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Chinese morphological awareness assessment and its relation to reading acquisition: a cross-cultural meta-analysis

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Morphological awareness involves understanding of morphemes and intraword morphological structure. This meta-analysis adopted a cross-cultural perspective to examine the strengths of correlations between morphological awareness assessment and a range of reading outcomes (word decoding, vocabulary, and reading comprehension) in morpho-syllabic Chinese, highlighting the nuanced role of morphological awareness in Chinese reading development for different learner populations. A total of 204 studies with 257 independent samples were included for a meta-analysis of coefficients and meta-regression. The samples involved 42,517 learners of Chinese as a first-language (L1) or a second-language (L2) from Chinese culture immersive contexts and non-immersive contexts. Results showed small to moderate correlations between morphological awareness and reading skills for L1 learners in immersive contexts, with culture having a stronger moderating effect than assessment. For L2 learners, moderate and significant correlations were found between morphological awareness and reading subskills, with both assessment and culture acting as independent and significant moderators.

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Introduction

Morphological awareness is often defined as a learner's ability to reflect upon, analyze, and manipulate morphemes and intraword morphological structures (Carlisle, 1995, 2000). It plays a pivotal role in reading development, particularly within the context of the morphosyllabic Chinese language, as each character usually represents a morpheme at the syllable level. This distinctive feature underscores the importance of morphological awareness as a predictor of reading success for both first-language (L1) and second-language (L2) Chinese learners (e.g., Zhang, 2017a, 2017b; Zhou et al., 2018). Despite the recognition of its significance, variations in the predictive power of morphological awareness across different cultural contexts highlight the need for a deeper understanding of its role in Chinese reading development (Yang et al., 2017). Recent meta-analytic research has begun to explore the moderator effects of grade level, Chinese decoding assessment, and script type on the correlation between morphological awareness and Chinese reading, yet has not paid sufficient attention to other critical reading outcomes (e.g., vocabulary and reading comprehension) or diverse learner backgrounds (i.e., L1 vs. L2; see an exception in Goodwin and Ahn, 2010, 2013). This meta-analysis adopted a cross-cultural perspective to examine the relationship between Chinese morphological awareness assessment and a range of reading outcomes (word decoding, vocabular, and reading comprehension) for two distinct learner populations (i.e., native Chinese-speaking learners v.s. learners of Chinese as a second language; L1 v.s. L2 Chinese learners henceforth), thereby contributing to a more comprehensive understanding of the impact of morphological awareness on Chinese reading development.

Literature review

Theoretical underpinnings of morphological awareness in relation to Chinese reading development: L1 and L2 perspectives. The pathways through which morphology contributes to reading development have been discussed in both L1 and L2 reading theories. Theories related to L1 include works by Kirby and Bowers (2017), Levesque et al. (2021), and Perfetti and colleagues (2002, 2007), while L2 theories have been explored by Chung et al. (2019) and Koda (2005). The Lexical Quality Hypothesis, proposed by Perfetti (2007) and Perfetti and Hart (2002), suggests that effective reading comprehension relies on high-quality lexical knowledge, which includes orthography, phonology, morphosyntax, and meaning, along with the integration of these elements. Kirby and Bowers (2017) further argued that morphology serves as the connecting element for phonological, orthographic, and semantic features of words. In 2021, Levesque et al. explored how morphology influences word reading, spelling, and comprehension, identifying morphological decoding and meaning analysis as crucial pathways for reading development. More recently, Verhoeven and Perfetti (2022) proposed that attending to morphological relations is one of the *language-universal* operating principles toward successful reading comprehension, because "[m]orphological [awareness] provides building blocks of meaning and meaning-related connections to grammatical systems" (p.159).

Recent theoretical conceptualization of L2 reading suggests that morphological awareness is a cross-linguistically shareable resource between a learner's L1 and L2 (e.g., Koda's 2005 transfer facilitation model; Chung et al. (2019) interactive framework of bilingual reading development). For example, L2 Chinese readers can transfer their L1 morphological awareness to facilitate L2 Chinese word reading, even for learners of two typologically distinct languages (e.g., learners of L1 English and L2 Chinese in Ke & Koda, 2021). However, Chung et al. (2019) noted that the extent to which morphological awareness (along with other metalinguistic resources such as phonological and orthographic awareness) can contribute to reading development across different languages is affected by sociocultural factors and the scientific rigor of the research design (which are represented by culture and assessment moderators examined in this meta-analysis). Intralingually speaking, morphological awareness has been found to be a unique predictor of early reading development in Chinese (Tong et al., 2009), whereas morphological awareness usually emerges as a key literacy predictor at upper-grade levels (Grade Three and above) in alphabetic languages (e.g., English, Berninger et al., 2010).

Interlingually speaking, recent meta-analyses have suggested that morphological awareness may play a more important role in L2 reading than in L1 reading (Goodwin & Ahn, 2010, 2013; Ke et al., 2023). For example, Goodwin and Ahn (2010) conducted a meta-analysis comparing the effect sizes of morphological instruction for different learner groups and observed that morphological instruction that emphasizes the study of meaningful units is particularly effective for a range of reading-related outcomes (e.g., phonological awareness, morphological awareness, vocabulary, spelling, and reading comprehension) among English language learners and struggling learners vis-à-vis learners with normal reading proficiency. Ke et al., (2023) meta-analysis focused on correlational evidence and found that the correlation effect sizes between L1 metalinguistic (including morphological, phonological, and orthographic) awareness and L1 word decoding were small, whereas the correlation effect sizes between L2 metalinguistic awareness and L2 word decoding were medium for bilingual child readers. Ke et al. (2023, p.1) conjectured that, "[r]eading in an L2, as compared to reading in an L1, can be even more metalinguistically demanding. Whereas successful adult L2 readers can be well cognizant of sharable metalinguistic resources between two languages and readily apply those resources to facilitate their L2 reading, this process can be a challenging task for children who are learning to read for the first time in an L2."

To date, there have been only a few studies investigating the role of morphological awareness in both L1 and L2 Chinese learners (e.g., Zhang & Koda, 2018; Zhou et al., 2018), and there have been contrasting findings. Zhang and Koda (2018) compared the subcomponents in relation to L2 Chinese vocabulary between Chinese heritage learners and non-Chinese heritage L2 learners from American universities. The correlation between morphological awareness and oral vocabulary and that between morphological awareness and print vocabulary were large for non-Chinese heritage learners (respective $r = 0.72, 0.61$) whereas these correlations were medium or small for Chinese heritage learners (respective $r = 0.49, 0.28$). In comparison, in a study of primary school Chinese-speaking L1 and non-Chinese-speaking L2 children in Hong Kong, Zhou et al. (2018) identified a significant correlation between Chinese morphological awareness and Chinese vocabulary knowledge ($r = 0.58$) with L1 Chinese children and did not find any notable correlation ($r = -0.01$) with L2 Chinese children. Nevertheless, in a more recent study, Zhou (2021) found that L2 Chinese kindergarteners in Hong Kong did benefit from Chinese morphological instruction, which improved their Chinese vocabulary.

Variations in the predictive power of morphological awareness in reading development: Lessons from existing meta-analyses. To reiterate, it is generally agreed that morphological awareness correlates significantly with reading development in Chinese as

well as 16 other languages in the world (for a review, see Verhoeven & Perfetti, 2022). However, there are significant variations in the correlation between morphological awareness and various reading outcomes. Emerging research has begun to examine the moderators that lead to the variations and provide a clearer understanding of the ways in which morphological awareness contributes to reading development (e.g., Ke et al., 2021, 2023; Liu et al., 2024), and more practically, how morphological instruction promotes reading development (e.g., Goodwin & Ahn, 2010, 2013). Liu et al. (2024) is among the first to conduct a meta-analysis of the moderators (script type and age) in the relationship between morphological awareness and Chinese reading (character vs. word reading). To situate this research in a larger context, the following review also briefly reports findings from meta-analyses of the role of morphological awareness in L1 Chinese-L2 English learners (Yang et al., 2017), English learners (Goodwin & Ahn, 2010, 2013), and bilingual learners of diverse language and writing system backgrounds (Ke et al., 2021, 2023).

