**Reading Comprehension and Metalinguistic Knowledge in Chinese Readers: A Meta-analysis**

**Abstract**

Metalinguistic knowledge has a facilitative effect on reading comprehension. This meta-analysis examined the relationship between metalinguistic knowledge and reading comprehension among Chinese students. By focusing on both Chinese and English scripts’ reading comprehension performance, this study synthesized 46 studies with 73 independent samples that represented 10,793 Chinese students from primary school to university levels. We found that, in both Chinese and English scripts’ reading, morphological awareness had the strongest correlation with reading comprehension, whereas both phonological awareness and orthographical skill had a similar medium correlation with reading comprehension. All three metalinguistic knowledge, which was not significantly influenced by the selected moderators of grade group, area, language type, and assessment, had an independent correlation with reading comprehension. The results suggested that reading stages did not significantly impact the function of metalinguistic knowledge on both Chinese and English scripts’ reading comprehension for Chinese students’. In addition, for Chinese students, morphological awareness plays a more important role than phonological awareness and orthographical skill in both Chinese and English scripts’ reading comprehension.

*Keywords*: reading comprehension; metalinguistic knowledge; phonological awareness; morphological awareness; meta-analysis

**Introduction**

Reading comprehension refers to the text mental image construction which comes from the interaction between text content and readers’ cognition process through vocabulary knowledge, inference ability, word reading, working memory and background knowledge (Oakhill, Cain, & Elbro, 2019; Snow, 2002; LervAag, Hulme, & Melby‐Lervåg, 2018). Reading comprehension is the foundation for knowledge acquisition, cultural engagement, and success in workplaces (Cheng *et al*, 2017; Chik *et al*., 2012a; García & Cain, 2014). When engaging in text comprehension activities, readers need more complex cognitive capacity and resources to achieve reading comprehension tasks. Metalinguistic knowledge, also known as “metalinguistic awareness” or “metalinguistic ability” about language, in reading comprehension directly worked on single word or character cognition process. Metalinguistic knowledge refers to the ability to consciously reflect on the nature of language as “knowing about knowing” on words or characters semantic meaning and structure organization identification (Alderson, Clapham, & Steel, 1997; Elder, Warren, Hajek, Manwaring, & Davies, 1999). Regarding single word/ character identification process, past studies mainly investigated the metalinguistic knowledge effect through three perspectives: Morphological awareness (MA), Orthographical skill (OS), and Phonological awareness (PA). Metalinguistic knowledge was regarded as the most powerful tool in basic reading ability measurement which could be used to predict reading comprehension performance among school-aged students through word reading (reading fluency, reading accuracy) and relevant decoding ability such as single word identification (Hoover & Gough, 1990; Tighe, Little, Arrastia-Chisholm, Schatschneider, Diehm, Quinn, & Edwards, 2019). Recently, Castles (2018) revealed that the foundation skill of metalinguistic knowledge might be phonological awareness for alphabetical language. However, Chinese logographic scripts’ reading material has a very different cognition system from alphabetical scripts’ reading material in terms of grammatical knowledge, character structure, and pronunciation rules (Ehrich, Zhang, Mu, & Ehrich, 2013; Tsai, Kuo, Horng, & Chen, 2012). Alphabetical language (e.g., English) followed spelling-to-sound mappings (Zhu, Nie, Chang, Gao, & Niu, 2014), that is most alphabetical languages have a left to right structure of letter strings and use letters mapping on to the phonemes. By contrast, logographic languages (e.g., Chinese) have less information on phonology, the logographic language construction followed the rule of graphic unit of the character rather than phoneme due to the richness of homophones in Chinese (Kuo & Anderson, 2006). Past studies reported the Chinese character syllable represents 3 to 5 morphemes (Chow, McBride-Chang, Cheung, & Chow, 2008). Whether Castles’ (2018) conclusion can be adapt to comprehension texts in logographic scripts, such as Chinese comprehension text, required further investigation. Moreover, little research has been conducted meta-analytic method to investigate the correlation between metalinguistic knowledge and reading comprehension in Chinese students’ whose background was logographical scripts. In addition, reading stage theory suggested students started learning to read at early primary school and started reading to learn when the basic knowledge of reading was obtained, with reading experience increasing, students become more professional in reading to learn at the university level (Chall, 1983). Whether the effects of three metalinguistic knowledge on reading comprehension were the same for Chinese students in different reading stages required further investigation. To fill this gap, this study tries to investigate the correlation between three types of metalinguistic knowledge (PA, OS, MA) and Chinese and English scripts’ reading comprehension in Chinese students.

**Literature Review**

**Metalinguistic Knowledge and Reading Comprehension**

Metalinguistic knowledge was regarded as a prominent feature in cognitive factors to predict reading comprehension performance through decoding and word identification on single word or character cognition process (Hoover & Gough, 1990; Tighe & Schatschneider, 2016). Metalinguistic knowledge, which starts to operate when a child enters the language world, is regarded as meta-cognitive resources for new words or character comprehension (Castles, Rastle, & Nation, 2018). The current study mainly investigated the effect of MA, OS, and PA which were selected by extensive studies as metalinguistic knowledge in the reading field.

**MA**. MA is the ability to manipulate words’ morphemes and the morphological structure (Kuo & Anderson, 2006). Because the majority of word readers encountered in printed school materials are multimorphemic and semantically complex, MA is important for both eastern and western countries’ students to guess word meanings (McBride-Chang et al., 2008; Nagy, Berninger, & Abbott, 2006). For example, a study showed MA of Grade 2 Canadian students significantly predicted their reading comprehension in later study periods, even after taking into account the influences of general intelligence and Grade 2 reading comprehension ability (Deacon & Kirby, 2004). Shu (1997) reported that Chinese students in Grades 3 and 5 could improve reading comprehension performance by improving their radical awareness of morphemes of characters. In both English and Chinese reading comprehension tasks, students who had better word’s radical knowledge resulted in better performance in reading comprehension tasks (Jeon & Yamashita, 2014). MA can enhance word or character recognition rates which are partially known, and thereby expand the range of recognizable words or characters. For example, a study reported Hong Kong students’ Chinese MA predicted their Chinese reading comprehension and students’ English MA predicted English reading comprehension (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). However, past studies showed inconsistent results in the association varies moderate to high between MA and reading comprehension (Shu, 2006; Zhang, 2013).

**PA**. PA is defined as the ability to manipulate the sounds of spoken language (Blachman, Tangel, Ball, & Black, 2019). PA is the reader’s sensitive cognition of the segmentation of sound structures through onset, rhyme, phoneme, and coda. This is a type of metalinguistic awareness that develops in school-aged students (Ziegler & Goswami, 2005). PA is also a great predictor of children’s reading performance in both Chinese and English reading comprehension tasks (Ruan, Georgiou, Song, Li, & Shu, 2018; Tibi & Kirby, 2018). PA contributes to the comprehension of alphabetical writing systems in which target words had predictable graphemes symbolizing phonemes. It also contributes to reading comprehension through various ways of word reading (Engen & Høien, 2002; Melby‐Lervåg & Lervåg, 2011; Nakamoto, Lindsey, & Manis, 2007). Firstly, the blending skill, one ability of PA, aims to transform graphemes into recognizable words (McBride-Chang, Cheung, Chow, Chow, & Choi, 2006). Secondly, onset-rime segmentation and blending skills can help readers with analogy reading. Thirdly, readers need to adapt the rule of graphemes to phonemes in the word for memory requirement (Castles, Rastle & Nation, 2018; Shu, Peng, & McBride-Chang, 2008). To comprehend a text, readers utilize to recognize many text words or characters for effective word reading. For example, a study reported that PA determined the process of Chinese participants' reading comprehension (Chow, McBride-Chang, & Burgess, 2005). However, the correlation between PA and reading comprehension was not consistent. Past studies showed different levels of correlation between PA and reading comprehension in Chinese students, from low to moderate correlation (Chang, 2010; Chen, 2008; Yan, 2007).

**OS**. OS refers to an ability to manipulate the rule of sound-symbol of characters (Koda, 2005; Muroya, Inoue, Hosokawa, Georgiou, Maekawa, & Parrila, 2017) and a sophisticated knowledge to manipulate irregular or infrequent words’ spellings (Jeon & Yamashita, 2014). Previous research tested the unique contribution of OS to reading comprehension (Kato, 2009; Nassaji & Geva, 1999). For example, Kato (2009) found that OS is a predictor of reading comprehension performance in high-ability university-level learners whose second language was English. Meanwhile, research revealed readers’ orthographic sensitivity, developed along with their reading comprehension ability, relied more on OS than PA on the print word(s) process with increasing age (Kato, 2009; Koda, 2007). Regarding Chinese reading comprehension, for example, Ho and Bryant (1997) reported that primary school Chinese readers’ OS levels predicted their reading comprehension performances. However, past results showed varied correlations ranging from low to high between OS and reading comprehension in Chinese participants (Cheung, 2007; Jia, 2015; Xia, 2017).

