161–180. http://dx.doi.org/10.1207/s15326985ep4103_3

*Lam, F. W. F., McBride-Chang, C., Lam, C. C. C., Wong, S. W. L., Chow, Y., & Doo, S. (2008). Towards early identification of dyslexia in Chinese preschool children: A study on reading and cognitive profile in children with genetic risk of dyslexia in Hong Kong. *Hong Kong Journal of Paediatrics, 13,* 90–98.

*Lei, L., Pan, J., Liu, H., McBride-Chang, C., Li, H., Zhang, Y., . . . Shu, H. (2011). Developmental trajectories of reading development and impairment from ages 3 to 8 years in Chinese children. *Journal of Child Psychology and Psychiatry, 52,* 212–220. http://dx.doi.org/10.1111/j.1469-7610.2010.02311.x

Li, H., Dronjic, V., Chen, X. I., Li, Y., Cheng, Y., & Wu, X. (in press). Morphological awareness as a function of semantics, phonology, and orthography and as a predictor of reading comprehension in Chinese. *Journal of Child Language*. http://dx.doi.org/10.1017/S0305000916000477

*Li, H., Shu, H., McBride-Chang, C., Liu, H. Y., & Peng, H. (2012). Chinese children's character recognition: Visuo-orthographic, phonological processing and morphological skills. *Journal of Research in Reading, 35,* 287–307. http://dx.doi.org/10.1111/j.1467-9817.2010.01460.x

*Li, L., & Wu, X. (2015). Effects of metalinguistic awareness on reading comprehension and the mediator role of reading fluency from grades 2 to 4. *PLoS ONE, 10,* e0114417. http://dx.doi.org/10.1371/journal.pone.0114417

Li, W., Anderson, R. C., Nagy, W., & Zhang, H. (2002). Facets of metalinguistic awareness that contribute to Chinese literacy. In W. Li, J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 87–106). Boston, MA: Kluwer Academic.

*Lin, D., McBride-Chang, C., Aram, D., & Levin, I. (2011). Mother-child joint writing in Chinese kindergarteners: Metalinguistic awareness, maternal mediation and literacy acquisition. *Journal of Research in Reading, 34,* 426–442. http://dx.doi.org/10.1111/j.1467-9817.2010.01446.x

*Lin, D., McBride-Chang, C., Aram, D., Shu, H., Levin, I., & Cho, J. R. (2012). Maternal mediation of word writing in Chinese across Hong Kong and Beijing. *Journal of Educational Psychology, 104,* 121–137. http://dx.doi.org/10.1037/a0025383

*Liu, D., Chen, X., & Chung, K. K. H. (2015). Performance in a visual search task uniquely predicts reading abilities in third-grade Hong Kong Chinese children. *Scientific Studies of Reading, 19,* 307–324. http://dx.doi.org/10.1080/10888438.2015.1030749

*Liu, D., Chung, K. K. H., Zhang, Y. M., & Lu, Z. (2014). Sensitivity to the positional information of morphemes inside Chinese compound words and its relationship with word reading. *Reading and Writing, 27,* 431–450. http://dx.doi.org/10.1007/s11145-013-9451-6

*Liu, D., & McBride-Chang, C. (2014). Morphological structure processing during word recognition and its relationship to character reading among third-grade Chinese children. *Journal of Psycholinguistic Research, 43,* 715–735. http://dx.doi.org/10.1007/s10936-013-9275-1

*Liu, P. D., & McBride-Chang, C. (2010). What is morphological awareness? Tapping lexical compounding awareness in Chinese third graders. *Journal of Educational Psychology, 102,* 62–73. http://dx.doi.org/10.1037/a0016933

*Liu, P. D., McBride-Chang, C., Wong, T. T. Y., Shu, H., & Wong, A. M. Y. (2013). Morphological awareness in Chinese: Unique associations of homophone awareness and lexical compounding to word reading and vocabulary knowledge in Chinese children. *Applied Psycholinguistics, 34,* 755–775. http://dx.doi.org/10.1017/S014271641200001X

*Mahony, D., Singson, M., & Mann, V. (2000). Reading ability and sensitivity to morphological relations. *Reading and Writing, 12,* 191–218. http://dx.doi.org/10.1023/A:1008136012492

McBride-Chang, C., Bialystok, E., Chong, K. K., & Li, Y. (2004). Levels of phonological awareness in three cultures. *Journal of Experimental Child Psychology, 89,* 93–111. http://dx.doi.org/10.1016/j.jecp.2004.05.001

*McBride-Chang, C., Cheung, H., Chow, B. W. Y., Chow, C. S. L., & Choi, L. (2006). Metalinguistic skills and vocabulary knowledge in Chinese (L1) and English (L2). *Reading and Writing, 19,* 695–716. http://dx.doi.org/10.1007/s11145-005-5742-x

*McBride-Chang, C., Cho, J. R., Liu, H., Wagner, R. K., Shu, H., Zhou, A., . . . Muse, A. (2005). Changing models across cultures: Associations of phonological awareness and morphological structure awareness with vocabulary and word recognition in second graders from Beijing, Hong Kong, Korea, and the United States. *Journal of Experimental Child Psychology, 92,* 140–160. http://dx.doi.org/10.1016/j.jecp.2005.03.009

McBride-Chang, C., Chung, K. K., & Tong, X. (2011). Copying skills in relation to word reading and writing in Chinese children with and without dyslexia. *Journal of Experimental Child Psychology, 110,* 422–433. http://dx.doi.org/10.1016/j.jecp.2011.04.014

McBride-Chang, C., & Ho, C. S.-H. (2000). Naming speed and phonological awareness in Chinese children: Relations to reading skills. *Journal of Psychology in Chinese Societies, 1,* 93–108.

*McBride-Chang, C., Lam, F., Lam, C., Chan, B., Fong, C. Y. C., Wong, T. T. Y., & Wong, S. W. L. (2011). Early predictors of dyslexia in Chinese children: Familial history of dyslexia, language delay, and cognitive profiles. *Journal of Child Psychology and Psychiatry, 52,* 204–211. http://dx.doi.org/10.1111/j.1469-7610.2010.02299.x

*McBride-Chang, C., Lam, F., Lam, C., Doo, S., Wong, S. W. L., & Chow, Y. Y. Y. (2008). Word recognition and cognitive profiles of Chinese pre-school children at risk for dyslexia through language delay or familial history of dyslexia. *Journal of Child Psychology and Psychiatry, 49,* 211–218.