Yang et al. (2017) screened 33 articles conducted in different regions (Canada, Hong Kong, and the U.S.) and found that the cross-language correlations of morphological awareness between L1 Chinese and L2 English ranged from small to moderate. These correlations were significantly moderated by cultural context and participants' age, with larger effect sizes observed in studies conducted in Hong Kong (compared to non-immersive contexts like Canada and the U.S.) and at the preK level (compared to the primary grade level). Goodwin and Ahn (2010, 2013) focused on the effects of morphological instruction on a range of reading-related outcomes (e.g., word decoding, vocabulary, and reading comprehension) in English learners of diverse backgrounds (e.g., monolingual English speakers vs. L2 English language learners). Based on 30 independent study samples, they identified an overall moderate effect of morphological instruction, with significant changes in word decoding and vocabulary, yet a non-significant effect on reading comprehension. In addition, Goodwin and Ahn (2010, 2013) identified school grade level, assessment type, and learner language background as significant moderators, noting greater effects for younger students than for middle school and upper elementary students, for researcher-designed assessments than for standardized assessments, and for L2 English language learners than for monolingual English speakers.

Inspired by Goodwin and Ahn's (2010, 2013) meta-analyses of morphological awareness in relation to reading development in English as the only target language, Ke et al. (2021) expanded the scope to include interlingual and intralingual correlations between morphological awareness and two reading outcomes (word decoding and reading comprehension) across 41 independent samples. These samples included ten languages (Arabic, Chinese, English, French, Hebrew, Korean, Malay, Spanish, Tagalog, and Vietnamese) when considering participants' L1 and L2. Ke et al. (2021) observed small to moderate effect sizes and significant moderator effects of morphological awareness assessment type and age. The effect sizes were larger for the compound structure awareness test developed by McBride-Chang et al. (2005) than for the test of morphological structure (also termed as inflectional and derivational awareness) developed after Carlisle (2000), and for the upper level (Grades Three to Five) than for the lower level (Kindergarten to Grade Two). Later in 2023, Ke et al. screened 16 independent samples that measured morphological awareness in both L1 and L2 reading and found that the correlations were larger for L2 reading than for L1 reading, which echoed Goodwin and Ahn's (2010, 2013) finding.

Most recently, Liu et al. (2024) explored the moderator effects on the relationship between morphological awareness and Chinese character and word decoding based on data from 84 articles, comprising 104 effect sizes and a sample of 14,348 children. They found that there was a stronger correlation in traditional script than in simplified script, and the correlation increased significantly with age. Yet, they did not find any significant moderating effect of decoding assessment type (i.e., character decoding vs. word decoding). It should be noted that the present meta-analysis differs from Liu et al.'s in the following ways: (1) its independent sample size is about twice that of theirs; (2) it focused on both L1 and L2 learners (see a similar approach in Goodwin and Ahn, 2010, 2013), whereas Liu et al. included L1 Chinese learners only; (3) its analyses covered a range of reading outcomes (word decoding, vocabulary, and reading comprehension) and three moderators (age, morphological awareness assessment type, and cultural context). Regarding cultural context, it was operationalized as Chinese culture immersive context (e.g., Chinese Taipei, Hong Kong, mainland China, Singapore) and non-immersive context, with geographic locations indicated in the moderator analyses. There was a limitation with Liu et al.'s (2024) analysis of script type as a moderator by not specifying the geographic locations. For instance, the simplified script is used in both mainland China and Singapore, the former mainly comprised of L1 Mandarin Chinese learners, and the latter mixed with L1 and L2 Mandarin Chinese learners; the traditional script is used in both Hong Kong and Chinese Taipei, the former dominated by Cantonese Chinese speakers and the latter by Mandarin Chinese speakers.

Morphological awareness assessment as a potential moderator. Regarding the assessment of Chinese morphological awareness, in spite of the consensus that morphological awareness is a key predictor of reading development in Chinese, most research has used inconsistent measurement tasks. The three most widely used tasks range from more language-general (e.g., compound structure awareness shareable between Chinese and a typologically different language like English) to more Chinese-specific (e.g., homophone awareness and homograph awareness). The compound structure task usually evaluates learners' ability to combine given morphemes according to the compound word formation rules predominantly used in Chinese (e.g., Zhang et al., 2012); the homophone awareness task has been used to assess children's sensitivity to unique morphemes with identical pronunciations (e.g., McBride-Chang et al., 2003); the homograph awareness task often requires children to odd one out, that is, to choose a print word from three options that shares a character with the different meaning (e.g., Xu & Liu, 2019). Liu and McBride-Chang (2010), based on their study with third graders, pointed out that compounding production may be optimal for tapping older Chinese children's morphological awareness as compared to other existing measures. However, to date, little meta-analytic research has been conducted to systematically compare the three major types of Chinese morphological awareness assessment and their relation to reading development.

Chinese culture context as a potential moderator. Moreover, another factor that has received increasing attention yet is often overlooked in the literature is *culture*, as reflected by the different literacy practices across Chinese diaspora societies (i.e., Chinese Taipei, Hong Kong, mainland China, and Singapore, and Chinese immigrant communities in the West). They vary in their spoken Chinese variety, Chinese scripts, as well as Chinese language and literacy input: In the Chinese mainland, Mandarin (or Putonghua) is the official language and Simplified Chinese script is used. Primary school educators will introduce Pinyin, a romanization system that uses Latin alphabets to transcribe Mandarin, in grade one and gradually phase it out. In Hong Kong, Cantonese is the local colloquial language, and Traditional Chinese script is

used at school. Jyutping, the de-facto standard romanization scheme for Cantonese, has been introduced in some primary schools, yet not systematically. The Hong Kong education system places a strong emphasis on biliteracy and trilingualism (Cantonese, Putonghua, and English). In Chinese Taipei, Mandarin is the official language and Traditional Chinese script is used. Zhuyin (bomomofo), instead of Pinyin, is used to indicate Mandarin sounds based on a set of character-like symbols. In Singapore, Mandarin is one of the four official languages and Simplified Chinese script is used. Singapore has a bilingual education policy aiming at nurturing students' English and mother tongue language skills. Among Chinese immigrant communities in the West, a variety of Chinese dialects are spoken at home and both Traditional and Simplified scripts are used. It should be noted that, there is emerging evidence contrasting reading development and its underlying cognitive skills between two Chinese diaspora societies (i.e., mainland China and Hong Kong) (McBride, 2016; McBride & Wang, 2015), but there has been little systematic review that compare the role of morphological awareness in reading development and expand the scope to a wider range of Chinese diaspora societies based on an ecologically valid account (McBride-Chang & Chen, 2003).

Viewed collectively, there is a consensus that morphological awareness is crucial for reading development in Chinese and other languages in the world, but there are significant variations in how morphological awareness predicts reading outcomes across different languages and contexts. A few meta-analyses have identified moderators such as age or grade level and script type. Nevertheless, the influence of morphological awareness assessment type, cultural context, and learner background (i.e., L1 vs. L2) on morphological awareness and Chinese reading development is underexplored. A systematic review is needed to understand these variations fully and to what extent the moderators affect the relationship between morphological awareness and Chinese reading development. Such insights might be particularly beneficial for implementing Chinese morphological instruction and assessment in classrooms mixed with L1 and L2 Chinese learners (e.g., K-12 schoolers in Hong Kong and Singapore).