Given the fact that the correlation picture between three metalinguistic knowledge and reading comprehension was not clear for Chinese students, the meta-analytic method should be applied to address this problem.

**Potential Moderators**

**Grade group.** Reading stage theory suggested the aim of reading was different from primary school students to university students, from learning to read at early primary school grades and transmit to reading to learn in later higher grades’ reading career (Chall, 1983). Previous studies reported that metalinguistic knowledge contributed to students’ reading comprehension since primary school to higher education (Castles, Rastle & Nation, 2018; McGee, Prior, Williams, Smart, & Sanson, 2002; Walley, Metsala & Garlock, 2003). In addition, past meta-analytic review of language learning showed grade group was a significant moderator for reading comprehension ability through different stages of learning period (Lervåg & Aukrust, 2010; Melby-Lervåg & Lervåg, 2014; Schatschneider, Fletcher Francis, Carlson, & Foorman, 2004). Therefore, the grade group was selected as a potential moderator.

**Language type**. The grammatical knowledge for Chinese scripts was different from English scripts in function words sequence (Chen, Lin, Ku, Zhang, & O’Connell, 2018; Cheng *et al*., 2017). Past studies showed differences between logographical scripts (e.g., Chinese) and alphabetical scripts (e.g., English) were phonology, syntax, semantics structure (Connor, 1996; Ehrich, Zhang, Mu, & Ehrich, 2013; Tsai, Kuo, Horng, & Chen, 2012). For example, Chinese scripts had its unique character structure which most characters consisted of a radical part for the semantic function of the character and the object character for pronunciation function (e.g., McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). The differences between Chinese scripts and English scripts may result in different correlations between metalinguistic knowledge and reading comprehension.

**Area.** There are two reasons for selecting the area as a potential moderator. Firstly, the writing version system is different between mainland China (simplified scripts) and Hong Kong and Taiwan (traditional scripts). Gao and Kao (2002) reported that the simplified version has approximately 22.5% fewer strokes than the traditional version. Characters from traditional scripts are more complicated than simplified scripts. Regarding character recognition process, the construction of each character may different between simplified scripts and traditional scripts, which may result students have different performances on MA and OS. Secondly, students from mainland China and Taiwan speak Mandarin, while students from Hong Kong speak Cantonese. It should be noted that the pronunciation for each character is also different, which students’ may have different performances in PA task. In mainland, students are introduced to a Pinyin system which used English letters to represent individual phonemes, however, in Taiwan, students were introduced Zhuyin Fuhao transcribes spoken pronunciation at the onset-rime level.

**Assessment.** A substantial difference of assessment, also called measurement, effects are found between standardized measures and researcher-developed measures (Koretz, 2002; Pike, 1996), which can provide more proximal measures on whether participants are applying the target reading practices that used in their research. For example, Pyle et al. (2017) reported the effect size of comprehension score was larger in researcher-developed measures than standardized measured. Measurement presentation also impacted the results. For example, in PA assessment, the difficulty of tasks was different between visual presentation and auditory presentation due to working memory load (Arrington, Kulesz, Francis, Fletcher, & Barnes, 2014; Friedman, Rapport, Raiker, Orban, & Eckrich, 2017).

**Review on Past Relevant Meta-analysis**

Extensive previous studies reported the effect of metalinguistic knowledge and reading comprehension for participants whose first language was alphabetical language (Bus, 1999; Ehri, Nunes, Stahl, & Willows, 2001; Ehri, Nunes, Willows, Schuster, Yaghoub‐Zadeh, & Shanahan, 2001; Jeon, & Yamashita, 2014; Mayberry, Del Giudice, & Lieberman, 2011; Melby‐Lervåg, & Lervåg, 2011; Melby‐Lervåg & Lervåg, 2014; Swanson, Trainin, Necoechea, & Hammill, 2003). For example, Mayberry’s team (2011) reported PA had a low to moderate correlation with reading comprehension in deaf individuals. Ehri, Nunes, Stahl, and Willows (2001) revealed that the effect size of PA on reading comprehension was moderate. Ehri, Nunes, Stahl, and Willows (2001) found the effect size of PA was larger in preschool than grade 1 of primary school. Moreover, Ehri, Nunes, Stahl, and Willows (2001) showed class size was not a significant moderator for the correlation between PA and reading comprehension. Swanson’s research team (2003) showed that when the extent of the relationship between PA and reading comprehension was moderate, the importance of PA on reading comprehension might be overstated. The correlation between metalinguistic knowledge and reading comprehension was not consistent. Melby‐Lervåg and Lervåg (2011) found the correlation between PA and reading comprehension was a range from low to moderate perspective from the cross-linguistic transfer. Melby-Lervåg and Lervåg (2014) reported the correlation effect size between PA and reading comprehension was large in L2 condition. Jeon and Yamashita (2014) reported the correlation between L2 reading comprehension and metalinguistic knowledge was low.

Only a few studies reported the correlation for participants whose first language background was logographical language (e.g., Chinese). Tan, Laird, Li, and Fox (2005) synthesized the correlation between PA on brain reading mappings, a higher correlation was found in L2 alphabetic language for Chinese participants. Song, Georgiou, Su, and Hua (2016) reported the PA had medium correlation with L2 reading in Chinese students. Ruan, Georgiou, Song, and Shu (2018) reported the MA had stronger correlation with reading comprehension than PA in Chinese reading comprehension, but they did not solve the significant heterogeneity problem which resulted a challenged conclusion. In addition, past studies had two obvious limitations. Firstly, past studies synthesized the correlation between metalinguistic knowledge and L2 reading comprehension, less studies investigated the effect size of metalinguistic knowledge on Chinese (L1) reading comprehension. Secondly, past studies only reported single factor’s (e.g., PA) effect size on reading comprehension, a few studies investigated and compared the effect size of MA, PA, and OS on reading comprehension. That is, a few studies written in either English or Chinese have attempted an investigation of the correlation between each metalinguistic knowledge (MA, PA, OS) and reading comprehension for Chinese students over the past few decades.

**Rationale for This Meta-analysis**

This study has outlined a range of potential moderators (Grade group, language type, area, and assessment) that might influence the strength of the correlation between metalinguistic knowledge and reading comprehension. Firstly, it would be difficult to take into account all these selected moderators in a single study. For example, the interaction effect of grade group on the correlation between three selected metalinguistic knowledge and reading comprehension could not be calculated in one empirical study. The available solution here is to conduct a meta-analysis to investigate the interaction effect across all possible grade groups. Secondly, the various correlations between selected metalinguistic knowledge and reading comprehension in past empirical studies, this meta-analytic approach enables us to integrate the various results through various samples and research designs.

**The Current Meta-analysis**

The current study expands the current literature to investigate the correlation between metalinguistic knowledge and reading comprehension in three ways. First, it is the only review using a meta-analytic approach to explore the effect of metalinguistic knowledge on reading comprehension for primary school, secondary school, and university Chinese students. Second, the current study investigated the effect of metalinguistic knowledge on Chinese students’ reading comprehension, whose L1 was a logographical language that is fundamentally different from the alphabetical language. In addition, the current study investigated the three popular metalinguistic knowledge (MA, OS, and PA) correlation with reading comprehension and further explored the reading stage’s effect contribution between metalinguistic knowledge and reading comprehension in Chinese students.

**Methods**

The official guidance of *PRISMA* was applied to the current method. *PRISMA* provided the detailed information for meta-analysis, included literature base, inclusion criteria, coding process, and meta-analytic procedure. PRISMA also provided the suggestions on data analysis, such as the risk of bias in individual studies.

**Literature Base**

All possible materials were related to Chinese students’ reading comprehension research. Publications, including dissertations, journal articles, and thesis, were written in Chinese and English, were all included in the database. This study searched English literature from PsycINFO, ERIC and Pro-Quest, and Chinese literature from the CNKI database which included all possible academic materials around China. Two groups of key words were used when searching for target studies. The first group related to metalinguistic knowledge: morphological awareness\*, morpheme discrimination\*, compound structure\*, meaning selection\*, radical identification\*, radical meaning\*, radical discrimination\*, morpheme\*, phonological awareness\*, onset detection\*, tone discrimination\*, phoneme\*, rhyme awareness\*, blending\*, orthographic\*, orthographic awareness\*, position awareness\*, and phonological awareness\*. The second group includes reading comprehension (sentence comprehension\*, paragraph comprehension\*, passage comprehension\*, text comprehension\*, reading comprehension\*, reading ability\*, comprehension ability\*, and reading acquisition\*). We selected all possible materials from between January 1st of 1998 and March 31th of 2019. As a result, yielding 1105 articles.