McBride-Chang, C., Lin, D., Liu, P. D., Aram, D., Levin, I., Cho, J.-R., . . . Zhang, Y. (2012). The ABC's of Chinese: Maternal mediation of Pinyin for Chinese children's early literacy skills. *Reading and Writing, 25,* 283–300. http://dx.doi.org/10.1007/s11145-010-9270-y

*McBride-Chang, C., Liu, P. D., Wong, T., Wong, A., & Shu, H. (2012). Specific reading difficulties in Chinese, English, or both: Longitudinal markers of phonological awareness, morphological awareness, and RAN in Hong Kong Chinese children. *Journal of Learning Disabilities, 45,* 503–514. http://dx.doi.org/10.1177/0022219411400748

McBride-Chang, C., & Manis, F. R. (1996). Structural invariance in the associations of naming speed, phonological awareness, and verbal reasoning in good and poor readers: A test of the double deficit hypothesis. *Reading and Writing, 8,* 323–339. http://dx.doi.org/10.1007/BF00395112

*McBride-Chang, C., Shu, H., Chan, W., Wong, T., Wong, A. M. Y., Zhang, Y. P., . . . Chan, P. (2013). Poor readers of Chinese and English: Overlap, stability, and longitudinal correlates. *Scientific Studies of Reading, 17,* 57–70. http://dx.doi.org/10.1080/10888438.2012.689787

McBride-Chang, C., Shu, H., Ng, J. Y. W., Meng, X., & Penney, T. (2007). Morphological structure awareness, vocabulary, and reading. In R. K. Wagner, K. Tannenbaum, & A. Muse (Eds.), *Vocabulary development and its implications for reading comprehension* (pp. 104–122). New York, NY: Guilford Press.

*McBride-Chang, C., Shu, H., Zhou, A. B., Wat, C. P., & Wagner, R. K. (2003). Morphological awareness uniquely predicts young children's Chinese character recognition. *Journal of Educational Psychology, 95,* 743–751. http://dx.doi.org/10.1037/0022-0663.95.4.743

*McBride-Chang, C., Wagner, R. K., Muse, A., Chow, B. W-Y., & Shu, H. (2005). The role of morphological awareness in children's vocabulary acquisition in English. *Applied Psycholinguistics, 26,* 415–435. http://dx.doi.org/10.1017/S014271640505023X

*McCutchen, D., Green, L., & Abbott, R. D. (2008). Children's morphological knowledge: Links to literacy. *Reading Psychology, 29,* 289–314. http://dx.doi.org/10.1080/02702710801982050

*McCutchen, D., & Logan, B. (2011). Inside incidental word learning: Children's strategic use of morphological information to infer word meanings. *Reading Research Quarterly, 46,* 334–349. http://dx.doi.org/10.1002/RRQ.003

Melby-Lervåg, M., Lyster, S. A., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. *Psychological Bulletin, 138,* 322–352. http://dx.doi.org/10.1037/a0026744

*Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40,* 665–681. http://dx.doi.org/10.1037/0012-1649.40.5.665

*Nagy, W., Berninger, V. W., & Abbott, R. D. (2006). Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology, 98,* 134–147. http://dx.doi.org/10.1037/0022-0663.98.1.134

*Nagy, W., Berninger, V., Abbott, R., Vaughan, K., & Vermeulen, K. (2003). Relationship of morphology and other language skills to literacy skills in at-risk second-grade readers and at-risk fourth-grade writers. *Journal of Educational Psychology, 95,* 730–742. http://dx.doi.org/10.1037/0022-0663.95.4.730

Newman, E. H., Tardif, T., Huang, J., & Shu, H. (2011). Phonemes matter: The role of phoneme-level awareness in emergent Chinese readers. *Journal of Experimental Child Psychology, 108,* 242–259. http://dx.doi.org/10.1016/j.jecp.2010.09.001

Nunes, T., & Hatano, G. (2004). Morphology, reading and spelling: Looking across languages. In T. Nunes & P. Bryant (Eds.), *Handbook of children's literacy* (pp. 651–672). Boston, MA: Kluwer Academic Publisher. http://dx.doi.org/10.1007/978-94-017-1731-1_34

Packard, J. L. (2000). *The morphology of Chinese: A linguistic and cognitive approach*. Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511486821

Pan, J., McBride-Chang, C., Shu, H., Liu, H., Zhang, Y., & Li, H. (2011). What is in the naming? A 5-year longitudinal study of early rapid naming and phonological sensitivity in relation to subsequent reading skills in both native Chinese and English as a second language. *Journal of Educational Psychology, 103,* 897–908. http://dx.doi.org/10.1037/a0024344

Perfetti, C. A., Landi, N., & Oakhill, J. (2005). The acquisition of reading comprehension skill. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 227–247). Oxford, UK: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch13

Perfetti, C. A., Liu, Y., & Tan, L. H. (2005). The lexical constituency model: Some implications of research on Chinese for general theories of reading. *Psychological Review, 112,* 43–59. http://dx.doi.org/10.1037/0033-295X.112.1.43

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review, 103,* 56–115. http://dx.doi.org/10.1037/0033-295X.103.1.56

Reed, D. K. (2008). A synthesis of morphology interventions and effects on reading outcomes for students in Grades K–12. *Learning Disabilities Research & Practice, 23,* 36–49. http://dx.doi.org/10.1111/j.1540-5826.2007.00261.x

*Roman, A. A., Kirby, J. R., Parrila, R. K., Wade-Woolley, L., & Deacon, S. H. (2009). Toward a comprehensive view of the skills involved in word reading in Grades 4, 6, and 8. *Journal of Experimental Child Psychology, 102,* 96–113. http://dx.doi.org/10.1016/j.jecp.2008.01.004

*Saiegh-Haddad, E., & Geva, E. (2008). Morphological awareness, phonological awareness, and reading in English–Arabic bilingual children. *Reading and Writing, 21,* 481–504. http://dx.doi.org/10.1007/s11145-007-9074-x

Savage, R. S., Frederickson, N., Goodwin, R., Patni, U., Smith, N., & Tuersley, L. (2005). Relationships among rapid digit naming, phonological processing, motor automaticity, and speech perception in poor, average, and good readers and spellers. *Journal of Learning Disabilities, 38,* 12–28. http://dx.doi.org/10.1177/00222194050380010201

Scarborough, H. S. (1998). Early identification of children at risk for reading disabilities: Phonological awareness and some other promising predictors. In B. K. Shapiro, P. J. Accardo, & C. A. J. Capute (Eds.), *Specific reading disability: A view of the spectrum* (pp. 75–119). Timonium, MD: York Press.