The present study

To reiterate, this meta-analysis was guided by Chung et al. (2019) interactive framework of bilingual reading development and set out to expand existing understanding of the role of Chinese morphological awareness in reading development. Three research questions (RQs) were generated: (RQ1) For L1 Chinese learners, to what extent is morphological awareness related with word decoding, vocabulary and reading comprehension? Is there any influence of Chinese morphological awareness assessment (i.e., compound structure, homograph, and homophone awareness) and culture (i.e., across Chinese diaspora societies including Chinese Taipei, Hong Kong, mainland China, and Singapore)? (RQ2) For L2 Chinese learners, to what extent is morphological awareness significantly related with word decoding, vocabulary and reading comprehension? Is there any influence of Chinese morphological awareness assessment and culture (i.e., Chinese culture immersive context vs. non-immersive context)? (RQ3) Are the correlations between Chinese morphological awareness and Chinese reading subskills moderated by assessment and cultural factors differently for L1 and L2 Chinese learners? Findings in response to RQ1 and RQ2 address how morphological awareness influences Chinese reading acquisition in L1 and L2 Chinese learner groups, respectively. Follow-up comparative findings in response to RQ3 between L1 and L2 learners will help identify both the similarities and differences in how morphological awareness functions in reading development for these two groups. This can inform reading practices and help educators tailor morphological awareness instruction as well as assessment and better support learners based on their language backgrounds and cultural contexts.

Methods

This meta-analysis follows the PRISMA guidelines as well as practices of recent meta-analyses of morphological awareness in relation to reading development (e.g., Ke et al., 2021; Liu et al., 2023; Ruan et al., 2018).

Study selection. Primary studies included must meet the following criteria: (1) was written in English between 1975 and 2024; (2) included participants without a learning or reading disability; (3) presented empirical data based on direct testing of L1 and/or L2 morphological awareness in Chinese; and (4) reported (or the authors shared upon contact) sample size and data for calculating effect sizes, including the correlation coefficient r and/or descriptive statistics with means and standard deviations. Repeated and review reports, as well as unpublished doctoral dissertations, were excluded.

Literature search. To locate pertinent primary studies, a set of keywords (i.e., morpho* AND Chinese AND reading OR literacy) were used in Boolean searches among four electronic databases: CNKI, ProQuest, PsycINFO, and Web of Science. As of November 18, 2024, a total of 3080 studies, including duplicated reports, were identified. After screening using the selection criteria stated above, 204 studies with 257 independent samples were included for this meta-analysis (as illustrated in Fig. 1).

Coding of effect sizes and moderator variables. The effect size was retrieved from a zero-order correlation matrix (i.e., Pearson's r in primary research). For primary studies of longitudinal design, only correlations recorded at the first time point were coded. For primary studies with multiple measures of Chinese morphological awareness (CMA) and of the targeted reading outcomes, the arithmetic mean of effect sizes for matched CMA measure per reading outcome category was calculated (after previous meta-analyses such as Ke et al., 2021; Ruan et al., 2018). The independent sample sizes for the six outcomes are as follows: $k = 154$ for L1 CMA and L1 word decoding; $k = 126$ for L1 CMA and L1 vocabulary; $k = 90$ for L1 CMA and L1 reading comprehension; $k = 15$ for L2 CMA and L2 word decoding; $k = 31$ for L2 CMA and L2 vocabulary; $k = 20$ for L2 CMA and L2 reading comprehension. This meta-analysis focuses on two moderators: CMA assessment and culture. For the CMA assessment, four categories were identified: compound structure awareness, homophone awareness, homograph awareness, and mixed. The culture was categorized as Chinese culture immersive (e.g., China's mainland, Hong Kong, Chinese Taipei, and Singapore) and non-immersive (e.g., Canada, Thailand, and the US). Since grade level can be a potential confounding factor, it was also coded (including four categories: lower grade levels ranging from kindergarten to grade two, upper-grade level ranging from grade three to grade twelve, university level, and mixed) (after Goodwin & Ahn, 2010, 2013; Ke et al., 2021).

Data coding. Two research assistants (RAs) were hired to code the primary studies. Training was provided by the corresponding author. The two RAs initially co-coded about 10% of the independent study samples. The agreement rate was 95.8%. Recoding continued until inconsistencies were resolved. The RAs then each code 40% of the independent samples.

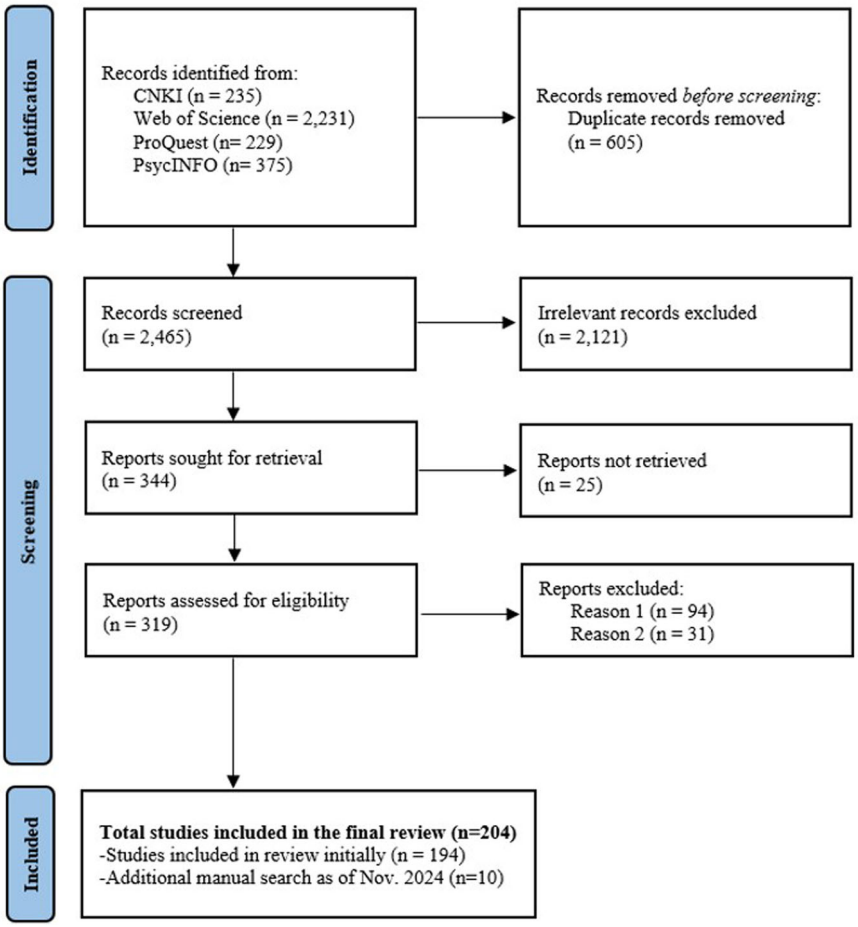

Fig. 1 Literature search and study screening. Reason 1 was that unpublished PhD studies were excluded. Reason 2 was that studies of learners with learning disabilities were excluded.

Statistical analysis. Data coding and analysis were performed using Comprehensive Meta-Analysis (CMA) software Version 4.0 (https://www.metaanalysis.com/), which calculated the overall correlations, namely the average of the correlations from the primary studies weighted by sample sizes (Borenstein et al., 2007). All data analyses utilized random-effects models (after Borenstein et al., 2009). Standard residuals were checked in the primary studies, and outliers (i.e., standard residual > 3.0) were removed for each focal correlational relationship. Additionally, a heterogeneity test (*Q* test) was conducted to assess variability among the correlations, with a significant result indicating such variability. To investigate moderator effects, an additional heterogeneity test (*Q* test) was conducted using random-effects modeling, both within and across subgroups defined by the moderator analyses. This analysis determined whether subgroup membership influences the correlational outcomes. A statistically significant difference between subgroups would suggest that a moderator affects the mean correlation. For subgroups with only one sample, a sensitivity analysis was performed by removing one sample at a time from each moderator analysis to check for changes in the results. Finally, publication bias was assessed using funnel plots for random-effects models to detect retrieval bias, indicated by an asymmetric funnel. No significant bias was found. The complete analysis results are available in the online database deposited at: osf.io/4rdm5.