**Inclusion Criteria**

Materials were discarded when they have any of the following features: (a) single case studies; (b) opinion or non-empirical articles; (c) participants were not Chinese students; (d) participants were diagnosed with serious special education needs (e.g., deaf, blind); (e) qualitative research design; (f) participants’ grade group was not clear or grade group was not independent; (g) if the research reported participants’ second language acquisition, the second language was not English; and (h) the first language of participants was not Chinese. In addition, we only included materials with the following required information: (a) materials provided the necessarily available correlation scores between reading comprehension and metalinguistic knowledge; (b) all possible indicators (e.g., sample size, *r*, *R*2, *t*-value and *p*-value) which could be used to measure the correlation effect size Fisher’s *z*; (c) all participants were primary school students, secondary school students, and college or university students; and (d) both metalinguistic knowledge and reading comprehension should be measured at the same time, because we wanted to report the current correlation. This inclusion criterion was applied to research with students rather than working professionals because García and Cain (2014) revealed that working professionals would not improve their reading competencies as quick as students. Due to the majority of Chinese participants started doing formal reading comprehension tasks since grade 1, we removed those studies which reported the correlation before grade 1.

**Coding Process**

Two independent coders coded materials through (a) year of publication, (b) first author’s surname, (c) area (Mainland, Hong Kong, Taiwan or other countries), (d) materials resources (written in Chinese or English), (e) sample size, (f) grade group, according to reading stage theory suggestion, from learning to learn to be professional in reading to learn, the current study divided students’ grade group into five grade groups: (1) *L* for grade 1 and grade 2 of primary school, *M* for grade 3 and grade 4 of primary school, *H* for grade 5 and grade 6 of primary school, *S* for secondary school, *U* for college and university students; (g) language type (L1 or L2), and (h) the effect size of Fisher’s *z*. Any unclear information would be confirmed by the articles’ author(s). If the study provided the correlation indicator in both standardized test and researcher-developed test, we reported the indicator from the standardized test. If one study provided more than one available effect sizes between one type of metalinguistic knowledge and reading comprehension (e.g., MA-reading comprehension), we followed the cluster regression method to calculate the unique effect size of the study (Hedges, Tipton, & Johnson, 2010; Tanner-Smith, Tipton, & Polanin, 2016), ensuring each study only provided one effect size for meta-analysis. If one article provided the correlation through different metalinguistic knowledge, for example, one study provided two correlations (MA-reading comprehension and PA-reading comprehension) at the same time, we treated this article as two independent studies. If one article provided the correlation between metalinguistic knowledge and reading comprehension through mixed-grade groups, the author(s) were contacted for clear details, this study removed those articles which the key indicators were not clear (e.g., grade group, language type, metalinguistic knowledge type).

Two coders coded materials independently. The first-round results of coding similarity ranged between 77% and 100% across all selected materials. The differences came from the sampling area, through contacting authors, two coders got consensus results on the sampling area.

**Meta-analytic Procedures**

There were eight outliers, correlations greater than 2.5 standard deviations from the mean (García & Cain, 2014), specifically, all outliers came from the correlation studies between MA and reading comprehension, this study removed two studies from Catherine (*No*.20a and *No*. 20b), two studies from Chen Jing (*No*.21 and *No*.47), two studies from Katie (*No*.52a and *No*. 52b), and two studies from Zhang Dongbo (*No*. 15 and *No*. 38), resulting in a final number of 46 articles with 73 independent studies (total *N* = 10793). This study followed the analytic procedures by Mol and Bus (2011). All correlation indicators were entered into Comprehension Meta-analysis to transform into Fisher’s *z*. We selected Fisher’s *z* as effect size because the variance of *z*’ is approximately constant, whereas the variance of the correlation follows an asymmetrical distribution (Borenstein, Hedges, Higgins, & Rothstein, 2009). According to Cohen (1988) interpretation on Fisher’s *z*, a Fisher’s *z* value of .10 (*r* = .10) can be interpreted as a small effect size, .31 (*r* = .30) as moderate, and .55 (*r* = .50) as large.

This study regarded Gates–MacGinitie Reading Test (GMRT), Lowa Tests of Basic Skills (ITBS), Group Reading Assessment and Diagnostic Evaluation (GRADE), Diagnostic Reading Analysis (DRA), Gray Oral Reading Test (GORT), Woodcock Reading Mastery Test (WRMT), Woodcock Language Proficiency Battery (WLPB), and Woodcock–Johnson Test of Achievement (WJ). Other measurements of reading comprehension were regarded as researcher-developed tests. This study regarded Morpheme production, Morpheme judgment as the standardized test for MA, Phoneme deletion, Onset/rime/tone judgment as the standardized test for PA, all measurement for OS was regarded as the researcher-developed test.

To be conservative, the random-effects model was used to measure the effect size (Borenstein, Hedges, Higgins, & Rothstein, 2009). This study also reported the 95% confidence interval (CI) and regarded those estimations as significant if CI did not include zero. Moderator analysis performed for significant *Q* value if the analysis group contained more than four studies (Mol & Bus, 2011). If the moderator analysis performed insignificant *Q* value, that could be interpreted as the meta-correlation was not interacted significantly with other potential moderators.

To compare effect sizes, this study applied *Teta* as an indicator, where if |*Teta*| ≥ 1.96, the two effect sizes were regarded as significantly different. *Teta* was measured by following: *Teta* = *Diff* / *SE*, *Diff* = Fisher’s z1 - Fisher’s z2, *SE* = sqrt (Variance Fisher’s z1 + Variance Fisher’s z2).

This study reported publication bias through four ways: Rosenthal’s fail-safe number, funnel plot, rank correlation test, and regression intercept test. Rosenthal’s fail-safe number, which showed the number of missing studies with null effects that would make the previous correlations become insignificant (Borenstein *et al*., 2009). We used a trim-and-fill approach to show the funnel plot of adjusted effect sizes.

**Results**

The results of the meta-analyses are presented in three sections. First, descriptive analysis (see table1). Second, interrelations between reading comprehension achievement and metalinguistic knowledge were explored in 3 subgroups (MA, PA, and OS). Third, this study compared the effect sizes of the three metalinguistic factors.

**Overview of Studies**

The majority (26) of the articles used a correlational design. 26 studies reported the correlation between metalinguistic knowledge and English reading comprehension, 47 studies reported the correlation between metalinguistic knowledge and Chinese reading comprehension. 16 studies reported the correlation between metalinguistic knowledge and reading comprehension in *L* grade group, 15 studies reported the correlation in *M* grade group, 24 studies reported the correlation in *H* grade group, 8 studies reported the correlation in *S* grade group, and 10 studies reported the correlation in U grade group. This study included all kinds of analytical methods in this review, aiming to investigate relationships between variables. More specific, 6 studies used longitudinal design and one article used experimental design. 61 studies reported the correlation between MA and reading comprehension. 22 studies revealed the correlation between PA and reading comprehension. 15 studies revealed the correlation between OS and reading comprehension. All details can be found in Table 1.

**Meta-analysis**

Table 2 demonstrated that the correlation between OS and reading comprehension was moderate (Fisher’s *z* = .37), and no selected moderators had any significant interactive effect (*Q* = 16.21, *p* > .05) on this correlation. The correlation between PA and reading comprehension was moderate (Fisher’s *z* = .33), and no significant moderators which were selected in the current study had any significant interaction (*Q* = 18.35, *p* > .05) with this correlation. The correlation between MA and reading comprehension achievement was large (Fisher’s *z* = .49), and no selected moderator had any significant interaction effect (*Q* = 50.99, *p* > .05) on this correlation.

Regarding correlation comparison, the difference between OS and PA was not significant (*Teta* < 1.96), yet the difference between OS and MA was considerable (*Teta* = 3.08, *p* < .01). The difference between MA and PA was significant (*Teta* = 9.90, *p* < .001).

**Discussion**

The current empirical review had two main findings. Firstly, for Chinese primary, secondary, and university students, the correlation between each category of metalinguistic knowledge (MA, OS, or PA) and reading comprehension was independent and was not moderated significantly by selected moderators, implicating reading stages’ effect was not significant between metalinguistic knowledge and reading comprehension in Chinese students. Secondly, for Chinese students, the MA had a significantly higher correlation with reading comprehension than PA and OS in both Chinese scripts text reading and English scripts text reading.