Seidenberg, M. (2011). Reading in different writing systems: One architecture, multiple solutions. In P. McCardle, B. Miller, J. Lee, & O. Tzeng (Eds.), *Dyslexia across languages. Orthography and the brain-gene-behavior link* (pp. 151–174). Baltimore, MD: Brookes.

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96,* 523–568. http://dx.doi.org/10.1037/0033-295X.96.4.523

Seymour, P. H. (2005). Early reading development in European orthographies. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 296–315). Oxford, UK: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch16

*Shankweiler, D., Crain, S., Katz, L., Fowler, A., Liberman, A., Brady, S., . . . Fletcher, J. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6,* 149–156. http://dx.doi.org/10.1111/j.1467-9280.1995.tb00324.x

*Shankweiler, D., Lundquist, E., Dreyer, L. G., & Dickinson, C. C. (1996). Reading and spelling difficulties in high school students: Causes and consequences. *Reading and Writing, 8,* 267–294. http://dx.doi.org/10.1007/BF00420279

Shu, H. (2003). Chinese writing system and learning to read. *International Journal of Psychology, 38,* 274–285. http://dx.doi.org/10.1080/00207590344000060

Shu, H., Chen, X., Anderson, R. C., Wu, N., & Xuan, Y. (2003). Properties of school Chinese: Implications for learning to read. *Child Development, 74,* 27–47. http://dx.doi.org/10.1111/1467-8624.00519

*Shu, H., McBride-Chang, C., Wu, S., & Liu, H. Y. (2006). Understanding Chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology, 98,* 122–133. http://dx.doi.org/10.1037/0022-0663.98.1.122

Shu, H., Peng, H., & McBride-Chang, C. (2008). Phonological awareness in young Chinese children. *Developmental Science, 11,* 171–181. http://dx.doi.org/10.1111/j.1467-7687.2007.00654.x

*Siegel, L. S. (2008). Morphological awareness skills of English language learners and children with dyslexia. *Topics in Language Disorders, 28,* 15–27. http://dx.doi.org/10.1097/01.adt.0000311413.75804.60

*Singson, M., Mahony, D., & Mann, V. (2000). The relation between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing, 12,* 219–252. http://dx.doi.org/10.1023/A:1008196330239

Siok, W. T., & Fletcher, P. (2001). The role of phonological awareness and visual-orthographic skills in Chinese reading acquisition. *Developmental Psychology, 37,* 886–899. http://dx.doi.org/10.1037/0012-1649.37.6.886

Song, S., Georgiou, G. K., Su, M., & Hua, S. (2016). How well do phonological awareness and rapid automatized naming correlate with Chinese reading accuracy and fluency? A meta-analysis. *Scientific Studies of Reading, 20,* 99–123. http://dx.doi.org/10.1080/10888438.2015.1088543

*Song, S., Su, M., Kang, C., Liu, H., Zhang, Y., McBride-Chang, C., . . . Shu, H. (2015). Tracing children's vocabulary development from preschool through the school-age years: An 8-year longitudinal study. *Developmental Science, 18,* 119–131. http://dx.doi.org/10.1111/desc.12190

*Swank, L. K. (1997). Linguistic influences on the emergence of written word decoding in first grade. *American Journal of Speech-Language Pathology, 6,* 62–66. http://dx.doi.org/10.1044/1058-0360.0604.62

Swanson, H. L., Trainin, G., Necoechea, D. M., & Hammill, D. D. (2003). Rapid naming, phonological awareness, and reading: A meta-analysis of the correlation evidence. *Review of Educational Research, 73,* 407–440. http://dx.doi.org/10.3102/00346543073004407

*Tolchinsky, L., Levin, I., Aram, D., & McBride-Chang, C. (2012). Building literacy in alphabetic, abjad and morphosyllabic systems. *Reading and Writing, 25,* 1573–1598. http://dx.doi.org/10.1007/s11145-011-9334-7

*Tong, X., Deacon, S. H., Kirby, J. R., Cain, K., & Parrila, R. (2011). Morphological awareness: A key to understanding poor reading comprehension in English. *Journal of Educational Psychology, 103,* 523–534. http://dx.doi.org/10.1037/a0023495

*Tong, X. L., & McBride-Chang, C. (2010). Chinese-English biscriptal reading: Cognitive component skills across orthographies. *Reading and Writing, 23,* 293–310. http://dx.doi.org/10.1007/s11145-009-9211-9

*Tong, X. L., McBride-Chang, C., Shu, H., & Wong, A. M. Y. (2009). Morphological awareness, orthographic knowledge, and spelling errors: Keys to understanding early Chinese literacy acquisition. *Scientific Studies of Reading, 13,* 426–452. http://dx.doi.org/10.1080/10888430903162910

*Tong, X. L., McBride-Chang, C., Wong, A. M. Y., Shu, H., Reitsma, P., & Rispens, J. (2011). Longitudinal predictors of very early Chinese literacy acquisition. *Journal of Research in Reading, 34,* 315–332. http://dx.doi.org/10.1111/j.1467-9817.2009.01426.x

Tong, X., Tong, X., & McBride, C. (2017). Unpacking the relation between phonological awareness and Chinese word reading: Levels of morphological awareness and vocabulary. *Contemporary Educational Psychology, 48,* 167–178. http://dx.doi.org/10.1016/j.cedpsych.2016.07.003