Results

The characteristics of selected studies. This meta-analysis included 204 correlational studies with 257 independent samples ($N = 42{,}517$). Two hundred and seventeen independent study samples (approximately 84.4%) focused on L1 Chinese learners ($N = 37{,}857$) while the rest were about L2 Chinese learners ($N = 4660$). Regarding the grade level of participants, 115 independent study samples (44.7%) focused on participants who were students below Grade 3 (i.e., approximately age 8 or younger); 69 samples (26.8%) included participants in Grades 3 through 12 (ages 9 to 18); 26 (10.1%) were of the university level; and 47 (18.3%) were of mixed grade levels. When it comes to reading subskill outcomes, 165 independent samples (64.2%) measured word decoding; 157 (61.1%) measured vocabulary; and 115 (44.7%) measured reading comprehension. In terms of the types of assessment investigated, 16 independent study samples (6.2%) focused uniquely on homograph awareness only; 91 (35.4%) on compound structure only; 11 (4.3%) on homophone awareness only; 2 (0.8%) on derivation only; 1 (0.4%) on radical awareness only; and another 136 samples (52.9%) were of mixed assessment. Finally, five major Chinese diaspora regions were covered by the selected studies, including 150 independent samples (58.4%) from mainland China; 75 (29.2%) from Hong Kong, 12 (4.7%) from Chinese Taipei, 5 (1.9%) from Singapore, and 15 (5.8%) from non-immersive contexts (including Canada, Thailand, and the United States).

Chinese morphological awareness assessment and its relation to L1 Chinese reading development. As suggested in Table 1, for L1 Chinese learners, the correlations between Chinese morphological awareness and Chinese word decoding, vocabulary, and

Table 1 Meta-correlations between Chinese morphological awareness (CMA) and reading outcomes in L1 and L2 Chinese.

Relationship	*k*	*r* [95% CI]	z (*p*)	Q test (*p*)	I^2 (%)	τ^2
L1 CMA-L1 w.d.	154	0.38 [0.35, 0.41]	24.91 (<0.001)	1031.729 (<0.001)	85.17	0.03
L1 CMA-L1 v.	126	0.40 [0.37, 0.42]	31.20 (<0.001)	466.30 (<0.001)	73.19	0.02
L1 CMA-L1 r.c.	90	0.36 [0.34, 0.39]	26.49 (<0.001)	250.03 (<0.001)	64.40	0.01
L2 CMA-L2 w.d.	15	0.45 [0.34, 0.54]	7.51 (<0.001)	80.34 (<0.001)	82.58	0.05
L2 CMA- L2 v.	31	0.45 [0.39, 0.50]	14.31 (<0.001)	124.83 (<0.001)	75.97	0.02
L2 CMA-L2 r.c.	20	0.44 [0.37, 0.50]	11.99 (<0.001)	79.96 (<0.001)	76.24	0.02

w.d. word decoding, *v.* vocabulary, *r.c.* reading comprehension, *L1* first language, *L2* second language.

reading comprehension were all significant and ranged from small to medium (respective $r = 0.38$, $k = 154$, $p < 0.001$; $r = 0.40$., $k = 126$, $p < 0.001$; $r = 0.36$, $k = 90$, $p < 0.001$), and there were significant variation across primary studies (respective $Q = 1031.729$, $p < 0.001$, $I^2 = 85.17$; $Q = 466.30$, $p < 0.001$, $I^2 = 73.19$; $Q = 250.03$, $p < 0.001$, $I^2 = 64.40$).

It should be noted that the interpretation of co-efficient effect sizes in this meta-analysis followed Plonsky and Osward's (2012) benchmarks (i.e., $r = 0.24$, 0.40, 0.60 for small, medium and large effect sizes respectively). The moderator analysis results are shown in Table 2. All three correlations were significantly moderated by the Chinese morphological awareness assessment. They were the highest for homograph awareness (respective $r = 0.52$, 0.47, 0.49). There was also a significant moderating effect from culture, but the patterns were mixed: (1) For the relationship between Chinese morphological awareness and Chinese word decoding, the correlation was large for Singapore ($r = 0.60$, $k = 2$), medium for Chinese Taipei and Hong Kong (respective $r = 0.48$, =7; $r = 0.41$, $k = 58$), and small for mainland China ($r = 0.35$; $k = 87$). (2) For the relationship between Chinese morphological awareness and Chinese vocabulary, it was large for Chinese Taipei ($r = 0.54$, $k = 6$) and the correlations were small for Hong Kong and mainland China (respective $r = 0.39$, $k = 48$; $r = 0.39$, $k = 71$). (3) For the relationship between Chinese morphological awareness and Chinese reading comprehension, it was larger for Hong Kong ($r = 0.39$, $k = 19$) than for mainland China ($r = 0.34$, $k = 69$).

Additionally, a potential developmental effect was considered, and grade level was thus included in the moderator analysis. Subgroup analysis results shown in Table 2 suggest that grade level did not have any significant effect on the correlation between Chinese morphological awareness and L1 Chinese vocabulary or reading comprehension (respective $p = 0.146$, 0.170), yet, it was a significant moderator for the correlation between Chinese morphological awareness and L1 Chinese word decoding only ($p < 0.001$). In subsequent meta-regression analyses, grade level was entered first, followed by culture and assessment. As illustrated in Table 3, after grade level was entered first in Model 1, it had a significant moderating effect, accounting for about 27% of the variance ($R^2 = 0.27$, $Q = 17.76$, df = 2, $p = 0.0001$); when culture was entered after grade level in Model 2, culture has an additional significant effect, accounting for about 9% of the variance over and above grade level ($R^2 = 0.36$, $Q = 10.29$, df = 3, $p = 0.016$); however, when assessment type was entered last in Model 2, it did not have any significant effect ($R^2 = 0.36$, $Q = 6.58$, df = 3, $p = 0.087$). When the entry order of culture and assessment type was reversed, the results remained unchanged and thus are not reported in Table 3.

Chinese morphological awareness assessment and its relation to L2 Chinese reading development. For L2 Chinese learners, the correlations between Chinese morphological awareness and Chinese word decoding, vocabulary and reading comprehension were all moderate and significant (respective $r =$. 45, $k = 15$, $p < 0.001$; $r = 0.45$, $k = 31$, $p < 0.001$; $r = 0.44$; $k = 20$, $p < 0.001$), and there was significant variance across the three relationships (respective $Q = 80.34$, $p < 0.001$, $I^2 = 82.58$; $Q = 124.83$, $p < 0.001$, $I^2 = 75.97$; $Q = 79.96$, $p < 0.001$, $I^2 = 76.24$). The meta-correlation results are reported in Table 1 above and the moderator analysis results are reported in Table 4 below.

For the correlation between Chinese morphological awareness and L2 Chinese word decoding, no significant moderating effect of assessment or culture was identified (respective $Q = 0.41$, $p = 0.521$; $Q = 1.13$, $p = 0.569$). There was no significant moderating effect of grade level either ($Q = 2.16$, $p = 0.271$). The forest plot and funnel plot are shown in Figs. 2 and 3, respectively. No notable publication bias was identified.