**MA Effect in Chinese Students**

The current meta-analytic review presents a different conclusion in Castles’ (2018) opinion which claimed the phonological awareness played the most important role on word identification and cognition process in English scripts reading comprehension for those students who regarded the alphabetical language as the first language, namely that for Chinese students, the morphological awareness had a larger effect size than phonological awareness in both Chinese and English reading comprehension scripts. This reinforces the argument put forward by several researchers that MA is fundamental to word reading in Chinese participants (e.g., Ruan, Georgiou, Song, Li, & Shu,, 2018; Song, Georgiou, Su, & Hua, 2016). The reason should be the morpho syllabic nature of the Chinese writing system (Cheng, Zhang, Wu, Liu, & Li, 2016), a great number of Chinese words with meanings that can be inferred from their morphemes. This means even though the readers may not know how to pronounce the morphemes accurately, they can guess the character's semantic meaning from its morpheme. For example, Zhang (2017) found that MA enhanced Chinese learners to understand the unfamiliar words through intro-word morphological properties during textual reading. Chung and Leung (2008) reported a very low percentage (approximately 25%) of Chinese characters with a regular phonetic radical, readers did not process effectively the target character through the phonetic radical, the importance of PA in Chinese students might downgrade. The second reason that MA had a larger correlation with reading comprehension achievement is the training system of Chinese students. For example, young Chinese students, without any phonetic transcription at the beginning, were suggested to focus on holistic character reading (Tong, 2009). Students developed graph morphological awareness on text comprehension because Chinese semantic radicals encode target characters’ meaning. The learning strategy would transfer to L2 learning. Even though English reading comprehension consists of a series of alphabets, most students still apply the learning strategy of Chinese when they learn English. They recognize English words by guessing the meaning of each morpheme, such as the affix “re-” represented the semantic meaning “repeated”. When readers processed the new words from the text, they would first try to find the stem of the target word and then guess its meaning.

**PA and OS Effect in Chinese Students**

Both PA and OS had a medium correlation with reading comprehension in Chinese students’ text reading comprehension performance. Firstly, the significant medium correlation between PA and reading comprehension was consistent with Song, Georgiou, Su, and Hua’s (2016) study, suggesting the phonetic radical of characters provided some clues for readers to process the characters’ semantic meaning. The moderate correlation effect size between PA and reading comprehension for Chinese students may come from the first language background, that is the percentage of Chinese characters’ pronunciation matched phonetic radical was very low (Chung & Leung, 2008), students did not use PA on word semantic meaning process as frequently as MA, resulting the smaller correlation between PA and reading comprehension than MA in Chinese students. Secondly, PA and OS had the similar correlation effect size with reading comprehension. This finding was consistent with Koda's (2005) hypothesis, which posited that the OS was a complex system with a basic knowledge of the sound-symbol relationship. Previous studies confirmed OS has a close relationship with PA since researchers have reported that readers’ OS development relies on their PA development (e.g., Ehri, 2017). For example, the letter-sound spellings rule of PA was considered to help students write words through retrieve spellings’ form (phonemic segmentation skill) from memory (Griffith, 1991), namely that PA helps readers to develop their knowledge of the target language characters' position. Similar results also confirmed the very close relationship between OS and PA.

**Reading Comprehension** **and Metalinguistic Knowledge**

The current study provided evidence that MA, PA, and OS showed an independent correlation with reading comprehension achievement which did not interact with any significant moderators. The effect of the reading stage was not been significantly found in the current study. The result of the MA correlation was large and not moderated by any language type in Chinese participants, no matter in Chinese or English scripts’ reading comprehension. The major reason should be the requirement of the reading task. Participants were required to do a silent reading task, in which MA played a major role during the cognition progress through single character or word semantic meaning inference. Another reason is due to the participants’ cognitive styles of understanding logographic Chinese, which is based on MA that is taught by their teachers. Therefore, Chinese participants may still tend to use MA to do comprehension tasks in both Chinese and English scripts, no matter in which reading stages. This result supported the Seidenberg (2011) statement of same set of mapping rules between speaking and writing on word semantic meaning identification for Chinese readers. That is the basic graphic unit of the character which represents a morpheme (not a phoneme) determined Chinese character cognition process. An alternative reason should be richness of homophones in Chinese characters (Chow, McBride-Chang, Cheung, & Chow, 2008; Kuo & Anderson, 2006), students did not distinguish and identify words with the same pronunciation by simply relying on PA, which means the spelling-to-sound mappings was not applicable for Chinese reading comprehension. In contrast, most Chinese characters semantic meaning was identified from the regular and informative morphemes, therefore, Chinese readers tend to rely more on MA on target character or word cognition (Ruan, Georgiou, Song, Li, & Shu, 2018; Tong, Deacon, Kirby, Cain, & Parrila, 2011).

The current result demonstrated that the PA was not checked by any significant moderators. This finding was different from the findings by Mayberry, Del Giudice and Lieberman (2011) and Swanson, Trainin, Necoechea, and Hammill (2003), who showed that grade group moderated the correlation between PA and reading comprehension achievement. The reason may be due to the linguistic characteristics of the target text, which were available in one alphabetical script (spelling-to-sound mappings), in particular, little PA could be used in Chinese scripts’ text comprehension task. Because of this, the transfer effect of MA may occur when they switch from Chinese reading comprehension to English reading comprehension. That is to say, the amount of PA knowledge (i.e. grammar, component combination rules) which could apply to Chinese students’ reading comprehension performance is limited. The independent effect of metalinguistic knowledge on reading comprehension tasks for Chinese students, informing the function of metalinguistic knowledge on text comprehension were word identification and word recognition only for text comprehension process, the aim of different reading stages did not impact the contribution of metalinguistic knowledge on reading comprehension.

**Limitations and Implications**

The current study has several limitations. First, the participants are typically-developing school students, while those who had special education needs (e.g., deaf) were not reported. Second, this study only included studies focusing on English and Chinese reading comprehension for Chinese students. Thus, studies of reading comprehension in other target languages were not reported. Moderator analysis showed the correlation between metalinguistic knowledge and reading comprehension was not significantly moderated by other comprehension factors, indicating that in any grade group or language type (Chinese or English scripts’ reading), reading comprehension ability could be predicted by metalinguistic knowledge. Secondly, since MA played the most important role in reading comprehension of the three metalinguistic knowledge, future intervention studies should pay more attention to MA training to improve Chinese students’ reading comprehension performance.

**Conclusion**

Based on the combined results of 73 independent studies conducted with 10,793 students, this meta-analysis has shown that the correlation between the three types of metalinguistic knowledge and reading comprehension was not moderated significantly by moderators. MA has a larger correlational effect than PA and OS on reading comprehension in Chinese students. PA and OS shared similar effects on reading comprehension achievement in Chinese students. The results highlighted the different effects of metalinguistic knowledge in Chinese and English reading comprehension among Chinese students in all grade groups. In addition, given the fact that grade group did not have any significant moderating effect, implicating reading stages did not impact the function of metalinguistic knowledge on text reading comprehension for Chinese students’ Chinese or English scripts’ reading.

**References**

Alderson, J. C., Clapham, C., & Steel, D. (1997). Metalinguistic knowledge, language aptitude and language proficiency. *Language Teaching Research*, *1*(2), 93-121.

Arrington, C. N., Kulesz, P. A., Francis, D. J., Fletcher, J. M., & Barnes, M. A. (2014). The contribution of attentional control and working memory to reading comprehension and decoding. *Scientific Studies of Reading*, *18*(5), 325–346.

\*Bai, L, M. (2002). The Roles of Breadth and Depth of Vocabulary Knowledge in Reading Comprehension (Master dissertation, Northwest Normal University)

Bus, A. G., & Van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology*, *91*(3), 403-414.

\*Bian, X. (2017). Morphological Awareness and Advanced EFL Learners’ Listening Comprehension.

Blachman, B. A., Tangel, D. M., Ball, E. W., & Black, R. (2019). Combining phonological awareness and word recognition instruction. *Perspectives on Language and Literacy*, *45*(2), 19-22.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). Converting among effect sizes. *Introduction to Meta-Analysis*, 45-49.

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*(1), 5-51.

Chall, J. (1983). *Stages of reading development*. New York, NY: McGrawHill.

\*Chang, Y. (2010). The Relationship between English Children's English Morpheme Consciousness and Reading Learning. *Journal of Inner Mongolia Normal University (Educational Science)*, (4), 103-107.

\*Chang, Y., Li, B, Y., & Wu, J, H. (2014). The effect of morpheme awareness training on improving college students' English reading ability. *Journal of Inner Mongolia Normal University (Educational Science)*, (3), 117-119.

\*Chen, B, G., & Chen, Y, L. (2008). The Relationships of Primary School Students’ Syntactic Awareness and Phonological Awareness with Their Performance of Reading Comprehension. *Journal of Psychological Science*, (04), 892-895.

\*Chen, J. (2015). *Character, Word, and Student Characteristics Contributing to Concept of Word in Chinese: Cross-Classified Multilevel Logistic Models* (Doctoral dissertation, The Ohio State University).