*Tong, X. H., Tong, X. L., Shu, H., Chan, S. F., & McBride-Chang, C. (2014). Discourse-level reading comprehension in Chinese children: What is the role of syntactic awareness? *Journal of Research in Reading, 37,* S48–S70. http://dx.doi.org/10.1111/1467-9817.12016

Treiman, R., & Kessler, B. (2014). *How children learn to write words*. New York, NY: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199907977.001.0001

Venezky, R. (1967). English orthography: Its graphical structure and its relation to sound. *Reading Research Quarterly, 2,* 75–105. http://dx.doi.org/10.2307/747031

*Wang, M., Cheng, C. X., & Chen, S. W. (2006). Contribution of morphological awareness to Chinese-English biliteracy acquisition. *Journal of Educational Psychology, 98,* 542–553. http://dx.doi.org/10.1037/0022-0663.98.3.542

*Wang, M., Yang, C., & Cheng, C. (2009). The contributions of phonology, orthography, and morphology in Chinese-English biliteracy acquisition. *Applied Psycholinguistics, 30,* 291–314. http://dx.doi.org/10.1017/S0142716409090122

*Wang, Y., McBride-Chang, C., & Chan, S. F. (2014). Correlates of Chinese kindergarteners' word reading and writing: The unique role of copying skills? *Reading and Writing, 27,* 1281–1302. http://dx.doi.org/10.1007/s11145-013-9486-8

*Wang, Y., Yin, L., & McBride, C. (2015). Unique predictors of early reading and writing: A one-year longitudinal study of Chinese kindergarteners. *Early Childhood Research Quarterly, 32,* 51–59. http://dx.doi.org/10.1016/j.ecresq.2015.02.004

*Wei, T. Q., Bi, H. Y., Chen, B. G., Liu, Y., Weng, X. C., & Wydell, T. N. (2014). Developmental changes in the role of different metalinguistic awareness skills in Chinese reading acquisition from preschool to third grade. *PLoS ONE, 9,* e96240. http://dx.doi.org/10.1371/journal.pone.0096240

*Wong, A. M. Y., Ho, C. S. H., Au, T. K. F., Kidd, J. C., Ng, A. K. H., Yip, L. P. W., & Lam, C. C. C. (2015). (Dis)connections between specific language impairment and dyslexia in Chinese. *Reading and Writing, 28,* 699–719. http://dx.doi.org/10.1007/s11145-015-9546-3

*Wong, A. M. Y., Kidd, J. C., Ho, C. S. H., & Au, T. K. F. (2010). Characterizing the overlap between SLI and dyslexia in Chinese: The role of phonology and beyond. *Scientific Studies of Reading, 14,* 30–57. http://dx.doi.org/10.1080/10888430903242043

Wu, N., Zhou, X., & Shu, H. (1999). Sublexical processing in reading Chinese: A development study. *Language and Cognitive Processes, 14,* 503–524. http://dx.doi.org/10.1080/016909699386176

*Xue, J., Shu, H., Li, H., Li, W., & Tian, X. (2013). The stability of literacy-related cognitive contributions to Chinese character naming and reading fluency. *Journal of Psycholinguistic Research, 42,* 433–450. http://dx.doi.org/10.1007/s10936-012-9228-0

Yang, J., Shu, H., McCandliss, B. D., & Zevin, J. D. (2013). Orthographic influences on division of labor in learning to read Chinese and English: Insights from computational modeling. *Bilingualism: Language and Cognition, 16,* 354–366. http://dx.doi.org/10.1017/S1366728912000296

*Yeung, P. S., Ho, C. S. H., Chan, D. W. O., & Chung, K. K. H. (2014). What are the early indicators of persistent word reading difficulties among Chinese readers in elementary grades? *Dyslexia: An International Journal of Research and Practice, 20,* 119–145. http://dx.doi.org/10.1002/dys.1471

*Yeung, P. S., Ho, C. S. H., Chik, P. P. M., Lo, L. Y., Luan, H., Chan, D. W. O., & Chung, K. K. H. (2011). Reading and spelling Chinese among beginning readers: What skills make a difference? *Scientific Studies of Reading, 15,* 285–313. http://dx.doi.org/10.1080/10888438.2010.482149

*Yeung, P. S., Ho, C. S. H., Wong, Y. K., Chan, D. W. O., Chung, K. K. H., & Lo, L. Y. (2013). Longitudinal predictors of Chinese word reading and spelling among elementary grade students. *Applied Psycholinguistics, 34,* 1245–1277. http://dx.doi.org/10.1017/S0142716412000239

Zhang, H. (in press). Development of morphological awareness in in young Chinese readers: Comparing poor comprehenders and good comprehenders. *Reading & Writing Quarterly*. http://dx.doi.org/10.1080/10573569.2016.1145562

*Zhang, J., & McBride-Chang, C. (2014). Auditory sensitivity, speech perception, L1 Chinese, and L2 English reading abilities in Hong Kong Chinese children. *Developmental Psychology, 50,* 1001–1013. http://dx.doi.org/10.1037/a0035086

*Zhang, J., McBride-Chang, C., Tong, X. L., Wong, A. M. Y., Shu, H., & Fong, C. Y. C. (2012). Reading with meaning: The contributions of meaning-related variables at the word and subword levels to early Chinese reading comprehension. *Reading and Writing, 25,* 2183–2203. http://dx.doi.org/10.1007/s11145-011-9353-4

*Zhang, J., McBride-Chang, C., Wong, A. M. Y., Tardif, T., Shu, H., & Zhang, Y. P. (2014). Longitudinal correlates of reading comprehension difficulties in Chinese children. *Reading and Writing, 27,* 481–501. http://dx.doi.org/10.1007/s11145-013-9453-4

Zhang, Y., Tardif, T., Shu, H., Li, H., Liu, H., McBride-Chang, C., . . . Zhang, Z. (2013). Phonological skills and vocabulary knowledge mediate socioeconomic status effects in predicting reading outcomes for Chinese children. *Developmental Psychology, 49,* 665–671. http://dx.doi.org/10.1037/a0028612

*Zhou, Y. L., McBride-Chang, C., Fong, C. Y. C., Wong, T. T. Y., & Cheung, S. K. (2012). A comparison of phonological awareness, lexical compounding, and homophone training for Chinese word reading in Hong Kong kindergartners. *Early Education and Development, 23,* 475–492. http://dx.doi.org/10.1080/10409289.2010.530478