For the correlation between Chinese morphological awareness and L2 Chinese vocabulary, assessment and culture were both significant moderators (respective $Q = 7.94$, $p = 0.019$; $Q = 6.33$, $p = 0.042$): In terms of assessment, the correlation for studies based on homophone awareness was small ($r = 0.35$), whereas those based on homograph awareness alone or mixed assessment were moderate (respective $r = 0.40$, 0.50). In addition, the correlations were larger for societies that have Chinese as the official language where learners could be immersive in Chinese culture (i.e., $r = 0.52$ in mainland China; $r = 0.42$ in Singapore) than the non-immersive context (=0.38). Again, there was no significant moderating effect of grade level ($Q = 2.81$, $p = 0.245$). Follow-up meta-regression analysis results suggested that assessment and culture were two independent moderators when they were entered independently into meta-regression (see Table 5).

Regarding the correlation between Chinese morphological awareness and L2 Chinese reading comprehension, there was a significant moderating effect of assessment ($Q = 7.19$, $p = 0.027$), and a nonsignificant moderating effect of culture ($Q = 1.93$, $p = 0.380$). Specifically, the correlations were larger for studies based on mixed assessment ($r = 0.49$) or compound structure assessment ($r = 0.40$) than the correlation based on studies of homograph awareness alone ($r = 0.33$). As suggested in Table 4, there was a significant moderating effect of grade level. However, after the effect of grade level was accounted for (according to the meta-regression analysis results presented in Table 6), Chinese morphological awareness assessment was the only significant predictor, explaining about 29% of the variance in the correlation between Chinese morphological awareness and L2 Chinese reading comprehension.

Discussion

Summary and discussion of key findings of RQ1. This meta-analysis adopted a cross-cultural perspective to examine the relationship between Chinese morphological awareness

Table 2 Moderator analysis results for L1 Chinese reading relationships.

L1 CMA-L1 w.d.					
Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	**Q test**
Assessment	Compound structure	67	0.37	0.34, 0.40	6.132 ($p = 0.105$)
	Homograph	6	0.52	0.39, 0.62	
	Homophone	9	0.49	0.25, 0.67	
	Mixed	71	0.36	0.34, 0.39	
Culture	Chinese, Taipei	7	0.48	0.43, 0.53	26.56 ($p < 0.001$)
	Hong Kong	58	0.41	0.38, 0.43	
	Mainland China	87	0.35	0.31, 0.39	
	Singapore	2	0.60	0.50, 0.69	
Grade level	K-G2	89	0.35	0.33, 0.38	16.68 ($p < 0.001$)
	G3-G12	46	0.39	0.33, 0.45	
	Mixed	18	0.50	0.44, 0.57	
L1CMA-L1 v.					
Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	**Q test**
Assessment	Compound structure	58	0.41	0.39, 0.44	6.47 ($p = 0.091$)
	Homograph	2	0.47	0.09, 0.74	
	Homophone	4	0.24	0.08, 0.39	
	Mixed	62	0.38	0.35, 0.41	
Culture	Chinese Taipei	6	0.54	0.44, 0.63	8.04 ($p = 0.018$)
	Hong Kong	48	0.39	0.35, 0.43	
	Mainland China	71	0.39	0.36, 0.41	
Grade level	K-G2	72	0.39	0.36, 0.42	3.85 ($p = 0.146$)
	G3-G12	39	0.38	0.34, 0.42	
	Mixed	14	0.45	0.39, 0.51	
L1 CMA-L1 r.c.					
Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	**Q test**
Assessment	Compound structure	26	0.36	0.32, 0.40	7.28 ($p = 0.064$)
	Homograph	7	0.49	0.38, 0.58	
	Homophone	4	0.41	0.27, 0.54	
	Mixed	52	0.34	0.31, 0.37	
Culture	Hong Kong	19	0.39	0.35, 0.44	4.21 ($p = 0.040$)
	Mainland China	69	0.34	0.31, 0.37	
Grade level	K-G2	41	0.34	0.30, 0.38	5.03 ($p = 0.170$)
	G3-G12	38	0.38	0.34, 0.42	
	University	3	0.26	0.11, 0.39	
	Mixed	8	0.39	0.33, 0.44	

CMA Chinese morphological awareness, *w.d.* word decoding, *v.* vocabulary, *r.c.* reading comprehension. Only one sample used radical-based morphological awareness, thus was not included in the moderator analyses that required at least two samples within each subgroup.

assessment and a range of reading outcomes (word decoding, vocabular, and reading comprehension) for two distinct learner populations (i.e., L1 Chinese learners and L2 Chinese learners). The 257 independent samples included 42,517 learners of Chinese as a first-language (L1) or a second-language (L2) from five major Chinese culture immersive regions (i.e., Chinese Taipei, Hong Kong, mainland China, and Singapore) and non-immersive contexts (covering Canada, Thailand, and the US).

For L1 Chinese learners, the correlation between morphological awareness and word decoding and that between morphological awareness and reading comprehension were both small yet significant, and that between morphological awareness and vocabulary was moderate and significant. Morphological awareness assessment and culture independently moderated the correlational relationships. Specifically, the correlations were largest for all three L1 Chinese reading outcomes (i.e., word decoding, vocabulary, and reading comprehension) when the selected studies used homograph awareness assessment type alone. In addition, the correlations were weaker for all three reading outcomes based on studies conducted in mainland China compared to other Chinese-speaking societies (i.e., Chinese Taipei, Hong Kong, and Singapore). Notably, the relative weights of assessment vs. culture on the correlations between Chinese morphological awareness and Chinese reading outcomes were compared via meta-regression, culture was the only significant moderator after grade level effect was controlled.

Summary and discussion of key findings of RQ2. The correlations between Chinese morphological awareness and word decoding, vocabulary, and reading comprehension were all moderate and for L2 Chinese learners. Assessment type has consistently significant moderating effects on the relationships between Chinese morphological awareness and the three reading outcomes. Notably, the largest effect sizes were observed for primary studies that used mixed assessment, followed by compound structure awareness, and the smallest for homograph awareness. Culture also had a significant moderating effect on the correlation between Chinese morphological awareness and L2 Chinese vocabulary, as the effect sizes were medium for societies that have Chinese as the official language where learners could be immersive in Chinese culture (i.e., Hong Kong, mainland China & Singapore), yet the effect size was small for the non-immersive contexts (e.g., Canada, Thailand, the United States). Moreover, meta-regression analyses suggested that assessment type and culture are two independent moderators for the correlational relationship Chinese morphological awareness and L2 Chinese vocabulary.

Table 3 Meta-regression analysis results with grade level as the covariate for the relationship between L1 Chinese morphological awareness and L1 Chinese word decoding.

Model 1	**Covariate**	**Coefficient**	**Stan-dard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
$R^2 = 0.27$	Intercept	0.369	0.019	0.332	0.405	19.79	<0.001
$Q = 17.76$, df = 2, $p = 0.0001$	Grade level: G3-12 (vs. K-G2)	0.046	0.032	−0.017	0.109	1.43	0.077
	Grade level: mixed (vs. K-G2)	0.188	0.045	0.100	0.276	4.19	<0.001
Model 2	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
$R^2 = 0.36$	Intercept	0.470	0.068	0.338	0.602	6.96	<0.001
$Q = 16.28$, df = 2, $p = 0.0003$	Grade level: G3-12 (vs. K-G2)	0.027	0.032	−0.035	0.090	0.87	0.193
	Grade level: mixed (vs. K-G2)	0.175	0.043	0.090	0.260	4.04	<0.001
$Q = 10.29$, df = 3, $p = 0.016$	Culture: Hong Kong (vs. Chinese Taipei)	−0.082	0.069	−0.217	0.053	−1.20	0.116
	Culture: mainland China (vs. Chinese Taipei)	−0.117	0.067	−0.249	0.015	−1.74	0.041
	Culture: Singapore (vs. Chinese Taipei)	0.193	0.130	−0.061	0.447	1.49	0.068
Model 3	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
$R^2 = 0.36$	Intercept	0.465	0.071	0.326	0.604	6.56	<0.001
$Q = 11.70$, df = 2, $p = 0.003$	Grade level: G3-12 (vs. K-G2)	0.015	0.033	−0.049	0.079	0.46	0.323
	Grade level: mixed (vs. K-G2)	0.155	0.045	0.066	0.243	3.41	0.0003
$Q = 8.55$, df = 3, $p = 0.036$	Culture: Hong Kong (vs. Chinese Taipei)	−0.081	0.069	−0.217	0.055	−1.17	0.121
	Culture: mainland China (vs. Chinese Taipei)	−0.125	0.068	−0.258	0.008	−1.84	0.033
	Culture: Singapore (vs. Chinese Taipei)	0.122	0.136	−0.145	0.387	0.9	0.185
$Q = 6.58$, df = 3, $p = 0.087$	Assessment: Homograph (vs. CS)	0.165	0.085	−0.001	0.331	1.95	0.026
	Assessment: Homophone (vs. CS)	0.101	0.058	−0.013	0.215	1.74	0.041
	Assessment: Mixed (vs. CS)	0.008	0.030	−0.050	0.067	0.28	0.390

CS = compound structure.