\*Chen, J., Lin, T. J., Ku, Y. M., Zhang, J., & O’Connell, A. (2018). Reader, Word, and Character Attributes Contributing to Chinese Children’s Concept of Word. *Scientific Studies of Reading*, 1-16.

\*Chen, P, R. (2011). The Characteristics of the Development of Chinese Morpheme Consciousness among High School Children and Their Relationship with Reading Comprehension (Master dissertation, Shaanxi Normal University).

\*Cheng, Y., Zhang, J., Li, H., Wu, X., Liu, H., Dong, Q., ... & Sun, P. (2017). Growth of compounding awareness predicts reading comprehension in Young Chinese students: A longitudinal study from Grade 1 to Grade 2. *Reading Research Quarterly*, *52*(1), 91-104.

\*Cheng, Y., Zhang, J., Wu, X., Liu, H., & Li, H. (2016). Cross-lagged relationships between morphological awareness and reading comprehension among Chinese children. *Frontiers in Psychology*, *7*, 1379-1291.

\*Cheung, H., Chan, M., & Chong, K. (2007). Use of Orthographic Knowledge in Reading by Chinese‐English Bi‐scriptal Children. *Language Learning*, *57*(3), 469-505.

\*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. (2012a). Syntactic skills in sentence reading comprehension among Chinese elementary school children. *Reading and Writing*, *25*(3), 679-699.

\*Chik, P. P. M., Ho, C. S. H., Yeung, P. S., Wong, Y. K., Chan, D. W. O., Chung, K. K. H., & Lo, L. Y. (2012b). Contribution of discourse and morphosyntax skills to reading comprehension in Chinese dyslexic and typically developing children. *Annals of Dyslexia*, *62*(1), 1-18.

Chow, B. W. Y., McBride-Chang, C., & Burgess, S. (2005). Phonological Processing Skills and Early Reading Abilities in Hong Kong Chinese Kindergarteners Learning to Read English as a Second Language. *Journal of Educational Psychology*, *97*(1), 81-87.

Chow, B. W. Y., McBride-Chang, C., Cheung, H., & Chow, C. S. L. (2008). Dialogic reading and morphology training in Chinese children: Effects on language and literacy. *Developmental Psychology*, *44*(1), 233-244.

Chung, F. H. K., & 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*(4-5), 379-389.

\*Chung, K. K., Ho, C. S. H., Chan, D. W., Tsang, S. M., & Lee, S. H. (2011). Cognitive skills and literacy performance of Chinese adolescents with and without dyslexia. *Reading and Writing*, *24*(7), 835-859.

\*Chung, K. K., Ho, C. S. H., Chan, D. W., Tsang, S. M., & Lee, S. H. (2013). Contributions of syntactic awareness to reading in Chinese‐speaking adolescent readers with and without dyslexia. *Dyslexia*, *19*(1), 11-36.

Connor, U., & Connor, U. M. (1996). *Contrastive rhetoric: Cross-cultural aspects of second language writing*. Cambridge University Press.

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*(2), 223-238.

Ehri, L. C. (2017). Reconceptualizing the development of sight word reading and its relationship to recoding. In *Reading Acquisition* (pp. 107-143). Routledge.

Ehri, L. C., Nunes, S. R., Stahl, S. A., & Willows, D. M. (2001a). Systematic phonics instruction helps students learn to read: Evidence from the National Reading Panel’s meta-analysis. *Review of Educational Research*, *71*(3), 393-447.

Ehri, L. C., Nunes, S. R., Willows, D. M., Schuster, B. V., Yaghoub‐Zadeh, Z., & Shanahan, T. (2001b). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta‐analysis. *Reading Research Quarterly*, *36*(3), 250-287.

Ehrich, J. F., Zhang, L. J., Mu, J. C., & Ehrich, L. C. (2013). Are alphabetic language-derived models of L2 reading relevant to L1 logographic background readers?. *Language Awareness*, *22*(1), 39-55.

Elder, C., Warren, J., Hajek, J., Manwaring, D., & Davies, A. (1999). Metalinguistic knowledge. *Australian Review of Applied Linguistics*, *22*(1), 81-95.

Engen, L., & Høien, T. (2002). Phonological skills and reading comprehension. *Reading and Writing*, *15*(7-8), 613-631.

Friedman, L. M., Rapport, M. D., Raiker, J. S., Orban, S. A., & Eckrich, S. J. (2017). Reading comprehension in boys with ADHD: The mediating roles of working memory and orthographic conversion. *Journal of Abnormal Child Psychology*, *45*(2), 273–287.

Gao, D. G., & Kao, H. S. (2002). Psycho-geometric analysis of commonly used Chinese characters. *Cognitive neuroscience studies of the Chinese language*, 195-206.

García, J. R., & Cain, K. (2014). Decoding and reading comprehension: A meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research*, *84*(1), 74-111.

Griffith, P. L. (1991). Phonemic awareness helps first graders invent spellings and third graders remember correct spellings. *Journal of Reading Behavior*, *23*(2), 215-233.

\*Guan, C. Q., Ye, F., Meng, W., & Leong, C. K. (2013). Are poor Chinese text comprehenders also poor in written composition?. *Annals of dyslexia*, *63*(3-4), 217-238.Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127-160.

\*Guan, C. Q., Ye, F., Wagner, R. K., Leong, C. K., & Meng, W. J. (2014a). Reading mediates the roles of morphological awareness, syntactic processing, and working memory in accounting for individual differences in Chinese written composition. *Journal of Educational Psychology*. 3-50.

\*Guan, C. Q., Ye, F., Wagner, R. K., Meng, W., & Leong, C. K. (2014b). Text comprehension mediates morphological awareness, syntactic processing, and working memory in predicting Chinese written composition performance. *Journal of Educational Psychology*, *106*(3), 779-798.

Hedges, L. V., Tipton, E., & Johnson, M. C. (2010). Robust variance estimation in meta‐regression with dependent effect size estimates. *Research synthesis methods*, *1*(1), 39-65.

Ho, C. S. H., & Bryant, P. (1997). Learning to read Chinese beyond the logographic phase. *Reading Research Quarterly*, *32*(3), 276-289.

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and writing*, *2*(2), 127-160.

\*Jia, Y, N. (2015). A Study of the Correlation between English Majors’ Lexical Quality and Reading Comprehension Proficiency (Master dissertation, Shenyang Normal University).

Jeon, E. H., & Yamashita, J. (2014). L2 Reading comprehension and its correlates: A meta‐analysis. *Language Learning*, *64*(1), 160-212.

Kato, S. (2009). Suppressing inner speech in ESL reading: Implications for developmental changes in second language word recognition processes. *The Modern Language Journal*, *93*(4), 471-488.

Koda, K. (2005). *Insights into second language reading: A cross-linguistic approach*. Cambridge University Press.

Koda, K. (2007). Reading and language learning: Crosslinguistic constraints on second language reading development. *Language Learning*, *57*(s1), 1-44.

Koretz, D. (2002). Limitations in the use of achievement tests as measures of educators' productivity. *Journal of Human Resources*, *37*(4), 752-777.

Kuo, L. J., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist*, *41*(3), 161-180.

\*Lam, K., Chen, X., Geva, E., Luo, Y. C., & Li, H. (2012). The role of morphological awareness in reading achievement among young Chinese-speaking English language learners: A longitudinal study. *Reading and Writing*, *25*(8), 1847-1872.

\*Leong, C. K., & Ho, M. K. (2012). Training orthographic and sentence structures helps poor readers in Chinese. *International Journal of Disability, Development and Education*, *59*(4), 359-378.

\*Leong, C. K., Ho, M. K., Chang, J., & Hau, K. T. (2013). Differential importance of language components in determining secondary school students’ Chinese reading literacy performance. *Language Testing*, *30*(4), 419-439.

\*Leong, C. K., Tse, S. K., Loh, K. Y., & Ki, W. W. (2011). Orthographic knowledge important in comprehending elementary Chinese text by users of alphasyllabaries. *Reading Psychology*, *32*(3), 237-271.

Lervåg, A., & Aukrust, V. G. (2010). Vocabulary knowledge is a critical determinant of the difference in reading comprehension growth between first and second language learners. *Journal of Child Psychology and Psychiatry*, *51*(5), 612-620.

LervAag, A., Hulme, C., & Melby‐Lervåg, M. (2018). Unpicking the developmental relationship between oral language skills and reading comprehension: It's simple, but complex. *Child Development*, *89*(5), 1821-1838.

\*Lin, X. (2015). Direct and Indirect Effects of Morphological Awareness on Reading Comprehension of Chinese EFL Learners in Senior High Schools (Master dissertation, Fujian Normal University).