*Zhou, Y., McBride-Chang, C., Law, A. B. Y., Li, T., Cheung, A. C. Y., Wong, A. M. Y., & Shu, H. (2014). Development of reading-related skills in Chinese and English among Hong Kong Chinese children with and without dyslexia. *Journal of Experimental Child Psychology, 122,* 75–91. http://dx.doi.org/10.1016/j.jecp.2013.12.003

Appendix A

Information on the Studies Included in the Meta-Analysis

Study	Language	Reading ability	Grade level	Sample size	Type of PA task	Type of MA task I	Type of MA task II	Type of MA task III	Reading accuracy	Reading fluency	Reading comprehension
Apel & Lawrence,	EN	Blank	Beginning	44	Blank				.61		
2011	EN	Blank	Beginning	44		Prod.	Oral	—	.52		
	EN	Normal	Beginning	44	Blank				.44		
	EN	Normal	Beginning	44		Prod.	Oral	—	.56		
Apel & Thomas-Tate,	EN	Unselct.	Interm.	30	Blank				.38		.02
2009	EN	Unselct.	Interm.	30		Prod.	Blank	—	.65		.21
Apel et al., 2012	EN	Unselct.	Beginning	26	Simple				−.19		−.02
	EN	Unselct.	Beginning	26		Prod.	Blank	—	.60		.71
	EN	Unselct.	Interm.	30	Simple				.03		.12
	EN	Unselct.	Interm.	30		Prod.	Blank	—	.13		.21
Berninger et al., 2006	EN	Poor	Blank	122	Blank				.72	.45	
	EN	Poor	Blank	122		Blank	Blank	—	.76	.53	
Carlisle &	EN	Unselct.	Preschool	101	Blank				.58		
Nomanbhoy, 1993	EN	Unselct.	Preschool	101		Ident.	Oral	—	.27		
	EN	Unselct.	Preschool	101		Prod.	Oral	—	.46		
Chen et al., 2009	CH	Unselct.	Beginning	59	Simple				.37		
	CH	Unselct.	Beginning	59	Simple				.34		
	CH	Unselct.	Beginning	59		Ident.	Oral	Comp.	.33		
	CH	Unselct.	Beginning	59		Prod.	Oral	Comp.	.54		
Cheung et al., 2010	CH	Unselct.	Blank	141	Blank				.28		
	CH	Unselct.	Blank	141		Prod.	Oral	Comp.	.41		
Chung & McBride-	CH	Unselct.	Preschool	85	Blank				.47		
Chang, 2011	CH	Unselct.	Preschool	85		Prod.	Oral	Blank	.40		
Cunningham &	EN	Blank	Interm.	74	Complex				.49		.15
Carroll, 2013	EN	Blank	Interm.	74		Prod.	Oral	—	.25		.30
Deacon & Kirby,	EN	Unselct.	Beginning	103	Complex				.67		.71
2004	EN	Unselct.	Beginning	103		Prod.	Oral	—	.65		.70
Deacon et al., 2007	EN	Unselct.	Beginning	76	Simple				.43		
	EN	Unselct.	Beginning	76		Prod.	Oral	—	.51		
Deacon et al., 2013	EN	Unselct.	Beginning	99	Blank				.70		
	EN	Unselct.	Beginning	99		Prod.	Oral	—	.53		
	EN	Unselct.	Beginning	99		Prod.	Oral	—	.49		
Deacon, 2012	EN	Unselct.	Beginning	123	Blank				.73		
	EN	Unselct.	Beginning	123		Prod.	Oral	—	.51		
	EN	Unselct.	Interm.	79	Blank				.67		
	EN	Unselct.	Interm.	79		Prod.	Oral	—	.40		
Farran et al., 2012	EN	Normal	Blank	83	Blank				.48	.29	
	EN	Normal	Blank	83		Ident.	Oral	—	.17	.03	
Fraser & Conti-	EN	Blank	Blank	71	Complex				.70	.67	.29
Ramsden, 2008	EN	Blank	Blank	71	Simple				.64	.49	.32
	EN	Blank	Blank	71	Simple				.57	.48	.31
	EN	Blank	Blank	71		Prod.	Blank	—	.37	.23	.52
Ho et al., 2011	CH	Poor	Preschool	101	Simple				.51		
	CH	Poor	Preschool	101		Prod.	Oral	Comp.	.35		
Hu, 2013	CH	Unselct.	Interm.	106	Complex				.28		
	CH	Unselct.	Interm.	106	Complex				.40		
	CH	Unselct.	Interm.	106		Prod.	Oral	Comp.	.33		
Jarmulowicz et al.,	EN	Normal	Interm.	76	Blank				.59		.61
2008, 2007	EN	Normal	Interm.	76		Ident.	Oral	—	.52		.55
Joanisse et al., 2000	EN	Poor	Interm.	61	Complex				.30		
	EN	Poor	Interm.	61		Prod.	Oral	—	.27		
	EN	Poor	Interm.	61		Prod.	Oral	—	.30		
	EN	Normal	Interm.	40	Complex				.36		
	EN	Normal	Interm.	40		Prod.	Oral	—	.17		
	EN	Normal	Beginning	37	Complex				.31		
	EN	Normal	Beginning	37		Prod.	Oral	—	.20		

(*Appendices continue*)

Appendix A (*continued*)