Table 4 Moderator results for L2 Chinese reading relationships.

L2 CMA-L2 w.d.

Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	***Q* test**
Assessment	Compound structure	4	0.40	0.20, 0.56	0.41 ($p = 0.521$)
	Mixed	8	0.47	0.34, 0.58	
Culture	Hong Kong	3	0.51	0.24, 0.70	1.13 (p =0.569)
	Non-immersive	8	0.37	0.26, 0.47	
	Singapore	2	0.47	0.11, 0.71	
Grade level	K-G2	3	0.43	0.16, 0.63	2.61 ($p = 0.271$)
	G3-G12	4	0.55	0.40, 0.67	
	Mixed	7	0.38	0.20, 0.54	

L2 CMA-L2 v.c.

Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	***Q* test**
Assessment	Compound structure	6	0.40	0.22, 0.54	7.94 ($p = 0.019$)
	Homograph	6	0.35	0.25, 0.45	
	Mixed	18	0.50	0.45, 0.55	
Culture	Mainland China	14	0.52	0.46, 0.57	6.33 ($p = 0.042$)
	Non-immersive	13	0.38	0.28, 0.47	
	Singapore	3	0.42	0.19, 0.60	
Grade level	G3-G12	4	0.45	0.32, 0.56	2.81 ($p = 0.245$)
	University	18	0.49	0.43, 0.55	
	Mixed	8	0.35	0.18, 0.50	

L2CMA-L2 r.c.

Moderator	**Moderator Variable**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**	***Q* test**
Assessment	Compound structure	3	0.40	0.33, 0.46	7.19 ($p = 0.027$)
	Homograph	5	0.33	0.25, 0.41	
	Mixed	12	0.49	0.40, 0.56	
Culture	Mainland China	10	0.44	0.35, 0.52	1.93 ($p = 0.380$)
	Non-immersive	7	0.37	0.27, 0.46	
	Singapore	2	0.46	0.37, 0.54	
Grade level	G3-G12	3	0.50	0.43, 0.56	9.80 ($p = 0.007$)
	University	14	0.44	0.36, 0.52	
	Mixed	3	0.32	0.22, 0.41	

CMA Chinese morphological awareness, *w.d.* word decoding, *v.* vocabulary, *r.c.* reading comprehension.

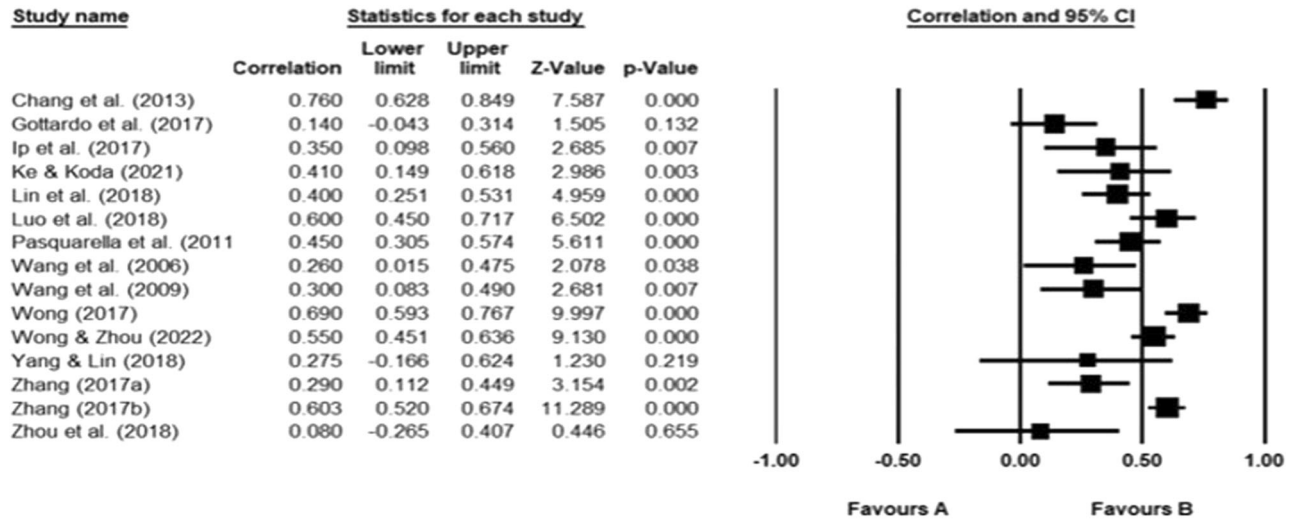

Fig. 2 Forest plot for L2 Chinese morphological awareness and L2 Chinese word decoding.