\*Lu, M. & Zhang, H. (2015). The correlation among metalinguistic, vocabulary knowledge and reading comprehension in middle school students. *Journal of PLA University of Foreign Languages*, *38*(4), 74-80.

\*Ma, Y. H., & Lin, W. Y. (2015). A study on the relationship between English reading comprehension and English vocabulary knowledge. *Education Research International*, *2015*. 1-14.

Mayberry, R. I., Del Giudice, A. A., & Lieberman, A. M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *The Journal of Deaf Studies and Deaf Education*, *16*(2), 164-188.

McBride-Chang, C., Cheung, H., Chow, B. Y., Chow, C. L., & Choi, L. (2006). Metalinguistic skills and vocabulary knowledge in Chinese (L1) and English (L2). *Reading and Writing*, *19*(7), 695-716.

McBride-Chang, C., Chow, B. W., Zhong, Y., Burgess, S., & Hayward, W. G. (2005). Chinese character acquisition and visual skills in two Chinese scripts. *Reading and Writing*, *18*(2), 99-128.

McBride-Chang, C., Shu, H., Zhou, A., Wat, C. P., & Wagner, R. K. (2003). Morphological awareness uniquely predicts young children's Chinese character recognition. *Journal of Educational Psychology*, *95*(4), 743-751.

McBride-Chang, C., Tardif, T., Cho, J. R., Shu, H. U. A., Fletcher, P., Stokes, S. F., ... & Leung, K. (2008). What's in a word? Morphological awareness and vocabulary knowledge in three languages. *Applied Psycholinguistics*, *29*(3), 437-462.

McGee, R., Prior, M., Williams, S., Smart, D., & Sanson, A. (2002). The long‐term significance of teacher‐rated hyperactivity and reading ability in childhood: findings from two longitudinal studies. *Journal of Child Psychology and Psychiatry*, *43*(8), 1004-1017.

Melby‐Lervåg, M., & Lervåg, A. (2011). Cross‐linguistic transfer of oral language, decoding, phonological awareness and reading comprehension: A meta‐analysis of the correlational evidence. *Journal of Research in Reading*, *34*(1), 114-135.

Melby-Lervåg, M., & Lervåg, A. (2014). Reading comprehension and its underlying components in second-language learners: A meta-analysis of studies comparing first-and second-language learners. *Psychological Bulletin*, *140*(2), 409-433.

Moher, D., Liberati A., Tetzlaff, J., Altman, D.G., Group, P. (2010). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg*, *8*(5):336–341. doi:10.1016/j. ijsu.2010.02.007

Mol, S. E., & Bus, A. G. (2011). To read or not to read: a meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, *137*(2), 267-296.

Muroya, N., Inoue, T., Hosokawa, M., Georgiou, G. K., Maekawa, H., & Parrila, R. (2017). The role of morphological awareness in word reading skills in Japanese: a within-language cross-orthographic perspective. *Scientific Studies of Reading*, *21*(6), 449-462.

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*(1), 134-147.

Nakamoto, J., Lindsey, K. A., & Manis, F. R. (2007). A longitudinal analysis of English language learners’ word decoding and reading comprehension. *Reading and Writing*, *20*(7), 691-719.

Nassaji, H., & Geva, E. (1999). The contribution of phonological and orthographic processing skills to adult ESL reading: Evidence from native speakers of Farsi. *Applied Psycholinguistics*, *20*(2), 241-267.

\*Pan, J., Song, S., Su, M., McBride, C., Liu, H., Zhang, Y., ... & Shu, H. (2016). On the relationship between phonological awareness, morphological awareness and Chinese literacy skills: evidence from an 8‐year longitudinal study. *Developmental Science*, *19*(6), 982-991.

Pike, G. R. (1996). Limitations of using students' self-reports of academic development as proxies for traditional achievement measures. *Research in Higher Education*, *37*(1), 89-114.

Pyle, N., Vasquez, A. C., Lignugaris, B., Gillam, S. L., Reutzel, D. R., Olszewski, A., ... & Pyle, D. (2017). Effects of expository text structure interventions on comprehension: A meta‐analysis. *Reading Research Quarterly*, *52*(4), 469-501.

Ruan, Y., Georgiou, G. K., Song, S., Li, Y., & Shu, H. (2018). Does writing system influence the associations between phonological awareness, morphological awareness, and reading? A meta-analysis. *Journal of Educational Psychology*, *110*(2), 180-202.

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology*, *96*(2), 265-282.

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.

Shu, H., & Anderson, R. C. (1997). Role of radical awareness in the character and word acquisition of Chinese children. *Reading Research Quarterly*, *32*(1), 78-89.

\*Shu, H., McBride-Chang, C., Wu, S., & Liu, H. (2006). Understanding chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology*, *98*(1), 122-133.

Shu, H., Peng, H., & McBride‐Chang, C. (2008). Phonological awareness in young Chinese children. *Developmental Science*, *11*(1), 171-181.

\*Siu, C. T. S., & Ho, C. S. H. (2015). Cross‐Language Transfer of Syntactic Skills and Reading Comprehension Among Young Cantonese–English Bilingual Students. *Reading Research Quarterly*, *50*(3), 313-336.

\*Siu, C. T. S., Ho, C. S. H., Chan, D. W. O., & Chung, K. K. H. (2016). Development of word order and morphosyntactic skills in reading comprehension among Chinese elementary school children. *Learning and Individual Differences*, *47*, 61-69.

Snow, C. (2002). *Reading for understanding: Toward an R&D program in reading comprehension.* Arlington, VA: Rand Corporation

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*(2), 99-123.

\*Sun, B., Zhou, H., & Zhu, B. (2013). Effects of English phonological awareness training on Chinese child EFL learners' literacy development. *Canadian Social Science*, *9*(1), 56-64.

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*(4), 407-440.

Tan, L. H., Laird, A. R., Li, K., & Fox, P. T. (2005). Neuroanatomical correlates of phonological processing of Chinese characters and alphabetic words: A meta‐analysis. *Human Brain Mapping*, *25*(1), 83-91.

Tanner-Smith, E. E., Tipton, E., & Polanin, J. R. (2016). Handling complex meta-analytic data structures using robust variance estimates: A tutorial in R. *Journal of Developmental and Life-Course Criminology*, *2*(1), 85-112.

Tibi, S., & Kirby, J. R. (2018). Investigating phonological awareness and naming speed as predictors of reading in Arabic. *Scientific Studies of Reading*, *22*(1), 70-84.

Tighe, E. L., Little, C. W., Arrastia-Chisholm, M. C., Schatschneider, C., Diehm, E., Quinn, J. M., & Edwards, A. A. (2019). Assessing the direct and indirect effects of metalinguistic awareness to the reading comprehension skills of struggling adult readers. *Reading and Writing*, *32*(3), 787-818.

Tighe, E. L., & Schatschneider, C. (2016). Examining the relationships of component reading skills to reading comprehension in struggling adult readers: A meta-analysis. *Journal of Learning Disabilities*, *49*(4), 395-409.

\*To, N. L., Tighe, E. L., & Binder, K. S. (2016). Investigating morphological awareness and the processing of transparent and opaque words in adults with low literacy skills and in skilled readers. *Journal of Research in Reading*, *39*(2), 171-188.

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*(3), 523-534.

\*Tong, X., McBride-Chang, C., Shu, H., & Wong, A. M. (2009). Morphological awareness, orthographic knowledge, and spelling errors: Keys to understanding early Chinese literacy acquisition. *Scientific Studies of Reading*, *13*(5), 426-452.

Tsai, C. H., Kuo, C. H., Horng, W. B., & Chen, C. W. (2012). Effects on learning logographic character formation in computer-assisted handwriting instruction. *Language Learning & Technology*, *16*(1), 110-130.

Tsung, L., Zhang, L., Hau, K. T., & Leong, C. K. (2017). Contribution of Working Memory, Orthographic and Sentential Processing to Chinese Text Comprehension by Tibetan and Yi Students. *The Reading Matrix: An International Online Journal*, *17*(1), 16-39.

Walley, A. C., Metsala, J. L., & Garlock, V. M. (2003). Spoken vocabulary growth: Its role in the development of phoneme awareness and early reading ability. *Reading and Writing*, *16*(1-2), 5-20.

\*Wang, M., Cheng, C., & Chen, S. W. (2006). Contribution of morphological awareness to Chinese-English biliteracy acquisition. *Journal of Educational Psychology*, *98*(3), 542-553.

\*Wu, X. (2011). Development of Morphological Awareness in both Chinese and English AND its Contribution to Vocabulary and Reading in Chinese Children (Master dissertation, Beijing Language and Culture University).