Study	Language	Reading ability	Grade level	Sample size	Type of PA task	Type of MA task I	Type of MA task II	Type of MA task III	Reading accuracy	Reading fluency	Reading comprehension
	EN	Normal	Beginning	37		Prod.	Oral	—	.26		
Kim, Apel, & Al Otaiba, 2013	EN	Poor	Beginning	304	Simple				.45		
	EN	Poor	Beginning	304	Blank				.62		
	EN	Poor	Beginning	304		Prod.	Oral	—	.59		
Kirby et al., 2012	EN	Unselct.	Beginning	103	Blank				.67	.56	.66
	EN	Unselct.	Beginning	103		Prod.	Oral	—	.20	.06	.07
Kruk & Bergman, 2013	EN	Blank	Beginning	157	Blank				.70		.70
	EN	Blank	Beginning	157		Ident.	Oral	—	.53		.54
	EN	Blank	Beginning	157		Prod.	Oral	—	.56		.62
Lam et al., 2008	CH	Poor	Preschool	80	Simple				.39		
	CH	Poor	Preschool	80	Complex				.35		
	CH	Poor	Preschool	80		Prod.	Oral	Comp.	.33		
Lei et al., 2011	CH	Unselct.	Preschool	261	Simple				.35	.32	
	CH	Unselct.	Preschool	261		Ident.	Oral	Comp.	.25	.17	
	CH	Unselct.	Preschool	261		Prod.	Oral	Comp.	.31	.29	
Li & Wu, 2015	CH	Normal	Beginning	135	Simple					.27	.35
	CH	Normal	Beginning	135	Complex					.25	.31
	CH	Normal	Beginning	135		Prod.	Oral	Hmph.		.42	.31
	CH	Normal	Beginning	135		Prod.	Oral	Comp.		.40	.32
	CH	Normal	Beginning	135		Prod.	Oral	Hmgr.		.52	.46
	CH	Normal	Interm.	142	Simple					.26	.27
	CH	Normal	Interm.	142	Complex					.30	.30
	CH	Normal	Interm.	142		Prod.	Oral	Hmph.		.29	.38
	CH	Normal	Interm.	142		Prod.	Oral	Comp.		.33	.28
	CH	Normal	Interm.	142		Prod.	Oral	Hmgr.		.41	.46
	CH	Normal	Interm.	138	Simple					−.08	−.05
	CH	Normal	Interm.	138	Complex					−.07	.13
	CH	Normal	Interm.	138		Prod.	Oral	Hmph.		.07	.18
	CH	Normal	Interm.	138		Prod.	Oral	Comp.		.16	.39
	CH	Normal	Interm.	138		Prod.	Oral	Hmgr.		.21	.40
Li et al., 2012	CH	Unselct.	Preschool	184	Simple				.07		
	CH	Unselct.	Preschool	184	Simple				.45		
	CH	Unselct.	Preschool	184		Ident.	Oral	Hmph.	.12		
	CH	Unselct.	Preschool	184		Prod.	Oral	Comp.	.35		
	CH	Unselct.	Blank	273	Simple				.32		
	CH	Unselct.	Blank	273	Complex				.19		
	CH	Unselct.	Blank	273		Ident.	Oral	Hmph.	.39		
	CH	Unselct.	Blank	273		Prod.	Oral	Hmgr.	.34		
Lin et al., 2012	CH	Unselct.	Preschool	63	Simple				.40		
	CH	Unselct.	Preschool	63		Prod.	Oral	Comp.	.24		
	CH	Unselct.	Preschool	43	Simple				.33		
	CH	Unselct.	Preschool	43		Prod.	Oral	Comp.	.45		
Liu & McBride-Chang, 2014	CH	Unselct.	Interm.	121	Blank				.32		
	CH	Unselct.	Interm.	121		Prod.	Oral	Blank	.56		
Liu et al., 2014	CH	Unselct.	Beginning	50	Blank				.33		
	CH	Unselct.	Beginning	50		Prod.	Oral	Comp.	.44		
	CH	Unselct.	Interm.	50	Blank				.49		
	CH	Unselct.	Interm.	50		Prod.	Oral	Comp.	.53		
Liu et al., 2015	CH	Unselct.	Interm.	92	Blank				.26		.20
	CH	Unselct.	Interm.	92		Prod.	Oral	Comp.	.43		.29
Mahony et al., 2000	EN	Normal	Blank	101	Complex				.57		
	EN	Normal	Blank	101	Complex				.65		
	EN	Normal	Blank	101		Prod.	Written	—	.61		
	EN	Normal	Blank	101		Prod.	Blank	—	.53		

(*Appendices continue*)

Appendix A (*continued*)