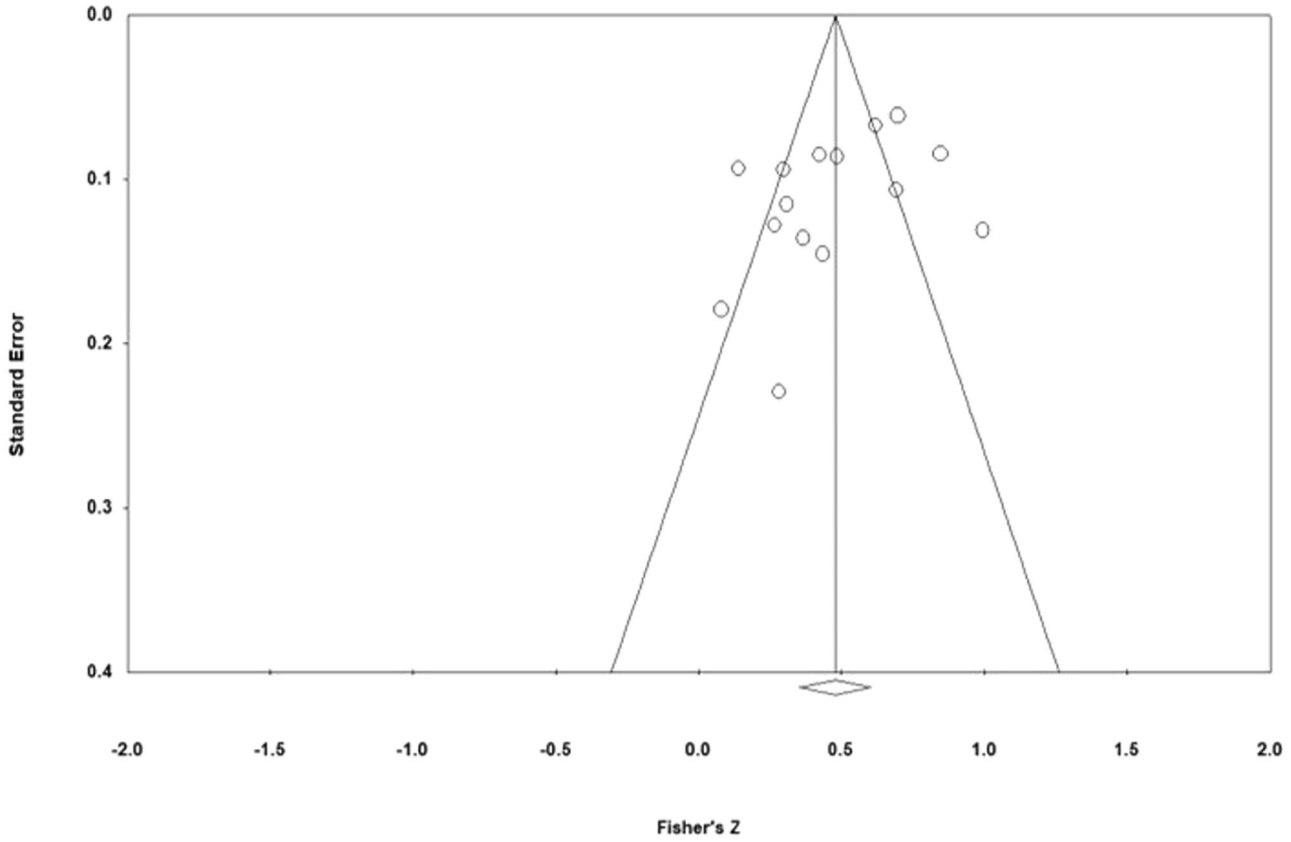

Fig. 3 Funnel plot for the relationship between L2 Chinese morphological awareness and L2 Chinese word decoding.

There may be doubt about potential confounding factors or moderator effects not examined in this meta-analysis. This research has examined the potential grade effect on Chinese reading development. Yet, meta-regression results indicated that, over and above grade level, culture was a significant moderator of L1 relationships. For L2 relationships, grade level did not have any significant moderating effect. It should be noted that neither assessment nor culture has been found to moderate the correlation between L2 Chinese morphological awareness and L2 Chinese word decoding either, in spite that the heterogeneity test was significant. Post-hoc moderator analyses were conducted for three potential categorical moderators (heritage status: heritage learner vs. non-heritage learner; measurement number: single vs. multiple; morphological awareness tasks: compound structure only; mixed with compound structure; without compound structure), but the Q tests were nonsignficant (ps = 0.730, 0.814, 0.449). The complete post-hoc analyses results are available at: osf.io/4rdm5.

Summary and discussion of key findings of RQ3

The strengths of morphological awareness in L1 vs. L2 Chinese reading. The overall correlational effects were larger for L2

Table 5 Meta-regression for the relationship between L2 Chinese morphological awareness and L2 Chinese vocabulary.

Model 1	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
	Intercept	0.486	0.070	0.349	0.622	6.97	<0.001
$Q = 5.10$, df=2, $p = 0.078$	Assessment: Homograph (vs. CS)	−0.112	0.098	−0.305	0.080	−1.15	0.252
	Assessment: Mixed (vs. CS)	0.063	0.079	−0.092	0.218	0.80	0.425
Model 2	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
	Intercept	0.516	0.080	0.361	0.671	6.54	<0.001
$Q = 1.89$, df=2, $p = 0.388$	Assessment: Homograph (vs. CS)	−0.056	0.114	−0.280	0.168	−0.49	0.623
	Assessment: Mixed (vs. CS)	0.074	0.085	−0.093	0.240	0.87	0.384
$Q = 2.27$, df=2, $p = 0.321$	Culture: Non-immersive (vs. mainland China)	−0.085	0.082	−0.245	0.075	−1.04	0.298
	Culture: Singapore (vs. mainland China)	−0.135	0.105	−0.341	0.072	−1.28	0.201
Model 3	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
	Intercept	0.573	0.044	0.487	0.660	12.95	<0.001
$Q = 4.88$, df=2, $p = 0.087$	Culture: Non-immersive (vs. mainland China)	−0.143	0.067	−0.273	0.012	−2.14	0.033
	Culture: Singapore (vs. mainland China)	−0.119	0.105	−0.324	0.087	−1.13	0.257
Model 4	**Covariate**	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
	Intercept	0.516	0.080	0.361	0.671	6.54	<0.001
$Q = 2.27$, df=2, $p = 0.321$	Culture: Non-immersive (vs. mainland China)	−0.085	0.082	−0.245	0.075	−1.04	0.298
	Culture: Singapore (vs. mainland China)	−0.135	0.105	−0.341	0.072	−1.28	0.201
$Q = 1.89$, df=2, $p = 0.388$	Assessment: Homograph (vs. CS)	−0.056	0.114	−0.280	0.168	−0.49	0.623
	Assessment: Mixed (vs. CS)	0.074	0.085	−0.093	0.240	0.87	0.384

Table 6 Meta-regression for the relationship between L2 Chinese morphological awareness and L2 Chinese reading comprehension.

	Covariate	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	***Z***	***p***
	Intercept	0.456	0.128	0.206	0.707	3.57	0.0004
$Q = 4.20$, df = 2, $p = 0.122$	Grade level: university (vs. G3-12)	0.024	0.100	−0.172	0.221	0.24	0.809
	Grade level: mixed (vs. G3-12)	−0.187	0.127	−0.437	0.062	−1.47	0.141
$Q = 6.60$, df = 2, $p = 0.037$	Assessment: Homograph (vs. CS)	−0.145	0.114	−0.369	0.079	−1.27	0.204
	Assessment: Mixed (vs. CS)	0.092	0.098	−0.099	0.283	0.95	0.344

Chinese readers than for L1 Chinese readers (see Table 1 above). This finding is consistent with recent conceptualization that morphological awareness plays a more important role in L2 reading than in L1 reading development (Goodwin & Ahn, 2010, 2013; Ke et al., 2023), as the meta-correlation effect sizes were medium for L2 relationships yet small for L1 relationships. There are two possible explanations for this finding: L2 learners are still at the stage developing their word decoding whereas L1 learners have more refined word decoding skills. Metalinguistic awareness enables learners to map the elements of spoken language onto the writing system and is thus fundamentally important for word decoding. The independent sample size for L1 learners is larger than that of L2 learners, which may lead to more intra-group variation for the L1 learners and smaller effect sizes.

Assessment effects on the association between Chinese morphological awareness and L1 vs. L2 Chinese reading. For both L1 and L2 learners of Chinese, assessment has been found to significantly moderate the relationship between morphological awareness and Chinese reading subskills. Notably, for L1 learners, there have been four types of assessment (i.e., compound structure, homophone awareness, homograph awareness, and mixed); whereas for L2 learners, only three types of assessment have been applied, not including homophone awareness. In addition, homograph awareness assessment generated larger correlations for L1 learners whereas mixed assessment seemed more important for L2 learners. Homograph awareness entails learners' refined understanding of phonology-orthography-morphology mapping specific to Chinese. Therefore, it is more important for L1 learners. For L2 learners, mixing different types of MA measures might tap into their developing understanding of phonology-orthography-morphology mapping in Chinese. This finding is consistent with Ke et al.'s (2023) meta-analysis of morphological awareness in relation to bilingual reading with English as the target L2 for the majority of primary studies. Ke et al. (2023) also found that L2 studies that adopted multiple measures of morphological awareness yielded larger correlation coefficients than studies that used one single measure only.