\*Wu, X., Anderson, R. C., Li, W., Wu, X., Li, H., Zhang, J., ... & Chen, X. (2009). Morphological awareness and Chinese children's literacy development: An intervention study. *Scientific Studies of Reading*, *13*(1), 26-52.

\*Xia, Z., Zhang, L., Hoeft, F., Gu, B., Gong, G., & Shu, H. (2017). Neural correlates of oral word reading, silent reading comprehension, and cognitive subcomponents. *International Journal of Behavioral Development*, 1-15.

\*Xiao, X. Y., & Ho, C. S. H. (2014). Weaknesses in semantic, syntactic and oral language expression contribute to reading difficulties in Chinese dyslexic children. *Dyslexia*, *20*(1), 74-98.

\*Yan, R,. Chi, Y, P., & Zhang, L. (2007). Effects of Non-English Major College Students' English Speech Processing on Vocabulary Size and Text Reading Comprehension. *Foreign Language Education*, *28*(6), 54-58.

\*Yeung, P. S., Ho, C. S. H., Chan, D. W. O., & Chung, K. K. H. (2016). Orthographic skills important to Chinese literacy development: the role of radical representation and orthographic memory of radicals. *Reading and Writing*, *29*(9), 1935-1958.

\*Yeung, P. S., Ho, C. S. H., Chan, D. W. O., Chung, K. K. H., & Wong, Y. K. (2013). A model of reading comprehension in Chinese elementary school children. *Learning and Individual Differences*, *25*, 55-66.

\*Zhang, D. (2016). Derivational Morphology in Reading Comprehension of Chinese-speaking Learners of English: A Longitudinal Structural Equation Modeling Study. *Applied Linguistics*, *38*(6), 871-895.

Zhang, D. (2017). Multidimensionality of morphological awareness and text comprehension among young Chinese readers in a multilingual context. *Learning and Individual Differences*, *56*, 13-23.

\*Zhang, D., & Koda, K. (2014). Awareness of derivation and compounding in Chinese–English biliteracy acquisition. *International Journal of Bilingual Education and Bilingualism*, *17*(1), 55-73.

\*Zhang, D., & Koda, K. (2012). Contribution of morphological awareness and lexical inferencing ability to L2 vocabulary knowledge and reading comprehension among advanced EFL learners: Testing direct and indirect effects. *Reading and Writing*, *25*(5), 1195-1216.

\*Zhang, D., & Koda, K. (2013). Morphological awareness and reading comprehension in a foreign language: A study of young Chinese EFL learners. *System*, *41*(4), 901-913.

\*Zhang, D., Koda, K., & Sun, X. (2014). Morphological awareness in biliteracy acquisition: A study of young Chinese EFL readers. *International Journal of Bilingualism*, *18*(6), 570-585.

\*Zhang, D., & Yang, X. (2016). Chinese L2 learners’ depth of vocabulary knowledge and its role in reading comprehension. *Foreign Language Annals*, *49*(4), 699-715.

\*Zhang, H. (2013). *A Study of the Relationship between English Morphological Awareness and Reading Comprehension among Junior High School Students* (Master dissertation, Shandong University).

\*Zhang, H. (2016). Morphological awareness in literacy acquisition of Chinese second graders: A path analysis. *Journal of Psycholinguistic Research*, *45*(1), 103-119.

\*Zhang, J., McBride-Chang, C., Tong, X., 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*(9), 2183-2203.

Zhu, L., Nie, Y., Chang, C., Gao, J. H., & Niu, Z. (2014). Different patterns and development characteristics of processing written logographic characters and alphabetic words: An ALE meta‐analysis. *Human Brain Mapping*, *35*(6), 2607-2618.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: a psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3-29.

Table 1

*Details for Selected Studies*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Study *No*. | First author | year | Area a | materials resources b | sample size |
| 1 | Zhang | 2013 | M | C | 108 |
| 2 | Lu | 2015 | M | C | 108 |
| 3 | Yan | 2007 | M | C | 118 |
| 4 | Chang | 2010 | M | C | 175 |
| 5 | Chen | 2008 | M | C | 30 |
| 6 | Chen | 2011 | M | C | 287 |
| 7 | Bai | 2002 | M | C | 61 |
| 7 | Bai | 2002 | M | C | 60 |
| 8 | Jia | 2015 | M | C | 40 |
| 9 | Xiao | 2014 | HK | E | 90 |
| 10 | Chang | 2014 | M | C | 78 |
| 11 | Cheung | 2007 | HK | E | 88 |
| 11 | Cheung | 2007 | HK | E | 88 |
| 12 | Shu | 2006 | M | E | 75 |
| 12 | Shu | 2006 | M | E | 77 |
| 13 | Lin | 2015 | M | C | 115 |
| 14 | Wu | 2011 | M | C | 78 |
| 14 | Wu | 2011 | M | C | 78 |
| 15 | Zhang  | 2012 | M | E | 130 |
| 16 | Yeung | 2013 | HK | E | 248 |
| 17 | Ma | 2015 | T | E | 124 |
| 18 | Guan | 2013 | M | E | 158 |
| 18 | Guan | 2013 | M | E | 156 |
| 19 | Zhang  | 2014 | M | E | 245 |
| 19 | Zhang  | 2014 | M | E | 245 |
| 20 | McBride-Chang | 2005 | HK | E | 100 |
| 20 | McBride-Chang | 2005 | M | E | 100 |
| 21 | Chen | 2015 | T | C | 164 |
| 22 | Zhang  | 2016 | US | E | 21 |
| 23 | Chung | 2011 | HK | E | 90 |
| 23 | Chung | 2011 | HK | E | 30 |
| 24 | Chik | 2012 | HK | E | 83 |
| 24 | Chik | 2012 | HK | E | 119 |
| 24 | Chik | 2012 | HK | E | 59 |
| 25 | Wang | 2006 | US | E | 64 |
| 26 | Tsung | 2017 | M | E | 111 |
| 26 | Tsung | 2017 | M | E | 42 |
| 27 | Chung | 2013 | HK | E | 78 |
| 28 | Cheng | 2016 | M | E | 149 |
| 28 | Cheng | 2016 | M | E | 127 |
| 29 | Siu | 2015 | HK | E | 202 |
| 29 | Siu | 2015 | HK | E | 202 |
| 29 | Siu | 2015 | HK | E | 211 |
| 29 | Siu | 2015 | HK | E | 211 |
| 30 | Zhang | 2016 | Singapore | E | 108 |
| 30 | Zhang | 2016 | Singapore | E | 108 |
| 31 | Siu | 2016 | HK | E | 86 |
| 31 | Siu | 2016 | HK | E | 168 |
| 31 | Siu | 2016 | HK | E | 133 |
| 32 | Leong | 2013 | HK | E | 1164 |
| 33 | Sun | 2013 | M | E | 80 |
| 34 | Cheng | 2017 | M | E | 149 |
| 35 | To | 2014 | US | E | 61 |
| 35 | To | 2014 | US | E | 89 |
| 36 | Xu | 2017 | M | E | 191 |
| 37 | Wu | 2009 | M | E | 154 |
| 37 | Wu | 2009 | M | E | 146 |
| 38 | Zhang  | 2012 | M | E | 130 |
| 39 | Zhang | 2013 | M | E | 245 |
| 40 | Zhang | 2014 | M | E | 96 |
| 40 | Zhang | 2014 | M | E | 96 |
| 41 | Zhang | 2016 | M | E | 123 |
| 42 | Leong | 2012 | HK | E | 73 |
| 43 | Xia | 2017 | M | E | 21 |
| 44 | Pan | 2016 | M | E | 294 |
| 45 | Leong | 2011 | HK | E | 80 |
| 45 | Leong | 2011 | HK | E | 80 |
| 46 | Yeung | 2016 | HK | E | 239 |
| 46 | Yeung | 2016 | HK | E | 239 |
| 47 | Chen | 2018 | M | E | 164 |
| 48 | Guan | 2014 | M | E | 261 |
| 48 | Guan | 2014 | M | E | 242 |
| 48 | Guan | 2014 | M | E | 246 |
| 49 | Zhang | 2012 | HK | E | 164 |
| 49 | Zhang | 2012 | HK | E | 164 |
| 50 | Chik | 2011 | HK | E | 272 |
| 51 | Guan | 2014 | M | E | 261 |
| 51 | Guan | 2014 | M | E | 242 |
| 51 | Guan | 2014 | M | E | 246 |
| 52 | Lam | 2011 | Canada | E | 46 |
| 52 | Lam | 2011 | Canada | E | 34 |

*Note*. a M=mainland, HK= Hong Kong, T= Taiwan. b material language: E=English, C=Chinese; c L= grade 1 and grade 2 of primary school, M = grade 3 and grade 4 of primary school, H = grade 5 and grade 6 of primary school, S = secondary school, U = university; d 1 = first language, 2 =second language