Study	Language	Reading ability	Grade level	Sample size	Type of PA task	Type of MA task I	Type of MA task II	Type of MA task III	Reading accuracy	Reading fluency	Reading comprehension
McBride-Chang et	CH	Unselct.	Preschool	100	Simple				.36		
al., 2003	CH	Unselct.	Preschool	100	Complex				.16		
	CH	Unselct.	Preschool	100		Ident.	Oral	Hmph.	.41		
	CH	Unselct.	Preschool	100		Prod.	Oral	Comp.	.52		
	CH	Unselct.	Beginning	100	Simple				.14		
	CH	Unselct.	Beginning	100	Complex				.33		
	CH	Unselct.	Beginning	100		Ident.	Oral	Hmph.	.17		
	CH	Unselct.	Beginning	100		Prod.	Oral	Comp.	.40		
McBride-Chang, Cho,	EN	Unselct.	Beginning	105	Blank				.43		
et al., 2005	EN	Unselct.	Beginning	105		Prod.	Oral	—	.10		
	CH	Unselct.	Beginning	100	Blank				.30		
	CH	Unselct.	Beginning	100		Prod.	Oral	Comp.	.39		
McBride-Chang,	EN	Unselct.	Preschool	115	Blank				.58		
Wagner et al.,	EN	Unselct.	Preschool	115		Ident.	Oral	—	.34		
2005b	EN	Unselct.	Preschool	115		Prod.	Oral	—	.40		
	EN	Unselct.	Beginning	105	Blank				.48		
	EN	Unselct.	Beginning	105		Ident.	Oral	—	.26		
	EN	Unselct.	Beginning	105		Prod.	Oral	—	.18		
McBride-Chang et	CH	Unselct.	Preschool	217	Simple				.49		
al., 2006	CH	Unselct.	Preschool	217	Complex				.19		
	CH	Unselct.	Preschool	217		Ident.	Oral	Comp.	.18		
	CH	Unselct.	Preschool	217		Prod.	Oral	Comp.	.37		
McBride-Chang et	CH	Poor	Preschool	72	Simple				.43		
al., 2008	CH	Poor	Preschool	72	Complex				.38		
	CH	Poor	Preschool	72		Prod.	Oral	Comp.	.46		
McBride-Chang et	CH	Poor	Preschool	47	Simple				.37		
al., 2011	CH	Poor	Preschool	47	Complex				.20		
	CH	Poor	Preschool	47		Prod.	Oral	Comp.	.55		
McCutchen & Logan,	EN	Unselct.	Advanced	88	Blank				.47		.32
2011	EN	Unselct.	Advanced	88		Prod.	Written	—	.63		.61
	EN	Unselct.	Advanced	88		Ident.	Written	—	.20		.43
	EN	Unselct.	Advanced	88		Ident.	Written	—	.38		.38
	EN	Unselct.	Advanced	74	Blank				.27		.14
	EN	Unselct.	Advanced	74		Prod.	Written	—	.40		.32
	EN	Unselct.	Advanced	74		Ident.	Written	—	.40		.40
	EN	Unselct.	Advanced	74		Ident.	Written	—	.31		.43
McCutchen et al.,	EN	Normal	Blank	72	Complex				.43		.23
2008	EN	Normal	Blank	72		Blank	Blank	—	.09		.16
	EN	Normal	Blank	72		Blank	Blank	—	.37		.41
Muter et al., 2004	EN	Unselct.	Beginning	90	Simple				.42		
	EN	Unselct.	Beginning	90	Simple				.28		
	EN	Unselct.	Beginning	90	Simple				.47		
	EN	Unselct.	Beginning	90	Simple				.42		
	EN	Unselct.	Beginning	90	Complex				.60		
	EN	Unselct.	Beginning	90	Complex				.55		
	EN	Unselct.	Beginning	90		Prod.	Oral	—	.32		
Nagy et al., 2003	EN	Poor	Beginning	98	Blank				.47	.14	.38
	EN	Poor	Beginning	98		Ident.	Blank	—	.22	−.04	.48
	EN	Poor	Beginning	98		Ident.	Blank	—	.18	.05	.46
	EN	Poor	Beginning	98		Ident.	Blank	—	.16	.11	.20
	EN	Poor	Interm.	97	Blank				.59	−.41	.51
	EN	Poor	Interm.	97		Ident.	Blank	—	.43	−.21	.47
	EN	Poor	Interm.	97		Ident.	Blank	—	.32	−.20	.47
	EN	Poor	Interm.	97		Ident.	Blank	—	.22	−.16	.39
Nagy et al., 2006	EN	Unselct.	Blank	182	Complex				.69	.61	.38
	EN	Unselct.	Blank	182		Blank	Blank	—	.67	.48	.76
	EN	Unselct.	Advanced	218	Complex				.65	.64	.53
	EN	Unselct.	Advanced	218		Blank	Blank	—	.65	.61	.65
	EN	Unselct.	Advanced	207	Complex				.53	.59	.53

(*Appendices continue*)

Appendix A (*continued*)

Study	Language	Reading ability	Grade level	Sample size	Type of PA task	Type of MA task I	Type of MA task II	Type of MA task III	Reading accuracy	Reading fluency	Reading comprehension
	EN	Unselct.	Advanced	207		Blank	Blank	—	.50	.55	.59
Roman et al., 2009	EN	Unselct.	Blank	92	Complex				.48		
	EN	Unselct.	Blank	92		Prod.	Oral	—	.64		
Saiegh-Haddad & Geva, 2008	EN	Unselct.	Blank	43	Blank				.55	.53	
	EN	Unselct.	Blank	43		Ident.	Oral	—	.41	.40	
	EN	Unselct.	Blank	43		Ident.	Oral	—	.43	.59	
Shankweiler et al., 1995	EN	Unselct.	Blank	353	Complex				.76		.66
	EN	Unselct.	Blank	353		Prod.	Oral	—	.70		.71
Shankweiler et al., 1996	EN	Blank	Advanced	65	Complex				.53		
	EN	Blank	Advanced	65		Prod.	Oral	—	.46		
Shu et al., 2006	CH	Poor	Advanced	75	Complex				.24		.24
	CH	Poor	Advanced	75	Blank				.34		.39
	CH	Poor	Advanced	75		Prod.	Oral	Hmgr.	.39		.20
	CH	Poor	Advanced	75		Ident.	Oral	Hmph.	.25		.25
	CH	Normal	Advanced	77	Complex				.46		.39
	CH	Normal	Advanced	77	Blank				.47		.54
	CH	Normal	Advanced	77		Prod.	Oral	Hmgr.	.64		.50
	CH	Normal	Advanced	77		Ident.	Oral	Hmph.	.27		.04
Siegel, 2008	EN	Blank	Advanced	1,238	Blank				.43	.47	.29
	EN	Blank	Advanced	1,238		Ident.	Written	—	.47	.49	.46
	EN	Blank	Advanced	1,238		Ident.	Written	—	.46	.46	.43
Swank, 1997	EN	Unselct.	Preschool	60	Complex				.56		
	EN	Unselct.	Preschool	60	Simple				.67		
	EN	Unselct.	Preschool	60	Simple				.49		
	EN	Unselct.	Preschool	60	Simple				.41		
	EN	Unselct.	Preschool	60	Simple				.29		
	EN	Unselct.	Preschool	60	Simple				.37		
	EN	Unselct.	Preschool	60		Blank	Blank	—	.35		
	EN	Unselct.	Preschool	60		Prod.	Blank	—	.48		
Tolchinsky et al., 2012	CH	Unselct.	Preschool	63	Simple				.36		
	CH	Unselct.	Preschool	63	Complex				.04		
	CH	Unselct.	Preschool	63	Complex				.08		
	CH	Unselct.	Preschool	63		Prod.	Oral	Comp.	.25		
Tong et al., 2011	CH	Unselct.	Preschool	187	Simple				.40		
	CH	Unselct.	Preschool	187		Ident.	Oral	Hmph.	.14		
	CH	Unselct.	Preschool	187		Prod.	Oral	Comp.	.45		
Wang et al., 2006	CH	Unselct.	Blank	64	Simple				−.11		.14
	CH	Unselct.	Blank	64	Simple				.35		.20
	CH	Unselct.	Blank	64	Complex				.09		.17
	CH	Unselct.	Blank	64		Ident.	Oral	Comp.	.29		.33
	CH	Unselct.	Blank	64		Prod.	Blank	Comp.	.38		.33
	CH	Unselct.	Blank	64		Ident.	Oral	Hmph.	.11		.21
Wang et al., 2009	CH	Unselct.	Beginning	78	Simple				.30		
	CH	Unselct.	Beginning	78	Simple				.19		
	CH	Unselct.	Beginning	78	Complex				.11		
	CH	Unselct.	Beginning	78		Ident.	Oral	Comp.	.30		
Wang et al., 2014	CH	Unselct.	Preschool	94	Simple				.03		
	CH	Unselct.	Preschool	94		Prod.	Oral	Comp.	.40		
Wang et al., 2015	CH	Unselct.	Preschool	73	Simple				.22		
	CH	Unselct.	Preschool	73		Prod.	Oral	Comp.	.23		
Wei et al., 2014	CH	Unselct.	Preschool	101	Simple				.29		
	CH	Unselct.	Preschool	101	Complex				.45		
	CH	Unselct.	Preschool	101		Prod.	Oral	Comp.	.29		
	CH	Unselct.	Preschool	101		Ident.	Oral	Hmgr.	.29		
	CH	Unselct.	Beginning	94	Simple				.12		
	CH	Unselct.	Beginning	94	Complex				.19		
	CH	Unselct.	Beginning	94		Prod.	Oral	Comp.	.27		
	CH	Unselct.	Beginning	94		Ident.	Oral	Hmgr.	.31		
	CH	Unselct.	Beginning	98	Simple				.42		