Cultural effects on the association between Chinese morphological awareness and L1 vs. L2 Chinese reading. There are two interesting findings regarding the influence of culture. First, for L1 Chinese learner population, the correlation coefficients for mainland China were the smallest across the three focus relationships. But it is unlikely due to the effect of simplified vs. traditional character script, as found by Liu et al.'s meta-analysis (2024), since the effect size for the relationship between L1 Chinese morphological awareness and L1 Chinese vocabulary was moderate ($r = 0.51$) for Chinese Taipei, and small for both Hong Kong ($r = 0.39$) and mainland China ($r = 0.39$). The effect sizes were both small for Hong Kong ($r = 0.39$) and mainland China ($r = 0.34$) for the correlation between L1 Chinese morphological awareness and L1

Chinese reading comprehension. However, for the correlation between L1 Chinese morphological awareness and L1 Chinese word decoding, the effect size was large for Singapore ($r = 0.60$), moderate for Chinese Taipei and Hong Kong (respective $rs = 0.42$, 0.41), and small for mainland China ($r = 0.36$). It is speculated that researchers in mainland China tended to measure Chinese word decoding with single-character words whereas researchers in the three other immersive contexts mixed one-character and two-character word items for Chinese word decoding. It should be noted that the percentage of two-character words significantly outnumber that of one-character words in modern (Mandarin) Chinese. In this regard, morphological awareness plays a more important role in multi-character word decoding (see also Ke & Koda, 2021).

The other finding in relation to culture is that the correlation effect sizes were larger for the immersive contexts than the non-immersive context for L2 Chinese learners (see Table 7 below). This is not surprising because L2 Chinese learners will receive more oral and written Chinese input from the immersive context, which may help strengthen the link between Chinese morphological awareness and Chinese reading subskills. However, there is an exception in the Singapore case (Zhang, 2017a, 2017b), where the effect sizes were large for L1 Chinese learners ($r = 0.60$, $k = 2$) and medium for L2 Chinese learners ($r = 0.47$, $k = 2$). There are two possible explanations: One is that Zhang (2017a, 2017b) measured word decoding fluency whereas other selected studies usually measured word decoding accuracy only. The other was that the sample sizes for Singapore were two small and may be biased.

Strengths and limitations. This research is one of the most comprehensive meta-analyses of the correlation between Chinese morphological awareness assessment and Chinese reading development with a focus of a range of reading subskills, both L1 and L2 Chinese learner populations from various Chinese culture contexts (i.e., China's mainland, Hong Kong, Chinese Taipei, Singapore, and non-immersive context), as well as a wide range of educational levels from kindergarten to university level. It has affirmed that while morphological awareness correlates significantly with a range of reading outcomes in both L1 and L2 Chinese, it plays a more important role in L2 Chinese reading than in L1 Chinese reading. More importantly, the findings have confirmed that assessment and culture are two significant moderators over and above the influence of grade level in L1 and L2 Chinese reading respectively. In L1 Chinese reading, homograph awareness yielded larger correlations with word decoding, vocabulary, and reading comprehension, and primary studies based on mainland China observed smaller correlation effect sizes. In L2 Chinese reading, larger correlations were identified from studies that use a mixed assessment of Chinese morphological awareness and were conducted in Chinese culture immersive contexts. The evidence mentioned above is consistent with the position held by Chung et al. (2019) interactive framework of bilingual reading development, that is, the utility of morphological awareness, as a cross-language transferrable resource, is constraint by sociolinguistic and social-cultural factor and the scientific rigor of the research design (operationalized as assessment type in this meta-analysis).

There are three main limitations that need to be addressed in future research. First, the evidence is correlational, not causal. Since the majority of pertinent empirical studies do not adopt a longitudinal or interventional design, it is challenging to conduct

Table 7 Correlational effect sizes compared by Chinese culture context (immersive vs. non-immersive) and Chinese language background (L1 vs. L2).

CMA-w.d.				
Chinese Culture Context	**Chinese Language Background (L1 vs. L2)**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**
Chinese, Taipei	Chinese L1	7	0.50	0.43, 0.53
	Chinese L2	1	0.76	N.A.
HK, China	Chinese L1	20	0.40	0.36, 0.43
	Chinese L2	3	0.51	0.24, 0.70
mainland China	Chinese L1	43	0.32	0.29, 0.36
	Chinese L2	1	0.28	N.A.
Singapore	Chinese L1	2	0.60	0.50, 0.69
	Chinese L2	2	0.47	0.11, 0.71
Non-immersive	Chinese L2	8	0.37	0.26, 0.47
CMA-v.				
Chinese Culture Context	**Chinese Language Background (L1 vs. L2)**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**
Chinese, Taipei	Chinese L1	6	0.54	0.44, 0.63
HK, China	Chinese L1	48	0.39	0.35, 0.43
	Chinese L2	1	−0.01	N.A.
mainland China	Chinese L1	71	0.39	0.36, 0.41
	Chinese L2	14	0.52	0.46, 0.57
Singapore	Chinese L1	1	0.42	0.29, 0.53
	Chinese L2	3	0.42	0.19, 0.60
Non-immersive	Chinese L2	13	0.38	0.28, 0.47
CMA-r.c.				
Chinese Culture Context	**Chinese Language Background (L1 vs. L2)**	**Number of Correlations (*k*)**	***r***	**95% CI (*r*)**
Chinese, Taipei	Chinese L1	1	0.63	N.A.
HK, China	Chinese L1	19	0.39	0.35, 0.44
	Chinese L2	1	0.80	N.A.
mainland China	Chinese L1	69	0.34	0.31, 0.37
	Chinese L2	10	0.44	0.35, 0.52
Singapore	Chinese L1	1	0.61	N.A.
	Chinese L2	2	0.46	0.37, 0.54
Non-immersive	Chinese L2	7	0.37	0.27, 0.46

CMA Chinese morphological awareness, *w.d.* word decoding, *v.* vocabulary, *r.c.* reading comprehension, *N.A.* not applicable.

a meta-analysis based on aggregated causal evidence for now. It is hoped that more studies will emerge along this line. Second, primary studies about Chinese learners with learning disabilities or dyslexia were excluded from this meta-analysis because their individual differences and literacy profiles make them distinct from the typically developed L1 and L2 Chinese learners included in this meta-analysis. There is definitely an urgent need for more research to the potential culture-moderating effect on Chinese reading difficulties or dyslexia. Last, it is also important to consider the modality (i.e., written versus oral or mixed) when assessing Chinese morphological awareness. It is notable that, in the coding process, it was difficult to identify the modality from the selected studies since it was not clearly defined in most studies.

Implications for future research and practice. Methodologically speaking, it is noted above that there are fewer primary studies examining the contributions of morphological awareness to vocabulary and reading comprehension as compared to decoding. Future empirical and meta-analytic research on Chinese reading should consider including a wider range of reading subskill outcomes. To reiterate, there is also a need for more meta-analytic evidence of the relationship between morphological awareness and Chinese reading development among normally developed L1 readers, L1 readers with reading difficulties or dyslexia, and L2 readers (see a similar approach applied to English reading by Goodwin & Ahn, 2010, 2013). As indicated by the independent sample sizes, much less research attention has been paid to L2 readers.

Practically speaking, there are two major implications from the findings of this study. First, the finding that the correlational effect sizes between morphological awareness and reading outcomes are larger for L2 readers than for L1 readers suggests that morphological awareness plays a more important role in L2 Chinese learners, thus, L2 Chinese teachers should pay close attention to assessing and teaching Chinese morphological awareness. Second, the meta-analytic results have revealed a higher correlation between homograph awareness and L1 reading outcomes and a higher correlation between mixed assessment type and L2 Chinese reading outcomes. Therefore, for L1 Chinese learners, homograph awareness should be stressed for assessment and instruction; whereas for L2 Chinese learners, mixed-modality assessment and instruction of Chinese morphological awareness is encouraged.

Appendix A. References of the primary studies meta-analyzed are available in the supplementary material.

Data availability

Data coding, sensitivity analysis results, and publication bias results are available at: osf.io/4rdm5.

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Author contributions

Ke was responsible for conceptualization, methodology, result analyses, as well as manuscript writeup and revisions.

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The author declares no competing interests.

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Ethical approval was not required as the study did not involve human participants.

Informed consent

Informed consent was not required as the study did not involve human participants.

Additional information

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