Table 1

*Continued*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Study *No*. | grade group c | language type d | MA | PA | OS |
| Fisher’s *z* | *SE* | Fisher’s *z* | *SE* | Fisher’s *z* | *SE* |
| 1 | S | 2 | 0.72  | 0.10  | 0.48  | 0.10  |  |  |
| 2 | S | 2 | 0.58  | 0.10  | 0.48  | 0.10  |  |  |
| 3 | U | 2 |  |  | 0.23  | 0.09  |  |  |
| 4 | H | 2 | 0.42  | 0.08  | 0.27  | 0.08  |  |  |
| 5 | M | 1 |  |  | 0.55  | 0.19  |  |  |
| 6 | M | 1 | 0.57  | 0.06  | 0.16  | 0.06  | 0.35  | 0.06  |
| 7 | U | 2 | 0.57  | 0.13  |  |  |  |  |
| 7 | U | 2 | 0.80  | 0.13  |  |  |  |  |
| 8 | U | 2 |  |  | 0.38  | 0.16  | 0.57  | 0.16  |
| 9 | H | 1 | 0.42  | 0.11  |  |  |  |  |
| 10 | U | 2 |  |  |  |  | 0.52  | 0.12  |
| 11 | M | 1 |  |  |  |  | 0.35  | 0.11  |
| 11 | M | 2 |  |  |  |  | 0.22  | 0.11  |
| 12 | H | 1 | 0.33  | 0.12  | 0.33  | 0.12  |  |  |
| 12 | H | 1 | 0.55  | 0.12  | 0.50  | 0.12  |  |  |
| 13 | S | 2 | 0.55  | 0.09  | 0.52  | 0.09  |  |  |
| 14 | M | 2 | 0.47  | 0.12  | 0.44  | 0.12  |  |  |
| 14 | M | 1 | 0.55  | 0.12  | 0.33  | 0.12  |  |  |
| 15 | U | 2 | 0.27  | 0.09  |  |  |  |  |
| 16 | M | 1 | 0.52  | 0.06  |  |  |  |  |
| 17 | U | 2 | 0.37  | 0.09  |  |  |  |  |
| 18 | H | 1 | 0.41  | 0.08  |  |  |  |  |
| 18 | H | 1 | 0.40  | 0.08  |  |  |  |  |
| 19 | H | 1 | 0.45  | 0.06  |  |  | 0.42  | 0.06  |
| 19 | H | 2 | 0.37  | 0.06  |  |  | 0.29  | 0.06  |
| 20 | L | 1 | 0.41  | 0.10  | 0.31  | 0.10  |  |  |
| 20 | L | 1 | 0.42  | 0.10  | 0.33  | 0.10  |  |  |
| 21 | H | 1 | 0.93  | 0.08  |  |  |  |  |
| 22 | U | 2 |  |  |  |  | 0.31  | 0.24  |
| 23 | S | 1 | 0.47  | 0.11  |  |  |  |  |
| 23 | S | 1 | 0.54  | 0.19  |  |  |  |  |
| 24 | H | 1 | 0.54  | 0.11  |  |  |  |  |
| 24 | L | 1 | 0.62  | 0.09  |  |  |  |  |
| 24 | H | 1 | 0.63  | 0.13  |  |  |  |  |
| 25 | L | 1 | 0.58  | 0.13  | 0.37  | 0.13  |  |  |
| 26 | H | 2 |  |  |  |  | 0.34  | 0.10  |
| 26 | H | 2 |  |  |  |  | 0.41  | 0.16  |
| 27 | S | 1 | 0.50  | 0.12  |  |  |  |  |
| 28 | L | 1 |  |  | 0.33  | 0.08  |  |  |
| 28 | L | 1 |  |  | 0.33  | 0.09  |  |  |
| 29 | L | 2 | 0.45  | 0.07  |  |  |  |  |
| 29 | L | 1 | 0.48  | 0.07  |  |  |  |  |
| 29 | M | 1 | 0.50  | 0.07  |  |  |  |  |
| 29 | M | 2 | 0.65  | 0.07  |  |  |  |  |
| 30 | M | 2 | 0.53  | 0.10  |  |  |  |  |
| 30 | M | 2 | 0.55  | 0.10  |  |  |  |  |
| 31 | L | 1 | 0.52  | 0.11  |  |  |  |  |
| 31 | H | 1 | 0.42  | 0.08  |  |  |  |  |
| 31 | M | 1 | 0.65  | 0.09  |  |  |  |  |
| 32 | S | 1 | 0.47  | 0.03  |  |  |  |  |
| 33 | L | 1 |  |  | 0.60  | 0.11  |  |  |
| 34 | L | 1 | 0.56  | 0.08  | 0.27  | 0.08  |  |  |
| 35 | U | 2 | 0.47  | 0.13  |  |  |  |  |
| 35 | U | 2 | 0.54  | 0.11  |  |  |  |  |
| 36 | U | 2 | 0.47  | 0.07  |  |  |  |  |
| 37 | L | 1 | 0.47  | 0.08  |  |  |  |  |
| 37 | L | 1 | 0.59  | 0.08  |  |  |  |  |
| 38 | U | 2 | 0.25  | 0.09  |  |  |  |  |
| 39 | H | 2 | 0.37  | 0.06  |  |  |  |  |
| 40 | H | 2 | 0.56  | 0.10  |  |  |  |  |
| 40 | H | 1 | 0.44  | 0.10  |  |  |  |  |
| 41 | L | 1 | 0.50  | 0.09  |  |  |  |  |
| 42 | S | 1 | 0.45  | 0.12  |  |  |  |  |
| 43 | H | 1 | 0.55  | 0.24  | 0.37  | 0.24  | 0.56  | 0.24  |
| 44 | H | 1 | 0.54  | 0.06  | 0.28  | 0.06  |  |  |
| 45 | H | 1 |  |  |  |  | 0.46  | 0.11  |
| 45 | H | 2 |  |  |  |  | 0.19  | 0.11  |
| 46 | L | 1 |  |  | 0.33  | 0.07  |  |  |
| 46 | M | 1 |  |  | 0.26  | 0.07  |  |  |
| 47 | H | 1 | 0.83  | 0.08  |  |  |  |  |
| 48 | H | 1 | 0.46  | 0.06  |  |  |  |  |
| 48 | H | 1 | 0.45  | 0.06  |  |  |  |  |
| 48 | M | 1 | 0.45  | 0.06  |  |  |  |  |
| 49 | L | 1 | 0.52  | 0.08  | 0.30  | 0.08  | 0.54  | 0.08  |
| 49 | L | 1 | 0.60  | 0.08  | 0.54  | 0.08  | 0.32  | 0.08  |
| 50 | L | 1 | 0.44  | 0.06  | 0.29  | 0.06  |  |  |
| 51 | H | 1 | 0.46  | 0.06  |  |  |  |  |
| 51 | H | 1 | 0.45  | 0.06  |  |  |  |  |
| 51 | M | 1 | 0.45  | 0.06  |  |  |  |  |
| 52 | L | 2 | 0.40  | 0.15  | 0.51  | 0.15  | 0.51  | 0.15  |
| 52 | L | 2 | 0.97  | 0.18  | 0.63  | 0.18  | 0.63  | 0.18  |

Table 2

*Metalinguistic Knowledge with Reading Comprehension Achievement*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | *k* | Sample *N* | Fisher’s *z* | *V* | 95%CI | *Q* | *I*2 | *N* fail-safe | *Teta* |
| OS | 15 | 1754 | .37 | .001 | [.32, .42] | 16.12 | 13.12 | 97 | MA > PA;MA> OS;OS = PA |
| MA | 57 | 9544 | .49 | <.001 | [.47, .51] | 50.99 | <.001 | 501 |
| PA | 22 | 2916 | .33 | <.001 | [.30, .37] | 18.35 | <.001 | 125 |

*Note*. \* *p*<.05 \*\* *p*<.01, \*\*\* *p*<.001, *V* = variance, MA=morphological awareness, PA = phonological awareness, OS = orthographical awareness



*Figure 1*. Funnel plot of MA



*Figure 2*. Funnel plot of OS



*Figure 3*. Funnel plot of PA

Records excluded for inclusion criteria
(n = 1053 )

Studies included in quantitative synthesis (meta-analysis)
(n = 46 )

Studies included in qualitative synthesis
(n = 0 )

Full-text articles excluded, with reasons for outliers
(n = 6 )

Full-text articles assessed for eligibility
(n = 52 )

Records screened
(n = 52 )

Records after duplicates removed
(n = 1105 )

Additional records identified through China CNKI sources
(n = 983 )

Records identified through English database searching
(n = 312 )

*Figure 4*. Flow chart