(*Appendices continue*)

Appendix A (*continued*)

Study	Language	Reading ability	Grade level	Sample size	Type of PA task	Type of MA task I	Type of MA task II	Type of MA task III	Reading accuracy	Reading fluency	Reading comprehension
	CH	Unselct.	Beginning	98	Complex				.31		
	CH	Unselct.	Beginning	98		Prod.	Oral	Comp.	.32		
	CH	Unselct.	Beginning	98		Ident.	Oral	Hmgr.	.33		
	CH	Unselct.	Interm.	98	Simple				.15		
	CH	Unselct.	Interm.	98	Complex				.30		
	CH	Unselct.	Interm.	98		Prod.	Oral	Comp.	.37		
	CH	Unselct.	Interm.	98		Ident.	Oral	Hmgr.	.19		
Wong et al., 2010	CH	Unselct.	Blank	34	Complex				.33	.41	
	CH	Unselct.	Blank	34	Complex				.13	.25	
	CH	Unselct.	Blank	35		Prod.	Oral	Comp.	.71	.69	
Wong et al., 2015	CH	Unselct.	Preschool	93	Simple				.33	.38	
	CH	Unselct.	Preschool	93	Simple				.24	.28	
	CH	Unselct.	Preschool	92		Ident.	Oral	Hmgr.	.56	.44	
	CH	Unselct.	Preschool	92		Prod.	Oral	Comp.	.59	.48	
Xue et al., 2013	CH	Unselct.	Beginning	408	Blank				.29		
	CH	Unselct.	Beginning	408		Prod.	Oral	Hmgr.	.24		
	CH	Unselct.	Interm.	428	Blank				.31		
	CH	Unselct.	Interm.	428		Prod.	Oral	Hmgr.	.32		
	CH	Unselct.	Advanced	496	Blank				.38		
	CH	Unselct.	Advanced	496		Prod.	Oral	Hmgr.	.27		
Yeung et al., 2011	CH	Unselct.	Beginning	290	Simple				.21		.15
	CH	Unselct.	Beginning	290		Ident.	Oral	Hmph.	.48		.39
Zhang & McBride-Chang, 2014	CH	Unselct.	Blank	153	Blank				.35		
	CH	Unselct.	Blank	153		Prod.	Oral	Comp.	.51		
Zhou et al., 2012	CH	Unselct.	Preschool	88	Simple				.50		
	CH	Unselct.	Preschool	88		Prod.	Oral	Comp.	.38		
	CH	Unselct.	Preschool	88		Prod.	Oral	Hmph.	.13		

Note. PA = phonological awareness; MA = morphological awareness; EN = English; CH = Chinese; Unselct. = unselected; Interm. = intermediate; Prod. = production; Judg. = judgement; Comp. = compounding; Hmph. = homophone; Hmgr. = homograph.

(*Appendices continue*)

Appendix B

Language Comparisons Within Phonological Awareness and Morphological Awareness (top half) and Meta-Linguistic Awareness Comparisons Within English and Chinese (bottom half) of Partial Correlations

	r-values (95% CI)				
	CH	EN	*r*-values defferences	$Q_{between}$	*p*
Phonological awareness					
Reading accuracy	.198*** [.148, .247]	.424*** [.375, .471]	EN > CH	40.233	<.001
Reading fluency	.159*** [.079, .236]	.404*** [.339, .465]	EN > CH	22.743	<.001
Reading Comprehension	.145*** [.082, .207]	.235*** [.133, .332]	n.s.	2.177	.140
Morphological awareness					
Reading accuracy	.329*** [.280, .376]	.288*** [.238, .336]	n.s.	1.385	.239
Reading fluency	.239** [.106, .365]	.191** [.077, .300]	n.s.	.302	.583
Reading comprehension	.319*** [.262, .374]	.393*** [.312, .468]	n.s.	2.184	.139
	PA	MA			
Chinese					
Reading accuracy	.198*** [.148, .247]	.329*** [.280, .376]	PA < MA	13.771	<.001
Reading fluency	.159*** [.079, .236]	.239** [.106, .365]	n.s.	1.061	.303
Reading comprehension	.145*** [.082, .207]	.319*** [.262, .374]	PA < MA	16.352	<.001
English					
Reading accuracy	.424*** [.375, .471]	.288*** [.238, .336]	PA > MA	15.154	<.001
Reading fluency	.404*** [.339, .465]	.191** [.077, .300]	PA > MA	11.044	.001
Reading comprehension	.235*** [.133, .332]	.393*** [.312, .468]	PA < MA	6.017	.014

Note. CH = Chinese; EN = English; PA = phonological awareness; MA = morphological awareness.
** $p < .01$. *** $p < .001$.

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